Section 2

Watershed Characterization

Photo Credit: Jessica Casillas

Section 2. Watershed Characterization

Watershed characterization considers the natural features of the land, the human elements that interact with them, and the relationship these factors have with water quality. This represents the first step in understanding the causes and sources of pollution in the watershed in order to identify effective means to address them. Evaluating all elements and factors that shape the connection between land and water is part of a watershed approach to improving water quality.

Geography

The watershed area of Spring Creek includes portions of Grimes, Harris, Montgomery, and Waller Counties (**Figure 1**). On the northwest side of the Houston-Galveston region, this drainage area is connected to the Houston metropolitan area by State Highway (SH) 249, and Interstate 45 (I45) transportation corridors.

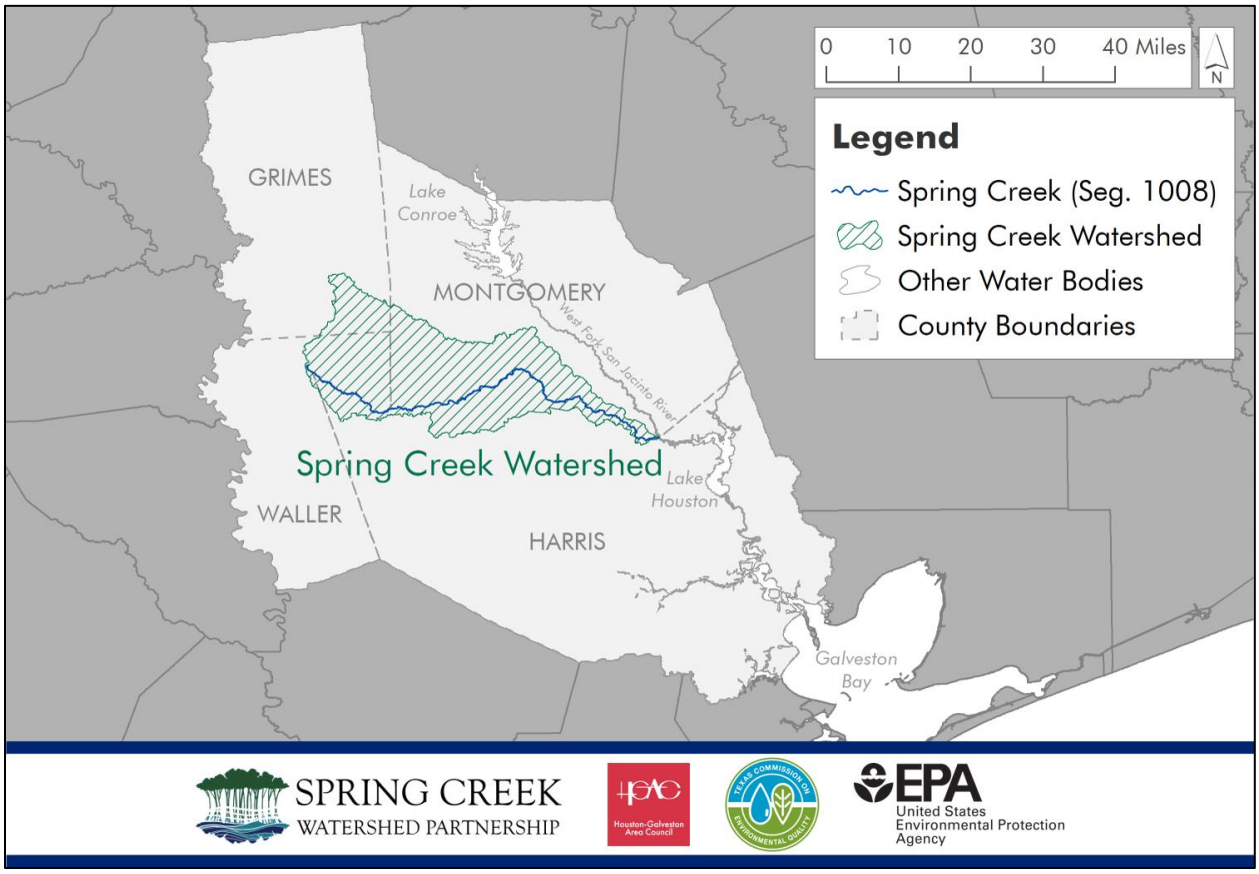

Figure 1. Regional context for the Spring Creek watershed

Regional Context

Spring Creek and its network of tributaries are part of the broader West Fork San Jacinto River Basin (Segment 1004) between Lake Conroe to the north, and Lake Houston to the south. Spring Creek flows into the West Fork of the San Jacinto River directly upstream of

that waterway's confluence with and Lake Houston. Lake Houston's prominence as a drinking water source, recreational venue, and as an integral part of the complicated hydrology of the San Jacinto River Basin make the contributions from Spring Creek and other tributaries especially important in a regional context.

Watershed Delineation

The Spring Creek watershed was delineated using a combination of existing data, map review, and field observations (**Figure 2**). The primary watershed and subwatershed delineations were developed from National Hydrography Dataset Plus (NHD+) watershed layers, with minor adjustments to reflect conditions on the ground, segregate tributaries, and normalize subwatershed size. NHD+ data was compared with United States Geologic Survey (USGS) Hydrologic Unit Code 12 and 10 data, and other local sources. Compared to aerials and known hydrologic boundaries, the NHD+ data was closest to expected actual drainage patterns in this system. Staff conducted map surveys using online mapping, and limited field reconnaissance to confirm assumptions.

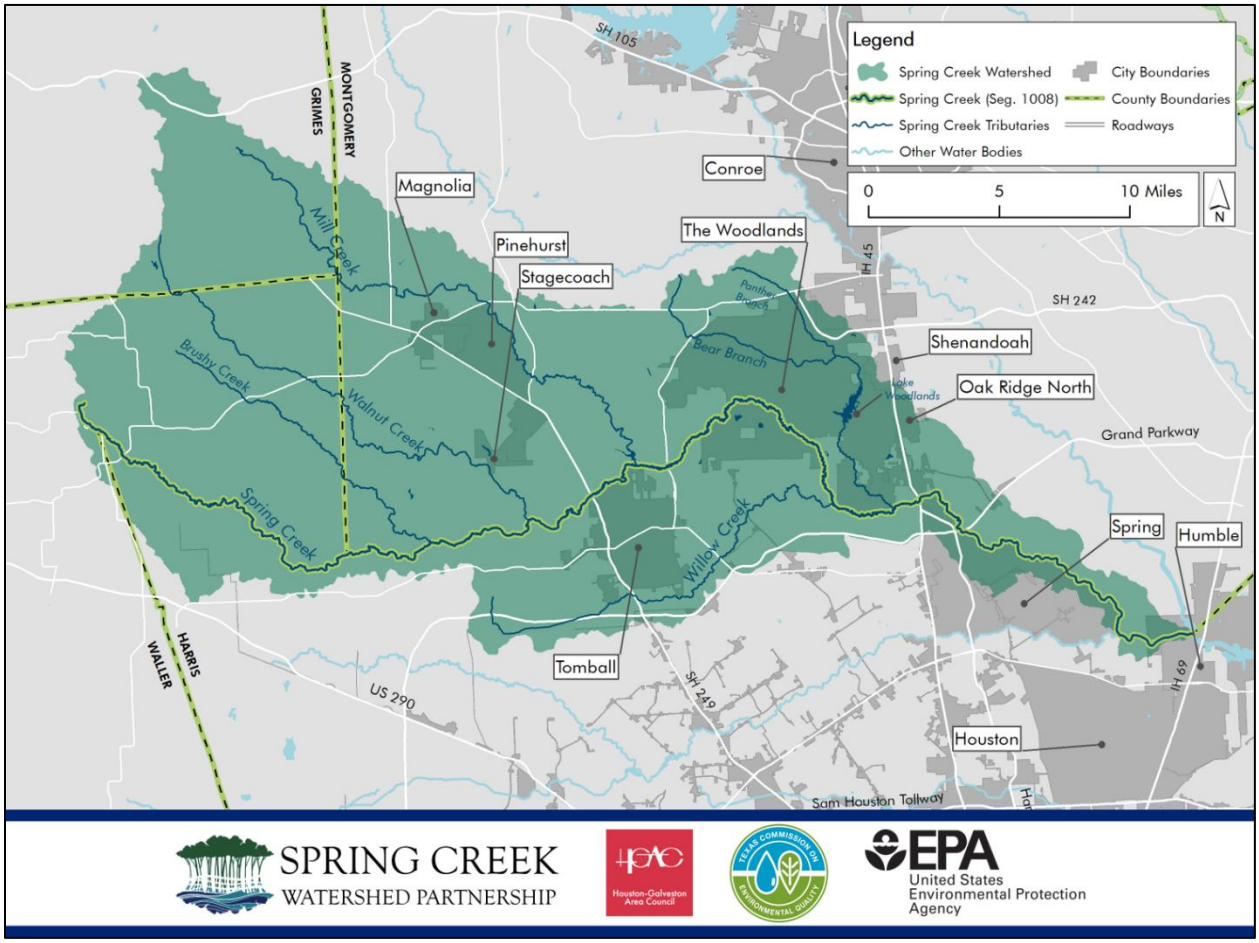

Figure 2. Spring Creek watershed

Subwatersheds were further delineated from a selection of existing and continuing water quality monitoring stations to ensure the ability to evaluate these areas during the implementation of the WPP (**Figure 3**). Considerations for the selection of the stations were their ability to represent different areas of the watershed, the natural hydrologic elements of the watershed (*e.g.*, major tributaries), and appreciable areas of developmental or land cover type, and general comparability in size. The resulting subwatersheds balance these interests, with the highest priority given to representation by ongoing monitoring stations at their terminal ends.

