MASTER DRAINAGE PLAN

City of Seguin, Texas

December 23, 2025
AVO 57484

SEGUIN TEXAS

halff

100 NE Interstate 410 Loop Suite 701,
San Antonio, TX 78216

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1.0 Executive Summary

Purpose

The City of Seguin (City) initiated a comprehensive Flood Risk Evaluation and Drainage Master Plan (DMP) to address recurring flooding issues, prioritize high-risk areas, and develop cost-effective mitigation strategies. This plan integrates hydrologic and hydraulic modeling, historical flood data, and stakeholder input to guide future infrastructure investments and projects.

Approach

The DMP was developed through the completion of consecutive tasks resulting in 4 technical memos. The following items outline tasks Halff completed to develop the final DMP report:

1. Developed a 2D Rain-On-Mesh (ROM) HEC-RAS Rapid Assessment (RA) model using Atlas-14 rainfall data and LiDAR terrain to simulate flood depths for multiple storm events including the 1%, 4%, 10%, 20%, and 50% Annual Exceedance Probability (AEP).

2. Identified 29 problem areas through modeling results and flood complaint data provided by the City.

3. Ranked risk areas using multi-criteria scoring matrices considering structural risk, roadway flooding, neighborhood access, complaints, future development impacts, and City staff input.

4. Compared RA model results to Digital Flood Insurance Rate Maps (DFIRM) and evaluated flood complaint locations to the effective floodplain.

5. Evaluated storm drain capacity in 8 priority areas using Bentley StormCAD and Rational Method hydrology.

6. Proposed conceptual mitigation projects for 16 selected risk areas.

Key Findings

The evaluation revealed that Tier 1 areas include locations with significant structural and roadway flooding, such as Bauer & Ireland (Risk Area B), Short Avenue (Risk Area K and X), and Hallmark Road (Risk Area D). These areas experience flood depths exceeding 2 feet during major storm events such as the 25-year and 100-year, posing risks to homes, businesses, and critical transportation routes. Several Tier 1 areas also serve single-access neighborhoods, increasing vulnerability during flood events.

Following stakeholder discussions, 16 areas were selected for project development. Proposed improvements may include storm drain upgrades, roadway elevation adjustments, and additional detention facilities. Areas not selected for immediate action remain documented for future consideration.

Proposed Mitigation Projects

The Seguin DMP recommends 16 conceptual mitigation projects aimed at reducing flood risk and improving stormwater management across the City. Key strategies include upsizing storm drains and adding inlets in neighborhoods such as Bauer Street, Olive Street, Nelda Street, and Bowie/Camp Streets; elevating and regrading roads like Friesenhahn Road and Sunbelt Road; constructing roadside channels and relief channels; and implementing detention facilities at Nelda Street and East Cedar Street to provide additional storage. Access improvements, such as extending Burr Oak to Jay Road and reconstructing the Twin Oak low-water crossing, will enhance emergency connectivity for single-access neighborhoods. These projects collectively address structural flooding, roadway inundation, and mobility concerns, offering significant benefits to public safety and infrastructure resilience. Detailed design and coordination to manage utility conflicts and property acquisition will be required for mitigation projects.

Estimated costs for the proposed mitigation projects vary significantly based on scope and complexity, ranging from approximately $250,000 for minor improvements such as the Twin Oak low-water crossing to over $7.6 million for major roadway and channel upgrades on Friesenhahn Road. Other high-cost projects include Hallmark Drive at $4.6 million, Nelda and Short Avenue at $2.9 million, and Camp Street at $2.7 million. Smaller-scale improvements, such as storm drain upgrades along Bauer Street, Olive Street, and Bowie Street, generally fall between $0.3 million and $1.8 million. These estimates provide a preliminary framework for prioritizing funding and phasing future capital improvement projects.

Recommendations

Recommendations include prioritizing projects listed under the initial Tier 1 areas for capital improvement planning, conducting preliminary engineering reports (PERs) for selected sites, and coordinating with ongoing projects to maximize efficiency and avoid conflicts. Future steps involve securing funding, refining project scopes, and maintaining public engagement to address evolving flood risks. Coordination with TxDOT and utility providers to address conflicts will be required for multiple projects. Additionally, detailed engineering studies for proposed projects will benefit from using advanced modeling tools that incorporate both storm drain and ROM modeling such as Infoworks ICM, XPSWMM, or more advanced versions of HEC-RAS that include storm drain modeling. The City should also implement GIS-based asset management for long-term monitoring of storm drain outfalls to the Guadalupe River.

Next Steps

The next steps involve advancing the proposed mitigation concepts to detailed design, which may include refining hydraulic and storm drain modeling using integrated 2D and pipe network simulations, such as InfoWorks ICM or XPSWMM. Additional tasks include utility coordination, property acquisition assessments, and evaluating downstream impacts to receiving streams and rivers. Each project will require constructability reviews, cost validation, and phasing plans to minimize traffic and neighborhood disruptions. Funding prioritization should focus on Tier 1 risk areas and projects with the greatest community benefit, while ensuring compliance with City and TxDOT design standards.

2.0 Introduction – Rapid Assessment Development

A rapid assessment flood evaluation was performed for the City of Seguin (City). This was done by conducting rapid assessment hydraulic modeling with the results from the analysis, in conjunction with historic flood data, to be used to determine areas with high flood risk.

To complete the rapid assessment analysis, a two-dimensional (2D) Rain-on-mesh (ROM) hydraulic model was developed for a portion of the Guadalupe watershed using the USACE HEC-RAS program version 6.6. Hydraulic and Hydrologic data was leveraged from a previously completed General Land office (GLO) River Basin Flood Study (RBFS) including a high level-of-detail hydrologic HEC-HMS model and hydraulic HEC-RAS model. Leveraged GLO models and data are provided in **Appendix A** of this report.

A single rapid assessment area was identified for hydraulic modeling (see **Exhibit 1**).

The rapid assessment model utilized both hydrologic and hydraulic components of the GLO RBFS models. Data leveraged includes:

Hydrology

- Upstream model inflows
- Guadalupe River initial condition points
- Guadalupe rating curve

Hydraulics

- Terrain
- Structures - 2D connections
- Inital cell mesh
- Breaklines
- Calibration regions

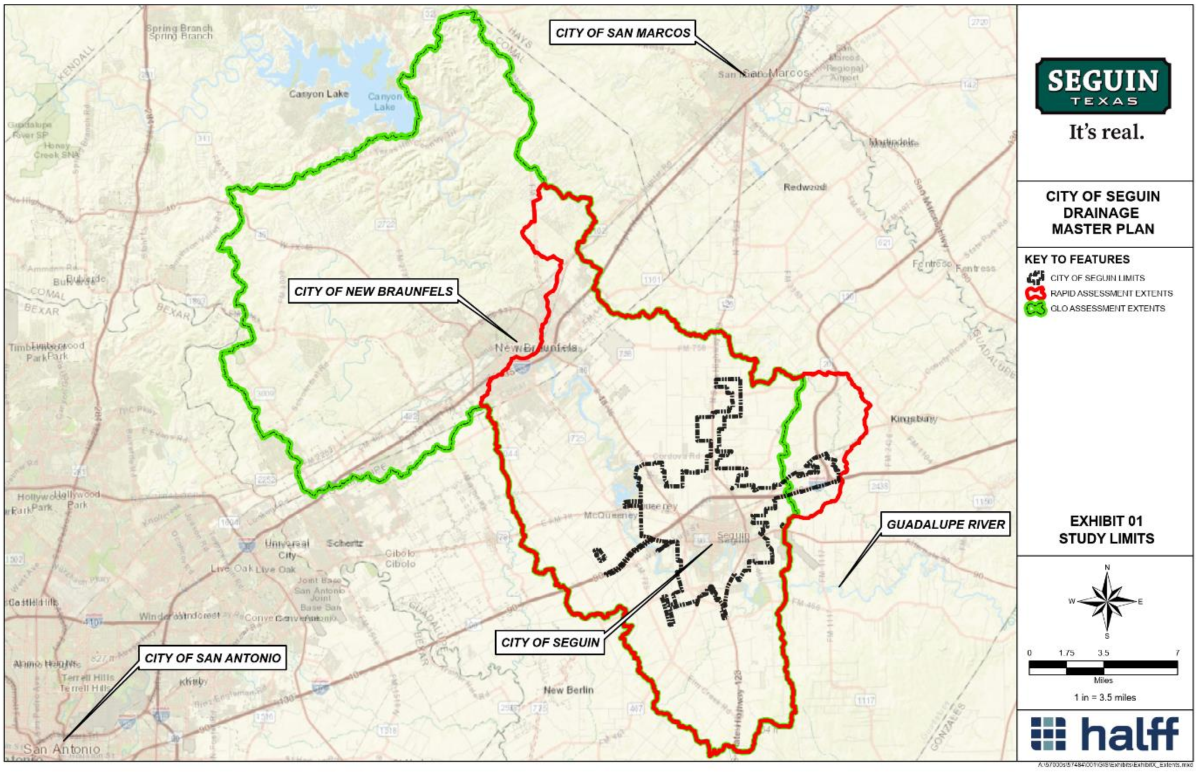


Exhibit 1. Rapid Assessment Limits

3.0 Hydrologic Modeling

3.1 GLO River Basin Flood Study Data

Hydrologic modeling for this rapid assessment model was primarily supplemented with the GLO RBFS model data. This includes both initial conditions points stationed along the Guadalupe River to simulate initial water surface elevations (WSE) and upstream inflows taken directly from the GLO HEC-RAS model.

3.2 Rainfall Hyetograph

To develop rainfall for the Rapid Assessment hydraulic models, a separate hydrologic analysis was used to produce rainfall hyetographs using a single-basin HEC-HMS version 4.12 model. Synthetic hyetographs were developed using the Frequency Storm type with depth durations taken from Table 3-2 of the City's Stormwater Criteria Manual.

The single-basin HEC-HMS model utilizes a single subbasin covering the extents of the rapid assessment area and applies the provided frequency storm uniformly. TP40 aerial reduction was utilized with an intensity duration of 5-minutes and intensity position of 50-percent.

The scope of this study includes the evaluation of only high-risk flood hazards, and as a result, the 1-percent annual expected probability (AEP) is the primary design storm event for this study. However, hyetographs were still created and simulated for the 1-percent AEP, 4-percent AEP, 10-percent AEP, 20-percent AEP, and 50-percent AEP. **Table 1** shows the total rainfall depths produced during this analysis for the 24-hour duration for the Atlas-14 TP-40 rainfall statistics.

Table 1. Cumulative Rainfall Depths

Source	Annual Chance Event	Rainfall Depth (in.)
Atlas 14, Seguin Stormwater Criteria Manual	1%	11.30
	4%	7.83
	10%	6.0
	20%	4.83
	50%	3.63

Additional hydrologic calculations that are typically included in traditional hydrologic models (hydrologic loss, hydrograph transforms, runoff routing, etc.) were applied directly within the HEC-RAS modeling software. The rainfall hyetograph is the main output from the HEC-HMS hydrologic model into the HEC-RAS hydraulic model.

3.3 Hydrologic Losses

Runoff losses were calculated using the Green and Ampt Loss Method. An infiltration layer was created in HEC-RAS using the NLCD land cover and SSURGO Hydrologic Soil Group (HSG) layers. Infiltration parameters are based on the recommended ranges in the HEC-RAS 2D User's Manual. The pore size distribution index was assumed based on the average pore size distribution of soil types generally consistent with each HSG soil group.

- **Land Use** – Land use was based on the National Land Cover Dataset (NLCD) developed in 2023. This data was further refined with existing building footprints larger than 5,000 square feet based on the Texas Water Development Board (TWDB) statewide buildings dataset "burnt" into the land cover raster. Building footprints smaller than 5,000 square feet were not "burnt" into the land cover raster to keep only large commercial buildings which cause obstructions to overland flow. This data set is presented in **Exhibit 2**.
- **Soil –** Soil information was obtained from the Natural Resources Conservation Service (NRCS) Web Soil Survey website. The City includes the full range of HSG's (A-D). Soil data is presented in **Exhibit 3**.

The Green and Ampt infiltration layer parameters used in this analysis are summarized in **Table *2***.

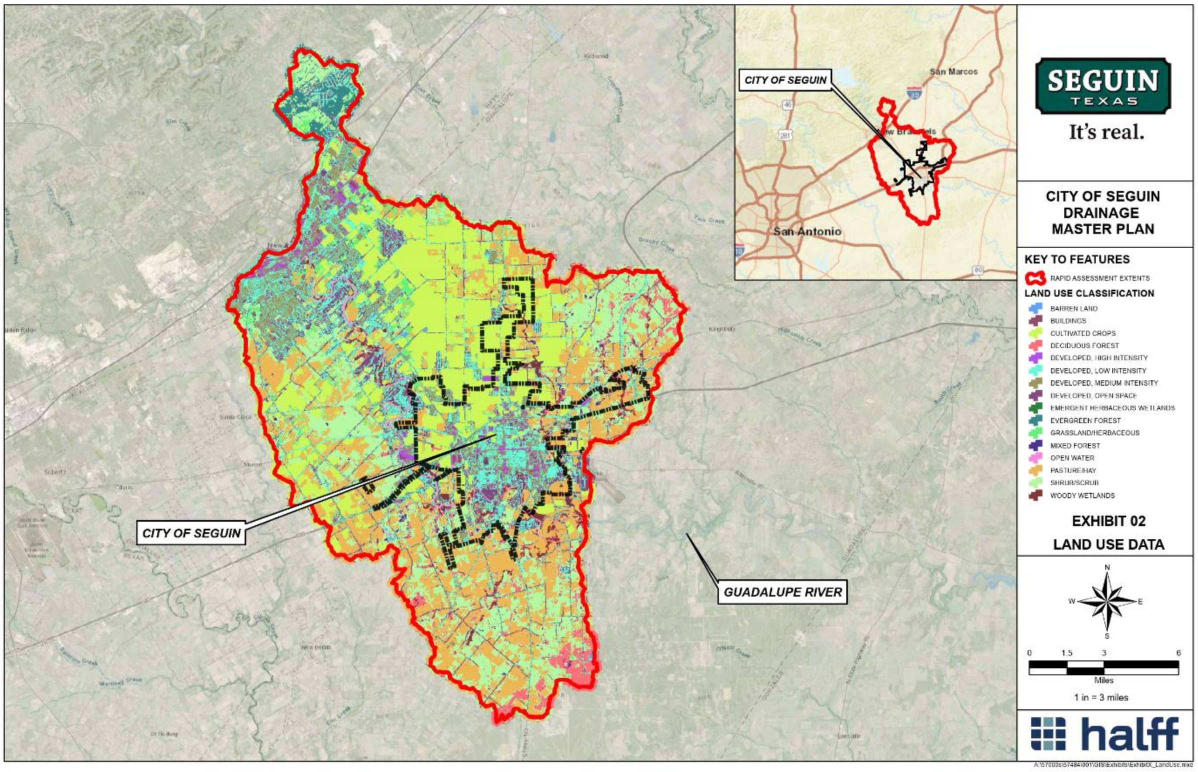


Exhibit 2. Seguin Rapid Assessment NLCD 2023 Land Cover

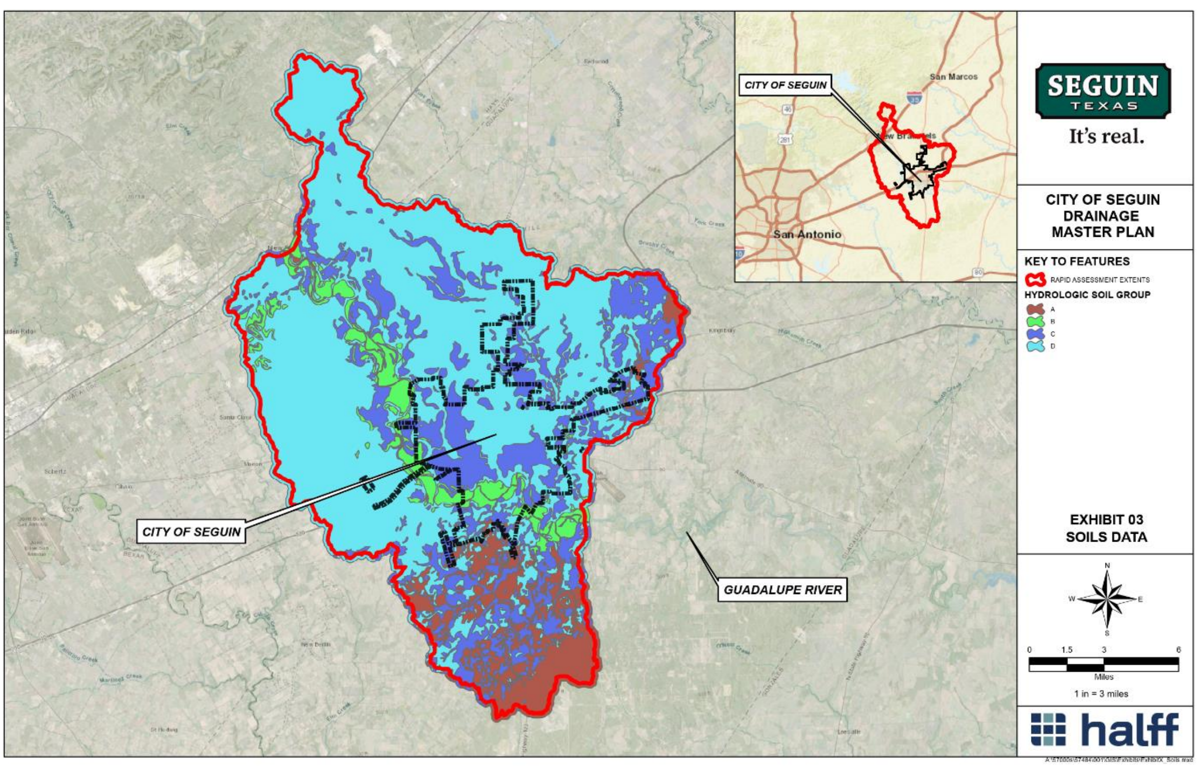


Exhibit 3. Seguin Rapid Assessment Soil HSG

Table 2. Green and Ampt Infiltration Parameters

HSG	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Distribution Index
A	2	0.35	0.33	0.44	0.05	0.694
B	4	0.20	0.34	0.45	0.10	0.553
C	8	0.08	0.35	0.46	0.20	0.296
D	12	0.02	0.35	0.47	0.30	0.191

