HARRIS-GALVESTON SUBSIDENCE DISTRICT

Evaluation of Subsidence Impacts in the Spring Creek Watershed

EXECUTIVE SUMMARY

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Executive Summary

The purpose of this study was to evaluate subsidence impacts on flood risk within the Spring Creek Watershed, an area along the northwestern border of Harris County. Spring Creek has a natural channel with limited conveyance and a larger natural floodplain than other streams in Harris County. The Spring Creek Watershed spans over 392 square miles, extending into portions of Harris, Montgomery, Grimes and Waller counties in southeastern Texas. Portions of major transportation routes, like Interstate 45 (I-45), are located within the watershed and serve as important evacuation routes for the Houston Region. This watershed also includes portions of the groundwater recharge zone for the Chicot and Evangeline aquifers, which are a primary source of groundwater for Texas' Gulf Coast Region.

Historically, this area has been largely undeveloped; however, development has increased in recent decades. The estimated population growth of this area from 2020 to 2070 is 47% with projected subsidence over three feet near The Woodlands (**Figure 1**). This study provides information on the increase in flood risk attributable to projected subsidence and future development across the watershed up to the year 2070. Additionally, the findings from this study provide an important perspective on the impacts of subsidence related to inland flooding and the economic consequences that may be used for future planning efforts.

Project Approach

This study developed a method to incorporate subsidence projected to 2070 into an existing model terrain for two different conditions, utilizing a baseline model to serve as a benchmark for comparison:

Conditions:

1. Projected Subsidence WITHOUT Future Development in 2070 - Includes only terrain changes due to subsidence.
2. Projected Subsidence WITH Future Development (SFD) in 2070 - Includes both subsidence-driven terrain changes and projected 2070 land use/land cover modifications. (For brevity purposes, this executive summary will focus on the results of this condition.)

Note - Both conditions were simulated for the 10-year (10% AEP) and 100-year (1% AEP) flood events.

The Hydrologic and Hydraulic (H&H) model HEC-RAS was used to quantify the impacts of subsidence on pluvial flood risk and economic consequences for each condition. The datasets used to build the baseline H&H model include topography, rainfall, streamflow, land use, and soil characteristics, which serve as the building blocks for simulating the movement and distribution of water within the watershed. A comparison of the H&H modeling results between the baseline and SFD condition was performed to evaluate the impact of subsidence on flood risk, including flood depth, floodplain acreage, water level and velocity.