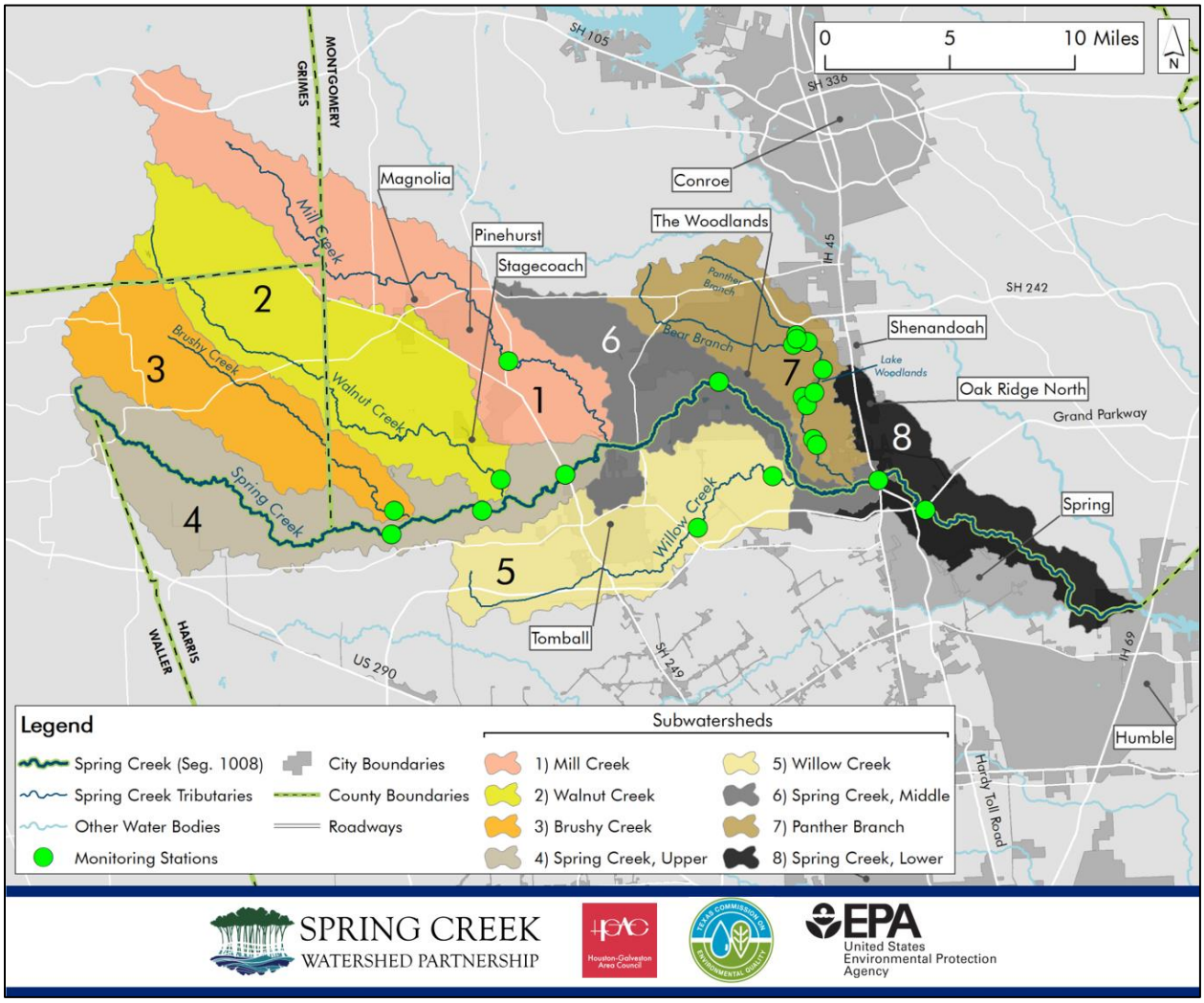

Figure 3. Spring Creek subwatersheds and monitoring station locations

Drainage Area and Stream Network

The full drainage area of the Spring Creek watershed covers over 440 square miles and the stream network that makes up its drainage system includes 903 linear miles of waterways (**Figure 4**). The drainage network includes both natural streams, modified waterways, and manmade drainage (channels and storm sewer systems) of varying size.

Each of Spring Creek's primary tributaries (Mill Creek, Upper and Lower Panther Branch, Bear Branch, Lake Woodlands, Willow Creek, Walnut Creek, and Brushy Creek) are themselves networks of smaller tributaries and drainage conveyances.

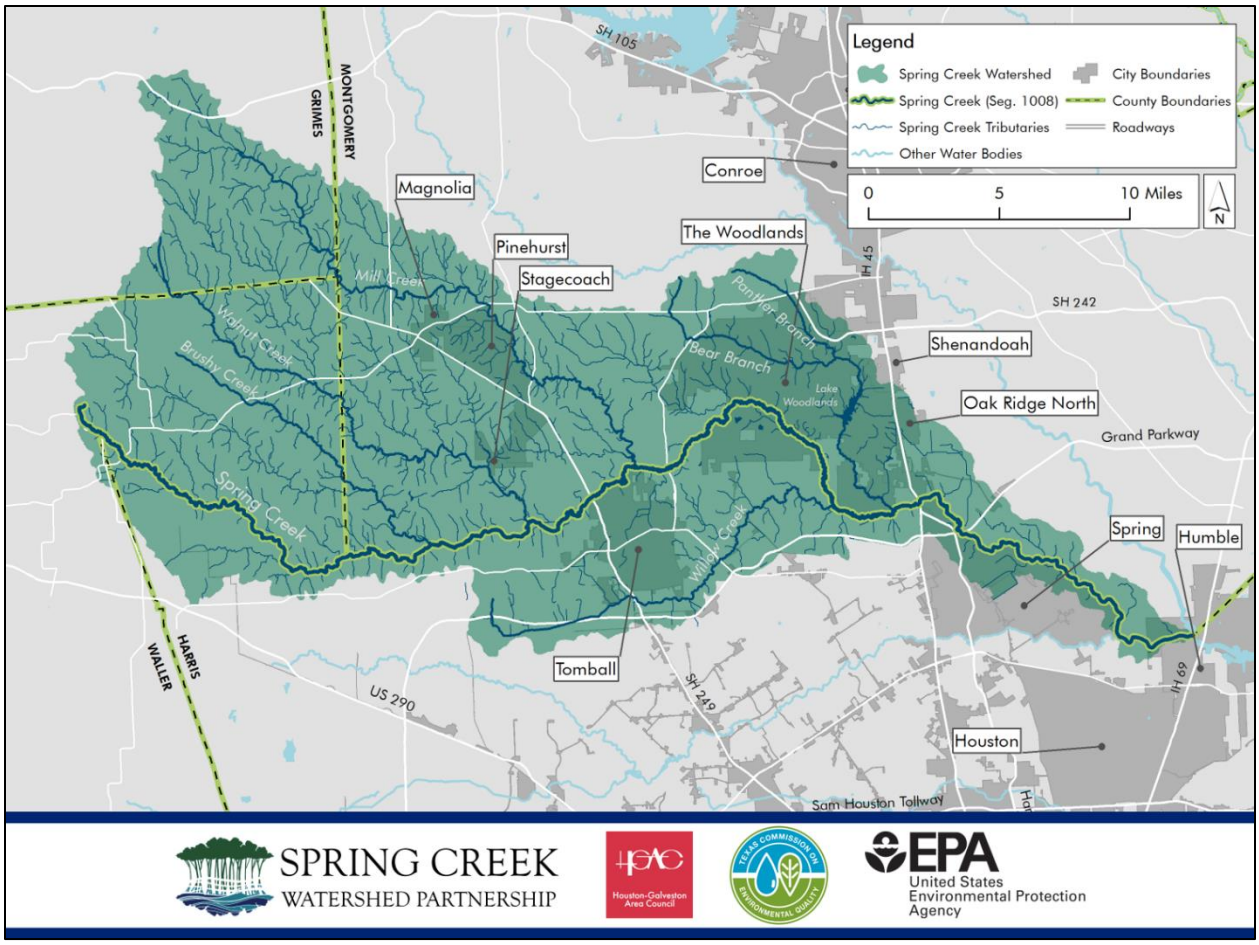

Figure 4. Hydrology in the Spring Creek watershed

The main channel of Spring Creek starts in the undeveloped areas of eastern Waller County and northwestern Harris County. As it progresses east, the waterway grows in size. Once the main channel passes into more developed area east of SH 249, the waterway is a moderately sized creek in normal flow conditions, though its presence and floodplain are much more expansive in high rainfall events. Throughout the rest of its meandering path it retains this character, although the area it traverses is primarily denser subdivision and commercial development. The stream network of the Spring Creek watershed contains many primary tributaries[1] (**Figure 5**). These include[2]:

[1] The primary tributaries discussed here are the unclassified segments which are assessed by TCEQ, and are the more prominent tributary systems in the watershed. Additional named tributaries exist in the watershed, but are considered part of the general drainage network for the purpose of this WPP.

- **Mill Creek (1008A)** — Mill Creek represents a portion of the headwaters for Spring Creek, forming a confluence with Spring Creek just north of Tomball. It is primarily characterized by more natural land types, excepting some developed areas including the Cities of Magnolia, Pinehurst, and Stagecoach.
- **Upper Panther Branch (Segment 1008B)** — Upper Panther Branch is a heavily modified waterway primarily serving as a drainage conveyance amidst dense suburban development.
- **Lower Panther Branch (Segment 1008C)** — Lower Panther Branch is also a heavily modified waterway primarily serving as a drainage conveyance amidst dense suburban development for The Woodlands Township. It forms a confluence with Spring Creek just west of its crossing at I-45.
- *Metzler Creek (Segment 1008D) — Metzler Creek is a tributary to Willow Creek.*
- **Bear Branch (Segment 1008E)** — Bear Branch is also a heavily modified waterway primarily serving as a drainage conveyance amidst dense suburban development. It forms a confluence with Upper Panther Branch just above Lake Woodlands.
- **Lake Woodlands (Segment 1008F)** — Lake Woodlands is a reservoir separating the upper and lower portions of Panther Branch located centrally in The Woodlands Township.
- **Willow Creek (Segment 1008H)** — Willow Creek serves as drainage conveyance for the Tomball area. It forms a confluence with Spring Creek upstream of the confluence between Lower Panther Branch and Spring Creek.
- **Walnut Creek (Segment 1008I)** — Walnut Creek represents a portion of the headwaters for Spring Creek, forming a confluence with Spring Creek just west of SH 249. It is primarily characterized by more natural land types.
- **Brushy Creek (Segment 1008J)** — Brushy Creek also represents a portion of the headwaters for Spring Creek, forming a confluence with Spring Creek upstream of the confluence between Walnut Creek and Spring Creek. It is primarily characterized by more natural land types.
- *Arnold Branch (Segment 1008K) — Arnold Branch is a tributary to Walnut Creek via Mink Branch.*
- *Mink Branch (Segment 1008L) — Mink Branch is a tributary to Walnut Creek.*
- *Sulphur Branch (Segment 1008M) — Sulphur Branch is a tributary to Walnut Creek.*

[2] Italics represent unclassified segments not assessed in the 2020 Integrated Report of Surface Water Quality.