3.4 Rapid Assessment

A 2D hydraulic model was developed for the rapid assessment area. While a typical rapid assessment model would ignore any riverine crossing structures (effects of pressure and weir flow at the crossings are ignored) as well as any underground storm systems, this assessment includes hydraulic structures along the Guadalupe River, Geronimo Creek, and Walnut Branch incorporated as 2D connections. The inclusion of these hydraulic structures comes from the ease of implementation of already developed structures from the GLO model and the presence of population centers adjacent to many of the outlined riverine systems. While this assessment does not necessitate the inclusion of hydraulic structures as the primary effort is the analysis of localized flooding and sheet flow, including these hydraulic features allows for more accurate modeling of the riverine systems and is more conservative in presenting riverine flooding that may impact the communities surrounding these systems. Imported GLO and Halff developed 2D connections are shown in **Exhibit 4** below.

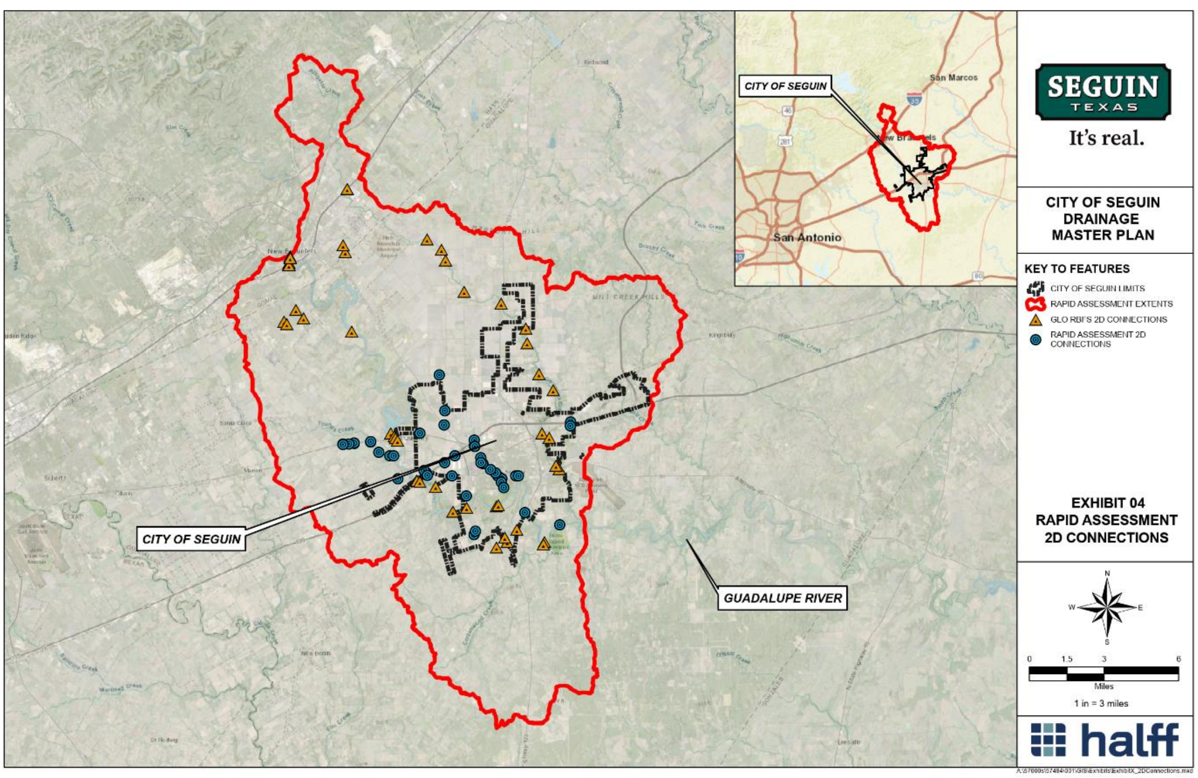


Exhibit 4. HEC-RAS 2D Connections

3.5 Model Development

HEC-RAS version 6.6 was used to perform the rapid assessment analysis. It has the capability to perform the 2D surface modeling and can spatially display modeled flood depths against other pertinent GIS data such as structure data, high density repetitive loss areas, etc. This functionality allows for a rapid review of the watershed to identify areas of high flood risk and facilitate the final identification of problem areas.

3.5.1 2D Flow Areas

The rapid assessment modeling is completely 2D dimensional. As a result, the entire watershed is modeled as a 2D mesh with the watershed boundary acting as the 2D flow area boundary. The key features of the 2D flow area include the 2D mesh, breaklines, 2D connections, and infiltration layer.

3.5.1.1 2D Mesh

A 2D mesh consists of 2D cells that can model the flow of water in two dimensions. Each cell develops a stage-volume curve based on the underlying terrain and each cell face develops a stage-discharge curve based on the cell wall cross-section cut over the underlying terrain and the underlying manning's n layer. The "Spatially Varied Manning's n on Faces" option for the 2D flow area was turned on to consider roughness coefficients along the entire cell face. Combining these features, the model can simulate flow entering the cell from adjacent cells, calculate headloss across the cell, calculate the storage in the cell based on the amount of incremental inflow, and simulate flow leaving the cell into neighboring cells (see **Figure 1** as an example). This, in turn, results in a seamless 2D flow pattern.

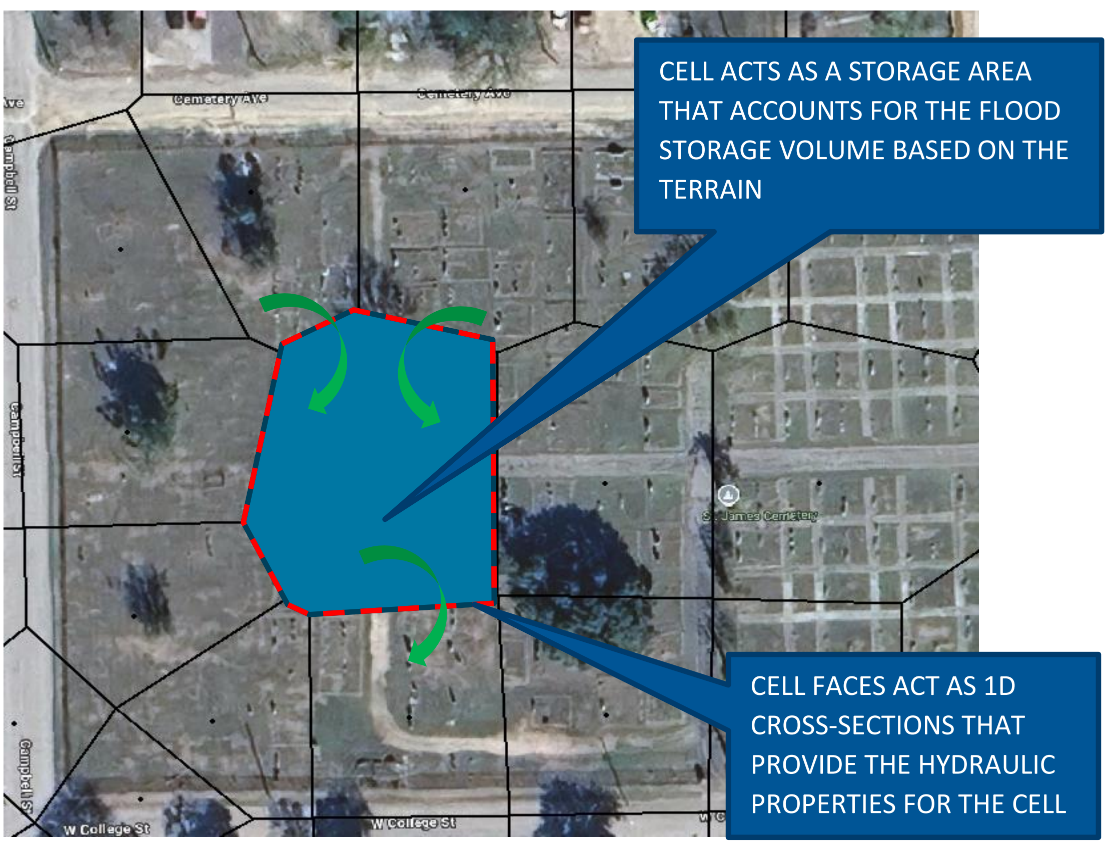


Figure 1. HEC-RAS 2D Cell

The 2D mesh density varies in size with smaller cells sizes generated around the City's center. In general, a mesh size of 300'x300' was used for the model with a minimum cell size of 100'x100' near the more populated areas of Seguin. A refinement region was created in HEC-RAS to develop these smaller cell sizes and is shown in **Exhibit 5**.

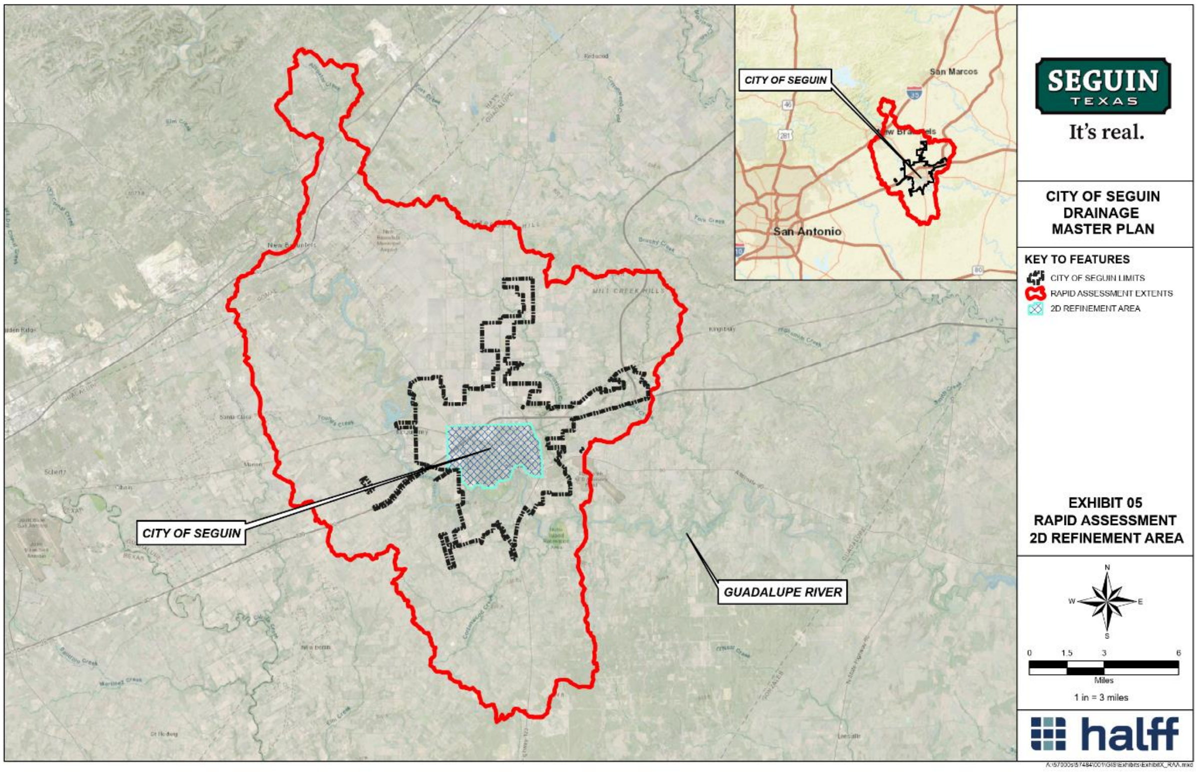


Exhibit 5. Cell Mesh Refinement Region

3.5.1.2 Breaklines

Breaklines force the 2D cells within a mesh to align along the highest elevation of the terrain. This gives the modeler flexibility in forcing cell faces to align in a particular direction, such as perpendicular to the channel flow line or parallel to a topographic ridge, so that larger cell sizes can be used without losing the detail of the underlying terrain. This is most often necessary to stop "leakage" where the cell faces do not adequately intersect and capture high points in the topography. Breaklines also allow for a smaller mesh size along the line for increased mesh detail. Breaklines were added where a finer cell size was needed for a local region and where a given area needed to be blocked off from the model until a low point along the perimeter of the area is breached.

Breaklines were added directly into RAS where a finer cell size was needed for a local region of the model and along berms and levees (roadways, dams, etc) to properly account for these prominent topographic features. They were also placed along the centerline of larger riverine systems such as the Guadalupe River to force the cell faces to be perpendicular to the direction of flow in high flow areas. See an example of typical breakline placement in **Figure 2**.

