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UPPER SAN JACINTO RIVER BASIN REGIONAL SEDIMENTATION STUDY

Technical Memorandum 1

Existing Data Inventory

Prepared for:

San Jacinto River Authority
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1 Introduction

Sedimentation in the lakes and streams of the Upper San Jacinto River Basin (USJRB) has been well documented over the last several decades and is believed to impact stormwater conveyance and flood risk in communities along these waterbodies. The USJRB Regional Sedimentation Study (Study) was conducted to understand the characteristics of sedimentation in the USJRB, including sediment sources, transport, and storage locations, and to ultimately develop feasible and cost-effective conceptual solutions, best management practices, and an overall implementation strategy that can help better manage sediment in the USJRB. The resulting Regional Sedimentation Management Plan will create a cost effective, sustainable sediment management plan for the watershed upstream of the Lake Houston Dam.

As a part of this effort, the Study team acquired and organized data that would be necessary to complete the analysis of sediment budgets, storage, and transport and the planning of sediment management strategies. Data describing the land use, soils, hydrography, topography, and other relevant environmental factors were gathered and processed for use in this Study. This technical memorandum summarizes and describes the data that were collected.

2 Summary of Geospatial Data

The boundary of the USJRB for the purposes of this Study is defined to be the portion of the San Jacinto River Basin upstream of the Lake Houston Dam (see Figure 1). The USJRB comprises three major subbasins: Spring subbasin (Hydrologic Unit Code [HUC] 12040102), West Fork San Jacinto subbasin (HUC 12040101), and East Fork San Jacinto subbasin (HUC 12040103). Geospatial data for the region was collected from multiple sources described below and clipped to the USJRB boundary. In this section, the datasets will be briefly described and sources and other important metadata will be noted.

2.1 Region Boundaries and Features

The USJRB boundary spans across seven Texas counties, including the entirety of Montgomery County and portions of Grimes, Harris, Liberty, San Jacinto, Waller, and Walker Counties, as shown in Figure 1. The figure also shows the major tributaries of the San Jacinto River and two drinking water supply reservoirs (Lake Conroe and Lake Houston) within the USJRB.

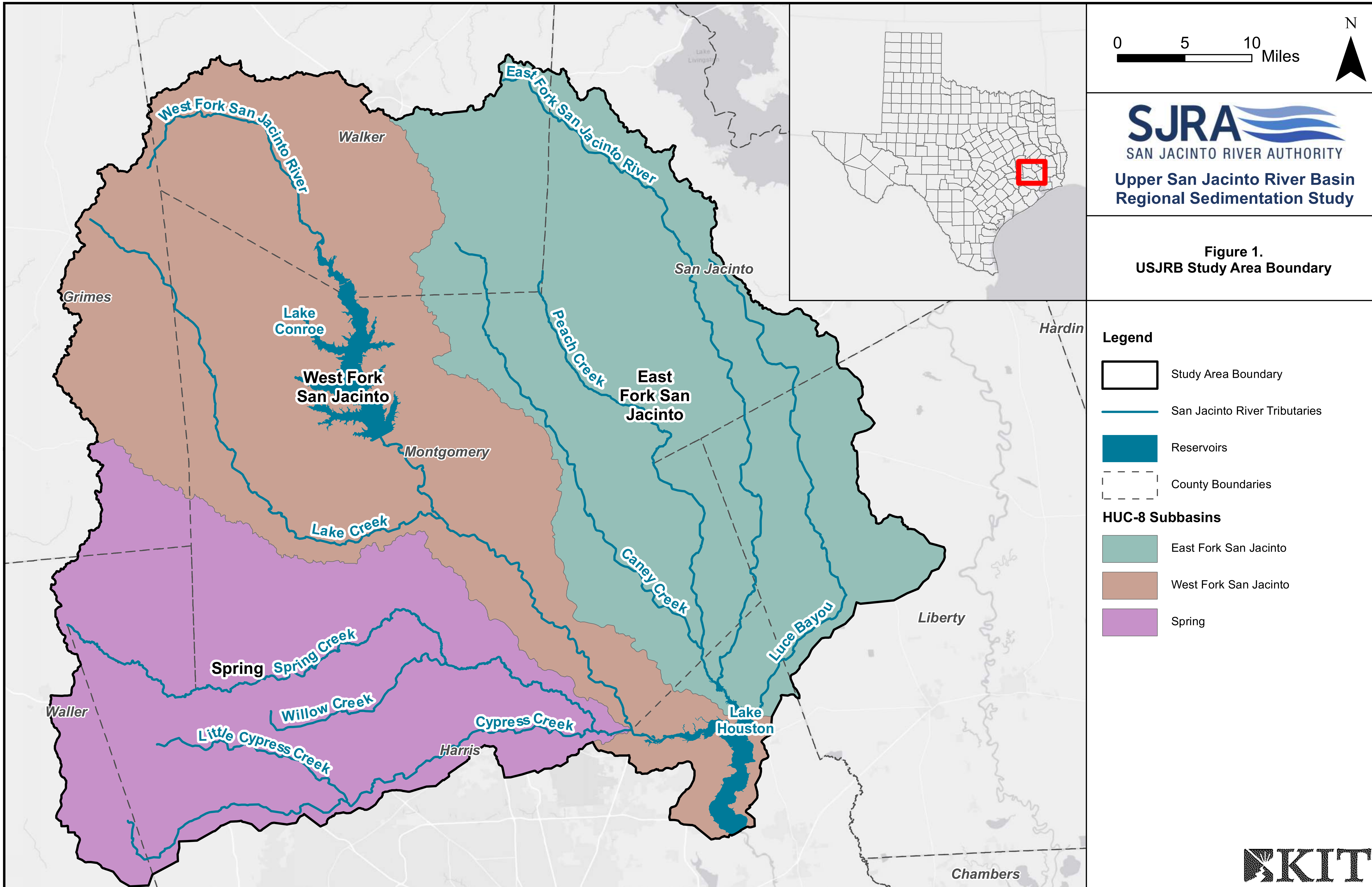

Figure 1.
USJRB Study Area Boundary

2.2 Watersheds

The United States Geological Survey (USGS) delineates boundaries of hydrologic units representing the area that drains to a portion of the stream network. The Watershed Boundary Dataset (WBD), maintained by the USGS, is a national dataset of the hydrologic units from regional granularity (HUC 2) to subwatersheds (HUC 12). The watershed (HUC 10) and subwatershed (HUC 12) boundaries within the USJRB were pulled from the WBD, but all future sediment management and flood mitigation solutions will be developed to be effectual at the HUC 10 level, consistent with Texas Water Development Board (TWDB) Flood Infrastructure Fund (FIF) requirements. There are eleven HUC-10 watersheds and 98 subwatersheds within the USJRB, as summarized in Table 1.

Table 1. Hydrologic Unit Counts within the USJRB Study Area

Subbasins (HUC 8)	Watersheds (HUC 10)	Subwatersheds (HUC 12)
3	11	98

The HUC-10 watershed and HUC-12 subwatershed boundaries are shown in Figure 2 and Figure 3, respectively.

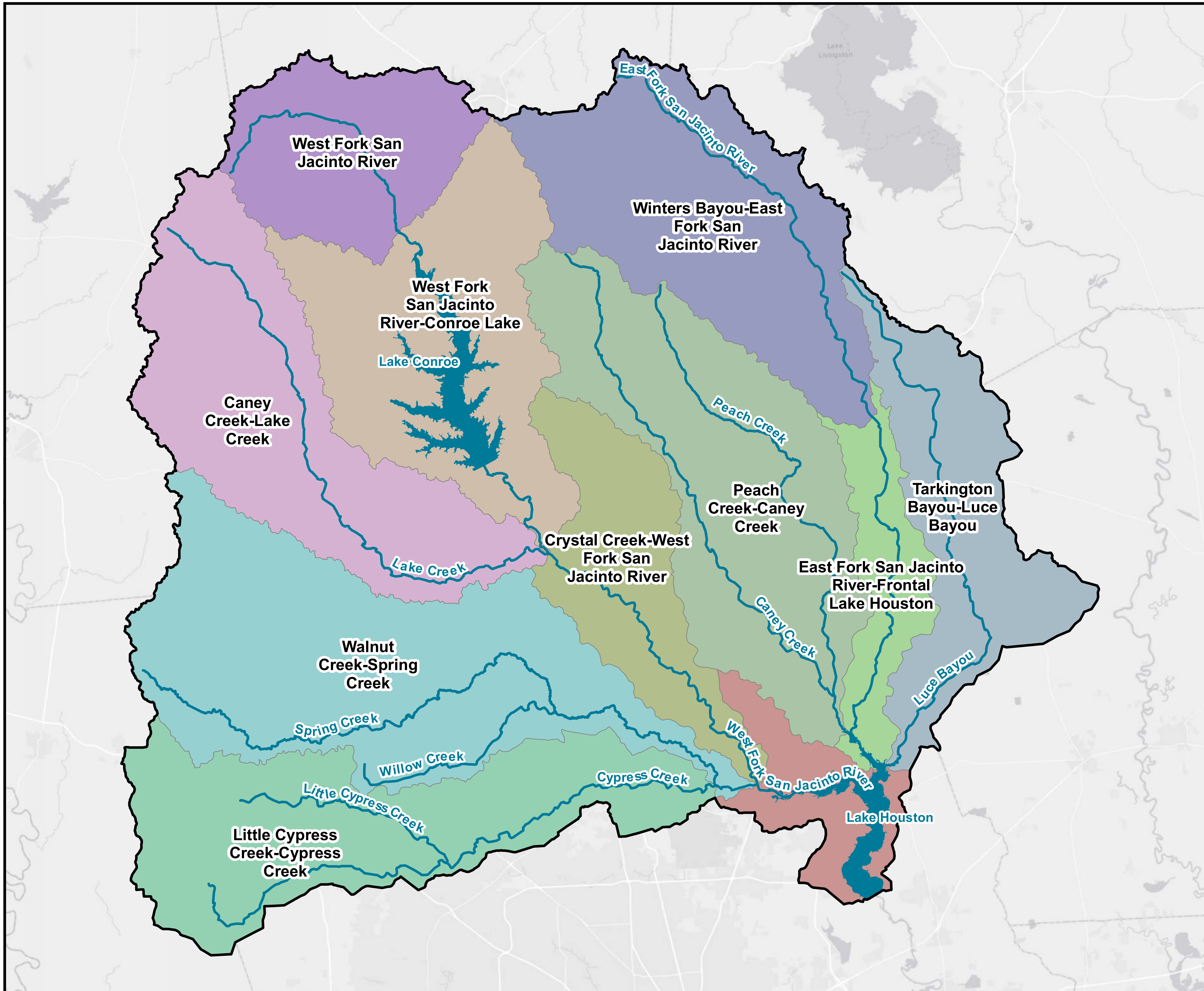

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Figure 2.
Watersheds (HUC 10 Boundaries) in the USJRB Study Area

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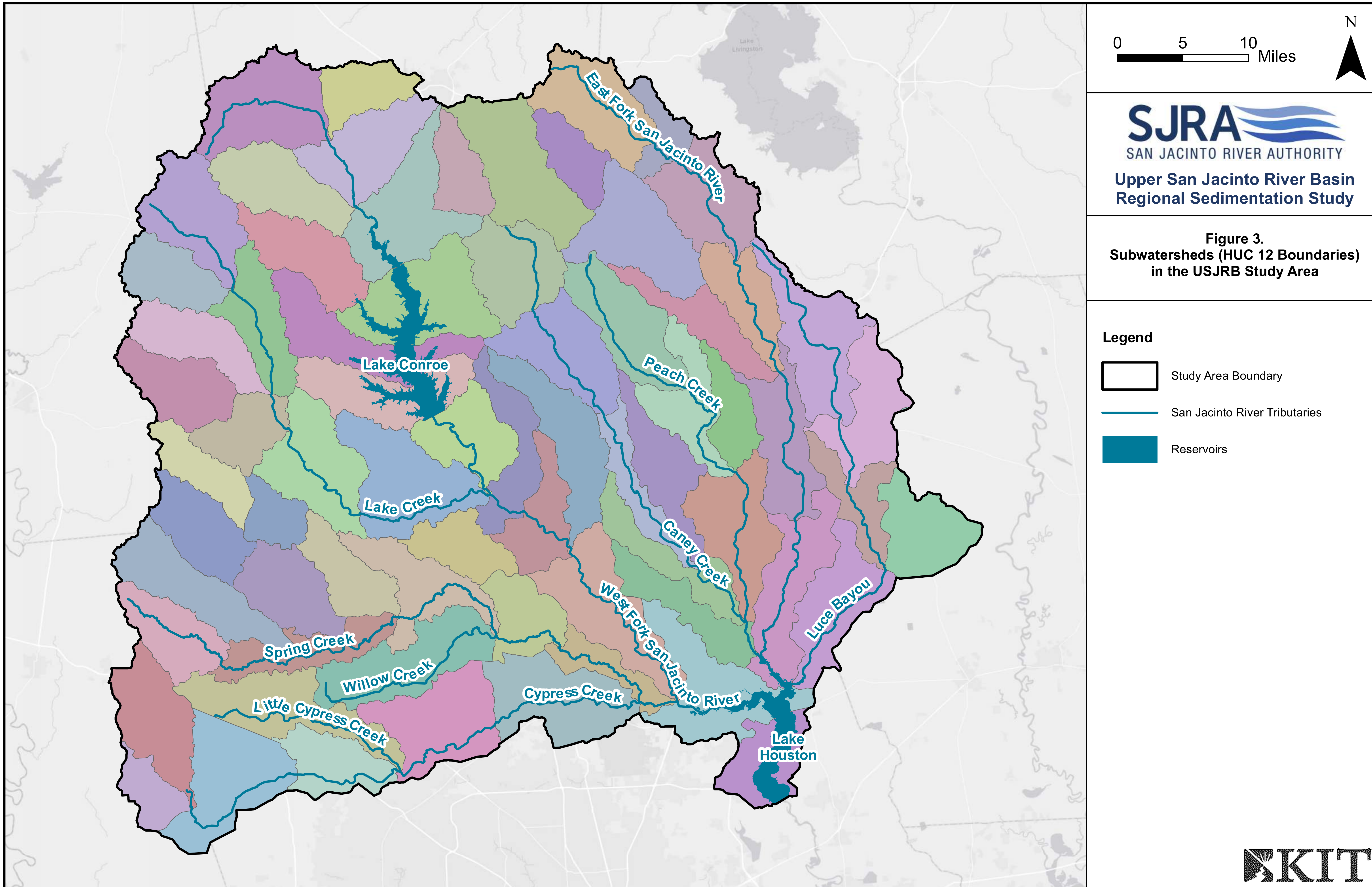