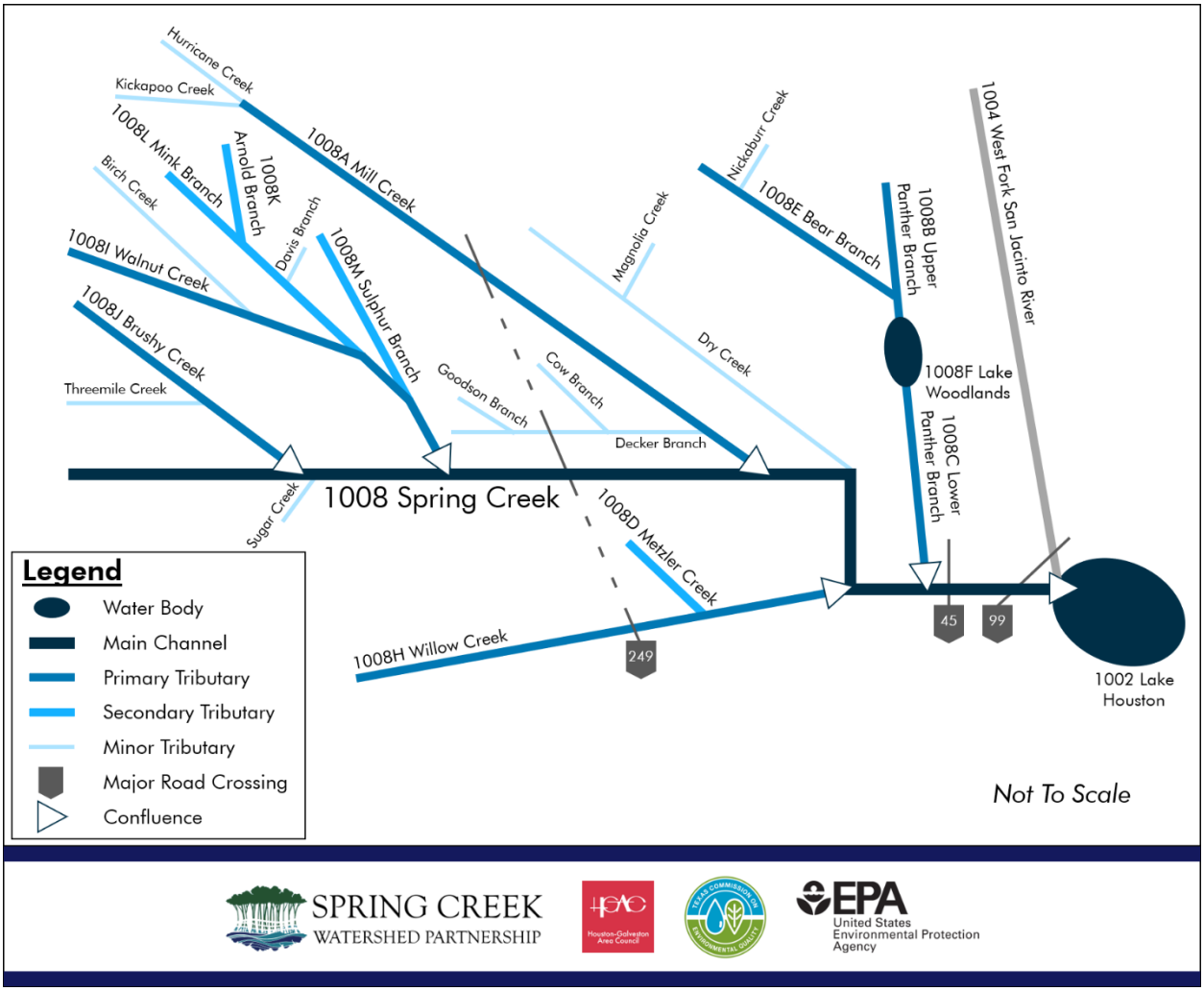

Figure 5. Stream network diagram

Recreational paddling and fishing are common on the main stem, and recreational trails are widespread and increasing in its riparian corridors. The system in general supports a high-quality aquatic ecosystem. Despite the rapid and expansive development along the transportation corridors, much of the waterway maintains a wooded riparian buffer.

Political Geography

The Spring Creek watershed includes a mix of land uses, with a primarily rural western third, a transitional middle third, and a densely suburban/urban eastern third. While the watershed encompasses or overlaps with portions of some cities or census-designated place communities (Magnolia, Pinehurst, Stagecoach, The Woodlands Township, Shenandoah, Oak Ridge North, Tomball, Spring, Houston, and Humble; **Figure 6**) some of the developed areas are communities represented by special districts (municipal utility districts, water control and improvement districts, utility districts, *etc.*) or private utilities within unincorporated areas. There are 103 of these districts or communities that provide

water or sewer service within the watershed, ranging from small municipal utility districts (MUDs) representing single neighborhoods, to large master-planned communities. These areas are a common form of residential development in the watershed by area.

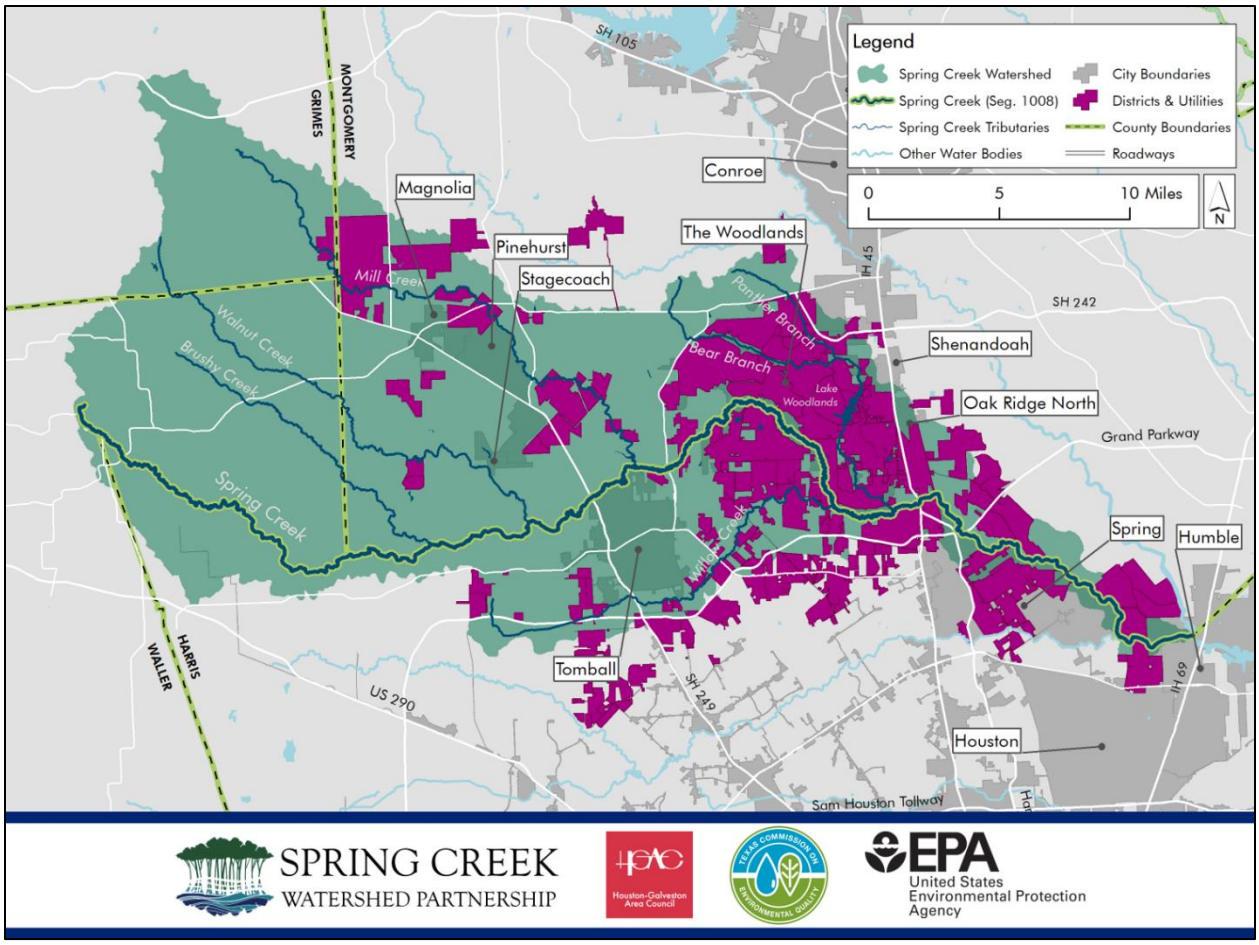

Figure 6. Districts and utilities in the Spring Creek watershed

The watershed includes portions of Grimes County Commissioner Precinct 2, Harris County Commissioner Precincts 3, and 4, Montgomery County Commissioner Precincts 2, 3, and 4, and Waller County Commissioner Precinct 2. Representation at the national level includes United States House of Representatives Districts 2, 8, 10, and 18 (in addition to the United States Senate general representation). Representation at the state level includes Texas House of Representatives Districts 3, 13, 15, 126, 127, 130, and 150; and Texas State Senate Districts 4, 5, 7, 15, and 18. In addition, the watershed overlaps the service area of a variety of other districts and authorities, including the North Harris County Regional Water Authorities, the San Jacinto River Authority, the Gulf Coast Waste Disposal Authority, the Coastal Water Authority, the Harris County Flood Control District, and Port of Houston Authority. Soil and Water Conservation Districts include those for Montgomery County, Harris County and Navasota. Additionally, several

independent school districts, and a number of other special purpose districts overlap with the watershed area.

Much of the population growth in the watershed has followed the major transportation corridors of I-45, SH 249, and SH 99. The focus of new development is westward, as growth continues to push out of the urban core of Houston. Development in the eastern portion of the watershed, especially east of SH 249, is primarily densely suburban in character, with some smaller industrial areas. While the primary development upstream of SH 249 is still light rural residential, agricultural, or undeveloped areas, development is pushing rapidly into this area and its eastern edges are in transition.

Water Rights

Water quality is the focus of this WPP, rather than issues of water supply. However, the Spring Creek watershed is a conduit for water augmenting public water supplies in Lake Houston (via the West Fork San Jacinto River) and includes developed areas with pollutant sources in or adjacent to floodplains. Therefore, water supply in this watershed can potentially impact water quality. Considerations for matters of water supply can also provide context for understanding the waterways.

Texas grants the right to use waters of the state (including waterways like Spring Creek) through water rights permits. There are 18 water rights permits in the Spring Creek watershed, representing a mix of on-channel reservoirs (impoundments) and diversion points (Table 1). The majority of the impoundments represent recreational use permits. The maintenance of the 3,852.1 acre-feet of existing impoundments are not likely to have an impact on average flows in Spring Creek except potentially in extreme drought conditions. Permits for diversions are chiefly oriented toward irrigation for development, particularly for the establishment of The Woodlands. The San Jacinto River Authority holds a substantial permit for the diversion of up to 14,644 acre-feet of groundwater based effluent return flows. Finally, Harris County Flood Control District No. 18 and Palmetto Transoceanic, LLC hold rights to a combined 260 acre-feet for the purposes of flood management. Excluding groundwater, only 1,877 acre-feet of diversions from the watershed are permitted annually.