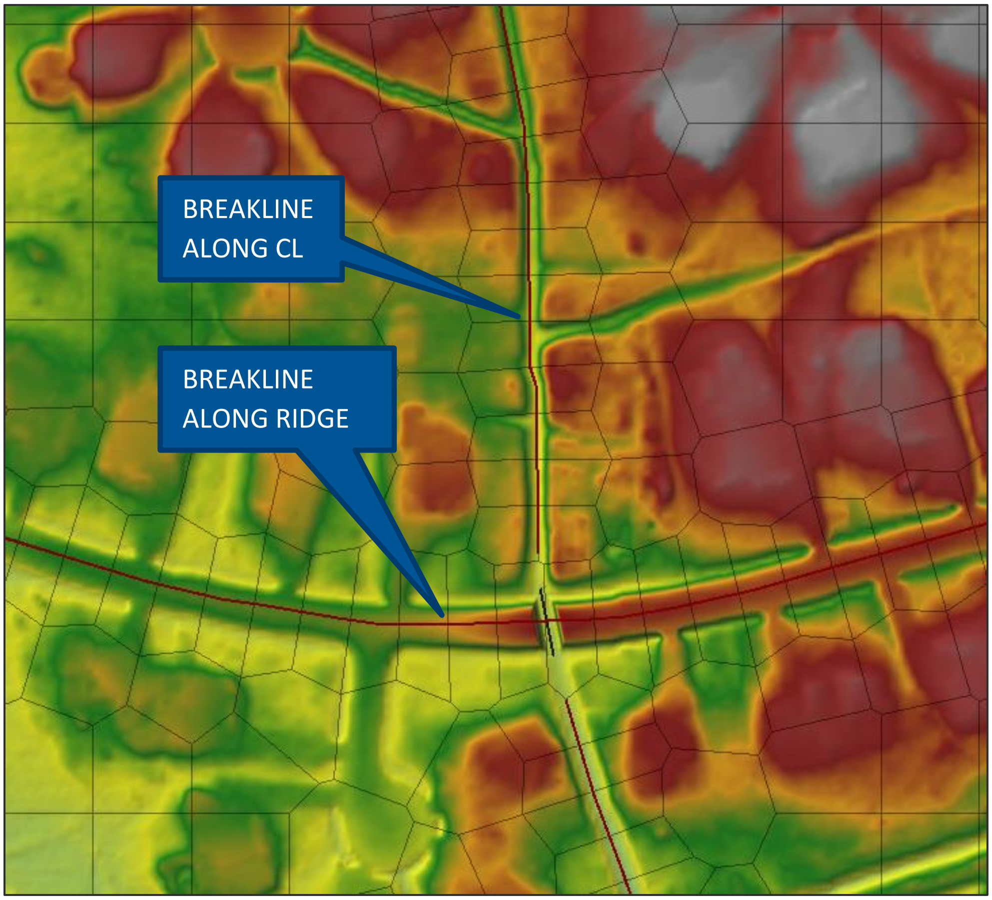


Figure 2. Breakline Example

3.5.2 Boundary Conditions

As with any hydraulic model, boundary conditions are required for the simulation. These typically include external points of inflow (flow hydrograph, rainfall, etc) or outflow (normal depth slope, stage hydrograph, etc.). While the GLO model utilized internal inflow lines within the rivers and creeks of the watershed, this rapid assessment model uses rainfall directly on the mesh to produce flood results. This required the removal of the GLO inflow boundary conditions and the incorporation of an external flow hydrograph boundary condition at the very upstream end of the rapid assessment area. In certain models, internal initial condition points are used to create an initial WSE to mimic stage height of riverine systems. The GLO RBFS utilized several initial condition points along the Guadalupe River which were kept for this rapid assessment model. Other types of boundary conditions were used for the unsteady analysis and consisted primarily of precipitation (overall), rating curve (outflow) and normal depth (outflow). Boundary conditions utilized can be seen in **Exhibit 6**.

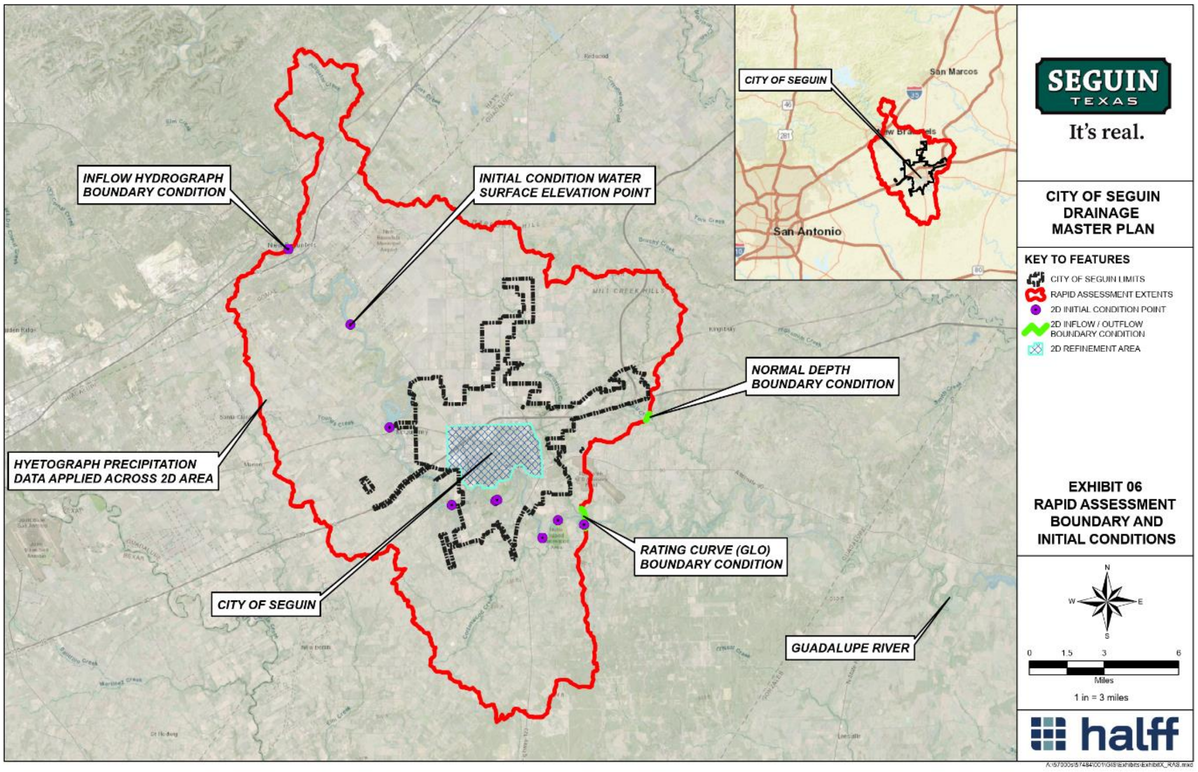


Exhibit 6. Boundary Conditions

3.5.2.1 Precipitation

The hyetograph data produced by the hydrologic analysis is uniformly applied to the entire model. This is applied to each cell incrementally and the rate of application is based on the hyetograph intensity and the time step of the simulation.

3.5.2.2 Normal Depth

The main watershed for the City outfalls into the Guadalupe River with an additional watershed to the east outfalling southeast away from the City and into Mill Creek. A normal depth boundary condition was applied at the downstream study limits for the eastern watershed. In order to accurately determine flood risk associated with only the studied creek, it was assumed that outfall to the east is not contributing to the flood hazard and has no tailwater effect. In this case, the normal depth of the Mill Creek was assumed to control the tailwater conditions. The energy grade-line slopes were estimated from the GLO RBFS LiDAR terrain data.

3.5.2.3 Initial Condition Points

A total of 11 initial condition points are included within the rapid assessment model and were imported directly from the GLO RBFS model. These initial condition points are used to give the Guadalupe River an initial WSE at the beginning of the model simulation and prevent unrealistic dry conditions within the river at the beginning of a storm event.

3.5.3 Terrain

3.5.3.1 2017 - 2021 LiDAR

The underlying terrain is a critical component of any 2D model as the accuracy of the dataset directly influences the accuracy of the 2D model. For this analysis, the topographic source LiDAR dataset was retrieved from the GLO RBFS. While originally scoped to utilize LiDAR developed by Halff for the City of Seguin Stormwater Utility Rate project completed in 2022, comparisons between the GLO and Halff datasets showed that the GLO LiDAR showed a higher resolution at 3'x3' and covered the entire rapid assessment extent. In contrast, the Halff LiDAR dataset was at a lower resolution of 10'x10' and did not cover the entire rapid assessment area. The RAS model uses this data to develop elevation-volume curves for each cell as well as cross-sectional profiles for each cell face based on the resolution of the terrain grid. Additional details on the utilized terrain can be found with the provided GLO RBFS report in **Appendix A**. **Exhibit 7** outlines the terrain used for this rapid assessment.

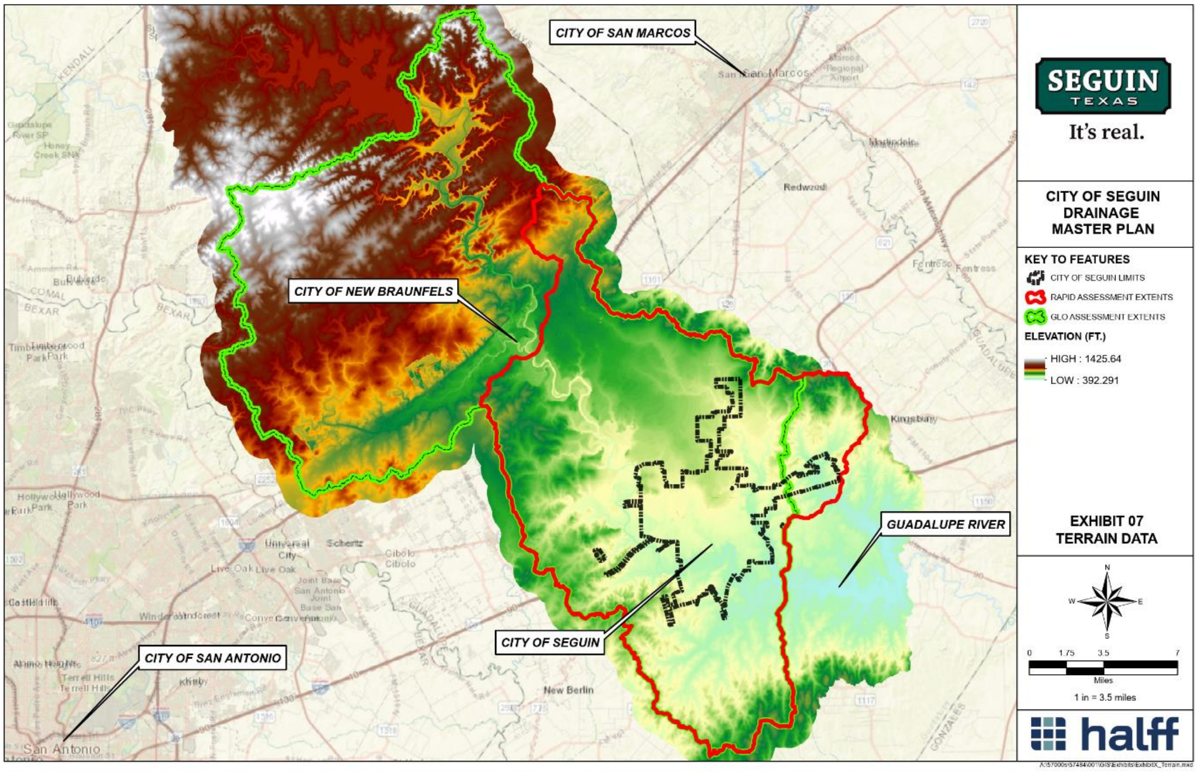


Exhibit 7. GLO RBFS Terrain

3.5.3.2 Terrain Conditioning

When LiDAR data is captured the technology oftentimes cannot penetrate through standing water, also known as bathymetry. This causes the terrain model to not accurately reflect the inner banks of channels that have ponding water. Additionally, the LiDAR cannot detect culverts under roadways. These issues can cause inaccuracy in the hydraulic modeling. To alleviate this, the terrain is conditioned to remove these inaccuracies by cutting the terrain away (i.e., "burning") in these locations. For instance, a vertical or trapezoidal section is stripped from a roadway to account for the culvert across the road. The size of the burn strips was chosen to be a smaller width than the culvert to better characterize the true open area of the culvert and thereby approximate the hydraulic losses across the culvert. An example of this conditioning is shown in **Figure 3**.

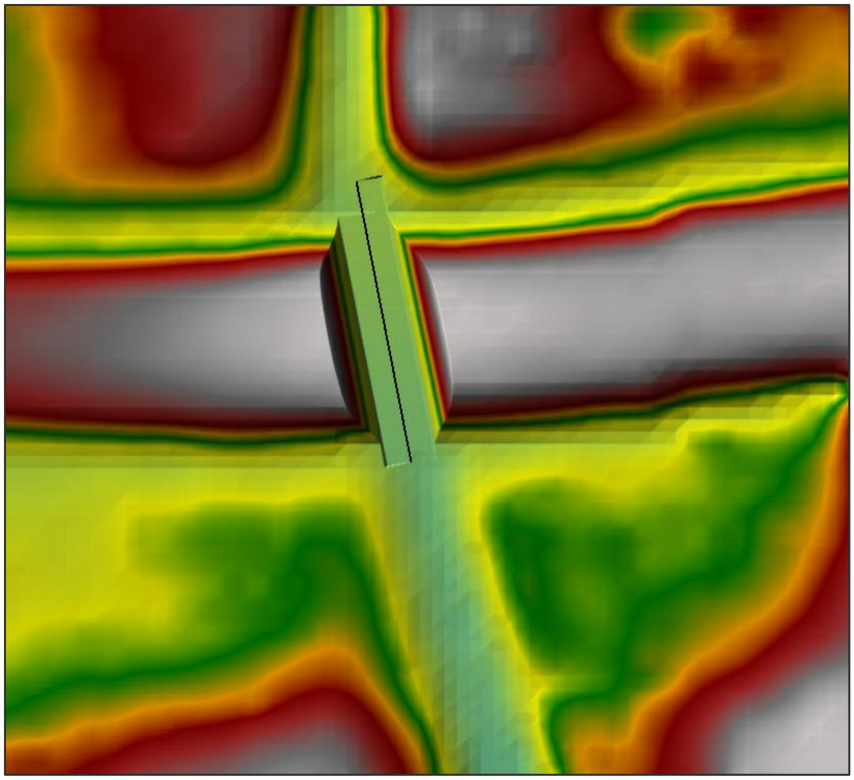


Figure 3. Terrain Conditioning Example

3.5.4 Infiltration Layer

The Green and Ampt dataset developed under Section 3.3 is applied to each model as an infiltration layer to calculate hydrologic losses in the hydraulic model. At each cell and time step, HEC-RAS retrieves the precipitation data, computes the hydrologic loss based on the underlying infiltration layer that is assigned to the cell, and applies the remaining excess precipitation runoff to the cell. Green and Ampt parameters used for the infiltration layer are highlighted in **Table *2***.

3.5.5 Manning's n Layer

A Manning's n roughness dataset was developed for the 2D mesh based on the NLCD land cover dataset. Manning's n-values were assigned to the different land cover types using the same values from the GLO RBFS. Traditionally, manning's n-values are developed assuming 1-dimensional (1D) flow patterns typical of channels and riverine floodplains. However, manning's n-values are actually a function of flow depth with shallower flow requiring higher manning's n-values to accurately reflect the high friction characteristic typical of shallow flow conditions. Manning's n-value calibration regions were added along the Guadalupe river and other riverine systems to provide finer resolution in the land cover layer. An example of these calibration regions is shown in **Figure 4**.

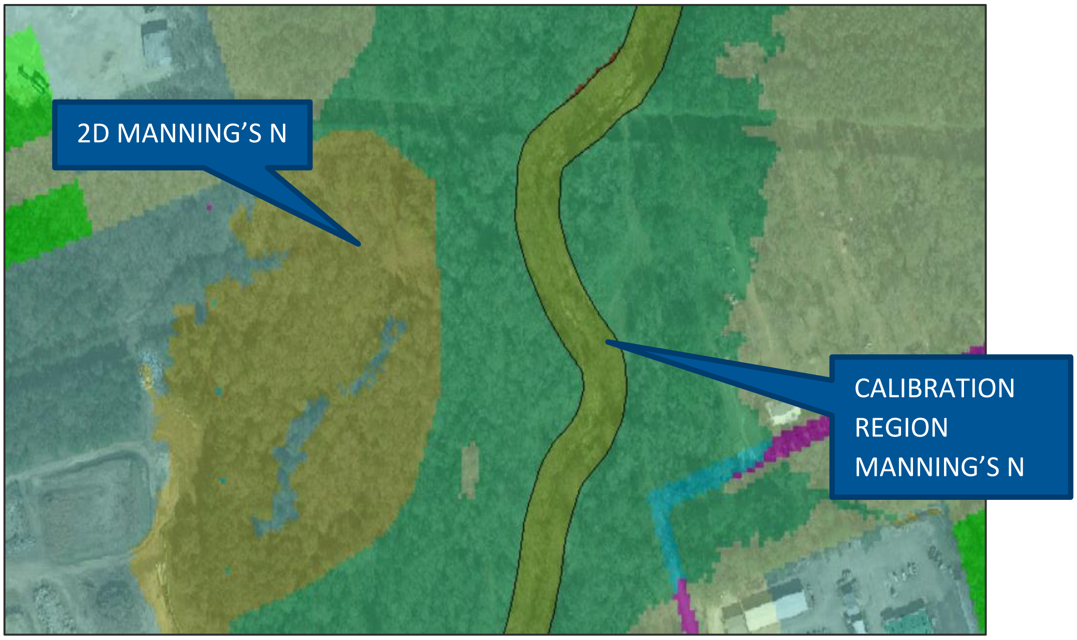


Figure 4. Manning's n Layer Example

3.5.6 Impervious Cover

Impervious percent values were added as a separate layer into the HEC-RAS model to account for imperviousness and vary from 0% impervious to 100% impervious. Impervious cover is shown in **Exhibit 8**.