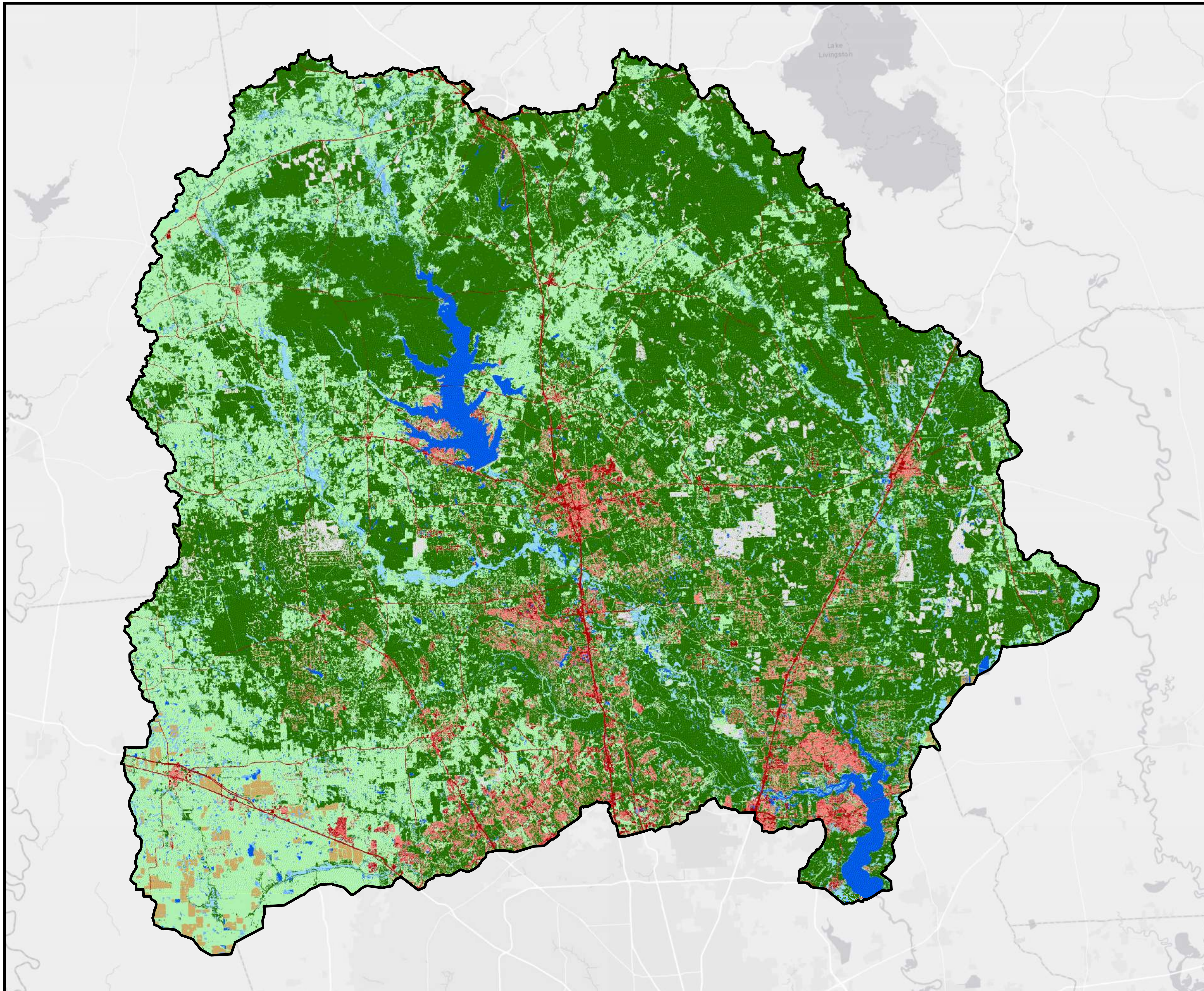
Figure 3.
Subwatersheds (HUC 12 Boundaries)
in the USJRB Study Area

2.3 Land Cover

Land cover plays a factor in influencing the magnitude and location of runoff and non-point sediment sources. Land cover data was sourced from the Houston-Galveston Area Council (H-GAC). To review the trends of land cover change over time, land cover data from 2002, 2008, and 2020 were gathered from H-GAC. Within each dataset, land cover is classified into a different number of classes, as shown in Table 2. The number of classes has grown over the years, and classes were therefore normalized into broad categories to facilitate direct comparison between the datasets. H-GAC land cover data for the USJRB from 2002, 2008, and 2020 are shown in Figure 4, Figure 5, and Figure 6, respectively.

Table 2. Differences in Land Cover Dataset Classes

<table>
<tr><th>Normalized Category</th><th>2002 Land Cover (9 Classes)</th><th>2008 Land Cover (10 Classes)</th><th>2020 Land Cover (15 Classes)</th></tr>
<tr><td rowspan="4">Developed</td><td>High Intensity Developed</td><td>Higher Intensity Developed</td><td>Developed, High Intensity</td></tr>
<tr><td rowspan="3">Low Intensity Develop</td><td rowspan="2">Lower Intensity Developed</td><td>Developed, Medium Intensity</td></tr>
<tr><td>Developed, Low Intensity</td></tr>
<tr><td>Open Space Developed</td><td>Developed, Open Space</td></tr>
<tr><td rowspan="4">Pasture / Agricultural / Shrub</td><td>Cultivated Land</td><td rowspan="2">Cultivated</td><td>Cultivated Crops</td></tr>
<tr><td rowspan="3">Grassland</td><td>Hay / Pasture *</td></tr>
<tr><td rowspan="2">Grassland / Shrub</td><td>Shrub / Scrub</td></tr>
<tr><td>Herbaceous</td></tr>
<tr><td rowspan="3">Forested</td><td rowspan="3">Woody Land</td><td rowspan="3">Forest</td><td>Deciduous Forest</td></tr>
<tr><td>Evergreen Forest</td></tr>
<tr><td>Mixed Forest</td></tr>
<tr><td rowspan="2">Wetlands</td><td>Palustrine Woody Wetland</td><td>Woody Wetland</td><td>Woody Wetlands</td></tr>
<tr><td>Palustrine Emergent Wetland</td><td>Herbaceous Wetland</td><td>Emergent Herbaceous Wetlands</td></tr>
<tr><td rowspan="2">Other</td><td>Bare / Transitional</td><td>Barren</td><td>Barren Land</td></tr>
<tr><td>Open Water</td><td>Water</td><td>Open Water</td></tr>
<tr><td colspan="4">* Area classified as Hay/Pasture in 2020 appears to have been classified as Grassland in 2002 and as Cultivated Land in 2008.</td></tr>
</table>



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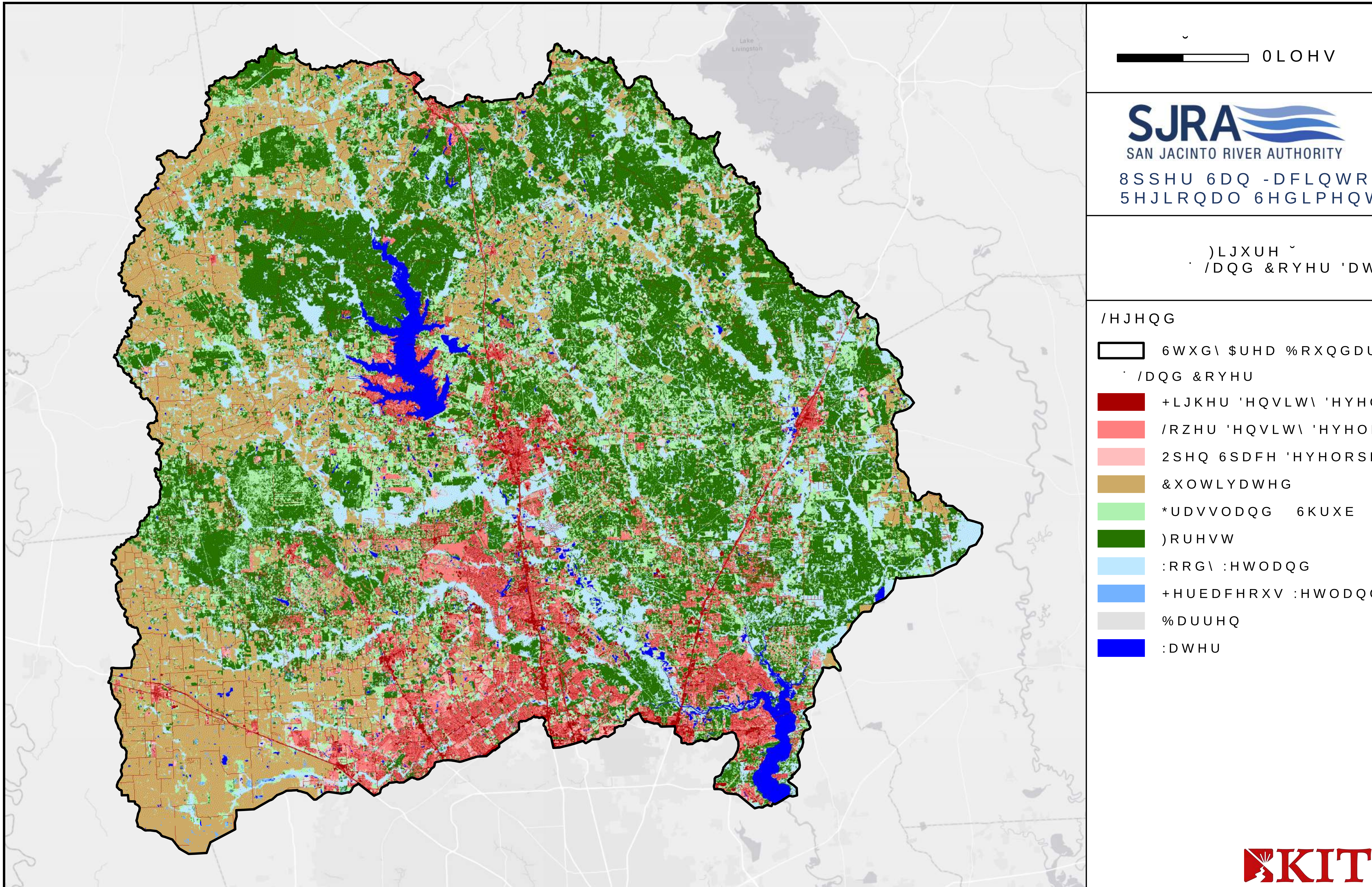