Table 1. Water rights in the Spring Creek watershed

Permit	Permittee	Impoundment Area (acre-feet)	Diversion (acre-feet)	Issue Date
2805	Woodlands Development Corporation	1,460	750	Mar. 14, 1986
2916A	Woodlands Commercial Development Company	20	NA	Mar. 14, 1986
		90	310	
2998	P. B. Smith	NA	25	Mar. 14, 1986
3099	C. R. Hocott, Trustee	36	NA	Mar. 14, 1986
		4.5	NA	
		3.8	NA	
		3.2	NA	
3155	Lester Neidigk	246	NA	Mar. 14, 1986
3185	Tennessee Gas Transmission Company	39	32	Mar. 14, 1986
3241	Stagecoach Farms Civic Club	101	NA	Mar. 14, 1986
		14	NA	
3244	Lake Winona Property Owners Association	85	NA	Mar. 14, 1986
3253A	Lake Hollyhill Owners Association, Inc.	52	NA	Mar. 14, 1986
3271	Woodlands Lakes Civic Culb, Inc.	45	NA	Mar. 14, 1986
3882	Woodlands Development Corporation	600	500	Jun. 8, 1982
5408	The Woodlands Corporation	92	NA	Jun. 26, 1992
5471	Properties of the Southwest, Inc.	563	NA	Jan. 10, 1994
5572	Properties of the Southwest, Inc.	11	NA	May 9, 1997
5576	Lipar Group, Inc.	345	NA	May 9, 1997
5809	San Jacinto River Authority	NA	14,944	May 14, 2004
12687	Harris County Improvement District No. 18	32	166	Jan. 10, 2013
12708	Palmetto Transoceanic, LLC	9.6	94	Dec. 2, 2013

Flood Mitigation

Approximately 17% of the watershed is in the 100- or 500-year floodplains (Figure 7). However, recent events like the floods of 2015 and 2016, and Hurricane Harvey have shown that the floodplains do not always accurately account for flooding potential in the watershed, which can exacerbate the release of pollutants into waterways. Areas in which flooding is unexpected may be especially vulnerable to erosion, flood damage, and pollution from sources not designed for flooding situations.

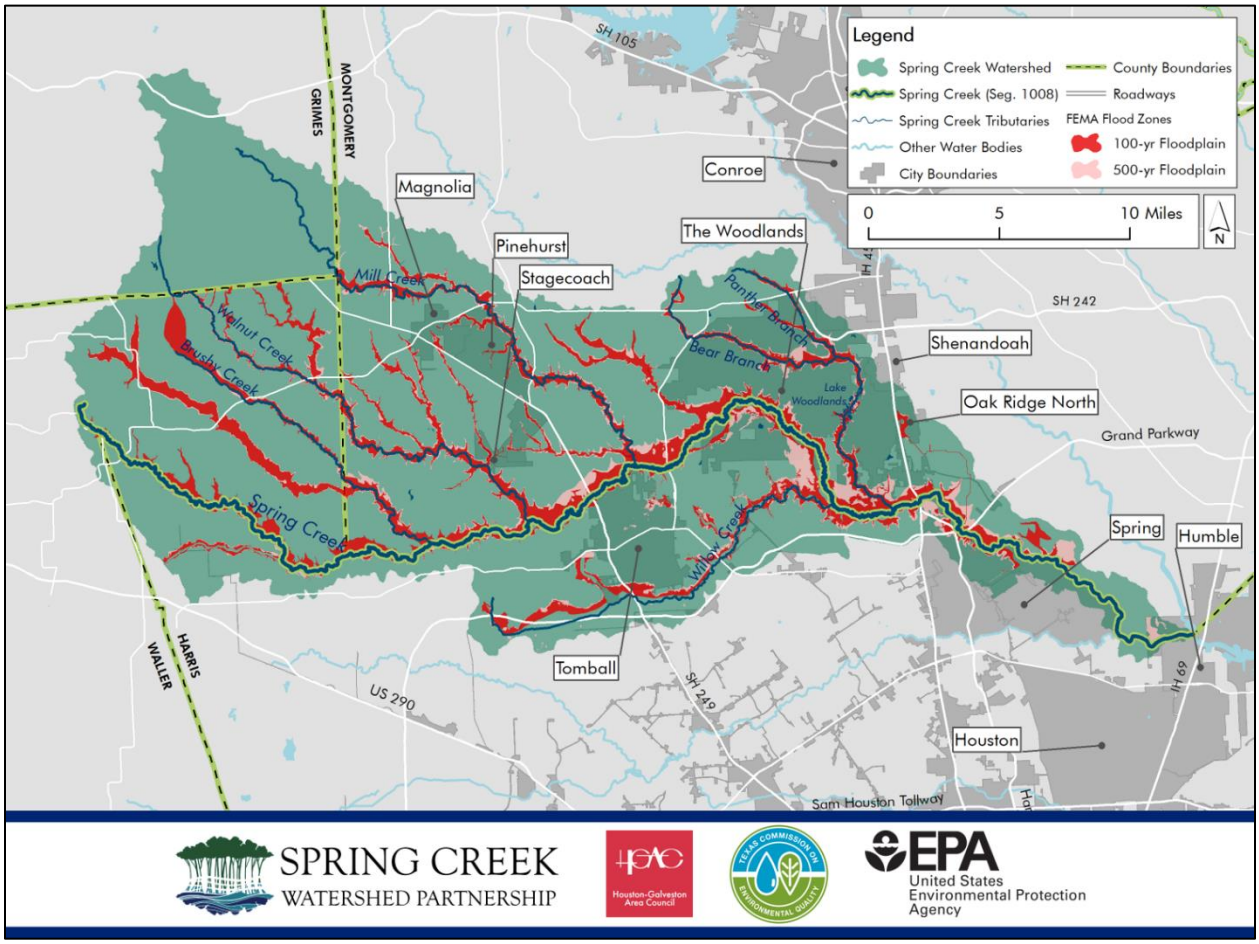

Figure 7. Floodplains in the Spring Creek watershed

Physical and Natural Characteristics

The physical aspects of watershed areas can impact how natural processes and effects of human development affect water quality.

Topography

The watershed area is along the transitional area between the Southern Central Plains and the Gulf Coast Plains. As such, it experiences more topographical variation than areas closer to the coast in the Houston-Galveston region (**Figure 8**).

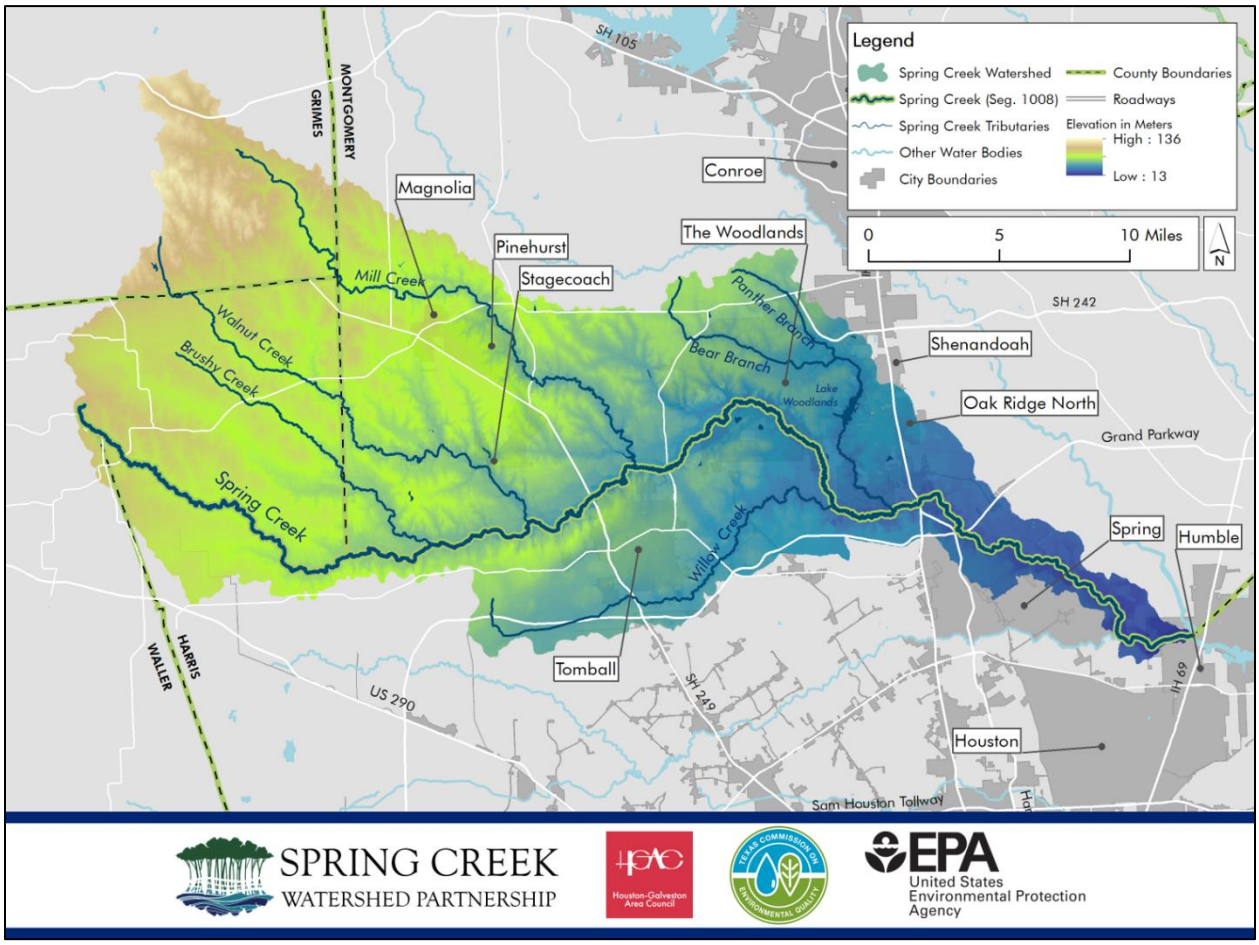

Figure 8. Elevation in the Spring Creek watershed

Elevation generally decreases from northwest to southeast, and from headwaters toward the drainage pathways. There is a 123-meter difference between the highest and lowest points[3] of the watershed.