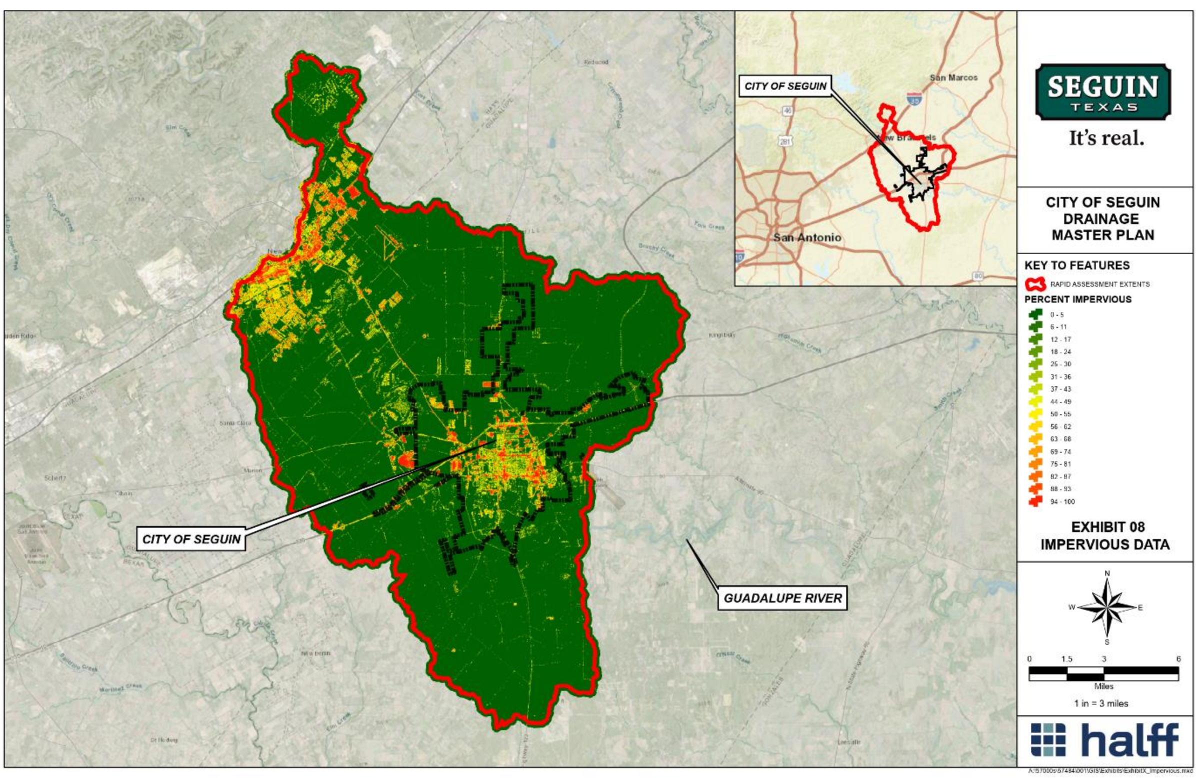


Exhibit 8. NLCD 2019 Impervious Cover

In urban areas, buildings often inhibit the flow of water but still provide floodplain storage if inundated. To account for this, the manning's n layer for areas such as residential developments typically have a higher value that is weighted high due to the structures on the lots. For this study, it was decided that additional detail needed to be provided for commercial areas where there are often large open parking areas that may have a low manning's n but are inaccurately weighted high due to the large buildings on the site. Therefore, commercial developments and urbanized areas falling under the land cover category Developed, High-Intensity and Developed, Medium-Intensity were given a lower manning's n of 0.02 to reflect the parking lots and any building greater than 5,000 square feet was given a much higher manning's n-value of 10. This threshold was chosen to pass over typical residential structures which are already reflected in the residential manning's n classification but still pick up the typical large commercial and industrial buildings. The high manning's n-value for buildings allows for the precipitation to be applied to the building area and be allowed to drain out of the cell while still providing enough friction to mimic the inhibitive effects of the building during high flood conditions. **Figure 5** shows this application to the manning's n layer.

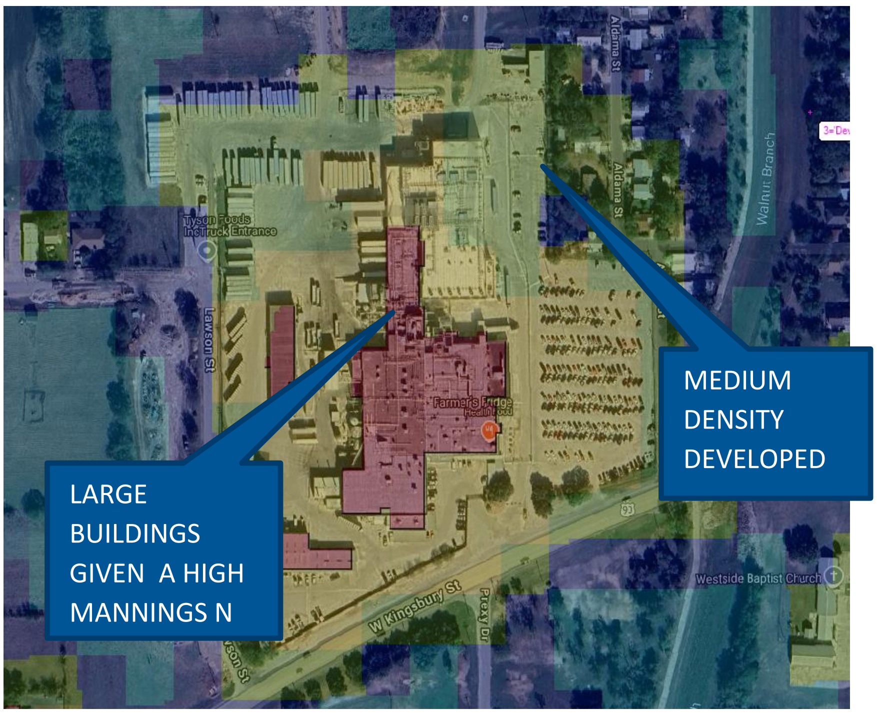


Figure 5. Building Manning's n Layer Example

Table 3 shows the manning's n-values assigned to the different land cover classifications.

Table 3. Manning's n Roughness

Land Cover Classification	Manning's n
Open Water	0.035
Developed, Open Space	0.04
Developed, Low Intensity	0.08
Developed, Medium Intensity	0.02
Developed, High Intensity	0.02
Barren Land (Rock/Sand/Clay)	0.03
Deciduous Forest	0.10
Evergreen Forest	0.15
Mixed Forest	0.12
Shrub/Scrub	0.08
Grassland/Herbaceous	0.04
Pasture/Hay	0.045
Cultivated Crops	0.05
Woody Wetlands	0.07
Emergent Herbaceous Wetlands	0.05
Buildings (>5,000 ft^2)	10.0

3.6 Results

The models were computed for each watershed for the 50-percent AEP, 20-percent AEP, 10-percent AEP, 4-percent AEP, and 1-percent AEP. Various spatial results can be provided as a result of the hydraulic simulation, but the primary results analyzed in this study are the water surface elevation and depth rasters. The water surface elevation raster provides a 2D grid of water surface elevations across the entire watershed. The depth raster provides a 2D grid of depth of ponding based on the referenced underlying terrain (see **Figure 6**).

Figure 6. Depth Raster Example

Modeling results for the 100-Year floodplain are included in **Exhibit – RAA FP** in **Appendix B**. Flood comparisons between the Seguin Rapid Assessment and Guadalupe BLE study and the GLO RBFS and Seguin Rapid Assessment study are provided as **Exhibit – BLE vs RAA** and **Exhibit – GLO vs RAA** respectively within **Appendix B**.

4.0 Introduction – Risk Area Identification

A flood risk evaluation was performed for the City of Seguin (City). This was done by completing rapid assessment hydraulic modeling and using the results from the analysis in conjunction with historical flood data and consultation with City staff to determine areas of current high flood risk. These high flood risk areas were identified as drainage problem areas that may see benefit through proposed projects.

5.0 Problem Area Identification Approach

Problem areas were identified based on 3 categories: City staff identified problem spots, existing drainage issues through flood complaint data points, and the number of flooded structures and roadways shown in preliminary modeling. Historically flooded structures were not considered at this time as all historical flood claim data points were within the Guadalupe River floodplain which are identified as regional project areas that may be considered for future studies. Overall, 29 problem areas were identified. After the initial identification, the projects were screened further using a scoring matrix to prioritize areas of higher impact. To be classified as a potential project, the problem area needed to have at least 1 inundated structure OR 1 inundated roadway in the rapid assessment modeling for the 25-Year flood event.

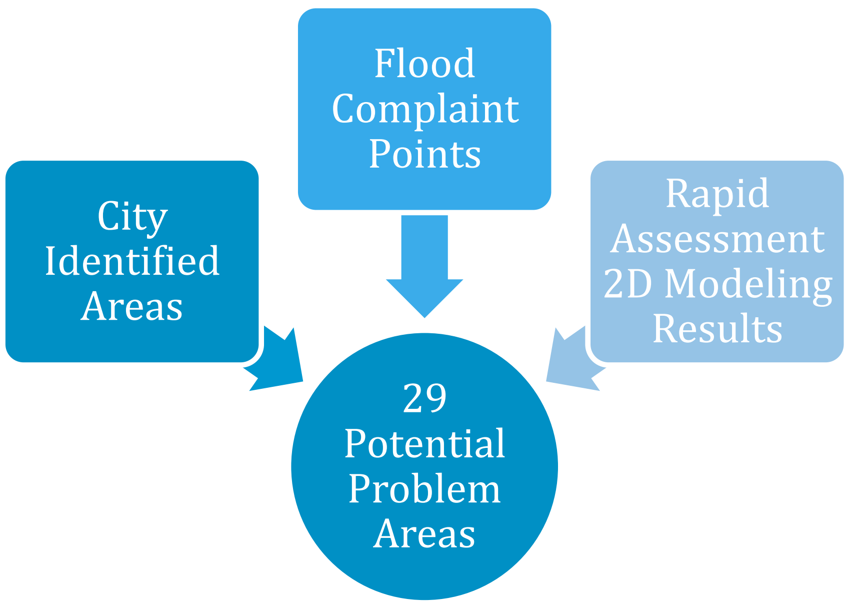


Figure 7. Problem Area Identification

The 29 problem areas were then separated into 11 Tier 1 risk areas, 7 Tier 2 risk areas and 11 Tier 3 risk areas, and 3 regional project areas that may considered for future studies.

5.1 Summary

A summary of all identified drainage problem areas is provided in **Table 4**. A variety of scoring systems were evaluated to explore project rankings by considering different score weights and categories. The score matrices are provided in **Table 5** along with the resulting project ranks in **Table 6** and **Table 7**. The problem areas are assigned a letter and a location identifier based on a road, road intersection, or area of interest. An overall view of the identified project areas is provided in **Exhibit – Risk Area Locations** which has been included in **Appendix B**.

Table 4. Identified Problem Areas

Risk Area	Location	At-Risk Structures (25-Year)	At-Risk Structures (100-Year)	At-Risk Roads (25-Year)	Single Access	Low Water Crossing	Potential Impacts from Future Development
A	N Guadalupe & Humphrey	15	15	2	NO	NO	NO
B	Baurer & Ireland	21	26	6	NO	NO	NO
BB	Baxter and Hiedeke	5	14	3	NO	NO	NO
C	Heideke & Mountain	1	11	1	NO	NO	NO
CC	Matthies Drive	0	0	0	YES	NO	YES
D	Hallmark Rd and E Walnut	2	2	1	NO	NO	YES
DD	Goodrich St. and Guadalupe St.	3	3	3	NO	NO	NO
E	Stanley Way	13	19	3	NO	NO	NO
F	Hexel Property & Highway 123	2	2	0	NO	NO	YES
G	New Braunfels St.	2	3	1	NO	NO	NO
H	Kingsbury at Walnut Branch and Aldana at Kingsbury.	43	54	5	NO	NO	NO
I	8th Street	0	0	1	NO	NO	NO
J	Burges St.	4	14	5	NO	NO	NO
K	Nelda and Fair	1	1	8	NO	NO	NO
L	FM 464 & Kingsbury	13	19	1	YES	NO	YES
M	River Oak & FM 725	0	0	2	NO	YES	YES
N	Villa Vista & Highway 46	4	8	1	YES	NO	NO
O	Burr Oak	1	2	2	YES	NO	NO
P	Twin Oak and Red Oak	0	0	1	YES	YES	NO

Table 4. Identified Problem Areas (Continued)

Risk Area	Area Name	At-Risk Structures (25-Year)	At-Risk Structures (100-Year)	At-Risk Roads (25-Year)	Single Access	Low Water Crossing	Potential Impacts from Future Development
Q	Woodstone	1	1	1	YES	YES	NO
R	Westgate	4	4	1	NO	NO	NO
S	Friesenhahn	0	0	1	NO	NO	YES
T	Cedar	0	0	1	NO	NO	NO
U	Middletown	0	0	4	NO	YES	NO
V	Old Town	0	0	1	YES	NO	NO
W	Montwood	0	0	1	YES	YES	NO
X	Short Ave.	35	38	5	NO	NO	NO
Y	Mesquite St.	3	7	7	NO	NO	NO
Z	Vincent Patlan Elementary School	0	0	1	NO	NO	NO

5.2 Ongoing Projects

The City provided Halff a list of ongoing projects to help better understand which risk areas may already have improvements that will not be reflected in modeling results or will likely have projects underway in the future. Ongoing projects are shown in **Exhibit – Ongoing Projects** provided in **Appendix B**.

5.3 Drainage Complaints

The City provided Halff with GIS shapefiles outlining public complaints due to flooding and was updated periodically throughout the risk analysis process as new complaints were received. These flood complaint points were used to help rank risk areas, with more complaints equating to a higher score for that risk area. An overview of collected flood issue points is shown in **Exhibit – Drainage Complaints** provided in **Appendix B**.

5.4 Single Access Neighborhoods

Single access neighborhoods were identified through aerial imagery and developed into a GIS point shapefile. These single access areas were used to help rank risk areas. An overview of single access neighborhoods is shown in **Exhibit – Single Access Neighborhoods** provided in **Appendix B**.

5.5 Low Water Crossings

Low Water Crossing data was retrieved from the City and used to help rank risk areas. Several areas not identified as a low water crossing in the city-provided shapefile were added to the overall shapefile. An overview of all low water crossings identified within city limits is shown in **Exhibit – Low Water Crossings** and provided in **Appendix B**.

5.6 Existing Storm Drain

Existing Storm Drain developed by SAM Inc. was assessed and used for risk area ranking. Storm drain systems are not reflected in rapid assessment modeling results and are therefore only used as an indicator that subsurface drainage exists and that flood results shown for risk areas may be inflated. Existing storm drain features will help identify potential projects and project limitations. An overview of existing storm drain is shown in **Exhibit – Existing Storm Drain** and provided in **Appendix B**.

5.7 Future Landuse

Halff utilized future landuse to help categorize risk areas to determine if there is potential for increases in stormwater runoff due to new development. Future landuse is shown in **Exhibit 9** below.