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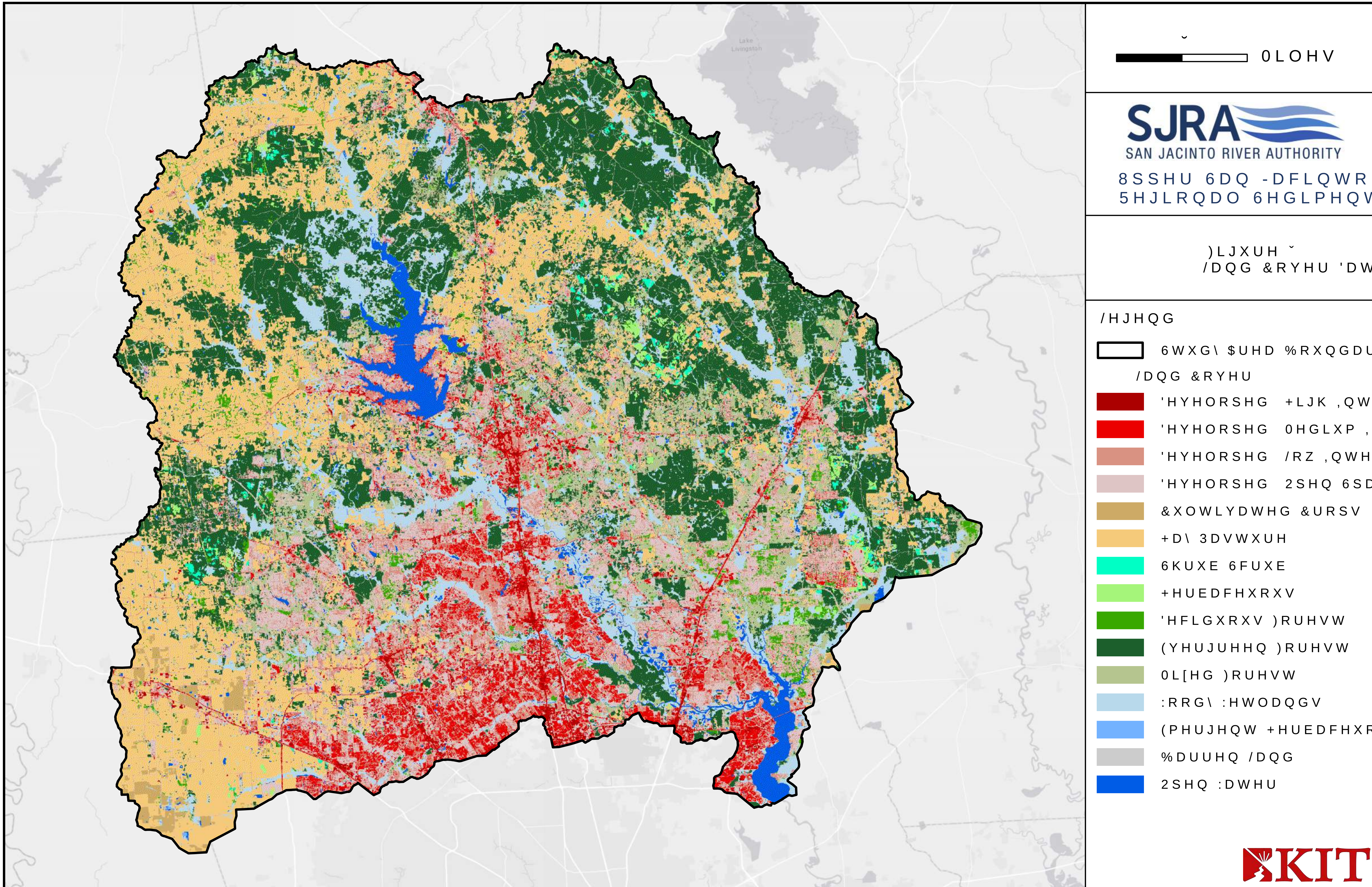
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To facilitate comparison of the three land cover datasets with different numbers of land cover classes, land cover was aggregated into the following broad categories:

- Developed (all levels)
- Forested (all types)
- Pasture / Agriculture / Shrub
- Wetlands (all types)
- Other (e.g., open water, barren, etc.)

Table 3 summarizes land cover in the USJRB on a percentage basis, as computed based on the three available H-GAC datasets. From 2002 to 2020, an additional 20% of the basin was developed. Between 2002 and 2008, developed area increased by 8% (1.3%/year) and forested area decreased by 19%, indicating that development most likely occurred primarily in previously forested areas. Between 2008 and 2020, developed land cover increased by 12% (1.0%/year). However, forested land cover was relatively stable, while pasture / agriculture / shrub and wetland cover collectively decreased by 13%. Note that some of these differences, such as the increase in wetland area between 2002 and 2008, likely result from discrepancies in classification methodologies. However, there is a clear increasing trend in developed land cover and an overall loss of forested and pasture / agriculture / shrub cover over time.

Table 3. Land Cover Percentages in the USJRB

Land Cover	2002 Coverage (%)	2008 Coverage (%)	2020 Coverage (%)
Developed	7%	15%	27%
Forested	52%	33%	34%
Pasture / Agriculture / Shrub	31%	34%	25%
Wetland	5%	14%	10%
Other	6%	3%	4%

2.4 Soil Types

The Soil Survey Geographic Database (SSURGO) contains detailed soil data collected by the US Department of Agriculture (USDA) National Resources Conservation Service (NRCS). SSURGO information includes digital soil maps and the accompanying soil properties and interpretations database. Additional soil information can be extracted from the Soil and Water Assessment Tool (SWAT) database by joining the two along a common map unit key. The hydrologic soil group, one of the soil properties in SSURGO, broadly classifies precipitation infiltration rates and runoff potential of the soil's dominant component. Table 4 contains descriptions of the hydrologic groups developed by the USDA NRCS, and Figure 7 shows the distribution of hydrologic soil groups within the USJRB. Additional soil properties, like erodibility or surface texture, can be extracted from the SSURGO database. Generally speaking, soils with high silt content are the most erodible, as silt is easily detached (unlike clay) and transported (unlike sand). Erodibility is discussed in greater detail in TM 2 – Watershed Characterization.

Table 4. Hydrologic Soil Group Definitions

Hydrologic Soil Group	Infiltration Rate	Soil Description
Group A	High	Deep, well drained sands or gravelly sands
Group B	Moderate	Moderately deep, moderately well drained soils with moderately fine to moderately coarse texture (silt, silt loam)
Group C	Slow	Soils having a layer that impedes the downward movement of water with a moderately fine texture (clay loams)
Group D	Very Slow	Soils consisting chiefly of clays, soils with a high water table, soils with a clay layer near the surface, or shallow soils covering impervious materials
Multiple Groups	Varies	Soils with a high water table but favorable saturated hydraulic conductivity for water transmission can be classified into multiple soil groups (A/D, B/D, or C/D). Infiltration behavior is dependent on whether the water table is drained or undrained
Sources:	*NRCS,2009; NRCS, 2022*	

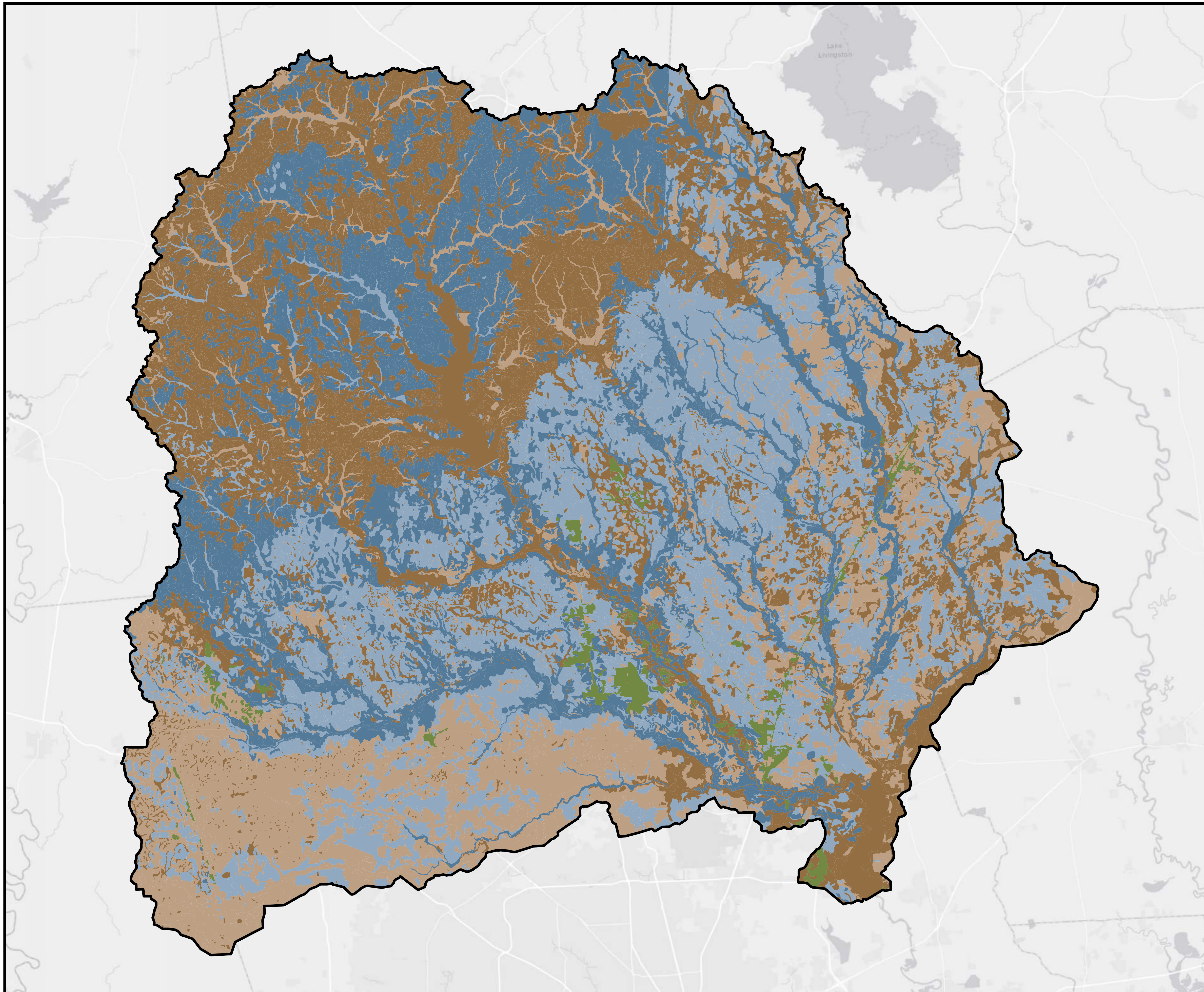

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Figure 7.
Hydrologic Soil Group Map

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Study Area Boundary

Hydrologic Soil Group

- Group A
- Group B
- Group C
- Group D
- Multiple Groups

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2.5 Geology

The USGS Mineral Resources Program (MRP) maintains mineral resources, geology, geochemistry, and geophysics data. The geology for the USJRB was extracted from the State Geologic Map Compilation Geodatabase. Geologic formations, their geologic ages, their lithologic constituents, and additional descriptive comments are available within the State Geologic Map Compilation Geodatabase. Figure 8 shows the surface geologic formations found within the USJRB, and Figure 9 shows the major lithologic components of each of the surface geologic formations. The USJRB surface geologic formations are primarily composed of unconsolidated materials deposited during the Cenozoic Era. Only the Whitsett and Fleming Formations, with mudstone and sandstone respectively, contain consolidated materials as a major component of their lithologic makeup.