Climate

The climate of the area is categorized as humid subtropical, indicating it has winters cold enough to generate occasional freezing conditions. Average rainfall for the area is between 42-50 inches of rain, with western areas being drier on the average than eastern areas of the watershed. However, drought events can have appreciable effect on the area, as evidenced in the 2011 drought. Throughout this period, western areas were

[3] Based on USGS Digital Elevation Model (DEM) 10-meter resolution spatial data.

exceptionally dry, and water elevations fell to record levels in downstream areas like Lake Houston—the reservoir into which Spring Creek drains.

Even though the watershed is not directly adjacent to the coast, the area is still well within the range of hurricanes and other large storms coming in from the Gulf of Mexico. The generally warm climate allows for a diverse array of flora and fauna but can exacerbate some water quality issues influenced by temperature (e.g., DO).

Soils

The soil mix[4] of the Spring Creek watershed represents the juncture of different landscapes the water bodies traverse. In general, soils south of Spring Creek are dominated by fine loamy soils mixed with coarse loam especially around the headwaters of Willow Creek. Loamy sediments are predominant in the riparian areas along the main stem of Spring Creek as well as its northern tributaries, and is mixed throughout with smaller areas of sandy soil. Beyond the riparian areas, land north of Spring Creek transitions from loamy to clayey soil types. The transition of soil drainage characteristics of the specific soil complexes reflects the transect between what were traditionally prairie areas in the southwest, and forested areas more common in the north and east reaches of the watershed (**Figure 9**). Erosion of soils is prominent in the alluvial sediments along the waterways, an area which is mined in this watershed for sand and/or gravel.

[4] A key to the soil types represented in the map can be found at the link provided in this note. Data provided by: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed on 5/3/2021 at: https://websoilsurvey.nrcs.usda.gov/. Soil survey dates and methods can differ from jurisdiction to jurisdiction and across time periods.

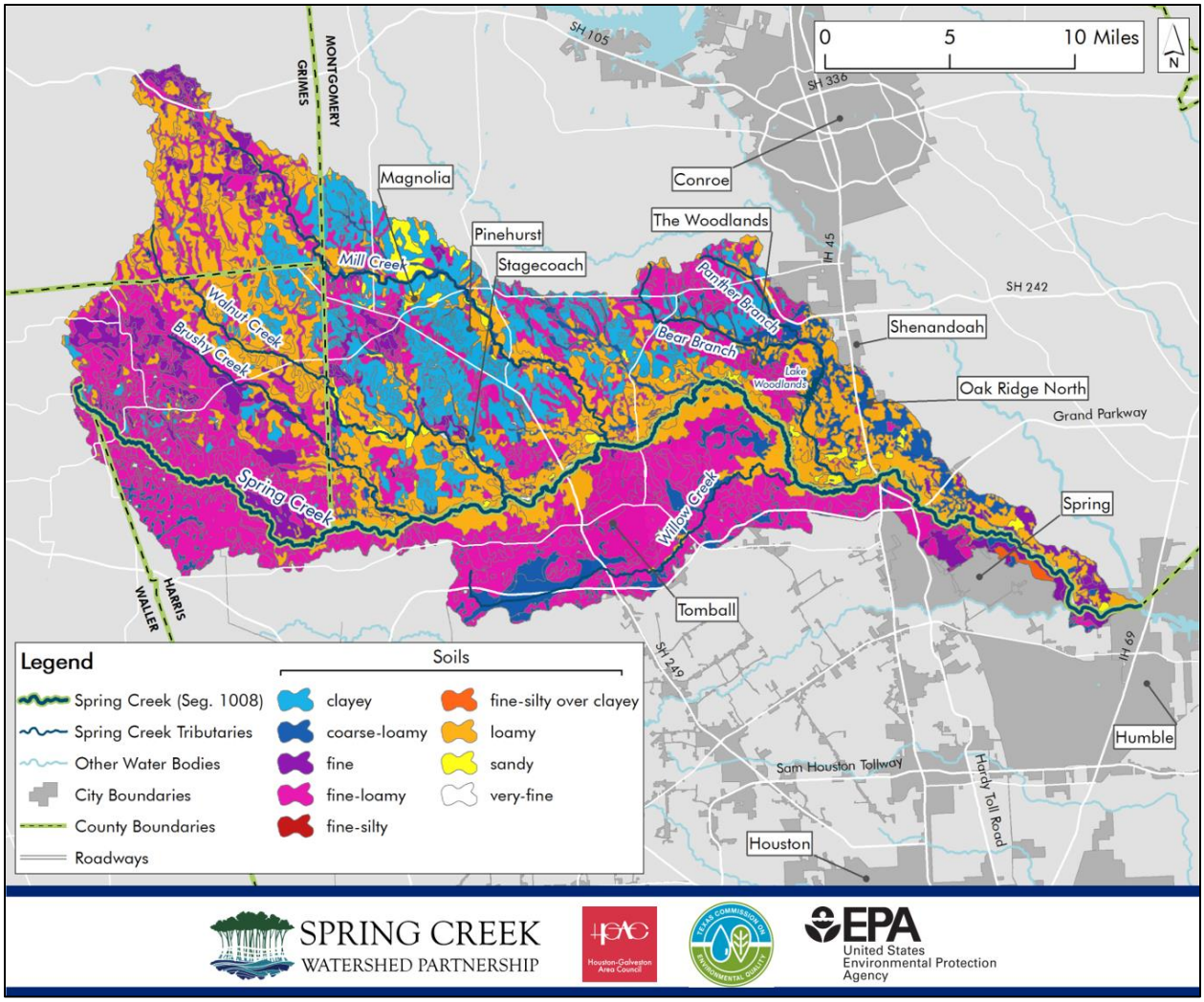

Figure 9. Soils in the Spring Creek watershed

Habitat and Wildlife

The Spring Creek watershed is like the Houston region in general, in that it straddles a transitional zone between several different ecosystems, encompassed in five designated ecoregions[5] (areas of similar climate, habitat, and landscape indicated in **Figure 10**). The majority of the watershed falls within the Southern Tertiary Uplands (EPA Level IV ecoregion 35c) and the Flatwoods (EPA Level IV ecoregion 35f) which both fall under the broader South Central Plains (EPA Level III ecoregion 35) designation. The southernmost reaches of the watershed are dominated by Northern Humid Gulf Coastal Prairies (EPA Level IV ecoregion 34a) of the Western Gulf Coastal Plain (EPA Level III ecoregion 34). Finally, the westernmost portion of the watershed overlaps with Southern Post Oak Savannah (EPA Level IV ecoregion 33b) of the East Central Texas Plains (EPA Level III

[5] Based on EPA Level III (broad) and Level IV (more specific) Ecoregion data accessed on 5/3/2021 at: https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

ecoregion 33), and a small portion of the northernmost tip of the watershed intersects the Southern Blackland/Fayette Prairie (EPA Level IV ecoregion 32b) of the Texas Blackland Prairies (EPA Level III ecoregion 32). Mixed grasses and other vegetation characteristic of the western portions of the Houston-Galveston region are common in the southwestern portion of the watershed. These areas transition into denser riparian forests concentrated in the northwest and expanding along waterways that approach the confluence with the West Fork of the San Jacinto River. These riparian areas are characterized by vegetation reflecting a mix of deciduous and coniferous trees and a variety of grass species similar to the northern and eastern extent of the region. Most important, however, to understanding the actual current habitat in the watershed is the extent of modified land cover, primarily urban/suburban that represents much of the eastern watershed. This modified habitat tends toward monocultures (live oaks, crepe myrtles, and similar residential plantings) and less overall habitat value than the remnant areas of western prairie and riparian corridor.

The broad range of landscapes, including those modified by human activity, host a diverse array of animal and plant species. Moderate winter temperatures and the location of the watershed in the Central Flyway for migratory birds support a dense and varied community of bird species year-round. Local bird species include wading birds (*e.g.*, Great Blue Heron, White Ibis), a wide variety of passerine species, and several raptors (*e.g.*, Red-tailed Hawk, Bald Eagle, Barred Owl). Notable local conservation areas include natural or restored lands like the Bayou Land Conservancy holdings east of SH 249, large mixed-use park areas (*e.g.*, Montgomery County Preserve, George Mitchell Preserve), and a patchwork of private conservation easements and similar single-landowner conservation parcels. Typical mammal species include White-tailed Deer, Virginia Opossum, Raccoons, Coyotes, Eastern Grey Squirrels, Striped Skunks, Nine-banded Armadillos, and numerous species of rodents and bats. The watershed is also home to many common reptiles and amphibians, including *Nerodia* water snakes, Red-eared Slider turtles, and bullfrogs.

Of particular concern to the watershed are some of the invasive species that are making it home. In addition to exotic plants (*e.g.*, Chinese Tallow) and various invasive animals, feral hogs (*Sus scrofa*) are a growing issue for the Houston region, and are present in the Spring Creek watershed. Feral hogs threaten native wildlife species through direct competition for food and destruction of habitat. Large feral hog populations can cause damage on agricultural lands, but are also a nuisance for suburban and exurban residential areas. Hogs tend to congregate in and around water bodies, causing damage to the riparian corridor and depositing fecal waste directly to the water body.