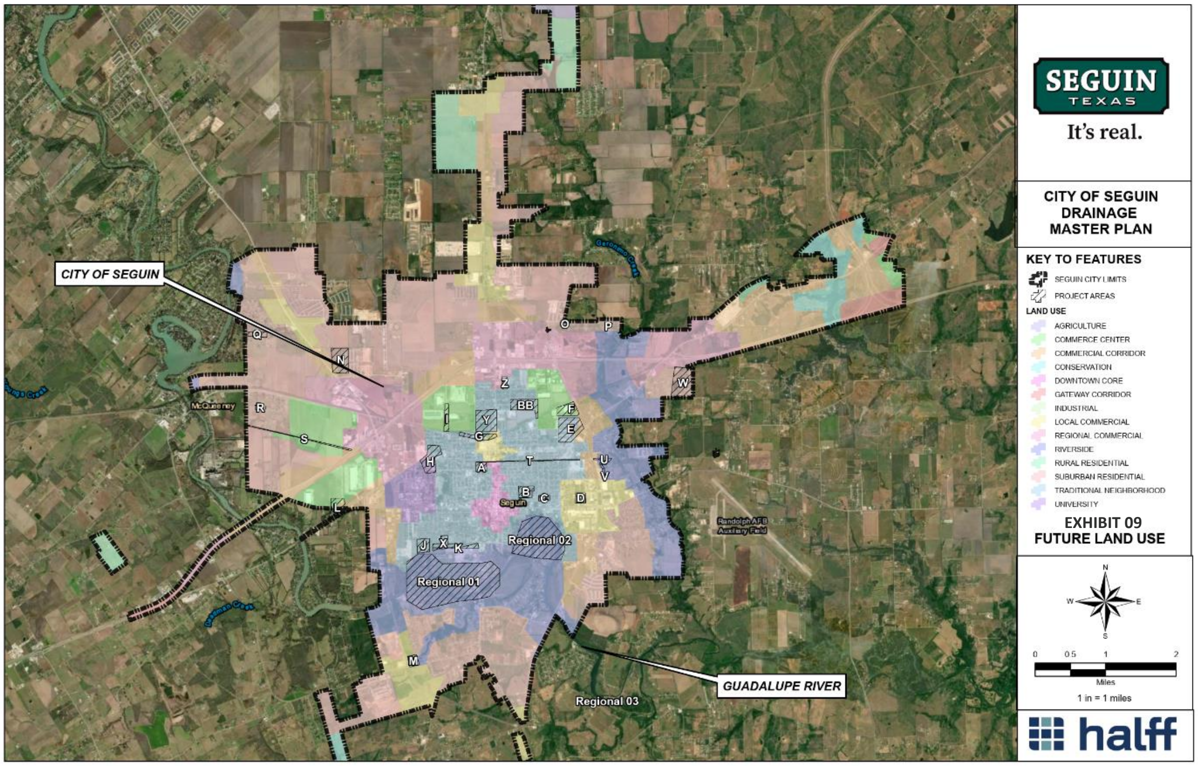


Exhibit 9. Future Land Use

5.8 Dam Locations

The National Inventory of Dams (NID) website was used to collect dam point data for the City. While only one dam, the Walnut Branch North Detention Dam, is located within city limits, 3 dams are located directly upstream and adjacent to the city. Public NID data for the Lake Meadow dam directly downstream of the City is provided in **Appendix C**. An exhibit outlining the 6 dams surrounding or within the City is shown in **Exhibit 10** below.

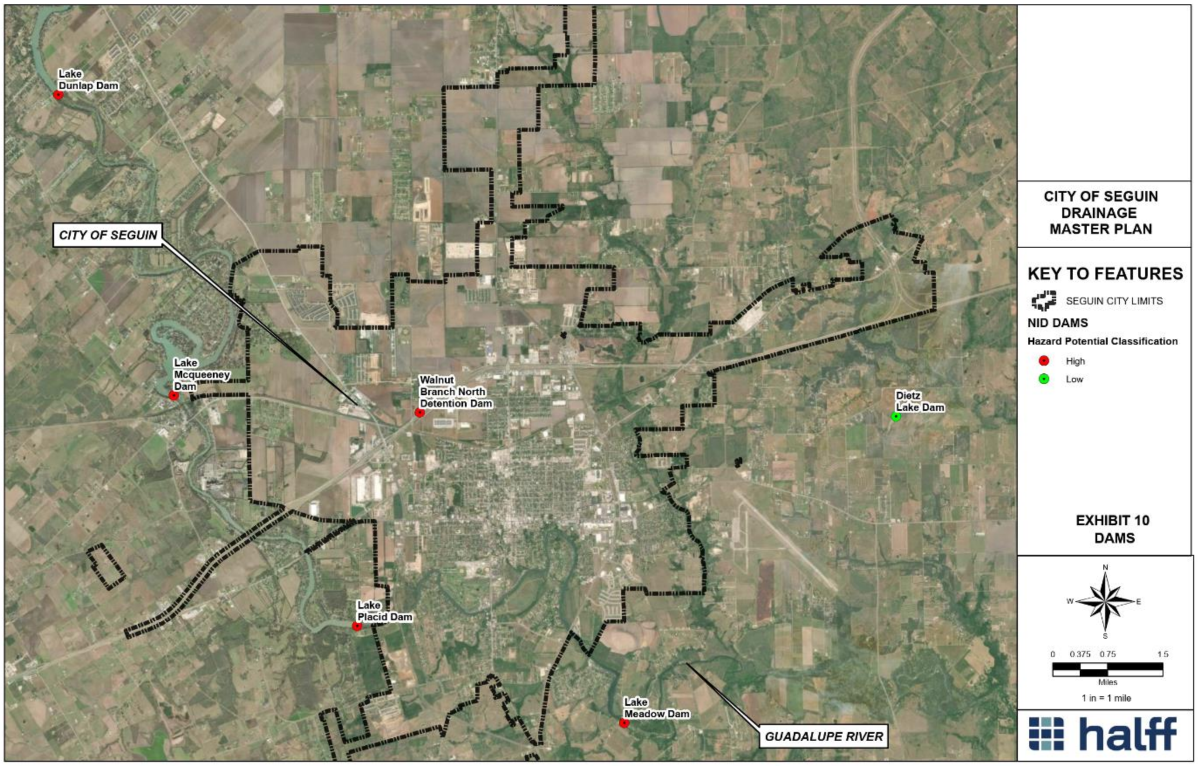


Exhibit 10. Dams

5.9 Structures

Building footprints were obtained from the Texas Water Development Board (TWDB) 2025 building dataset. Buildings were reviewed in each risk area to determine if any structural inundation would occur during the modeled storm events. The 25-Year storm event was mainly used for this impact assessment.

5.10 Risk Area Ranking

The ranking matrices were created to help identify project areas of greater concern and develop an overall ranking system to better determine order for capital improvement project development. Below are the categories used for project scoring and how they were scored based off modeling results and city provided data. Some scoring categories are named the same but utilize and apply modeling results differently. Scoring matrices are further defined in **Table 5**.

- **Scale of Structural Flood Risk (Matrix 1):**
  - Utilizes rapid assessment modeling results to identify buildings intersecting floodplains. Any building touching the floodplain was counted as inundated. This ranking was based on the occurrence of inundation of any structure in the various storm events (10-Year, 25-Year, and 100-Year) and not based on how many structures were in each storm event. Number of buildings intersecting floodplains was not considered. If a single building is within the 10-year floodplain, the category was scored at

the highest level at 15. If a single building is within the 100-year floodplain but no other floodplains, the category was scored at the lowest level.

- **Scale of Structural Flood Risk (Matrix 2 - 3):**
  - Utilizes 25-Year modeling results to identify buildings intersecting floodplains. Any building touching the floodplain was counted as inundated. The number of buildings intersecting the floodplain was considered. The more buildings inundated, the higher the category was scored.
- **Scale of Structural Flood Risk (Matrix 4):**
  - Utilizes modeling results to identify buildings intersecting floodplains and an assumed building replacement value (BRV). BRV's utilize a default dollar amount of $100 (designated by FEMA for benefit costs analysis purposes) and the building's area and is calculated as BRV = $100 x building area (sq ft). This category is not meant to act as a predictor of total flood damages, but as a rough estimate on potential dollar impact within risk areas.
- **Road flooding and Mobility:**
  - 25-Year inundation depths along roadways were assessed and categorized as either passable or impassable. Road inundation 1.0 ft or above was classified as impassable and given a higher score.
- **Neighborhood Access:**
  - Single access neighborhoods were identified through aerial imagery. Any project area associated with a single access neighborhood was given a higher score.
- **Reported Flood Complaints:**
  - Project areas were given higher scores with the presence of identified flood complaints. No flood complaints gave the lowest score and 3 or more complaints gave the highest.
- **Potential Impacts from Future Development:**
  - Future landuse data was utilized to assess whether the identified project area was within an area that may receive increased runoff through city development. Landuse categories that were assessed to contribute to potential runoff increases are Commercial Corridor, Commerce Center, and Industrial.
- **Presence of Storm Drain:**
  - Storm drain data provided by SAM Inc. was used to confirm the presence of storm drain within project areas. An extensive storm drain network would result in a lower score and no storm drain would result in a higher score.
- **Expected Road Impacts:**
  - Total length of inundated roads during the 25-Year event was assessed for project areas. Any flood depth at or above 0.5 feet was assumed as inundated and added to the total length of road inundation for that area. Road inundation did not need to be continuous along the entire road to be accounted for and any presence of flooding was measured and accounted for.

Table 5. Scoring Matrix

Scoring Matrix 1		
Ranking Category	**Sub Category Weight**	**Scoring**
Scale of Structural Flood Risk	15	0: No structural flood risk 5: 100-Year structural flood risk 10: 25-Year structural flood risk 15: 10-Year structural flood risk

Scoring Matrix 1 (Continued)		
Road Flooding and Mobility (25-Year)	10	5: Isolated roadway and intersection flooding 10: Flood depths make road impassable
Neighborhood Access	5	2: Single access or low water crossing 5: Single access and Low water crossing.
Reported Flood Complaints	5	0: No flood complaints 2: 1 or more flood complaints 5: 3 or more flood complaints
Potential Impacts from Future development	5	0: Not within a high-density development area 5: Within a high-density development area

Scoring Matrix 2		
Ranking Category	**Sub Category Weight**	**Scoring**
Scale of Structural Flood Risk (25-Year)	15	0: No structural flood risk 5: 1-5 inundated structures 10: 5-10 inundated structures 15: 10 or more inundated structures
Road Flooding and Mobility (25-Year)	10	5: Isolated roadway and intersection flooding 10: Flood depths make road impassable
Neighborhood Access	5	2: Single access or low water crossing 5: Single access and Low water crossing.
Reported Flood Complaints	5	0: No flood complaints 2: 1 or more flood complaints 5: 3 or more flood complaints
Potential Impacts from Future development	5	0: Not within a high-density development area 5: Within a high-density development area

Scoring Matrix 3		
Ranking Category	**Sub Category Weight**	**Scoring**
Scale of Structural Flood Risk (25-Year)	15	0: No structural flood risk 5: 1-5 inundated structures 10: 5-10 inundated structures 15: 10 or more inundated structures
Road Flooding and Mobility (25-Year)	10	5: Isolated roadway and intersection flooding 10: Flood depths make road impassable

Scoring Matrix 3 (Continued)		
Presence of Storm Drain	9	0: Extensive storm drain network 3: Some storm drain 9: No storm drain present
Neighborhood Access	5	2: Single access or low water crossing 5: Single access and Low water crossing.
Reported Flood Complaints	5	0: No flood complaints 2: 1 or more flood complaints 5: 3 or more flood complaints
Potential Impacts from Future development	5	0: Not within a high-density development area 5: Within a high-density development area

Scoring Matrix 4		
Ranking Category	**Sub Category Weight**	**Scoring**
25-Year Structural Impact Value (Dollars)	15	0: No structural flood risk 5: < $2,000,000 impacted 10: < $4,000,000 impacted 15: > $5,000,000 impacted
Expected Road impacts (Feet)	15	0: No road impacts 5: < 1,000 ft of road inundation 10: < 3,000 ft of road inundation 15: < 5,000 ft of road inundation
Road Flooding and Mobility (25-Year)	10	5: Isolated roadway and intersection flooding 10: Flood depths make road impassable
Neighborhood Access	5	2: Single access or low water crossing 5: Single access and Low water crossing.
Reported Flood Complaints	5	0: No flood complaints 2: 1 or more flood complaints 5: 3 or more flood complaints
Potential Impacts from Future development	5	0: Not within a high-density development area 5: Within a high-density development area

5.11 Risk Area – Scoring Results

Each risk area was scored 4 different times using the provided matrices to allow the City to choose one matrix over the others if desired. An average risk area score was created from the 4 resulting scores. **Table 6** lists results from all scoring matrices and

Table 7 lists the averages scores ranked. Final scores were separated into 3 Tiers. With a total maximum possible score of Tier 1 including the highest ranked risk areas with scores at or above 25. Tier 2 includes lower-ranked risk areas with scores at or above 20 that may still be of interest to the City of Seguin for potential projects. Any risk area below a score of 20 was categorized as Tier 3 and will likely be of less concern to the city for potential projects.

A total of 11 risk areas are included in Tier 1, 7 risk areas in Tier 2, and 11 risk areas in Tier 3.

Table 6. Scoring Results – All Matrices

Scoring List 01		Scoring List 02		Scoring List 03		Scoring List 04	
L	32	BB	30	L	36	H	40
BB	30	H	30	H	33	BB	35
D	30	B	27	B	30	D	35
H	30	L	27	BB	30	X	35
Q	30	A	25	S	28	Y	35
Y	30	E	25	X	28	B	32
B	27	X	25	N	26	E	30
C	27	C	22	A	25	K	30
J	27	D	20	C	25	S	29
N	27	F	20	E	25	J	27
A	25	Y	20	Q	24	L	27
DD	25	S	19	R	24	A	25
E	25	M	18	D	23	M	23
K	25	J	17	F	23	C	22
R	25	N	17	Y	23	N	22
X	25	O	17	U	21	O	22
O	22	DD	15	V	21	T	22
S	22	K	15	J	20	U	22
G	20	P	15	O	20	DD	20
F	17	Q	15	I	19	G	20
M	17	R	15	Z	19	P	20
P	15	W	15	M	18	Q	20
W	15	T	12	P	18	R	20
T	12	U	12	CC	16	W	20
U	12	V	12	DD	15	V	17
V	12	G	10	K	15	F	15
Z	12	I	10	W	15	I	15
I	10	Z	10	G	13	Z	15
CC	7	CC	7	T	12	CC	7

Table 7. Scoring Results – Averaged

Average Score Sorted	
Risk Area	Score
Risk Area H – Kingsbury & Aldama	33
*** Risk Area L – FM 464 & Kingsbury**	32
Risk Area BB - Baxter & Ireland	31
Risk Area B – Bauer & Ireland	29
Risk Area X – Short Ave.	28
Risk Area D – Hallmark & Walnut	27
Risk Area DD – Goodrich and Guadalupe	27
Risk Area Y – Mesquite St.	27
Risk Area E – Stanley Way	26
Risk Area A – Guadalupe & Humphrey	25
***Risk Area S - Friesenhahn Rd.**	25
Risk Area C - Heideke & Mountain	24
***Risk Area N - Villa Vista & Highway 46**	23
Risk Area J - Burges St.	23
***Risk Area Q - Woodstone & Rudeloff**	22
Risk Area K – Nelda & Fair	21
Risk Area R – Westgate St.	21
***Risk Area O – Burr Oak**	20
Risk Area M – FM 725 & River Oaks	19
Risk Area F – Hexcel Property	19
***Risk Area P – Twin Oak & Red Oak**	17
***Risk Area U – Middletown Rd.**	17
***Risk Area W – Montwood Rd.**	16
Risk Area G – New Braunfels St.	16
***Risk Area V – Old Town Rd.**	16
Risk Area T – Cedar St.	15
Risk Area Z – Vincent Patlan Elementary School	14
Risk Area I – 8th St.	14
***Risk Area CC – Matthies Drive**	12

Each risk area was inspected after ranking to verify results and determine if the ranking seemed reasonable relative to flood impacts within the other risk areas. Some risk areas are marked with a * to indicate that a single access neighborhood is present. While some of these * risk areas ranked low in the overall risk area ranking due to little structural inundation or less extensive roadway inundation, these areas may still be of interest to the city for potential projects as access may be completely cut off during certain storm events.

5.12 Risk Area Overview

Each risk area was analyzed using 25-Year rapid assessment modeling results and City provided GIS data. The following section summarizes each risk area and provides a general visual overview of the area as a figure.

Risk Area A – Guadalupe and Humphrey

The subdivision N Guadelupe and W Humphrey encounters significant flooding with some structures and roads experiencing flooding up to 2.0 feet in depth. 100-Year flood depths inundate 11 structures and N Guadalupe St and W Humphreys St show significant flooding. An existing storm drain system is shown along both Guadalupe and Humphreys with modeling results likely worse than real-life conditions in this area. Potential scope of proposed project may include upgrades to both roadway and drainage infrastructure.