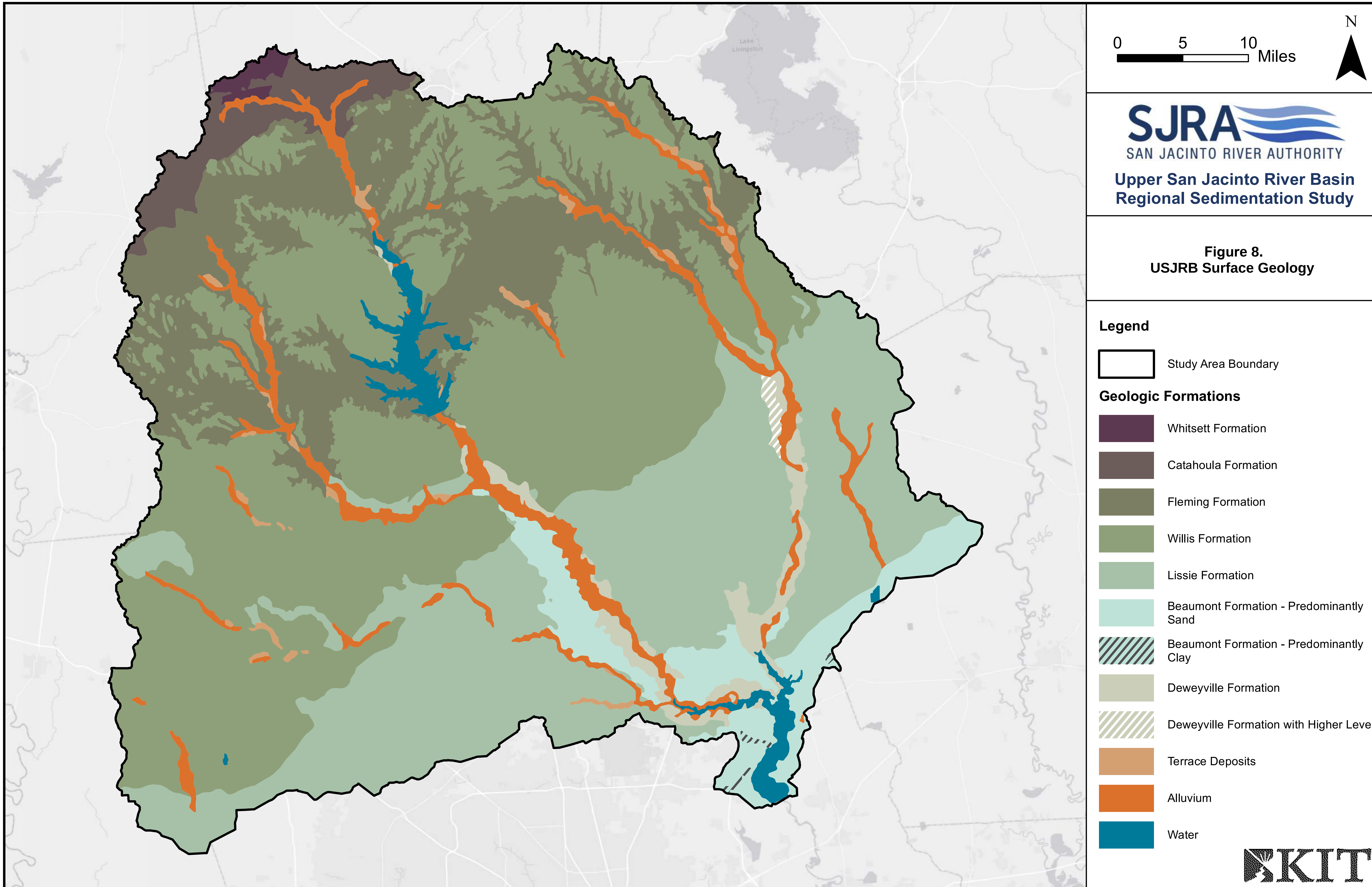

Figure 8.
USJRB Surface Geology

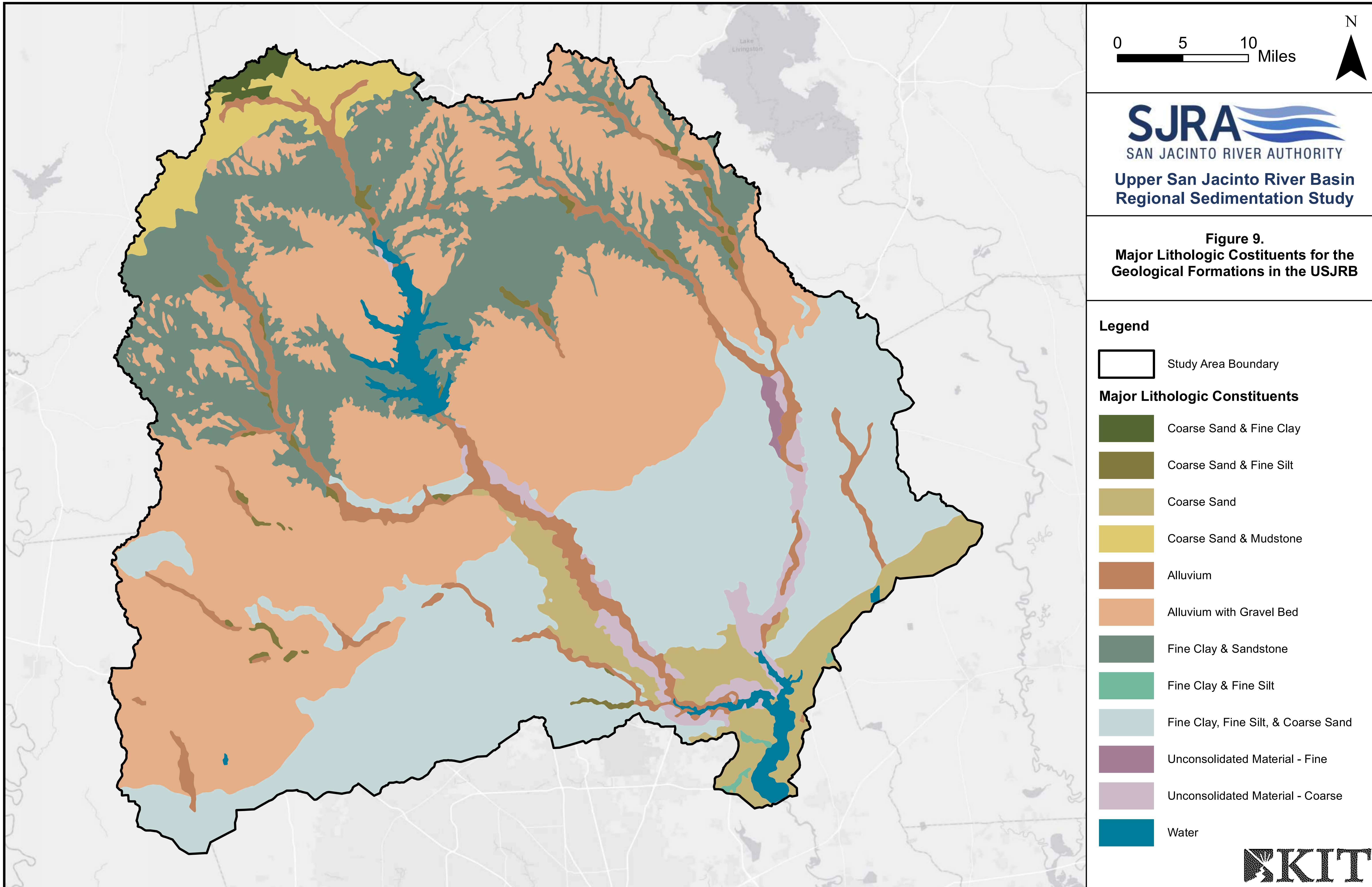

Figure 9.
Major Lithologic Costituents for the Geological Formations in the USJRB

2.6 Elevation

2.6.1 Digital Elevation Model

The 3D Elevation Program (3DEP) of the USGS maintains topographic data for the United States. Digital elevation model (DEM) data were available for the Study area in 1-degree by 1-degree sections. Six sections comprising approximately 2.4 million acres were needed to cover the extent of the USJRB; all six sections were available at a 1 arc-second resolution (approximately 30 meters), but were published at different times between 2018 and 2021. The original DEM data reports orthometric heights in meters (m) referenced to the North American Vertical Datum of 1988 (NAVD 88). Figure 10 illustrates the USGS elevation data within the USJRB, with elevations in feet (ft).

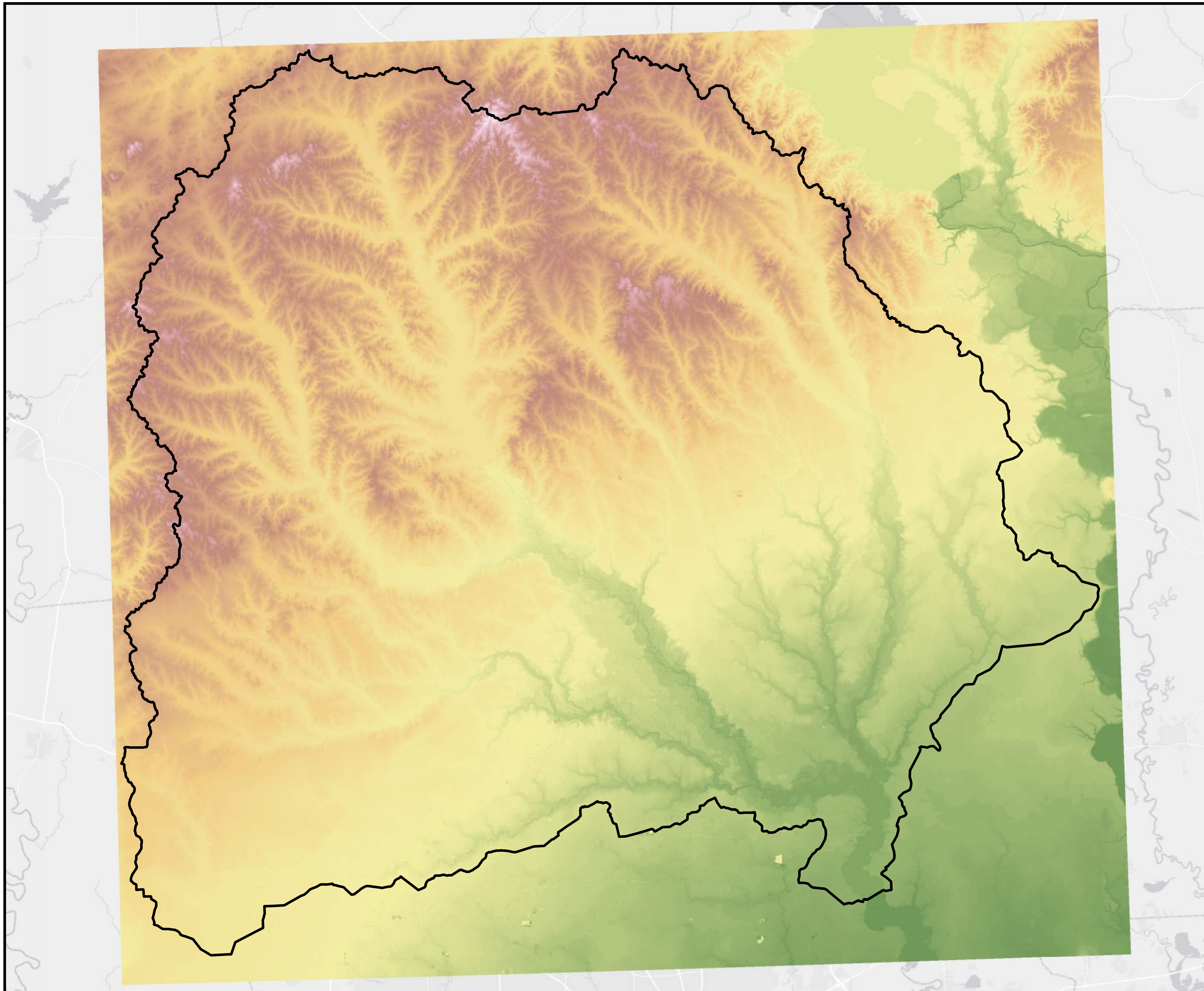

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Figure 10.
Elevation Data Map
(2019 USGS 3DEP Data)

Legend

Study Area Boundary

Elevation

505 ft (NAVD 88)

23 ft

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2.6.2 LiDAR Data

Two light detection and ranging (LiDAR) datasets were obtained. A 2008 dataset, which was available from a prior study in the USJRB, has 1.5-m by 1.5-m (approximately 5 ft x 5 ft) resolution. A 2018 dataset was acquired from the Texas Natural Resources Information System (TNRIS). The 2018 data have 1-m by 1-m (approximately 3.3-ft by 3.3-ft) resolution. This more recent dataset was compiled to meet 18.5-cm vertical accuracy at 95 percent confidence level, which meets project accuracy specifications of the National Standard for Spatial Data Accuracy (NSSDA). Both datasets are referenced to the NAVD 88 vertical datum and should therefore be directly comparable.

Neither dataset provided complete coverage of the USJRB due to both measurement extents and cloud cover interference. Given the resolution and size of these datasets, the data are available in the form of several hundred smaller tiles that can be mosaiced for analysis. Both datasets were trimmed to valley corridors for the major tributaries by masking irrelevant LiDAR index tiles. The trimmed LiDAR tile index boundaries and data for the 2008 dataset are shown in Figure 11. As can be seen in the figure, not all index tiles have available data, and data coverage is predominantly limited to the southern half of the watershed. Nonetheless, the dataset does have relatively thorough coverage of valley corridors for the lower portions of Lake Houston's major tributaries.

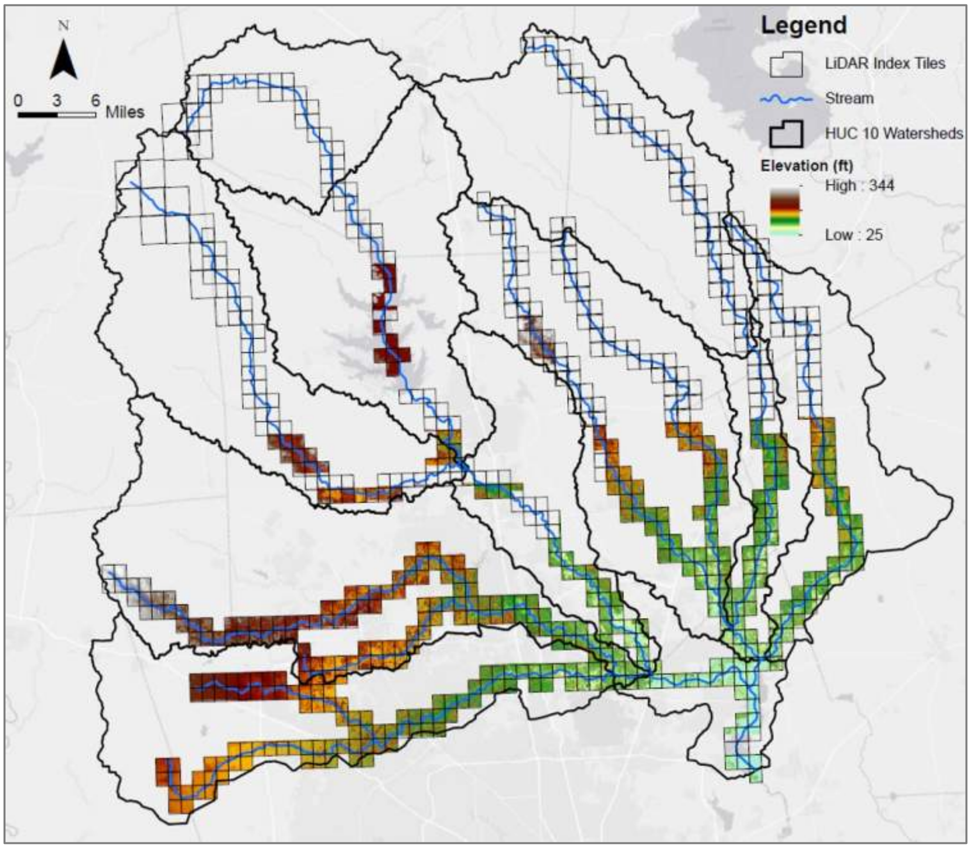

Figure 11. 2008 LiDAR Data

The trimmed LiDAR tile index boundaries and data for the 2018 dataset are shown in Figure 12. Similar to the 2008 dataset, the more recent data have some coverage gaps. However, the 2018 data generally have relatively thorough coverage of valley corridors, with the exception of the northernmost portions of the USJRB. Comparisons of LiDAR data can be executed for areas that have coverage from both the 2008 and 2018 datasets. Excluding occurrences due to differences in measurement methodology and corrections (e.g., removal of tree cover from the data), elevation reductions may identify areas of significant erosion along streambanks.