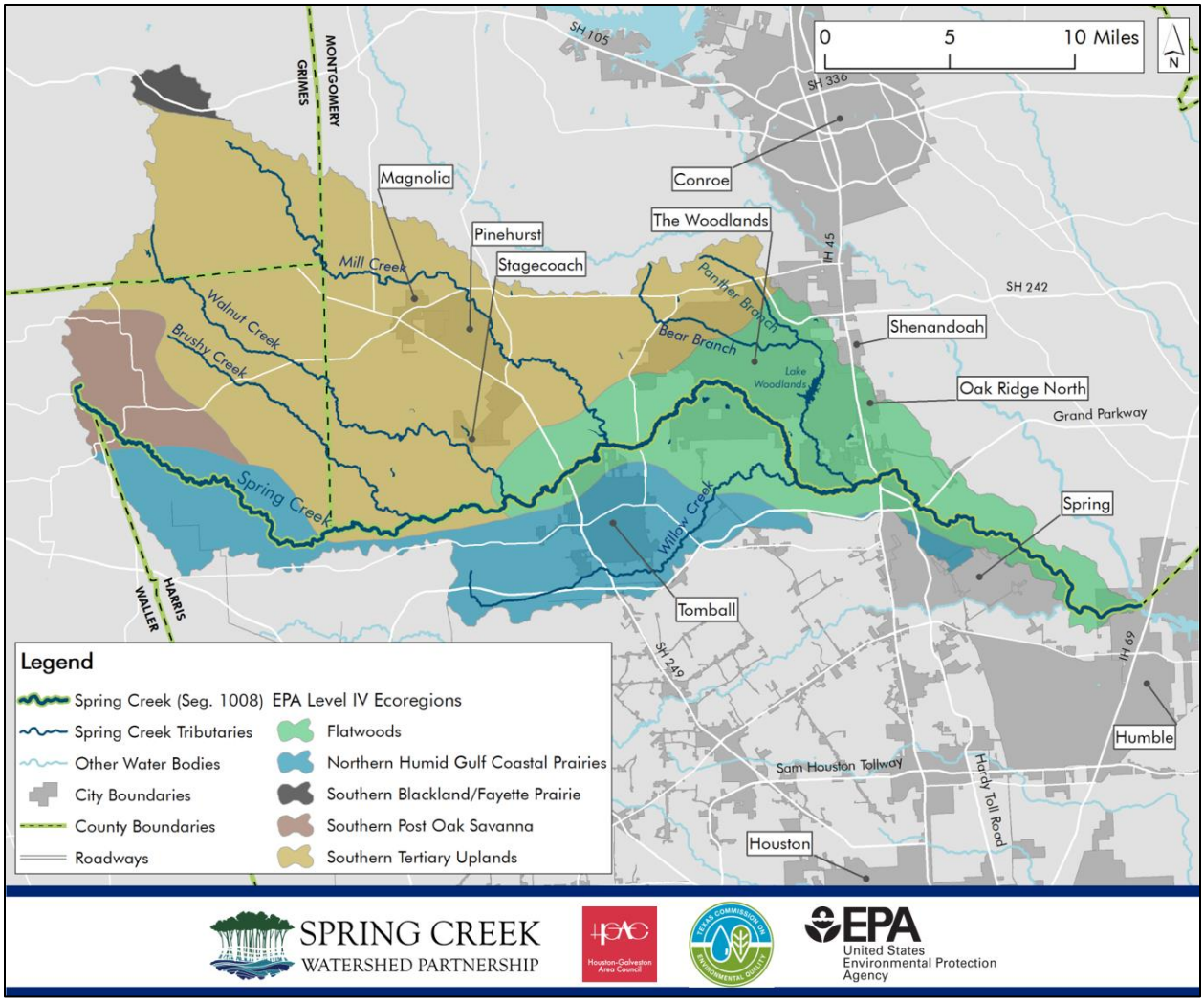

Figure 10. EPA Level IV Ecoregions in the Spring Creek watershed

Land Cover and Development

The mixture of natural landscapes in the Spring Creek watershed is further diversified by the modifications made to the land by human development. The character and balance of land cover in the watershed greatly influences the density and transmission of pollutant sources, and considerations for implementing solutions.

Land Cover

In general, the watershed transitions from undeveloped areas in the western third of the watershed, through a middle transitional zone of small rural communities west of SH 249, to dense suburban/commercial areas for most of the remaining eastern third of the watershed (**Figure 11**).

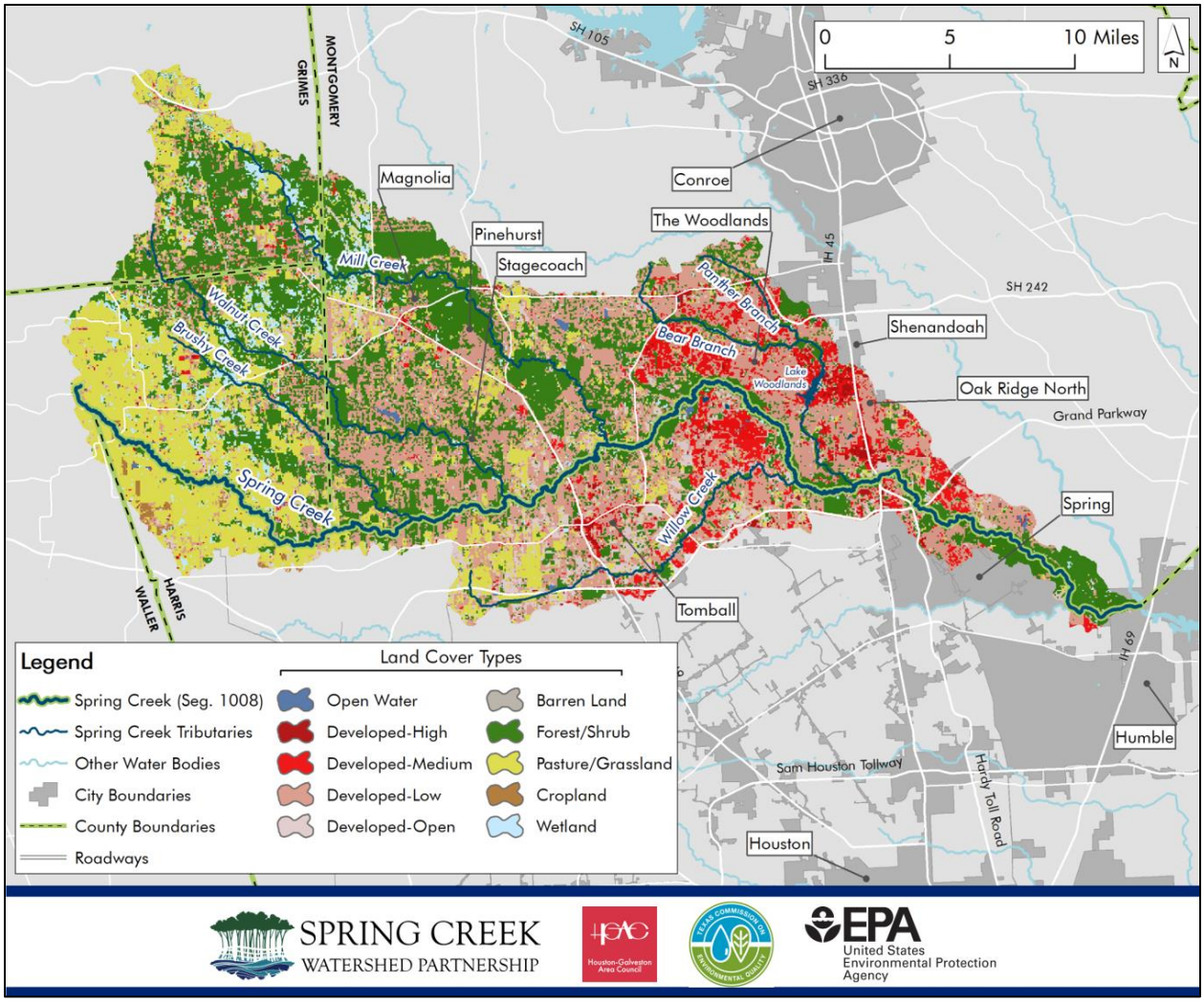

Figure 11. Land cover in the Spring Creek watershed

Table 2. Land cover as a percentage of watershed area

Land Cover Category	Percentage of Watershed Area
Open Water	0.41%
Developed-High Intensity	1.57%
Developed-Medium Intensity	5.59%
Developed-Low Intensity	29.07%
Developed-Open Space	5.63%
Barren Land	0.40%
Forest-Shrub	32.37%
Pasture-Grassland	19.76%
Cropland	0.65%
Wetland	4.55%

Harris and Montgomery County have experienced rapid change in recent decades, with growth pushing up and out from the Houston area around the I-45 corridor, and out from the Conroe area. The most prominent change in land cover types has been the conversion of agricultural and undeveloped land uses to residential areas. Change in the Grimes and Waller County portion of the watershed has been less extensive with the primary conversion being from agricultural activities to fallow land, light residential, or small scale industrial/commercial development. These trends are expected to continue for the foreseeable future.

While developed land uses make up a substantial portion (~42%) of the total area of the watershed, natural (~57%) and agricultural uses (<1%) account for more than half the remaining area (**Table 2**)[6]. The percentages are more telling when identified at a subwatershed level, with subwatersheds 1, 2, 3, and 4 being dominated by agricultural and natural land cover types, and subwatersheds 5, 6, 7, and 8 being mostly developed land cover. The mix of land cover and uses in different areas of the watershed emphasizes the WPP focus on selecting locally-appropriate measures to address local challenges, identifying multiple areas in the watershed at which to monitor progress, and the need to coordinate with a broad array of partners throughout the watershed area.

Agriculture

Agriculture is generally in decline in most of the watershed area, with most remaining production taking place in the northwest portion of Harris County or the southern end of Subwatershed 5 (Willow Creek). The transition away from agriculture to other land uses affects estimated future shifts in pollutant sources and land cover. In both counties, economic pressure from encroaching development, declining commodity prices, and the impacts of the 2011 drought are reasons commonly cited by the stakeholders for the decline of agricultural activity in the area[7].

- **Grimes County** – Agriculture in Grimes County was the historical foundation for local communities[8]. Early settlers farmed a variety of crops and livestock, but the introduction of cotton and plantation agriculture in the 1800s led to its overwhelming dominance until the early 1900s. During that time and through the modern era, cattle ranching and timber have been a prominent focus of

[6] Data for this analysis represents 10-class data produced by H-GAC in 2018. NLCD and other typical land cover datasets did not have data current enough for this WPP effort given the area's growth rate.

[7] Data reflected in this section is from 2017, the latest data available. Based on anecdotal accounts from stakeholders and partner agencies, the declines in production have continued if not accelerated in the interim.

[8] Handbook of Texas Online, Charles Christopher Jackson, "Grimes County," accessed 5/3/2021 at: http://www.tshaonline.org/handbook/online/articles/hcg11

the county's production. According to the 2017 United States Department of Agriculture (USDA) Census of Agriculture[9], Grimes County saw a 5% increase in the number of farms, but an 18% decrease in the amount of land under production since 2012. Market value of sold products dropped by 1%. Reflecting the greater reliance on cattle ranching, Grimes County has a large percentage of farms in larger size classes with over 64% of the farmland in pasture. However, the majority of farms (78%) are under 180 acres. Current production value is weighted heavily (>70%) toward livestock. Over 60% of farmers are new or beginning with the slight majority (53%) between the ages of 35 and 64.

- **Harris County** – Agriculture in the Harris County area of the watershed was an historical mainstay of the local economy. Farming was common in early communities in western Harris County, with rice, cotton, various row crops, and ranching making up the historical agricultural profile of the area. According to the 2017 USDA Census of Agriculture[10], Harris County saw a 14% decrease in the number of farms, and an 8% decrease in the amount of land under production since 2012. Market value of sold products dropped by 22% in the same period. Most farms in the county are under 180 acres (92%) and many are under 50 acres (80%). However, there are several operations of 1,000 acres or larger. Current production value is heavily weighted toward crops (73%) as opposed to livestock (27%), but this is not reflected by total acreage for each type, with pastureland making up 62% of the total farmland, and cropland (24%) and other uses being smaller shares, proportionally. Only 5% of farmland is irrigated, and while agriculture is in overall decline in the county, over a third of the 3,106 producers are new and beginning. While these numbers are county-wide, discussions with stakeholders, and the concentration of agricultural activity in the western portion of the county, indicate that they are relatively representative of the western watershed area.