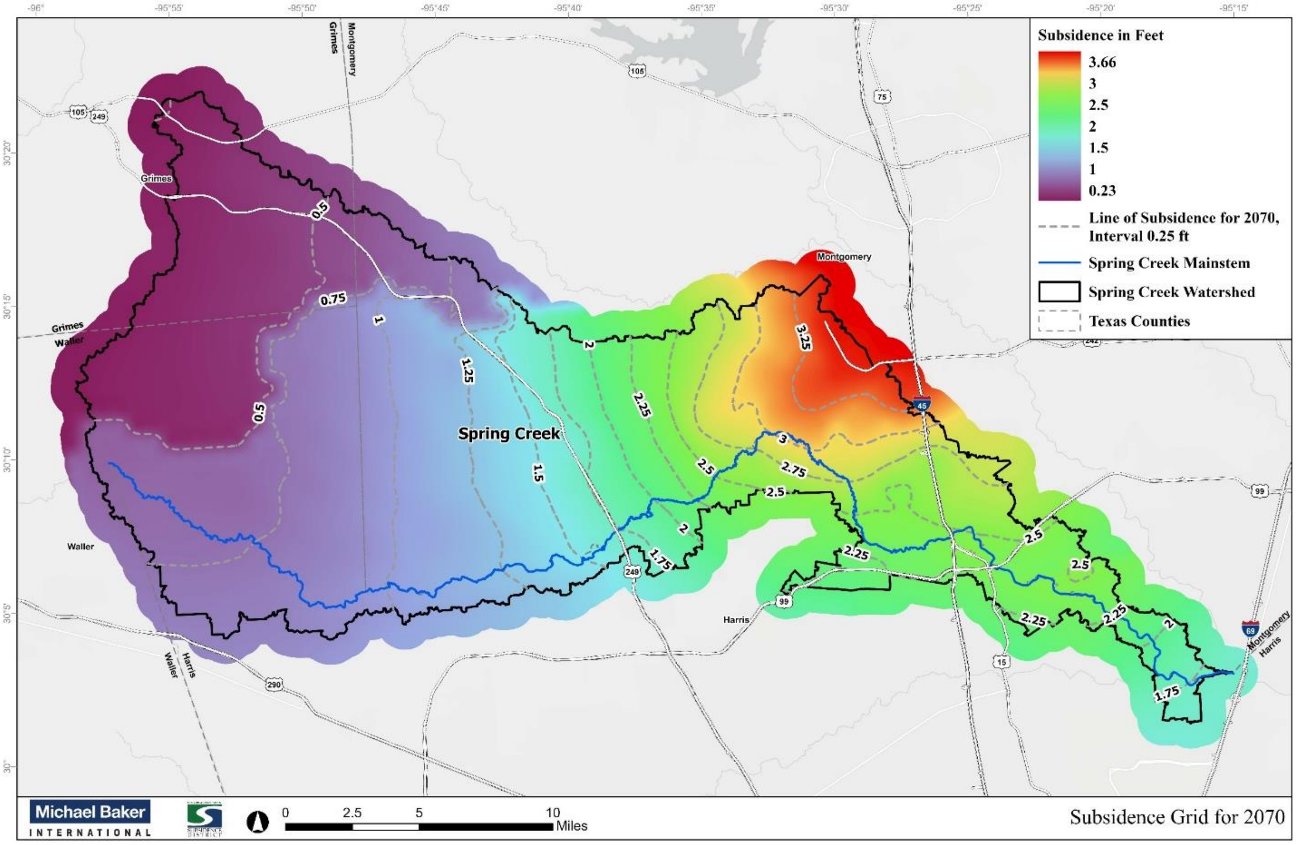

Figure 1. Location of the study area for the Spring Creek Watershed, located in southeast Texas, and the total projected subsidence from 2019 to 2070 shown in feet.

Flooding Impacts

The impact of subsidence on flooding was evaluated in terms of the following flood hazards:

1. **Flood Depths** - The SFD condition showed an increase in flood depth up to 1 ft from the baseline in several areas of the watershed (**Figure 2**). A few localized spots around major road crossings, such as I-45, show an increase of greater than 1 ft.
2. **Velocity** - With less projected subsidence upstream and more projected subsidence downstream, stream slope is impacted, resulting in increased velocities upstream and slower velocities downstream. The SFD condition showed an overall increase in flow velocities compared to the baseline scenario, although many areas experienced only minimal changes. Even small changes in velocity can affect sediment transport and localized flood hazards.
    a. *Increased velocities* - Erosion and bank instability as well as structural damage risk at road crossings and infrastructure.
    b. *Decreased velocities* - Longer inundation, more waterlogging, and increased property damage.
3. **Floodplain Acreage** – The SFD condition showed an increase of 1,739 acres of land inundated over the baseline.