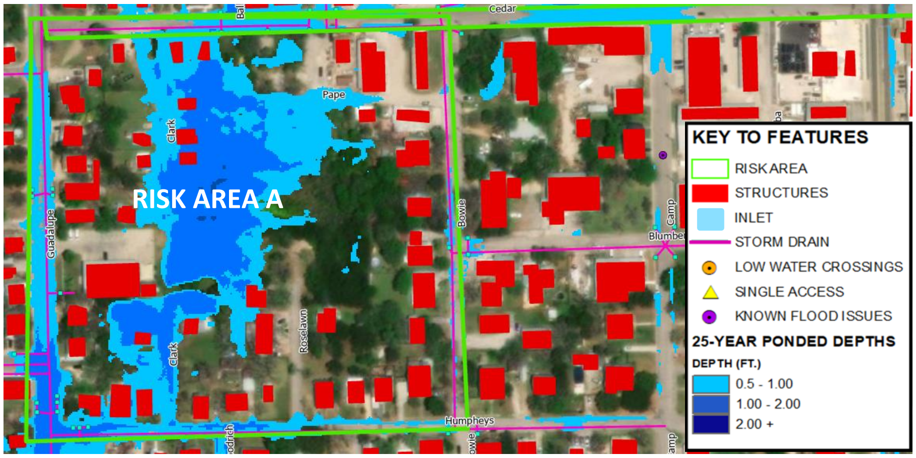


Figure 8. Risk Area A

Risk Area B – Bauer and Ireland

Extensive flooding along N Brauer St., E Ireland St., and E Walnut St. A total of 26 structures are inundated during the 100-Year event for this risk area. A storm drain network is present along E Ireland and Bauer and likely drains excess flooding at the Bauer and Ireland intersection. Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated. Potential scope of proposed project may include upgrades to both roadway and drainage infrastructure.

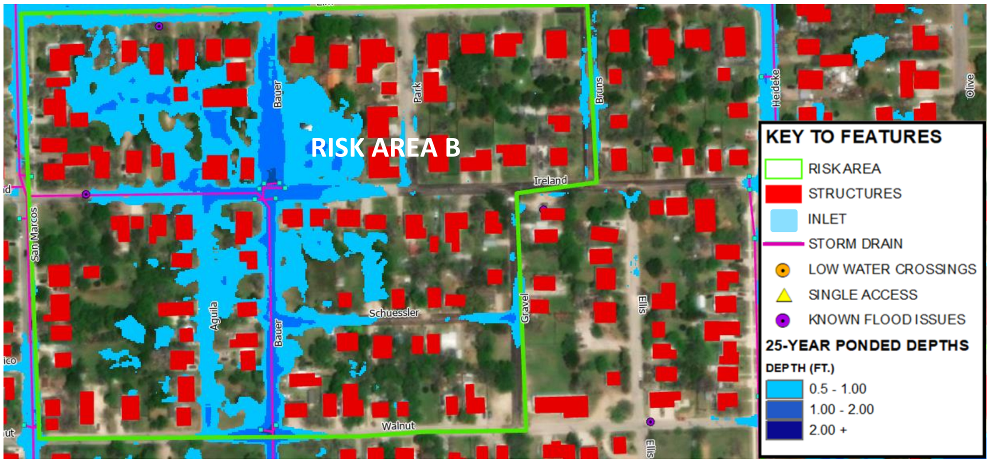


Figure 9. Risk Area B

Risk Area BB – Heideke

Severe flooding greater than 2.0 ft along E Baxter St. Flooding up to 2.0 ft along N Heideke St. 10 structures inundated within risk area. This risk area is part of a larger GLO drainage project (North Heideke Street Drainage Improvement Project) and does not account for storm sewer improvements. Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated.

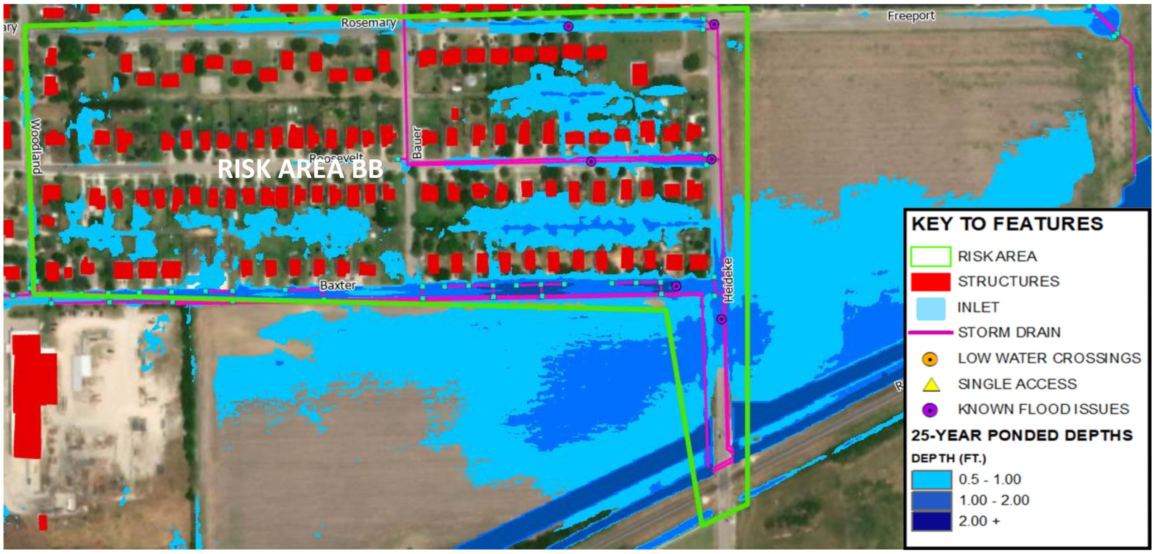


Figure 10. Risk Area BB

Risk Area C – Heideke and Mountain

Severe flooding of over 2.0 ft at intersection of E Mountain, N Heideke, and Olive St. 5 structures inundated during the 100-Year. Storm sewer system is present a the downstream end of the risk area that likely relieves flood waters built up along E Mountain St. Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated. Potential scope of proposed project may include upgrades to both roadway and drainage infrastructure.

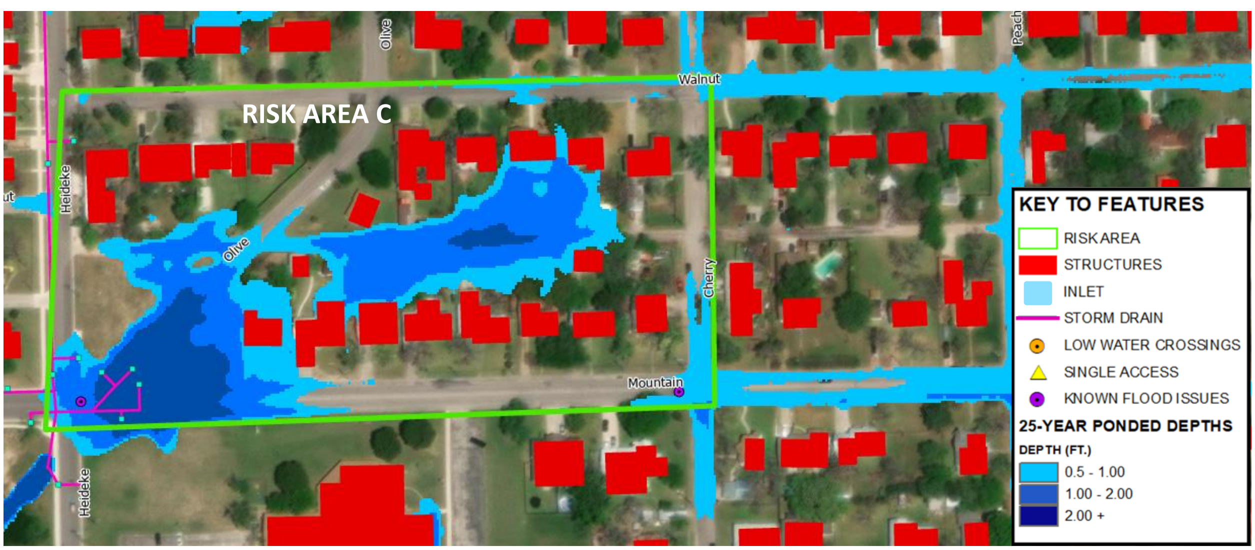


Figure 11. Risk Area C

Risk Area CC – C.H. Matthies Drive

Ponding within fields outside of Stone Ranch Townhomes with depths up to 2.0 ft of water for the 25-Year event. Subdivision is single access. No structural inundation for the 25-Year or 100-Year event but current flood conditions makes surrounding area undesirable for further development.

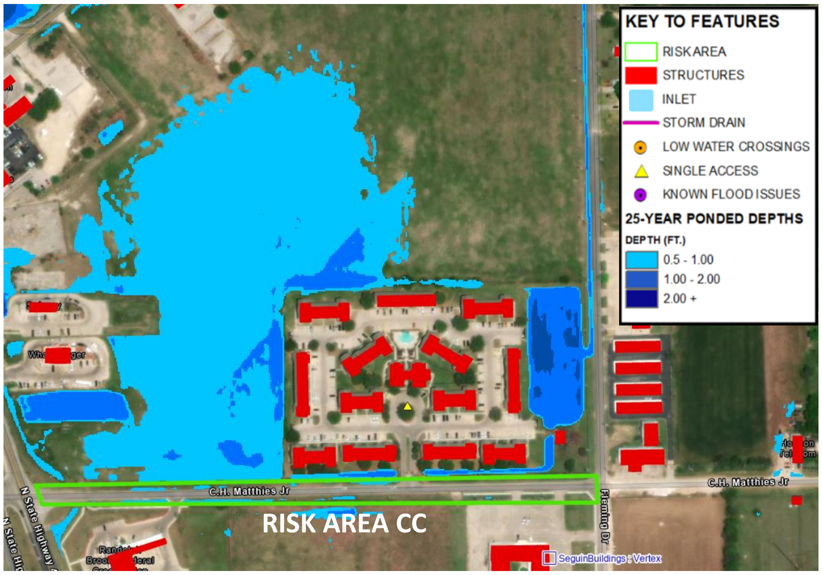


Figure 12. Risk Area CC

Risk Area D – Hallmark Rd. and E Walnut St.

Large area of ponding along privately owned ROW Hallmark Rd. and Leonard Ln. Storm drain system upstream of College St. is all directed into this area and is unable to drain properly to the storm drain system underneath Guadalupe Regional Medical Center.

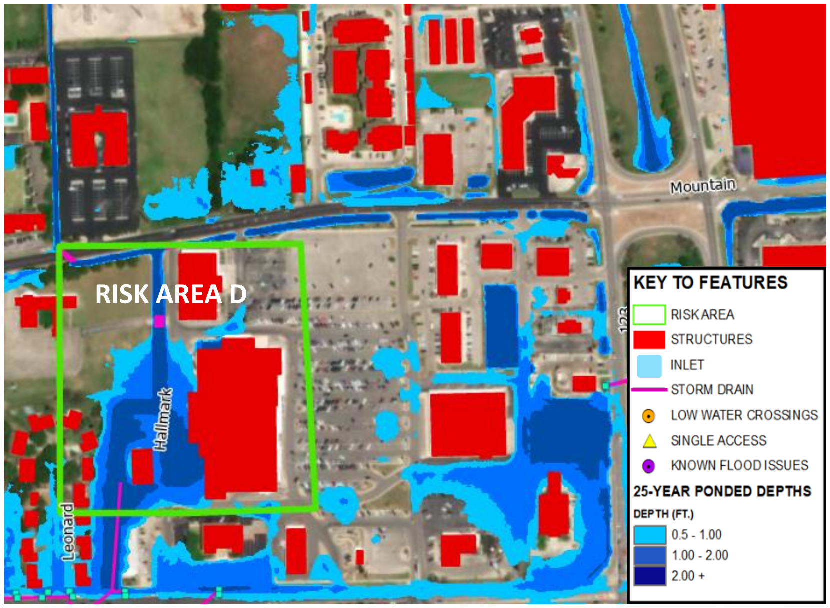


Figure 13. Risk Area D

Risk Area DD – Goodrich and Guadalupe

Road inundation up to 2 ft along Jefferson Ave, Live Oak St, and Goodrich St for the 25-Year storm event. Slight inundation of structures for the 25-Year and 100-Year storm event. Risk area likely to benefit from an existing conditions analysis for existing storm drain.

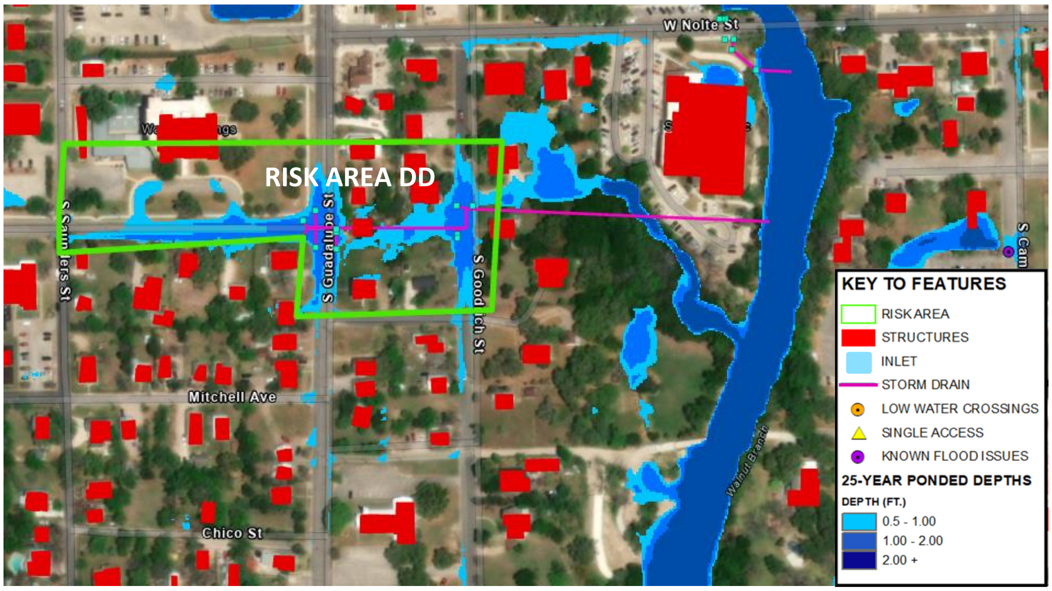


Figure 14. Risk Area DD

Risk Area E – Stanley Way

Road inundation at Sycamore and Vetter St. Some structural damage among houses along Sycamore St. and within the new development at the southern edge of the risk area. Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated. Potential scope of proposed project may include upgrades to both roadway and drainage infrastructure.

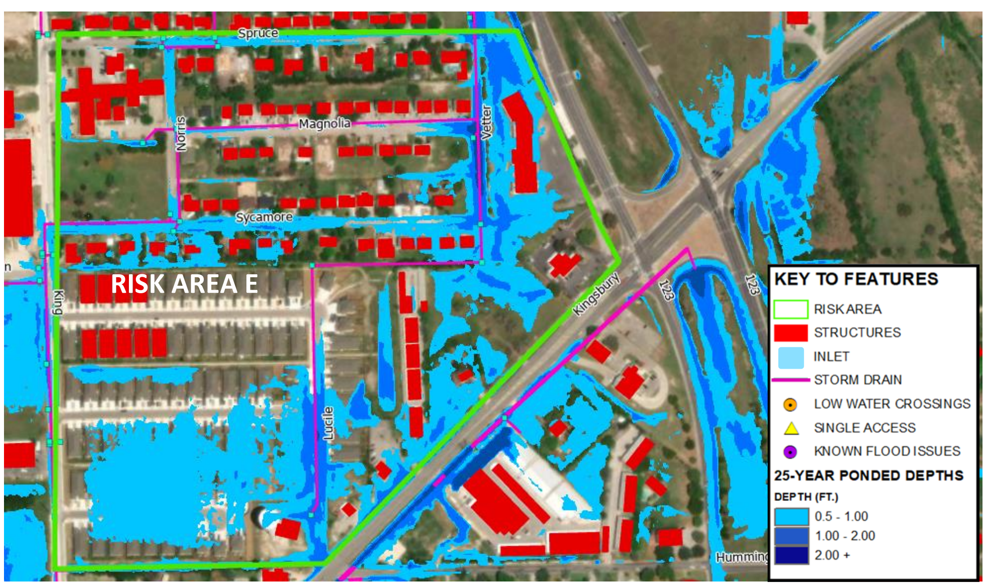


Figure 15. Risk Area E

Risk Area F – Hexcel Property

Some ponding along property parking areas. An undersized stormwater system along Highway 123 is present. There is considerable ponding along Highway 123 at the southeast section of the risk area.