- **Montgomery County** – Agriculture in Montgomery County was an historical mainstay of the local economy[11]. Farming and timber were early activities, with cotton, tobacco, various row crops, and ranching making up part of this historical agricultural profile of the area. According to the 2017 USDA Census

[9] Derived from the USDA 2017 Census of Agriculture State and County profiles for Texas, accessed on 5/3/2021 at: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Texas/

[10] See note above.

[11] Derived from "Montgomery County – Birthplace of the Texas Flag", retrieved on 5/3/2020 at: https://montgomery.agrilife.org/

of Agriculture[12], Montgomery County saw a 1% increase in the number of farms, but a 7% decrease in the amount of land under production since 2012. Market value of sold products increased by 8% in the same period. Most farms in the county are under 180 acres (90%) and many are under 50 acres (69%) Current production value is largely weighted (74%) toward livestock. Cattle are the predominant livestock product by value. As with neighbors in Grimes County, most farmers (66%) are new or beginning with a majority (63%) between the ages of 35 and 64.

- **Waller County** – Agriculture in Waller County was the historical foundation for local communities, and continues to be a greater economic force than in adjacent Harris County, relative to the overall economic output of the counties. Overall character of cropland and transition is like Harris County, though less economic pressure from development currently exists in the watershed area of Waller County. According to the 2017 USDA Census of Agriculture[13], Waller County saw only a 2% decrease in the number of farms, but a 20% decrease in the amount of land under production since 2012. Market value of sold products increased in this period by 14%. Like Harris County, most farms in Waller County are under 180 acres (87%), though a smaller number are under 50 acres (64%). Farmed land area is similarly weighted toward pastureland (56%), with cropland being a smaller share (28%). However, the share of sales for each type are disproportionate to their land area, with cropland representing 75% of sales value, and livestock being 25%. Only 3% of farmland is irrigated.

Recreation

Spring Creek is a popular destination for a variety of recreational activities as one of the only two undeveloped creeks in Harris County (the other is Clear Creek). Local partners have invested significant time and effort in developing natural spaces for recreation benefits. Many of the prominent parks and natural areas[14] are adjacent to the creek system and are points of access for recreation (**Figure 13**). Both recreational and subsistence fishing is popular along the waterway, and in lakes in adjacent parkland[15].

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[12] Derived from the USDA 2017 Census of Agriculture State and County profiles for Texas, accessed on 5/3/2021 at: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Texas/

[13] See note above.

[14] This map is not exhaustive of all parks in the watershed.

[15] More information on some of the access points and guidance for fishing can be found on Harris County Precinct 4's website at: https://www.hcp4.net/parks/fishing/

Among the most significant natural areas in the watershed is the Spring Creek Greenway[16], the longest connected urban forested corridor in the nation. Though parts of the Greenway project are still ongoing, the 14.5 miles of trails open to the public are currently well used. When complete, the trails will total a distance of 40 miles and connect the area between SH 249 and US 59. This project represents a collaboration between Harris County Precinct 4 and Montgomery County Precinct 3 with partnership from other local entities such as The Woodlands Township and the Bayou Land Conservancy.

The Township of The Woodlands is recognized as one of the top master planned communities in the nation and supports 148 parks in addition to over 220 miles of hike and bike trails[17]. Furthermore, approximately 28% of the total acreage remains natural and consists largely of forested area.

The Bayou Land Conservancy is a land trust that currently protects over 14,000 acres in 63 preserves throughout the Houston Region, 13 of which occur along Spring Creek. Their objective is to preserve land along streams in order to control flooding, maintain clean water, and provide habitat for wildlife. Volunteers with the Bayou Land Conservancy's Spring Creek Nature Trail Stewards maintain natural surface trails on the north side of Spring Creek which are popular among area residents.

Figure 12. Nature enthusiasts on the Spring Creek Nature Trail

[16] For more information, see: https://www.hcp4.net/parks/scg/ and https://www.bayoulandconservancy.org/spring-creek-greenway
[17] For more information, see: https://www.thewoodlands.com/

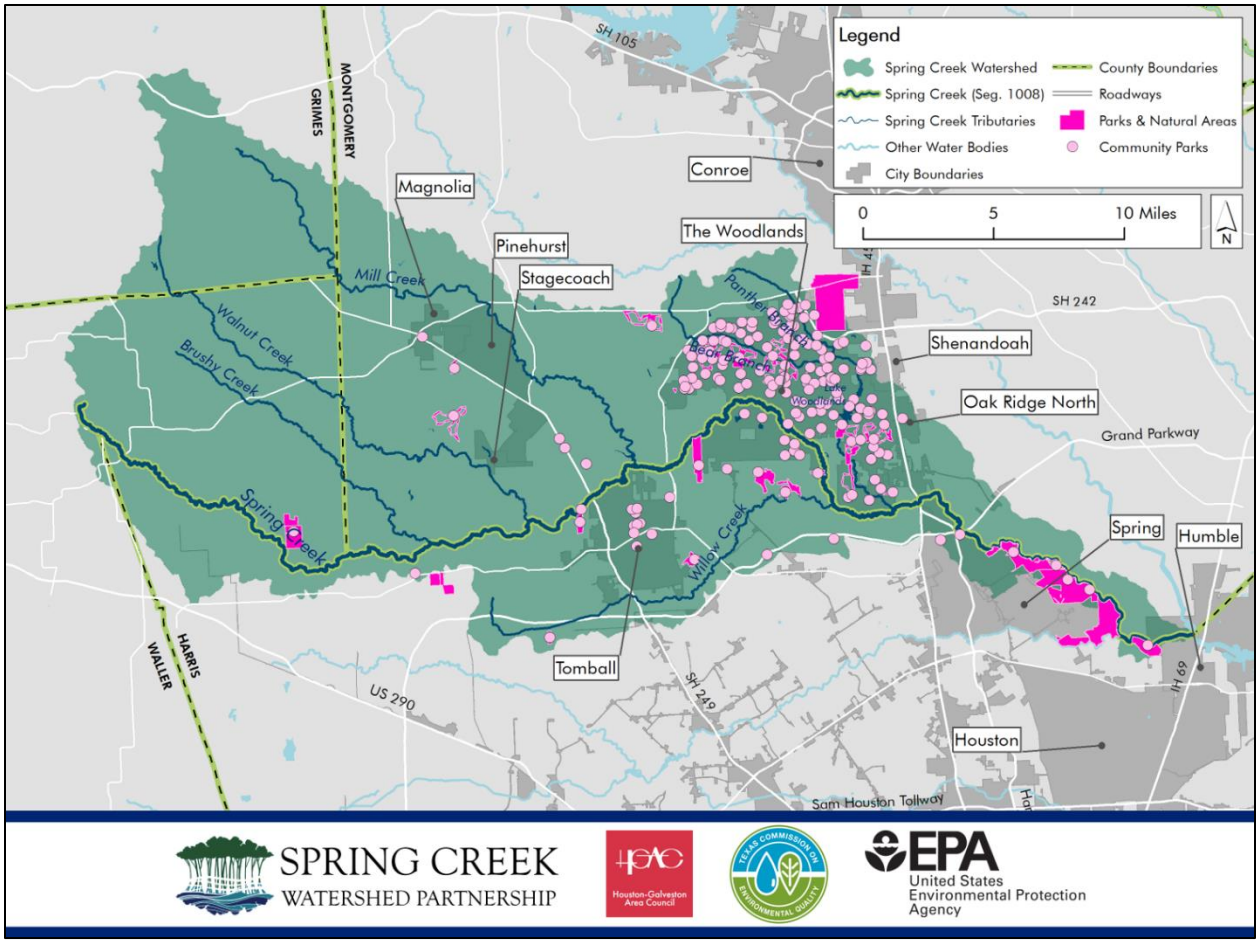

Figure 13. Parks and natural areas in the Spring Creek watershed

Water Quality

For the State of Texas' routine water quality assessments of its water bodies, water quality parameters are strictly defined and tied to the uses we derive from a waterway (**Table 3**). However, water quality for local stakeholders includes other factors specific to the values their community places on their local waterway, and they may have concerns not reflected in ambient water quality monitoring that range from other contaminants like trash to more qualitative concepts such as sense of place and aesthetic quality. This WPP recognizes that the defined water quality parameters discussed herein should be considered alongside other stakeholder concerns and valuations.

Water Quality Standards

For the lakes, creeks, streams, rivers, bays and bayous of Texas, water quality is evaluated based on SWQSs. Under the delegated authority of the CWA, TCEQ develops the SWQSs and is responsible for ensuring they are met. The intent of the standards is to establish explicit goals and limits to ensure Texas' surface waters continue to support recreation, drinking water supply, aquatic communities, and other established uses.

Table 3. Designated uses for water bodies

	The **aquatic life use** designation reflects the ability of the waterways to support aquatic ecosystems and habitat. Compliance with this use is determined by the availability of DO and an assessment of the diversity and health of existing ecological communities (fish, macrobenthics, and their habitat). High levels of chlorophyll-*a*, and elevated levels of nutrients, can indicate potential issues related to low DO.
	The **contact recreation use** designations indicate the waterway is used for recreational activities, such as swimming, that involve a greater chance of ingesting water. The basis of the SWQS for contact recreation standards is to protect public health. Ubiquitous fecal indicator bacteria organisms (*E. coli* and Enterococcus) are used as indicators of the potential contamination level from fecal pathogens. In freshwater systems like the Spring Creek watershed, elevated levels of *E. coli* are a sign the waterway does not meet the SWQSs.
	The **public water supply use** designation indicates a waterway is used for public water supply. The assessment of compliance for this use is a measure of the suitability of the waterway to serve as a current or future drinking water source. A variety of criteria are used to evaluate this use, including temperature, total dissolved solids, DO, pH range, fecal indicator bacteria, chlorine, and sulfates levels.
	The **general use** designation reflects the overall health of the waterway as measured by criteria for temperature, pH, chloride, sulfate, and other parameters.

The vast network of surface water bodies is divided into segments, which are cohesive groupings of waterways and associated tributaries. The primary segment in the Spring Creek watershed is Segment 1008 (Spring Creek). Major tributaries or waterways of interest within these segments are delineated as subordinate unclassified segments. Unclassified segments in this watershed include 1008A (Mill Creek), 1008B (Upper Panther Branch), 1008C (Lower Panther Branch), 1008E (Bear Branch), 1008F (Lake Woodlands), 1008H (Willow Creek), 1008I (Walnut Creek), and 1008J (Brushy Creek). Other contributing waterways and drainage networks also contribute to the system, but are either not designated as unclassified segments by TCEQ or are not actively assessed.