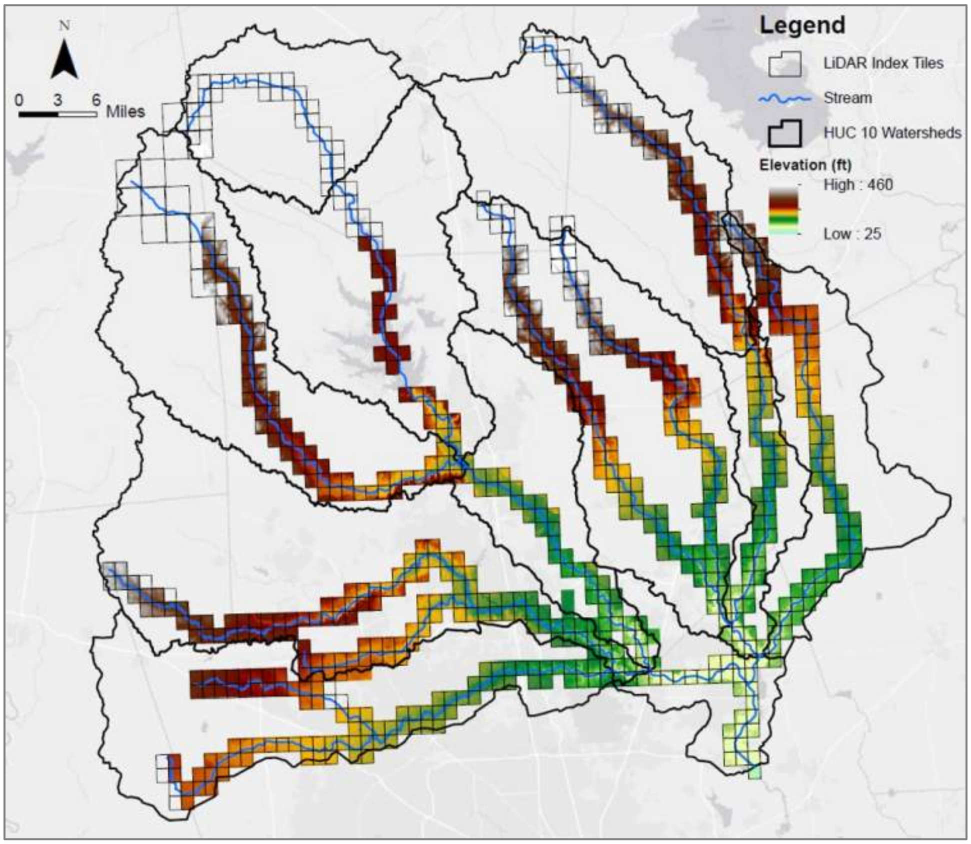

Figure 12. 2018 LiDAR Data

2.7 Aerial Imagery

The USGS and the National Aeronautics and Space Administration (NASA) jointly operate the Landsat satellite program to collect remote sensing data used most often to document land use and land change. Three years of satellite imagery of the USJRB were acquired to view the change in land use and development over time. The natural color spectral bands have a resolution of 30 meters. Landsat imagery collected in 1984, 2000, and 2022 are shown in Figure 13, Figure 14, and Figure 15, respectively. Similar to the land cover data, these images show losses of forest cover and pasture / agricultural land (generally visible as green and brown coloration) over time due to development (generally visible as white and gray coloration, with light brown / tan coloration where development construction is occurring).

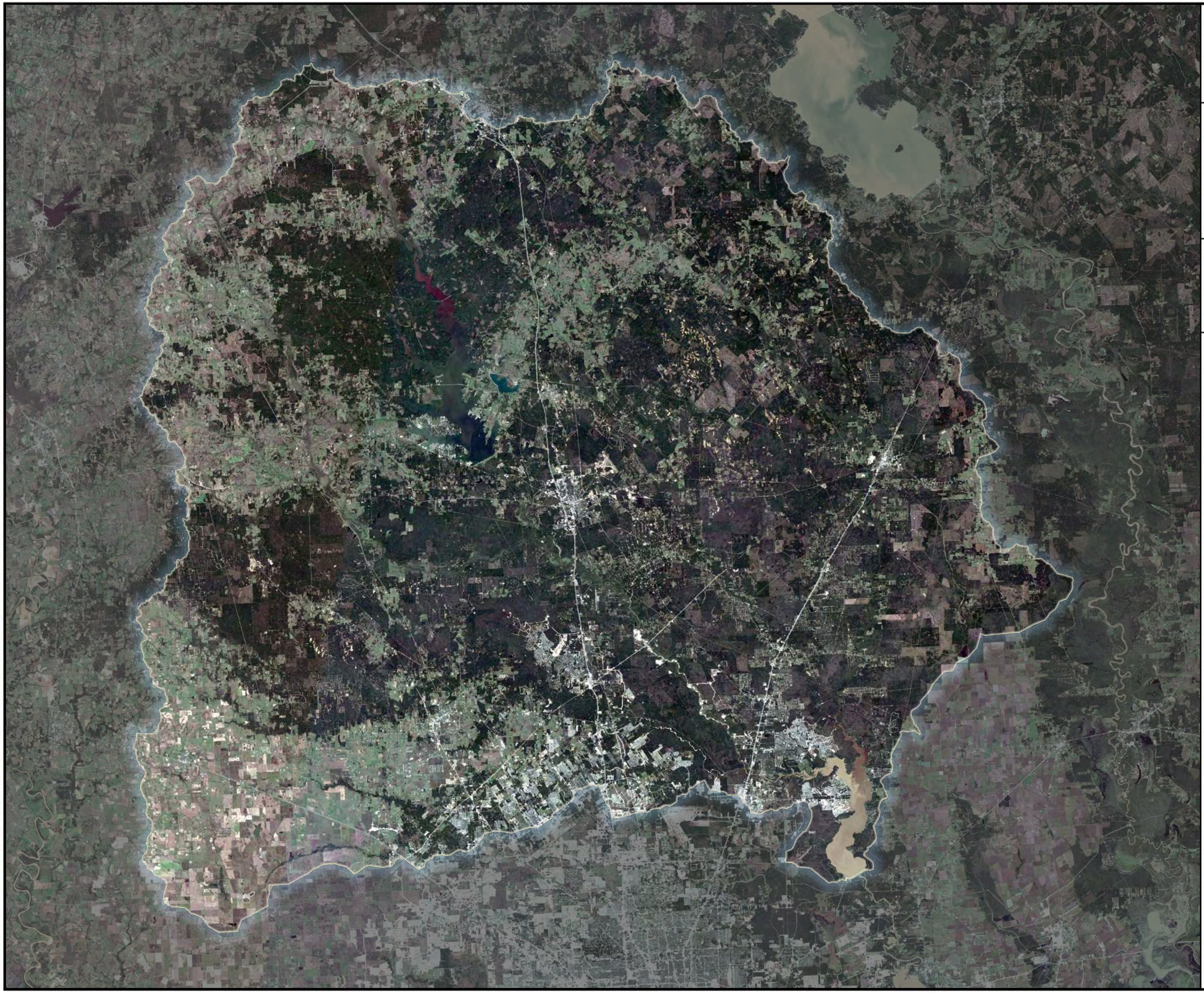

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Figure 13.
1984 Landsat Imagery

Legend

Study Area

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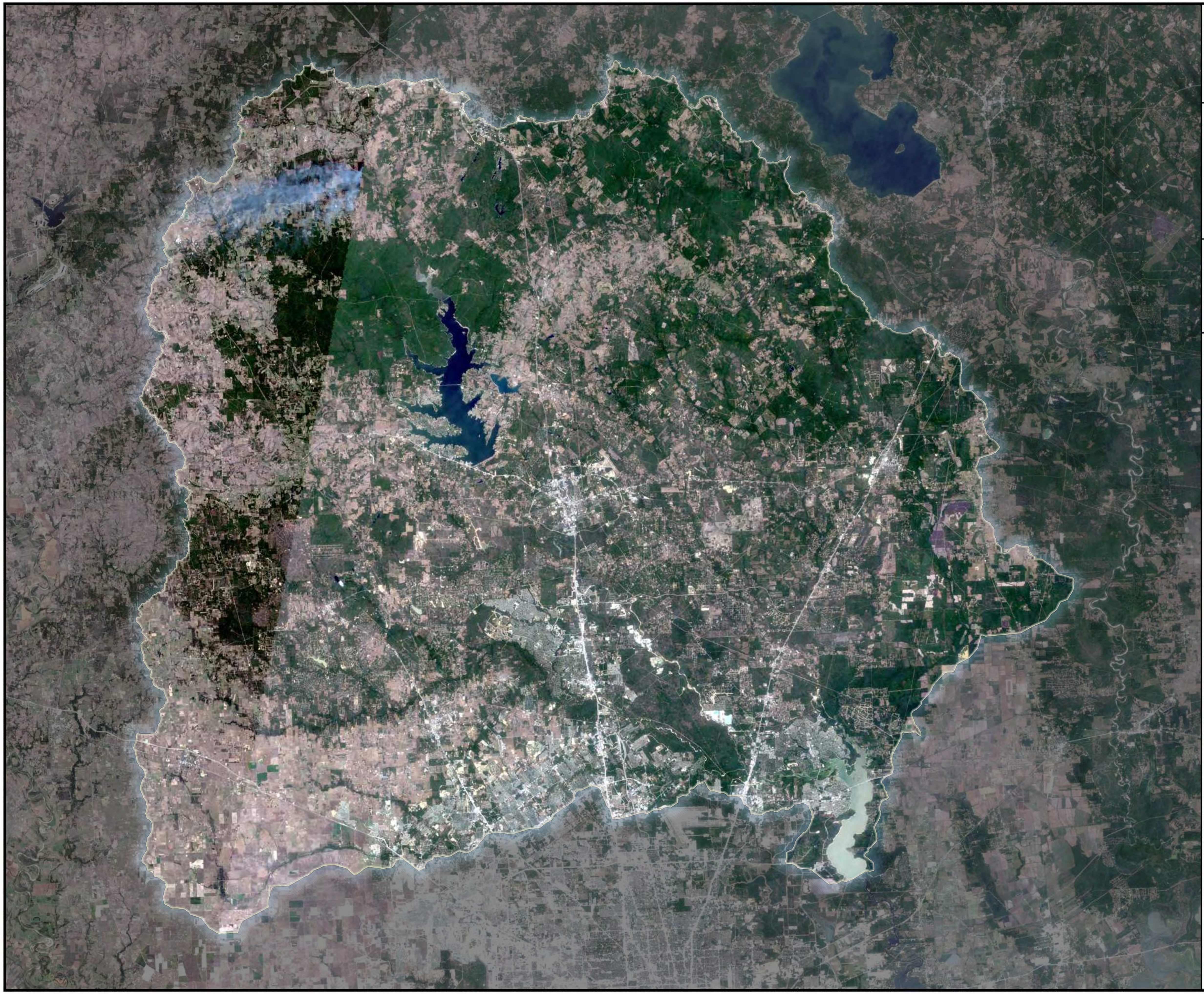

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Figure 14.
2000 Landsat Imagery