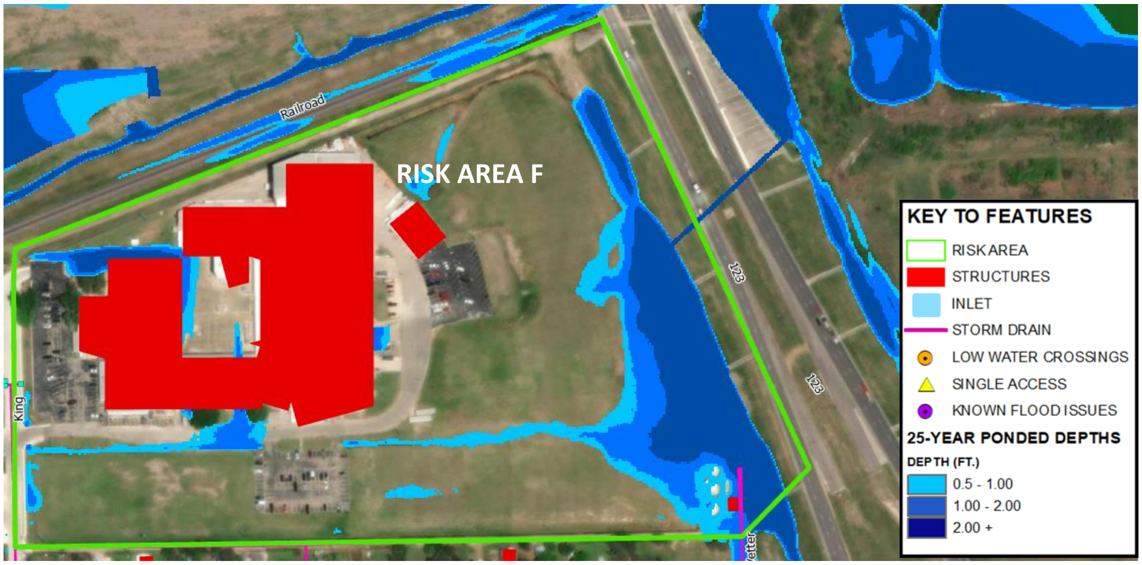


Figure 16. Risk Area F

Risk Area G - New Braunfels St.

Considerable ponding along railroad. N Guadalupe St. experiences up to 1.0 ft of flooding at the railroad crossing. Some structural inundation to industrial buildings. A GLO drainage and roadway project south of the railroad along W New Braunfels St. and Guadalupe St. was designed and constructed in 2024 and incorporates an improved storm drain and inlet system. This new system drains from west to east into another storm drain network under Collins Ave. and eventually outfalls south into Walnut Branch Creek near the intersection of 8th St. and San Antonio Ave.

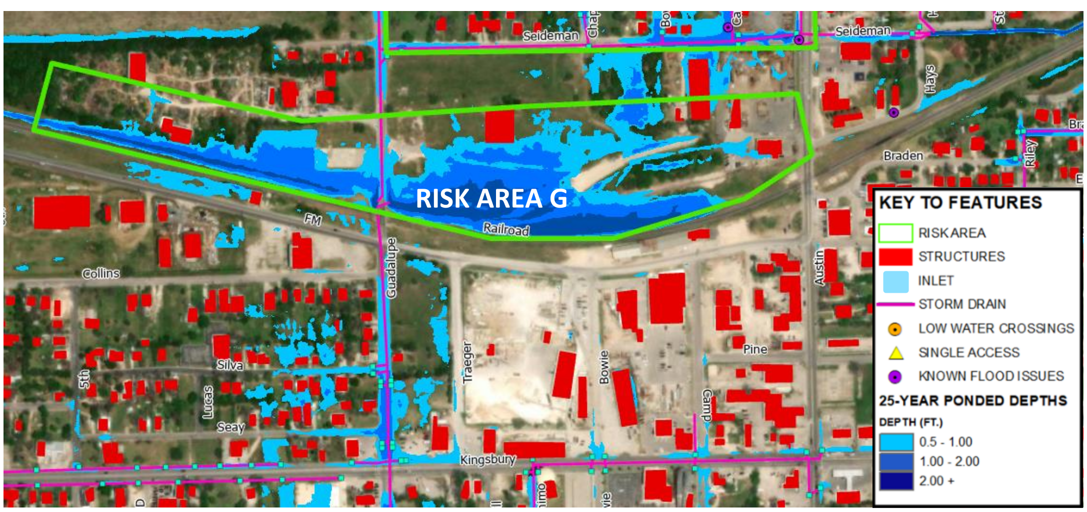


Figure 17. Risk Area G

Risk Area H – Kingsbury at Walnut Branch

Areas both north and south along Walnut Branch experience large flood depths over 2.0 ft. Much of the development North of Kingsbury is inundated with both structures and roadways experience 1 – 2 ft of inundation. The crossing at San Antonio Ave. includes recent roadway and culvert improvements but still shows flood inundation for the 25-Year and 100-Year flood events. There is extensive structural flooding just north of San Antonio Ave. reaching 1 – 2 ft in depth.

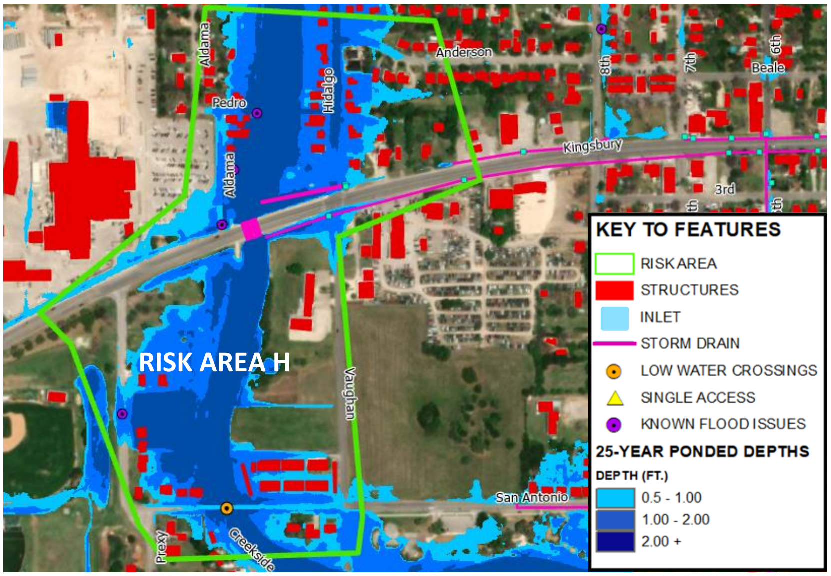


Figure 18. Risk Area H

Risk Area I – 8th street.

8th Street experiences flooding up to 2.0 ft at the very southern end of the street. A road improvement project overseen by Pape Dawson was completed in 2023 and is not represented within the rapid assessment model results shown.

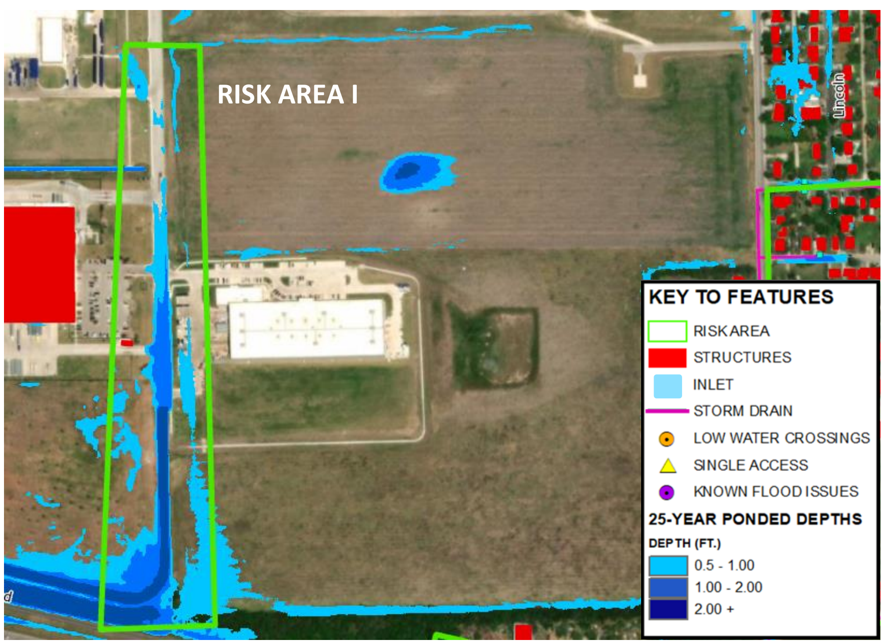


Figure 19. Risk Area I

Risk Area J – Burges Street

Minor impacts to structures but all roads experience high flood depths. Stormwater conveyance largely conducted by road drainage and directed to an existing 40" reinforced concrete pipe (RCP) system that drains south to the Guadalupe River.

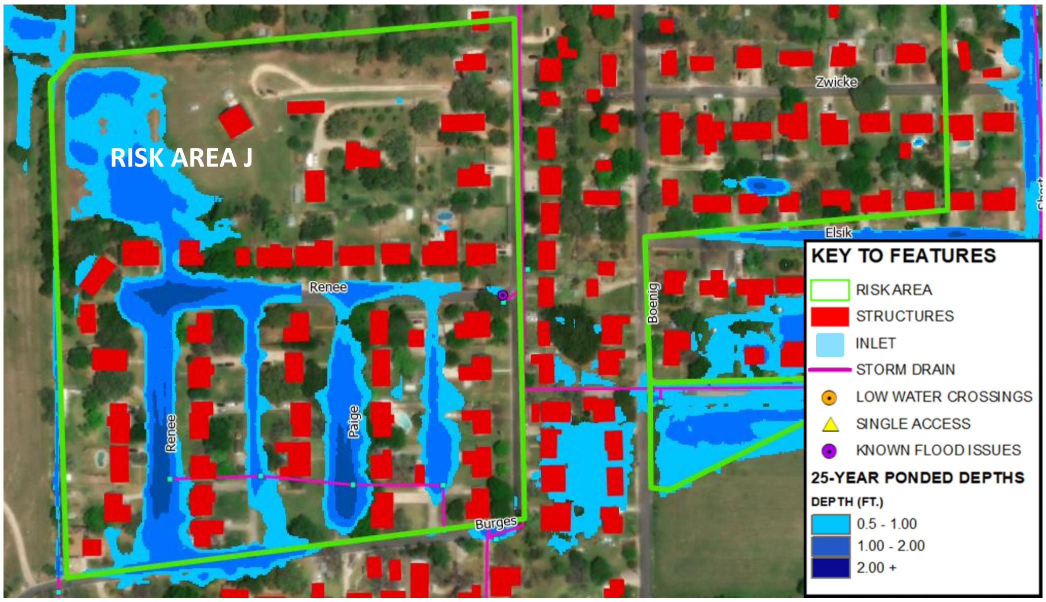


Figure 20. Risk Area J

Risk Area K – Nelda and Fair

Extensive street flooding along Nelda St. and Fair St. Flood depths increase going east and depths above 2.0 ft are experienced at the intersection of S Saunders St. and Fair St. Storm drain appears undersized with the majority of incoming RCP's at 18" and the trunkline RCP along Fair St. at 48". Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated. This risk area may benefit from a preliminary engineering report (PER) and help determine project limits in conjunction with Risk Area X.

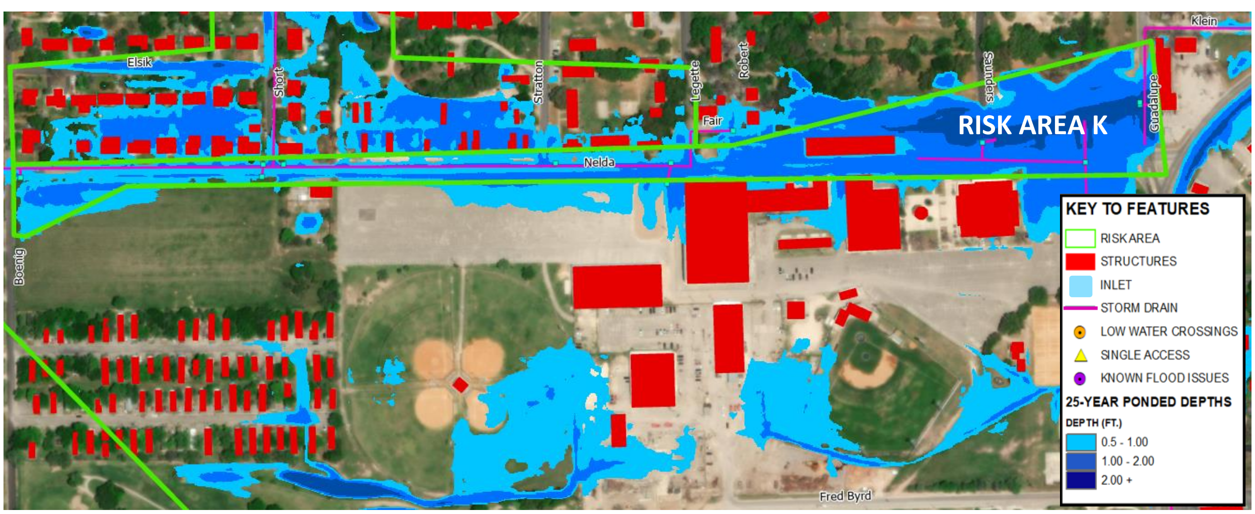


Figure 21. Risk Area K

Risk Area L – FM 464 and Kingsbury

Minor flooding of mobile homes north of FM 464. Mobile home lot is single access but does not have any inundation which prevents vehicle passage for the 25-Year. Vehicle passage during the 100-Year event will be unsafe as depths exceed 1.0 ft at the entrance/exit of the lots. FM 464 experiences large inundation depths near the intersection with Kingsbury.

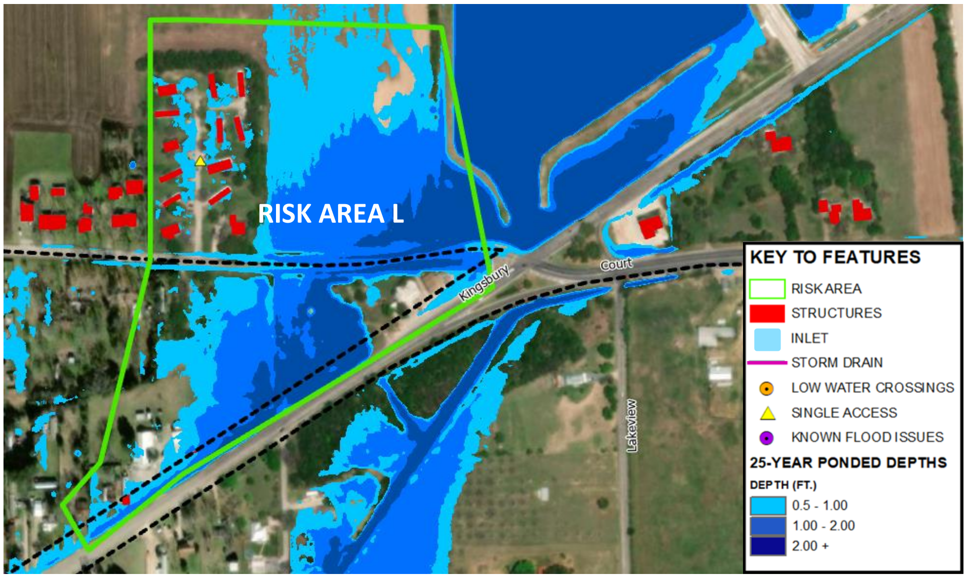


Figure 22. Risk Area L

Risk Area M – FM 725 and River Oaks at Mays Creek

Existing low water crossing at River Oak Dr. experiences flood depths above 2.0 ft. A GLO project for Mays Creek for channel grading and culvert improvements is ongoing and will realign the roadway.