Surface water segments are further divided into assessment units (AUs), the fundamental targets for assessments that determine whether a water body is in compliance with applicable standards. AUs are designated as the segment number followed by the AU number (e.g., 1008_01 for Spring Creek, AU 1). AUs in the Spring Creek system (**Table 4**; **Figure 14**) include:

Table 4. Spring Creek segments and assessment units

Segment	Assessment Units
Spring Creek - 1008	01, 02, 03, and 04
Mill Creek - 1008A	01
Upper Panther Branch - 1008B	01, and 02
Lower Panther Branch - 1008C	01, and 02
Bear Branch - 1008E	01
Lake Woodlands - 1008F	01, 02, 03, and 04
Willow Creek - 1008H	01
Walnut Creek - 1008I	01
Brushy Creek - 1008J	01

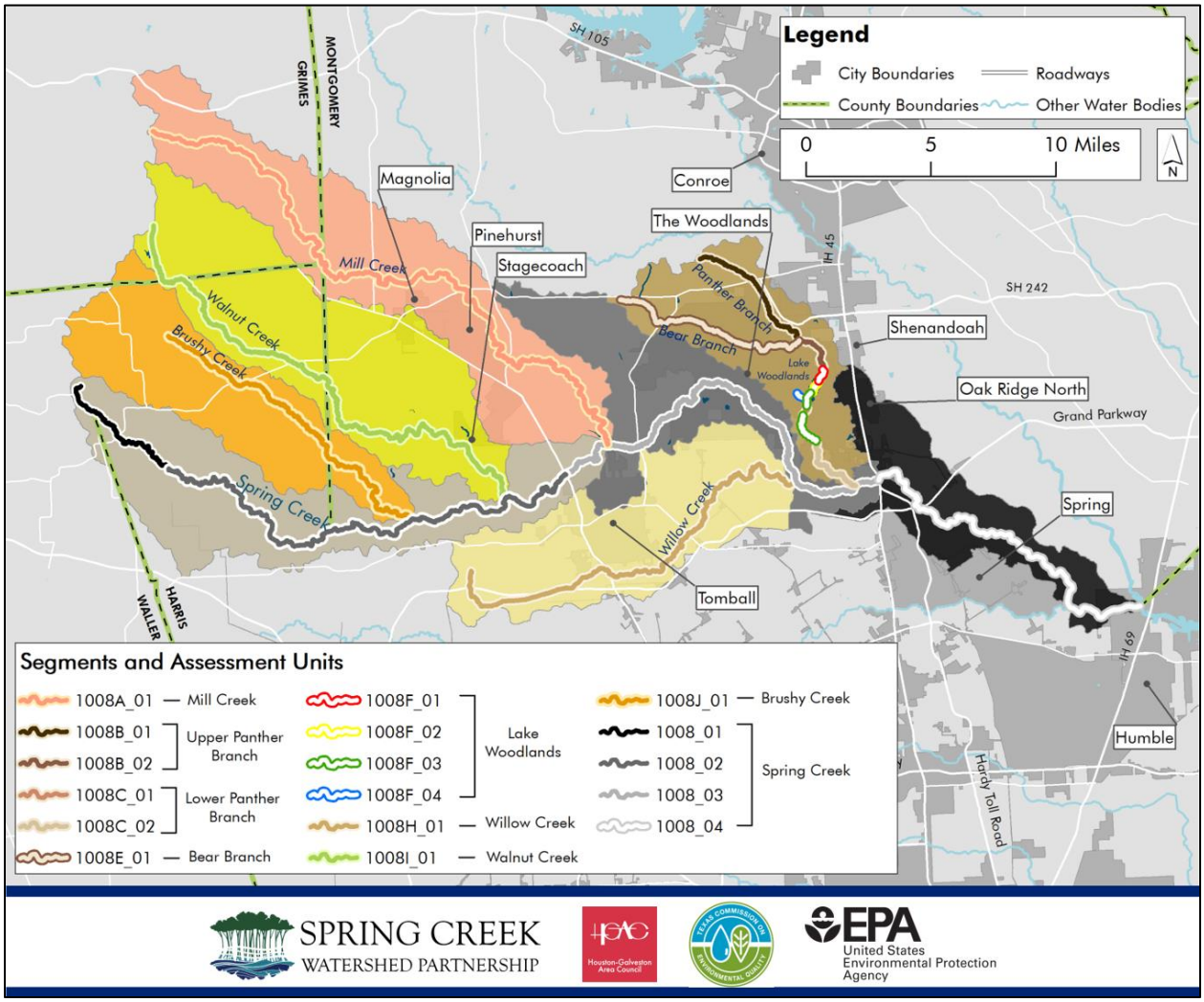

Figure 14. Segments and AUs in the Spring Creek watershed

Assessments are made based on data collected under the state's Clean Rivers Program (CRP) and other quality-assured data. TCEQ conducts assessments every two years for the state's water bodies, reviewing the previous seven years of data against the

designated uses for the waterways. The results are included as part of TCEQ's Texas Integrated Report of Surface Water Quality (Integrated Report). The results of the assessments of the Spring Creek AUs only reflect ambient surface water quality, not the quality of tap water provided by utilities in the watershed, which is not the focus of this WPP.

State of the Water

The water quality of the Spring Creek system is affected by numerous factors, including human activities, natural processes, availability of rainfall, and releases and natural seepage from impoundments to which it is connected. Based on assessment of water quality data[18], many of the AUs in the watershed have existing water quality challenges. As development continues over the coming decades, additional sources of contamination may exacerbate these issues if no mitigating action is taken.

Impairments and Concerns

When a water body is unable to meet one or more of the SWQSs, it has an **impairment** for that standard. When an impairment may be imminent, or when substandard water quality conditions exist for a parameter that does not have an established numeric standard, the water body may be listed as having a **concern**. For example, water bodies are protected from excessive nutrient levels using screening levels. When concentrations of certain nutrients are above these screening levels, the water quality is characterized as a concern. Water quality in the Spring Creek and its tributaries is typical of challenges seen in other freshwater creeks and bayous in the area[19].

According to recent versions of the Integrated Report, current assessed water quality issues in Spring Creek and its assessed tributaries include elevated levels of *E. coli*, and concerns related to potential indicators or precursors of low dissolved oxygen (**Table 5**). The contact recreation impairment exists across many of the watershed's AUs, and is the primary focus of this WPP. Concerns related to elevated levels of nitrogen and phosphorus compounds are also widespread, and though less common, concerns over dissolved oxygen have also been observed.

[18] For more information on detailed water quality assessments and modeling, refer to Section 3 of this document. For in-depth information on water quality trends in the watersheds, please refer to the *Water Quality Data Analysis Summary Report* available on the website for this WPP project at: https://springcreekpartnership.weebly.com/uploads/1/3/0/7/130710643/10159_3.3_spring_creek_data_analysis_summary_report.pdf

[19] References to assessments and water quality status refer, unless otherwise noted, to the 2020 Integrated Report of Surface Water Quality, the most current report available at the time of publication.

The 2020 impairments and concerns reflect the current formal assessment status by TCEQ and are the starting point for evaluating water quality in the watershed. Overall water quality data analysis includes data through 2018 and is current with the 2020 Integrated Report.

Table 5. Impairments and concerns in the Spring Creek watershed, 2016-2020

Integrated Report Year	Assessment Unit(s) Impaired for *E. coli*	Concern Parameter and Affected Assessment Unit(s)				
		DO (grab)	Nitrate	Total Phosphorous	Cadmium	Fish Community
2016	1008_02, 1008_03, 1008_04, 1008B_02, 1008C_01, 1008C_02, 1008E_01, 1008H_01, 1008I_01, 1008J_01	1008C_02, 1008F_01, 1008J_01	1008_03, 1008_04, 1008B_02, 1008C_01, 1008H_01	1008_03, 1008_04, 1008B_02, 1008C_01, 1008C_02, 1008H_01	1008B_01	1008_02
2018	1008_02, 1008_03, 1008_04, 1008C_01, 1008C_02, 1008H_01, 1008I_01, 1008J_01	1008C_02, 1008F_01, 1008I_01, 1008J_01	1008_03, 1008_04, 1008B_01, 1008C_01, 1008C_02, 1008H_01	1008_03, 1008_04, 1008B_01, 1008C_01, 1008C_02, 1008H_01	1008B_01	1008_02
2020	1008_02, 1008_03, 1008_04, 1008B_02, 1008C_01, 1008C_02, 1008H_01, 1008I_01, 1008J_01	1008C_02, 1008F_01	1008_04, 1008B_01, 1008C_01, 1008H_01	1008_04, 1008B_01, 1008C_01, 1008C_02, 1008H_01	1008B_01	1008_02

Other Concerns

While the primary focus of this WPP is to address water quality impairments and concerns, all water bodies have a range of issues that impact human and wildlife uses. The WPP model is inclusive of other stakeholder concerns as part of a broader effort to improve the waterway. During the development of this WPP, stakeholders identified several other issues as being secondary priorities for implementation activities.

Trash

While illegal dumping is not reported by the stakeholders to be a widespread issue in the watershed, there were hot spots identified in the development of the WPP. Ambient trash from stormwater was raised as a concern as well.

Sediment

The sinuous channels of the waterways of this system have intermittent sand or gravel banks in many places. These alluvial sediments are attractive to aggregate mining operations whose activities have increased in the last decade. While this issue is not as pronounced as it is in the West Fork San Jacinto River, sediment load from Spring Creek has been studied in the past as a potential issue for the San Jacinto. Increased development and decreased riparian buffers will likely lead to faster runoff velocities, increased erosion, and decreased filtration. Increased sediment can impact the benthic habitats of aquatic life, shelter bacteria, and increase water treatment costs in addition to exacerbating flooding concerns. Of regional importance is the potential impact of sediment on the water supply capacity of the Lake Houston reservoir.

Flooding

Even prior to the flooding and storm events of recent years, local stakeholders expressed concern over drainage, flooding, and potential channel modifications. While flood management is outside the scope of this WPP, changes to flow regimes or increased flooding can alter the impact of pollutant sources. These concerns are being included in this WPP based on their potential water quality impact, and the need to coordinate these efforts with the many flood mitigation projects underway or planned for the system. The primary concern of this WPP is that water quality considerations are included in future decisions that may affect flooding or hydrologic modification of the waterways.

Conservation of Natural Areas/Function

Even prior to the flooding and storm events of recent years, local stakeholders expressed strong concern over continuing loss of natural areas. Using natural infrastructure to improve water quality, flood mitigation, maintain rural character, and protect natural landscapes and habitat was a standing concern among the stakeholders.