Legend

Study Area

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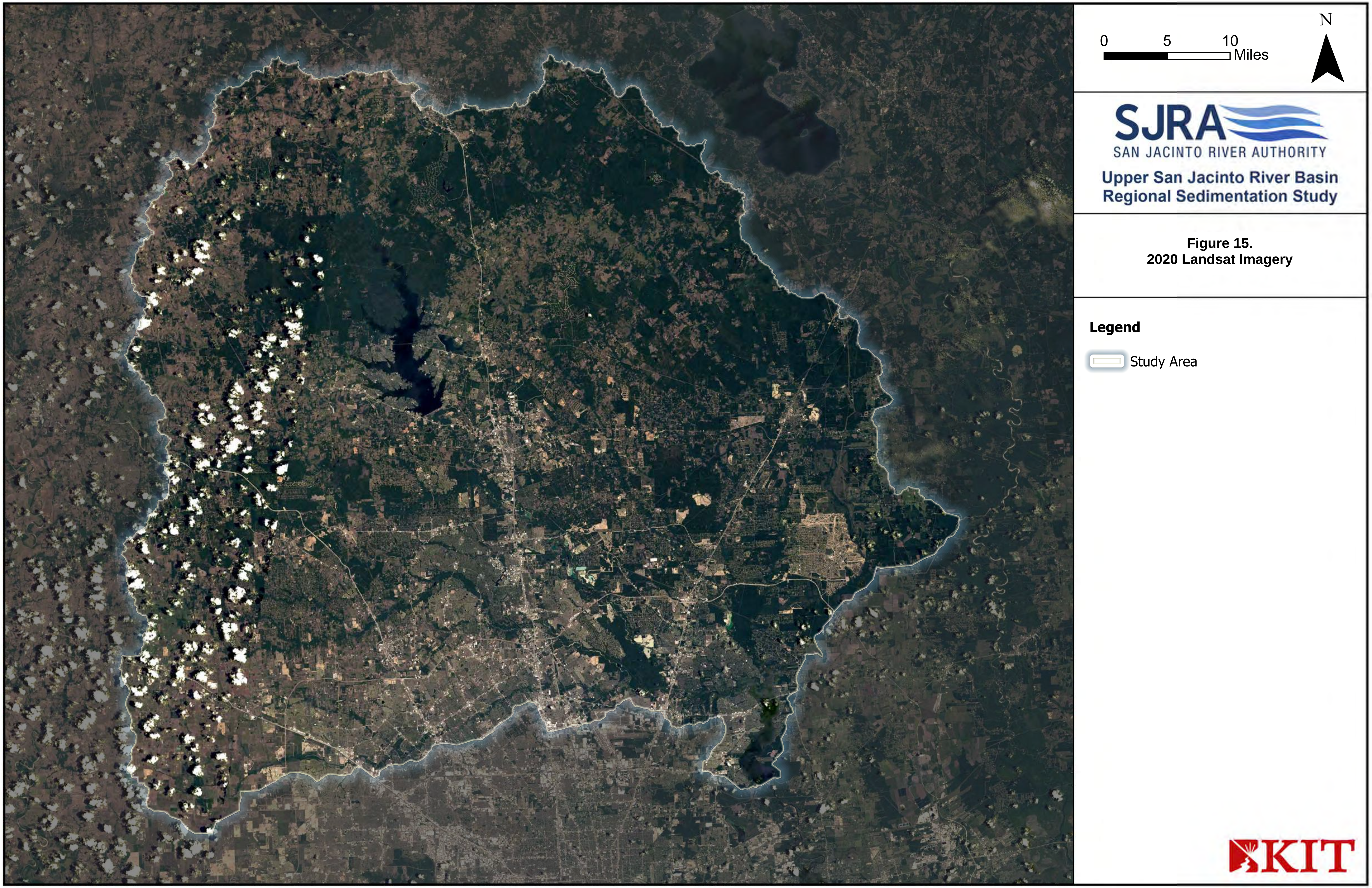

Figure 15.
2020 Landsat Imagery

3 Summary of Flow and Water Quality Data

Flow rates and water quality data, including suspended solids and sediment data, are collected within the USJRB by the USGS and the TCEQ.

3.1 USGS Gauge Sites, Flow Data, and Water Quality Data

The USGS collects surface water data, such as stage and streamflow, at gauge sites in major streams and reservoirs across the U.S. Additionally, water quality data, such as pH, temperature, and, notably, sediment and suspended solids concentrations are collected at a subset of the gauge sites. The USGS actively operates 52 surface water gauges within the USJRB as shown in Figure 16. The historical stage, streamflow, and water quality data through 2018 were previously downloaded for selected gauges within the USJRB as part of a prior study effort. In this Study, these data sets have been supplemented with any additional data collected since 2018.

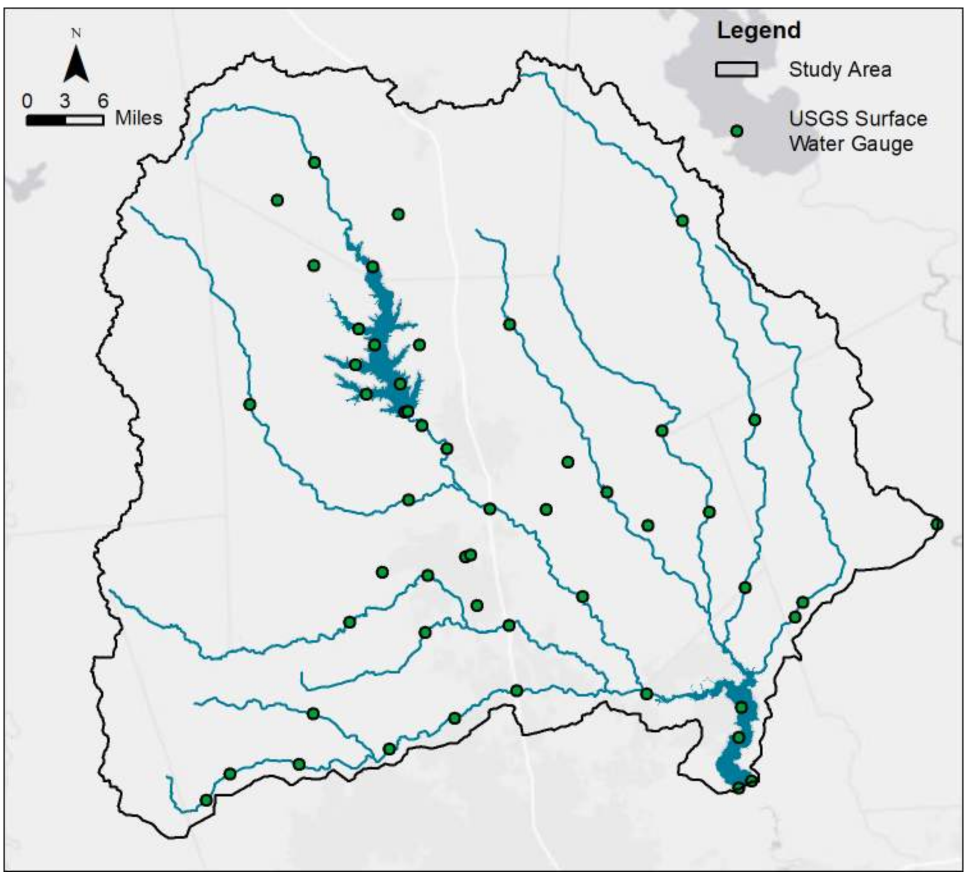

Figure 16. USGS Surface Water Gauge Sites in the USJRB

3.2 TCEQ Monitoring Sites

As part of the TCEQ's Clean Rivers Program, entities across the state of Texas monitor lake and stream water quality at over 1,800 stations. These data are collected and aggregated by the TCEQ and made publicly available via their Surface Water Quality Monitoring (SWQM) database. Within the USJRB, there are 97 active SWQM stations with current and historic water quality data, as shown in Figure 17. Available data for all the sites in the USJRB were downloaded from the TCEQ's SWQM web viewer. Sampled constituents and sampling frequencies vary by site, but commonly include suspended solids parameters.

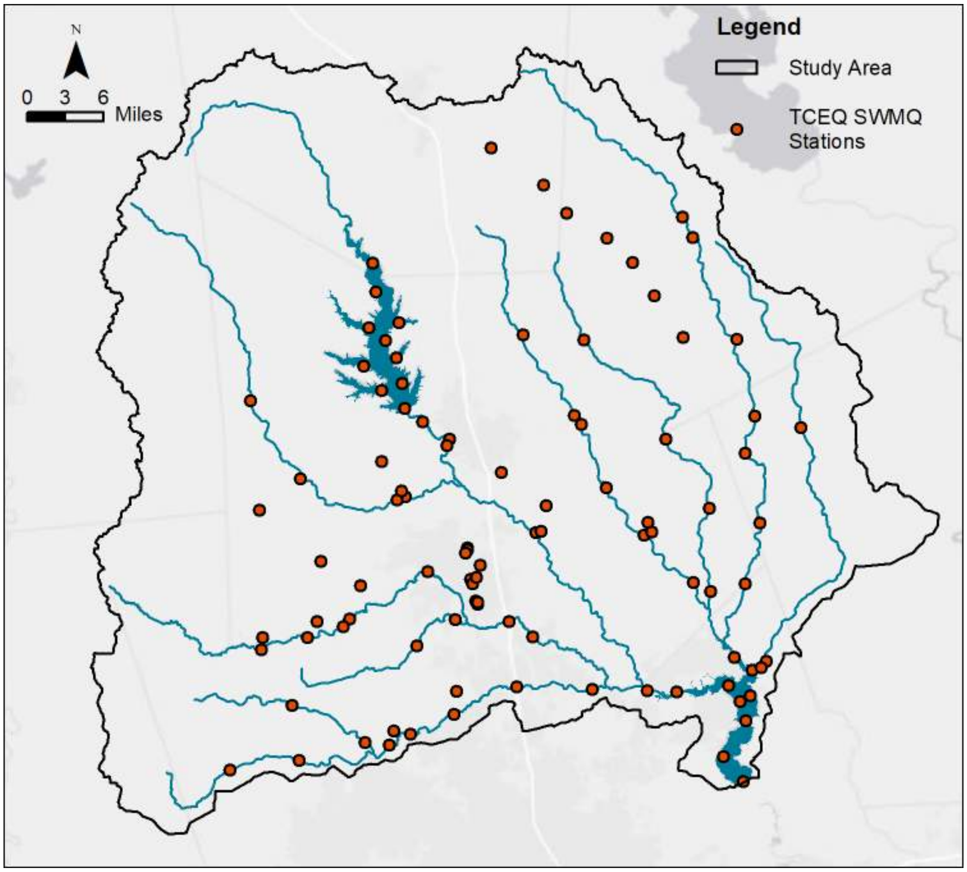

Figure 17. TCEQ SWMQ Stations in the USJRB

4 Summary of Models and Model Exports

4.1 Hydrologic and Hydraulic (H&H) Models

The Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HEC-HMS) and River Analysis System (HEC-RAS) allows users to simulate the hydrologic processes and model hydraulics and transport in natural watershed systems. HEC-HMS and HEC-RAS models developed as part of the 2020 San Jacinto Regional Watershed Master Drainage Plan (SJMDP) were provided for use in this Study. The HEC-HMS v.4.3 model included over 400 subbasins, shown in Figure 18, using both the initial and constant losses as well as Green & Ampt infiltration. These values were calibrated to historical storm events, and average values were then applied to simulate frequency-based storms. The models provided included seven frequency storm simulations (50%, 20%, 10%, 4%, 2%, 1%, and 0.2% annual exceedance probability (AEP)) and four historical storms (October 1994, May 2015, Harvey 2017, and Imelda 2019).

Figure 18. Subbasins in HEC-HMS Model

The HEC-RAS v.5.0.7 model included the unsteady geometry and flow files for 11 studied streams combined into a single model. Cross sections, shown in Figure 19, were established from the 2018 LiDAR data, and the models were calibrated to two historical storm events. Averaged values were used for the frequency storm simulations. The models provided included the same seven frequency storm simulations (50%, 20%, 10%, 4%, 2%, 1%, and 0.2% AEP) and four historical storms (October 1994, May 2015, Harvey 2017, and Imelda 2019).