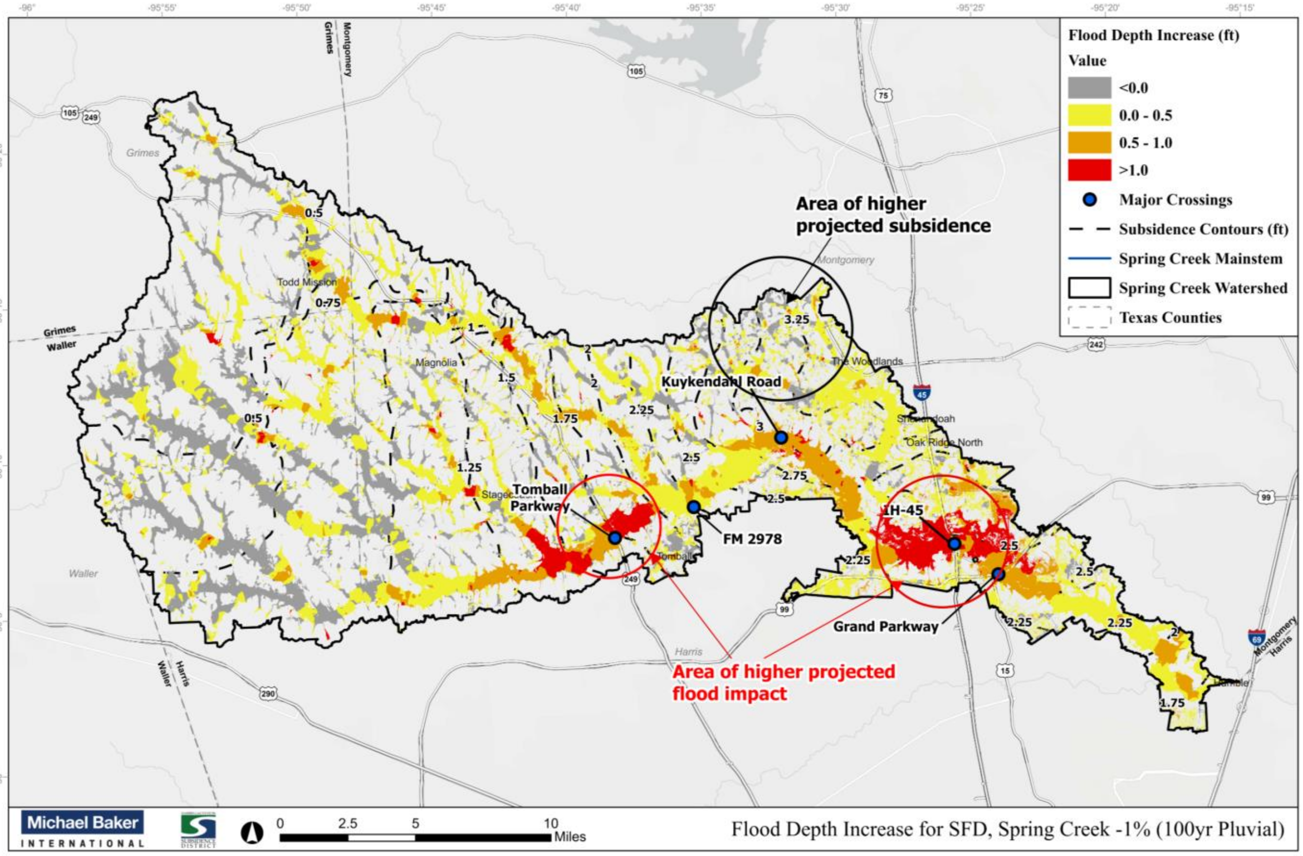

Figure 2. Flood depth increase, in feet, for the Subsidence with Future Development modeled for a 100-year flood event.

Structures and roadways were also included in the impact analysis. Flooded structures were categorized into four severity levels dependent upon the flood depth and ranged from six inches to over three feet. As shown in **Table 1**, the SFD condition resulted in over 3,700 new flooded structures when compared to the baseline. Flooded roadways can cause transportation disruptions that could result in challenges for emergency services, repairs, and closures. The SFD condition showed an additional 40 miles of flooded roadways. A summary of new flooding impacts experienced in the SFD condition when compared to the baseline is provided in **Table 1**.

Table 1. Number of new additional flooding impacts for the Subsidence with Future Development condition when compared to the Baseline.

Flooding Impact	Subsidence with Future Development
Floodplain	+ 1,700 acres
Flood depth	+ 1 foot
Streamflow	+ 3,500 cubic feet per second (cfs)
Flooded structures	+ 3,700
Flooded roadways	+ 40 miles

Areas with the highest projected subsidence of over three feet, such as the northern area of The Woodlands and southern portion of Conroe, experienced a minor change in flood risk. Communities downstream of these areas located near the Harris-Montgomery County border showed the highest increase in flood risk (**Figure 2**).

Economic Impacts

The direct and indirect economic losses were calculated using the estimated flood depth from the pluvial model for the three conditions (i.e., Baseline, SWFD, and SFD) and two storm events (i.e., 10-year and 100-year).

Direct losses were categorized based on the occupancy type of the structure – Residential, Commercial, Public, and Industrial – and included contents such as appliances, drywall, and vehicles, where appropriate. In all conditions, the largest contribution to direct losses was attributed to residential structures, followed by commercial structures. The SFD condition had the largest contribution to direct losses from residential structures with 62% for a 100-year event and 67% for a 10-year event. Indirect losses were evaluated based on gross domestic product and labor loss. The reduction in labor workface was represented as the number of displaced workers and not assigned a dollar value.

- SFD Condition: Showed significantly higher direct and indirect losses compared to the baseline. The highest additional losses were found for the 100-year event to be $559.5 million, along with a reduction in labor workforce of 3,253 people (**Table *2***).

Table 2. Economic impact from flooding in the Subsidence with Future Development condition in the Spring Creek Watershed calculated in 2024 US Dollars.

Flood Event	Economic Loss	Subsidence with Future Development (Million USD)
10-year	Direct Loss	113
	Indirect Loss (GDP)	51
	Total Loss	**164**
100-year	Direct Loss	446
	Indirect Loss (GDP)	114
	Total Loss	**560**

Potential losses to structures and infrastructure due to faulting in the area associated with active subsidence were estimated within a 200-ft hazard band along the fault lines using the baseline infrastructure data. These hazard bands included a total of 56 structures, estimated damages at $38.3 million and 43 road segments, estimated reconstruction cost of $11.3 million. Other potential losses, including railways, transmission pipelines, storm sewers, water supply pipelines, and sanitary sewers, were also assessed. The total estimated potential loss to infrastructure from the fault lines in the Spring Creek Watershed is $70.6 million.

Conclusions

This study identified the following flood risks and economic impacts from projected subsidence with future development in the Spring Creek Watershed for a 100-year flood event:

- Expansion of 100-year floodplain by over 1,700 acres
- Average increase in flood depth by 1 foot
- Additional 3,700 flooded structures with the majority being residential
- Increase of flooded roadways by 40 miles
- Damages up to $560 million per 100-year flood event with approximately $446 million attributed to direct loss (e.g., structure and contents)
- Potential for $71 million in losses from faulting within a 200-ft hazard band

Recommendations

Subsidence poses significant flood and economic risks in the Spring Creek watershed. To address these challenges, the following actions were recommended:

- **Infrastructure and environment** – Evaluate subsidiary impacts of subsidence, including bank erosion, land destabilization, agricultural and environmental damages, and datum shifts, to provide a more comprehensive economic analysis of subsidence impacts.
- **Planning and policy** – Implement comprehensive strategies to address factors driving subsidence including minimizing groundwater extraction.
- **Monitoring** – Include regular measurements of the land surface across the watershed.
- **Community awareness** – Promote the understanding of subsidence impacts and varying community vulnerabilities.