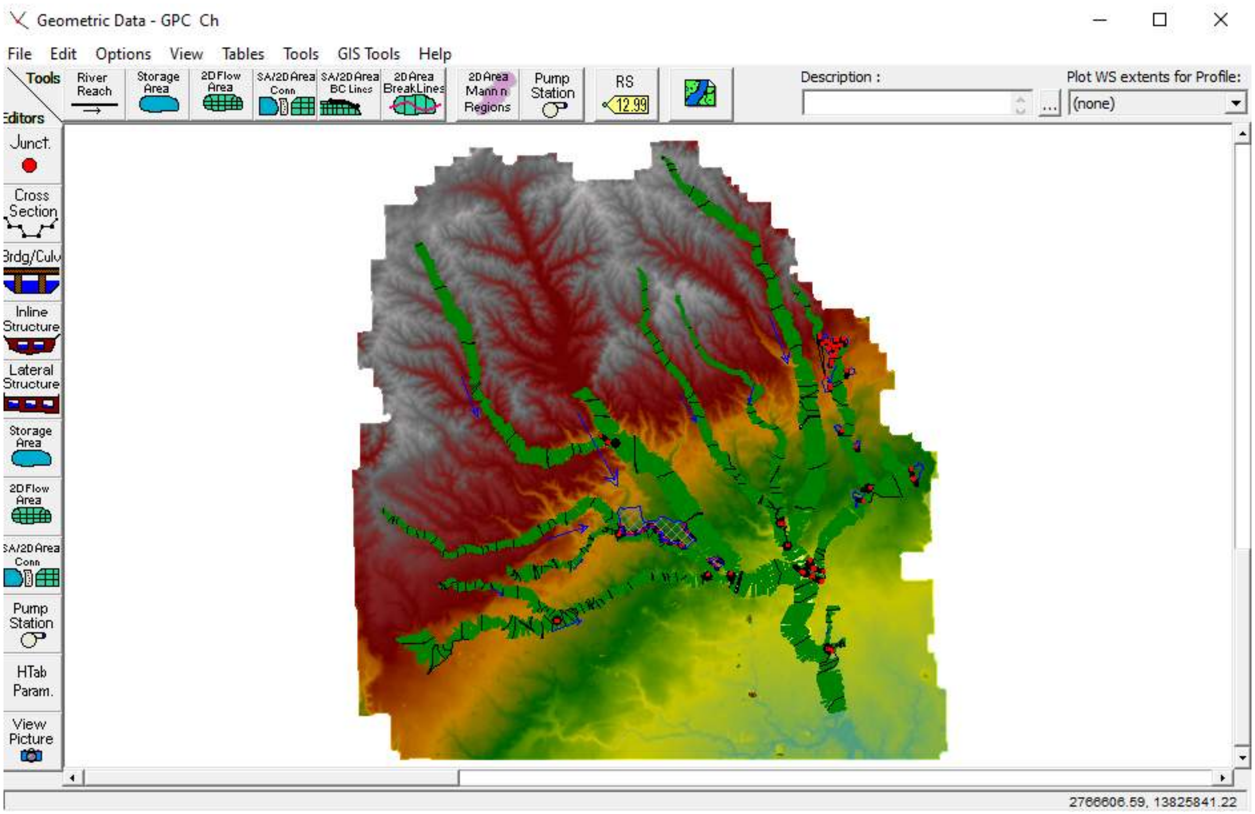

Figure 19. HEC-RAS Channel Cross-Section Extents

4.2 USGS SPARROW Model Results

Spatially Referenced Regression on Watershed Attibutes (SPARROW) models were developed by the USGS to estimate the long-term average values of selected contaminants (phosphorus, nitrogen, and suspended sediment) within the waters of the United States. In 2019, USGS released the results of the SPARROW model, which was developed and calibrated to a 15-year data period and then normalized to the hydraulic conditions of 2012. The suspended sediment model outputs for the southwestern United States (the model region containing the USJRB) were downloaded, and the catchments within the USJRB were extracted from the larger dataset. The resulting database contains accumulated and incremental suspended sediment loads (mass over time) and yields (load per unit area) for each catchment area and by the estimated source of the suspended sediment. As an example, Figure 20 displays the accumulated suspended sediment load (in metric tons [Mt] per year) for all the catchment areas within the USJRB.

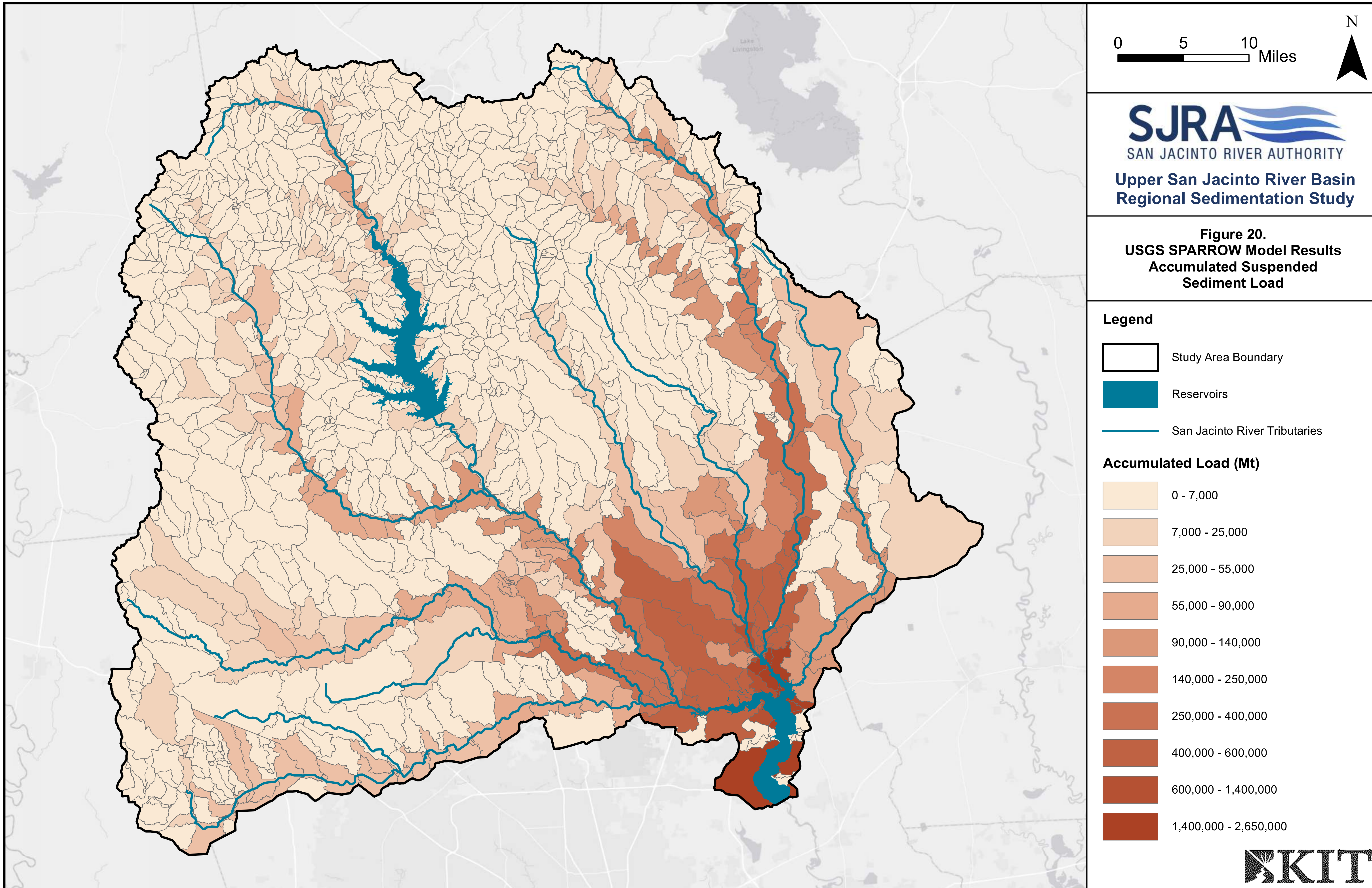

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Figure 20.
USGS SPARROW Model Results Accumulated Suspended Sediment Load

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5 Watershed Management Data

5.1 Source Water Intakes and Wastewater Outfalls

The Texas Commission on Environmental Quality (TCEQ) maintains information on source water intakes for Public Water Systems and permitted wastewater outfalls across Texas. Wastewater outfalls into the tributaries of the San Jacinto River include treated domestic sewage and wastewater outfalls, as shown in Figure 21. Domestic sewage and wastewater outfalls are unlikely to be contributors of sediment, but can indicate development within the watershed. Development is known to disturb and expose soils, which can contribute to sediment loading, and increase surface runoff, which can contribute to streambank scour. Sedimentation solutions that safeguard Public Water System intake locations, shown in Figure 21, can further protect public drinking water from sediment or other stormwater runoff contaminants.

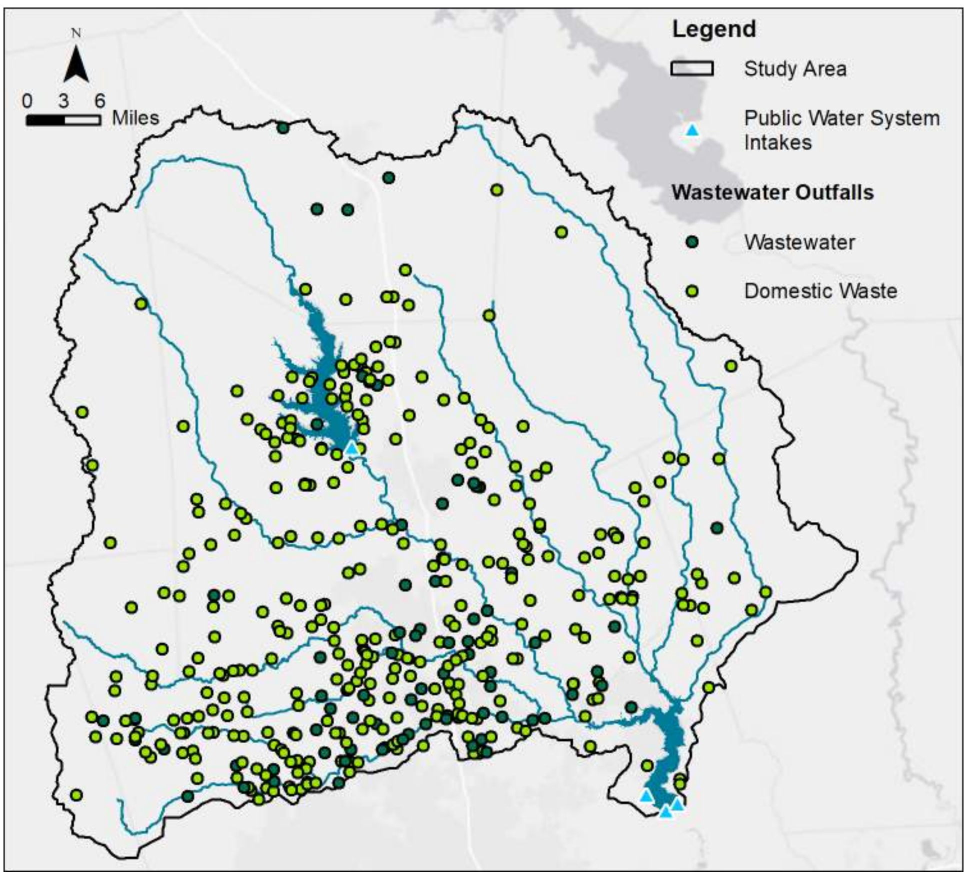

Figure 21. Source Water Intakes and Permitted Wastewater Outfalls in the USJRB

5.2 Total Maximum Daily Loads

The U.S. Environmental Protection Agency (EPA) directs state agencies (e.g., the TCEQ) to develop an Integrated Report of Surface Water Quality, including identifying surface water bodies that do not meet water quality standards. These impaired water bodies may then be subjected to a total maximum daily load (TMDL), or a maximum amount of pollutant allowed to enter the water such that it can still meet the state's water quality standards. There are no waterbodies in Texas with TMDLs for sediment, but some waterbodies have TMDLs for other contaminants.

In the USJRB, a significant portion of the major streams within the basin, as shown in Figure 22, have approved TMDLs due to bacteriological impairment. The Implementation Plan for Seventy-Two Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region (I-Plan) was developed to identify strategies that can be used to reduce bacteria entering the waterways in the Houston-Galveston Region. The primary focus of the I-Plan is to reduce bacterial loading from wastewater outfalls and from non-point sources, such as agricultural activities and domesticated and wild animal populations.

Although the I-Plan focuses on bacteria, not sediment, it has multiple implementation strategies focused on expanding stormwater management programs, improving compliance and enforcement of stormwater permits, and reducing illicit discharges. Any strategies that could potentially provide reductions in sediment loading will be reviewed during the solutions development efforts in this Study.

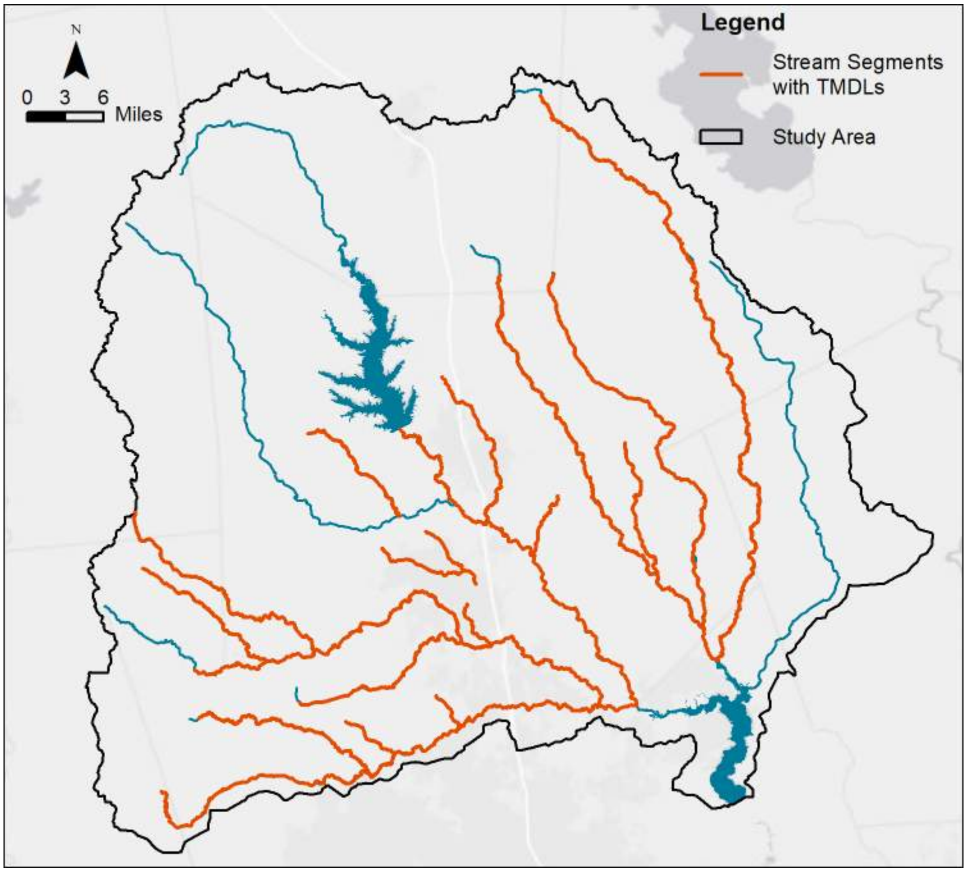

Figure 22. Stream Segments in the USJRB with TMDLs

5.3 Watershed Management Plans

The TCEQ and the Texas State Soil and Water Conservation Board (TSSWCB) also support the development of Watershed Protection Plans (WPPs). The WPPs are documents developed by stakeholders within the community to identify sources of pollution within an impaired watershed and outline strategies to reduce pollution and improve the overall water quality within the watershed. The EPA has laid out nine elements for WPP development, as outlined in their Handbook for Developing Watershed Plans to Restore and Protect Our Waters. Currently there are three WPPs developed or in-development for watershed areas on the western side of the USJRB, as shown in Figure 23. In addition, the SJRA has developed a WPP for the Lake Conroe watershed following the same EPA guidance to ensure the Lake Conroe watershed stays unimpaired. The *Cypress Creek WPP* and *West Fork San Jacinto River and Lake Creek WPP* have been accepted by the EPA, and the final draft of the *Spring Creek WPP* is being prepared for final agency review. The Lake Conroe, West Fork San Jacinto and Lake Creek, and Spring Creek WPPs recommend stormwater strategies, such as promoting and implementing riparian buffers and low impact development, that would reduce stormwater runoff, erosion, and pollutant loading, including sediment, into the waterbodies. The Cypress Creek WPP includes similar recommendations, but also outlines some specific projects for implementation in the watershed including rainwater harvesting, vegetated filter strips, bio-swales, and stormwater assessments. The BMPs and projects summarized within the WPPs will be beneficial sources of information for this Study and for aligning goals across the watersheds.

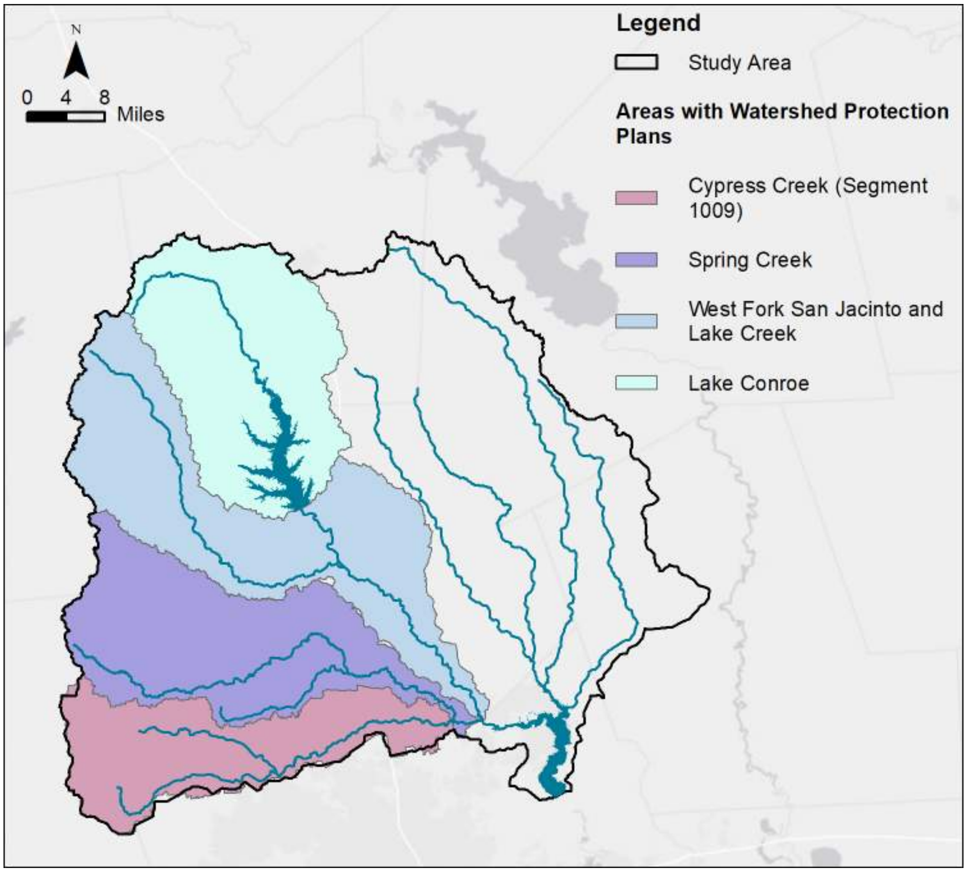

Figure 23. Watershed Protection Plan Extents in the USJRB

5.4 TCEQ Potential Sources of Contamination

Although there are no known permitted mining discharges within the USJRB, sand mining operations (also known as aggregate production operations [APOs]) can still be a significant point-source of sediment. During periods of significant rainfall and high flows, breaches of APO containment dikes adjacent to tributaries can trigger unpermitted releases of process water laden with sediment. During Hurricane Harvey in 2017, West Fork San Jacinto floodwaters overtopped streambanks and inundated numerous APOs, potentially exposing stockpiles and other exposed sediments to downstream transport (Reduce Flooding, 2018). There have additionally been allegations of intentional unpermitted discharges (Reduce Flooding, 2021), but the occurrence, frequency, and magnitude of such releases has not been confirmed.

The TCEQ's Source Water Assessment and Protection Program assesses public drinking water sources' susceptibility to contamination. As a part of this program, potential sources of contamination (PSOCs) are detailed and cataloged. The locations of mining operations were extracted from the PSOC database maintained by the TCEQ. Figure 24 shows the distribution of mining PSOCs and potential unpermitted sediment sources across the USJRB. Note that the TCEQ database flags the location and type for each PSOC, but details regarding operational status are not available. Thus, the flagged locations may not indicate active mining operations.

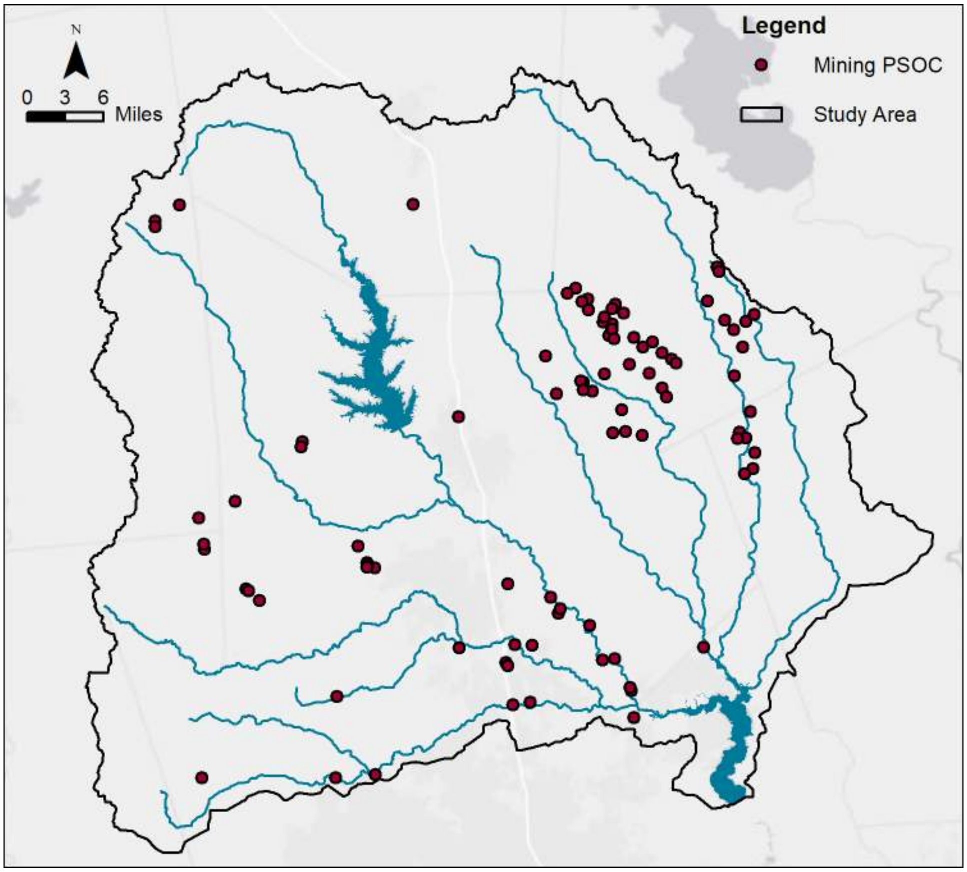

Figure 24. Mining PSOCs in the USJRB

5.5 Prospect- and Mine-Related Features

The USGS MRP additionally maintains data related to mining operations and features within the US. The “Active Mines and Mineral Processing Plants in the United States in 2003” data set includes mineral and metal operations surveyed by the USGS that were considered active in 2003. The “Prospect- and Mine-Related Features from the U.S. Geological Survey 7.5- and 15-Minute Topographic Quadrangle Maps of the United States” data set, as a digitized database of mining operations denoted on USGS’s historical topographic maps, captures a broader spectrum of mining operations from the late 1950s to late 1990s within the Study area. This latter database contains both point and polygon geospatial features denoting mining operations. Both USGS mining databases are displayed in Figure 25. Due to the age of the data, additional validation will be required to determine what mines may still be active or abandoned/uncovered that may be contributing sources of sediment in the basin.

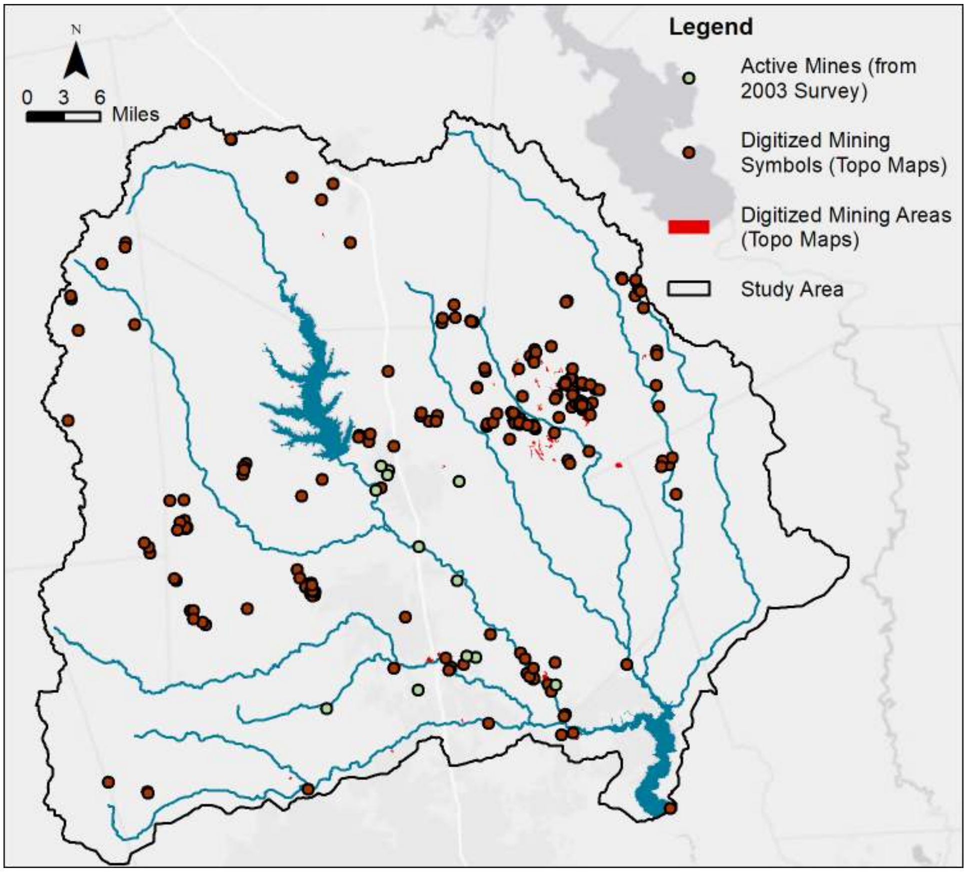

Figure 25. USGS MRP Mining Site Locations

6 Conclusions

In this Technical Memo, existing geospatial and tabular data covering hydrologic, hydraulic, geologic, and environmental factors of the USJRB with relevance to the Study were briefly summarized. Sources of data included federal (e.g., USGS) databases, state level (e.g., TCEQ) databases, and entities on a more local level, such as the H-GAC. The collected data will be used in subsequent Study tasks to complete the analysis of sediment budgets, storage, and transport and planning of sediment management strategies.

While the existing datasets are considered to be relatively robust, there is a need for additional data. Many of the inventoried datasets comprise the entire USJRB, but upland processes may differ substantially from the more local processes occurring within the stream channels. Subsequent Study tasks will therefore augment these data by collecting erosion hazard, sediment fingerprinting, and sediment bedload transport data to better understand and quantify sedimentation in Lake Houston and its tributaries.

7 References

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