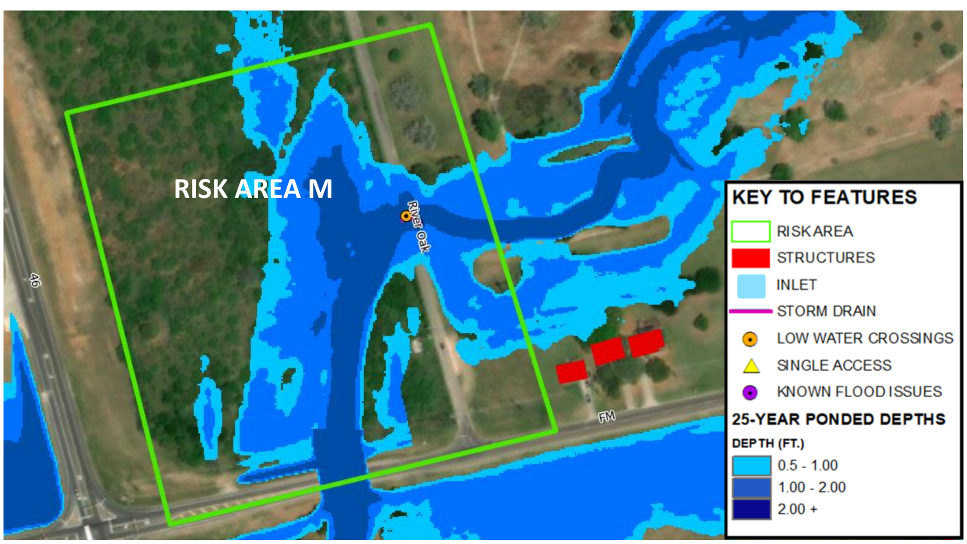


Figure 23. Risk Area M

Risk Area N – Villa Vista and Highway 46

Single access mobile home neighborhood. Minor structural impacts for the 25-Year and 100-Year events. Neighborhood is single access with entrance/exit impassible for all storm events. Roads within mobile home neighborhood are private.

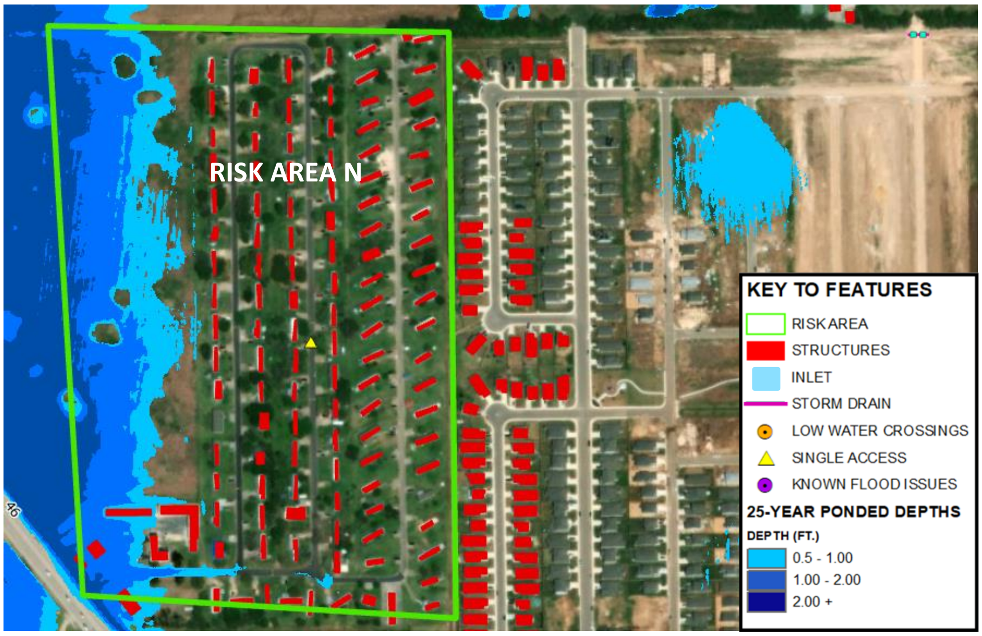


Figure 24. Risk Area N

Risk Area O – Burr Oak

Single access entry at Burr Oak. Intersection at Burr Oak and E. Martindale becomes inundated with up to 1.0 ft of water during the 100-Year flood event.

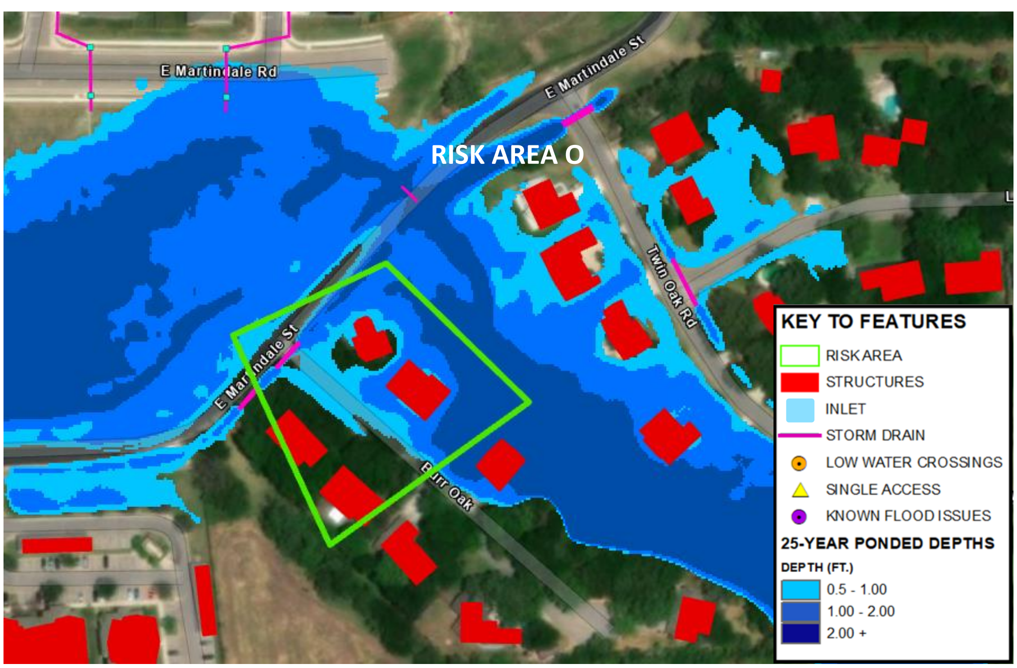


Figure 25. Risk Area O

Risk Area P – Twin Oak and Red Oak

Low water crossing with a single access neighborhood located east. Crossing experiences depths up to 1.0 ft for the 2-Year event.

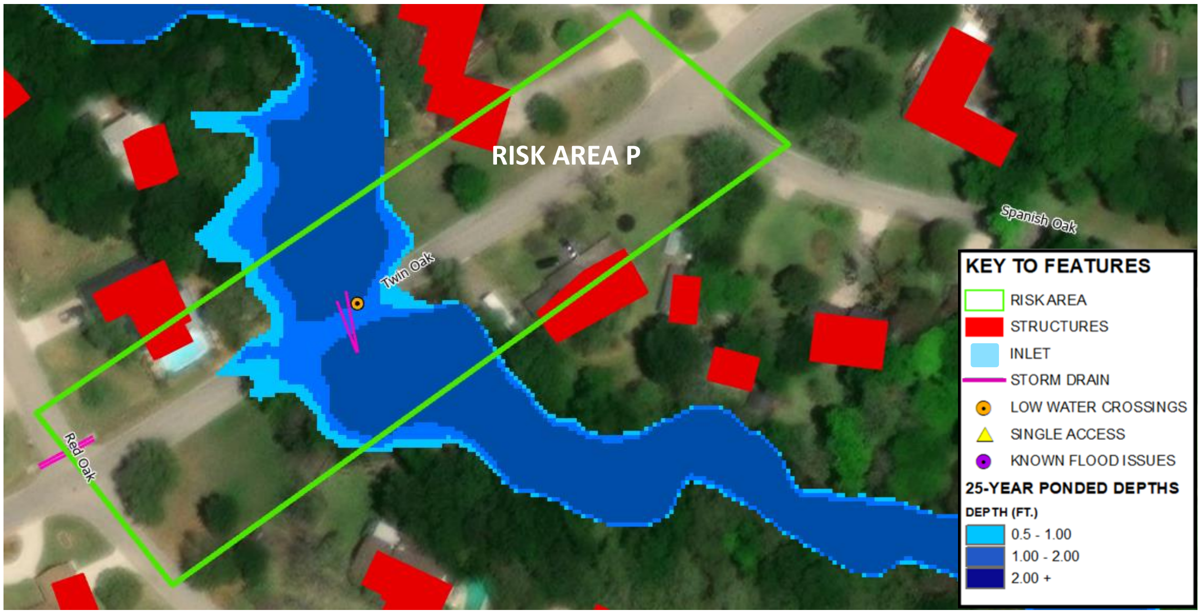


Figure 26. Risk Area P

Risk Area Q – Woodstone and Rudeloff

Low water crossing at single access neighborhood. Road becomes inundated with up to 2.0 ft of water during the 2-Year event. City has classified this risk area as low priority.

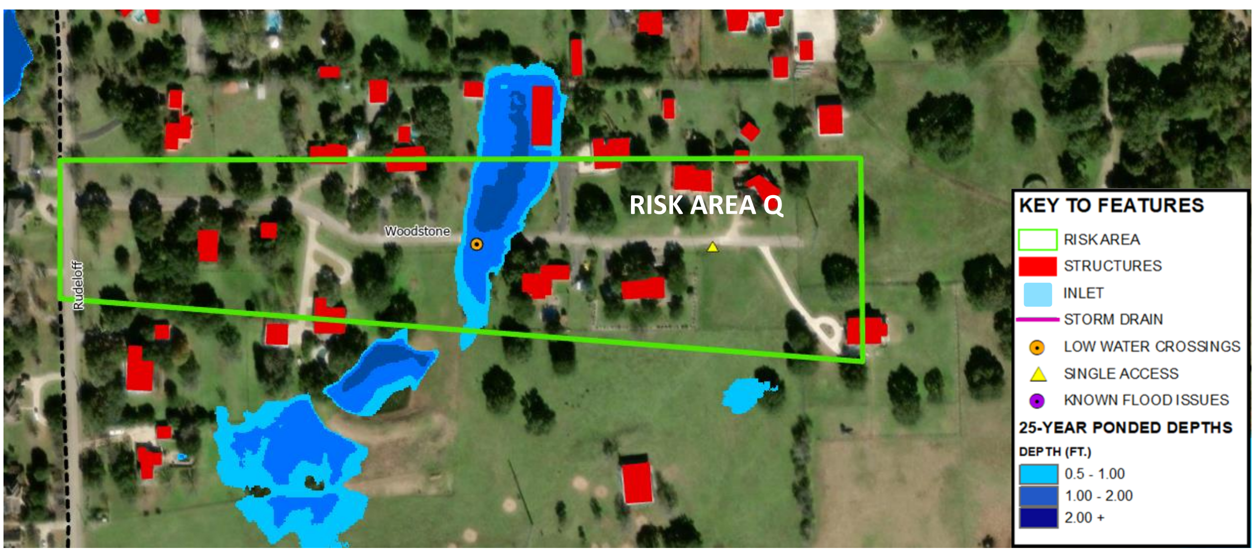


Figure 27. Risk Area Q

Risk Area R – Westgate

High flood depths along Westgate St. Depths for the 2-Yeare event exceed 1.0 ft. City has assessed this neighborhood resides on a septic system. Mitigation assessments may include additional expense to determine and avoid the spray field and systems.

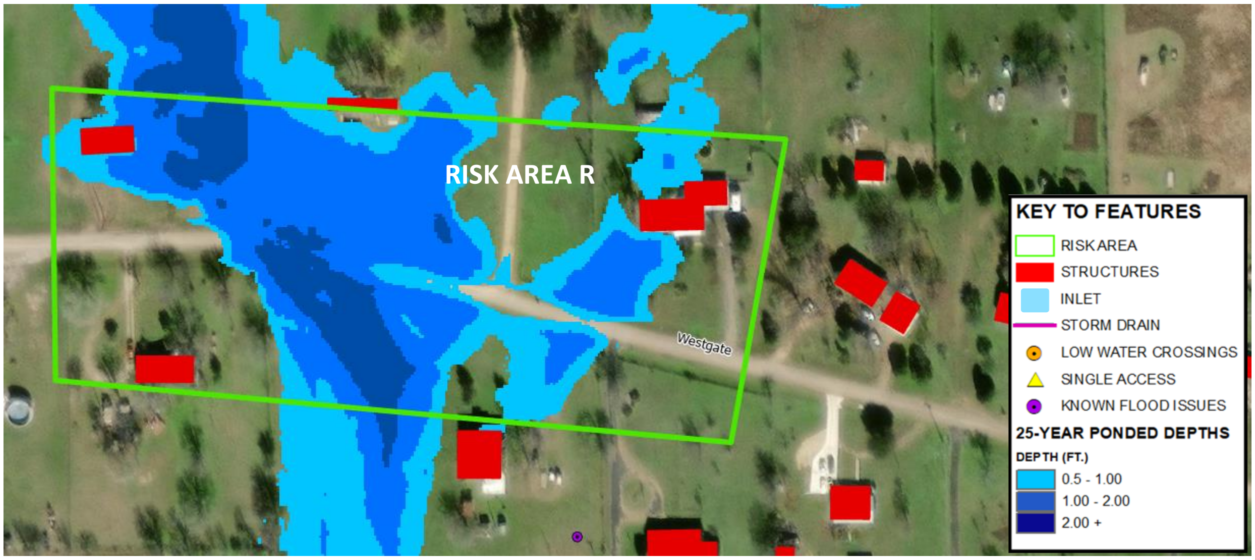


Figure 28. Risk Area R

Risk Area S – Friesenhahn Road

Western portion of Friesenhahn Rd. near High Point Dr. and Huckleberry Ln. experiences severe flooding with depths up to 2.0 ft. A single access neighborhood with approximately 5 residences is present within the more flood prone area of this risk area. This risk area may benefit from a roadway project.

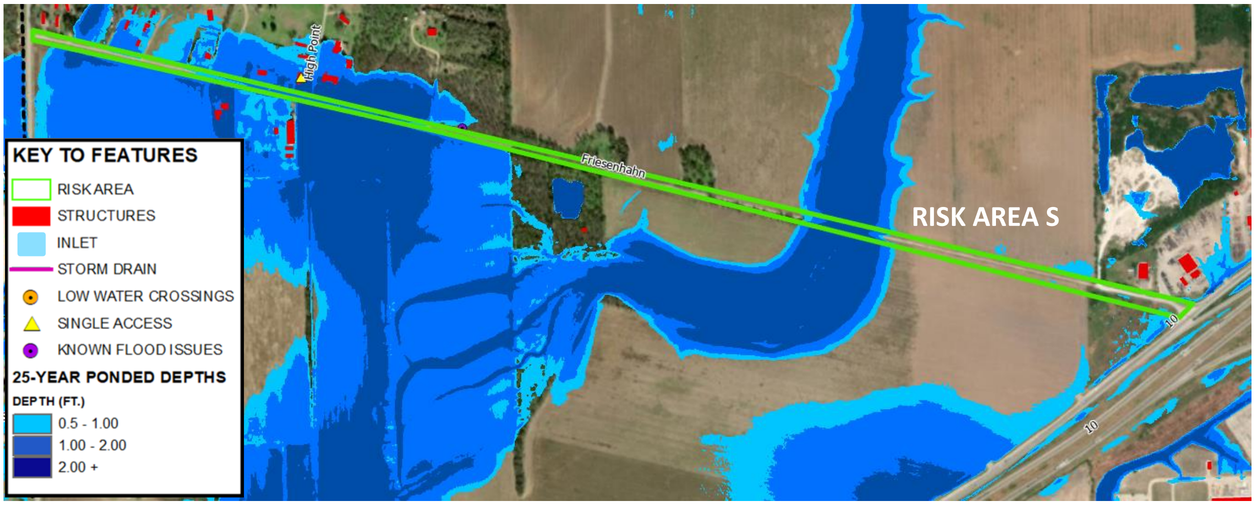


Figure 29. Risk Area S

Risk Area T – Cedar Street

Risk Area is focused on all of Cedar St. from N Guadalupe St. to Cardinal Ln. Road inundation occurs at various spots along Cedar and at several intersections. Flooding is more severe at Cedar and Bruns and Cedar and Seguin High School. Storm drain is present in most areas of flooding and is not currently reflected in modeling results. This risk area may benefit from a PER to help determine scope of project and project limits.

Figure 30. Risk Area T

Risk Area U – Middletowne Road

Road flooding along Middletown Rd. between 1.0 – 2.0 ft. Neighborhood is single access and may benefit from roadway improvements.

Figure 31. Risk Area U

Risk Area V – Oldtowne Road

Road flooding along Middletown Rd. between 1.0 – 2.0 ft. Neighborhood is single access.

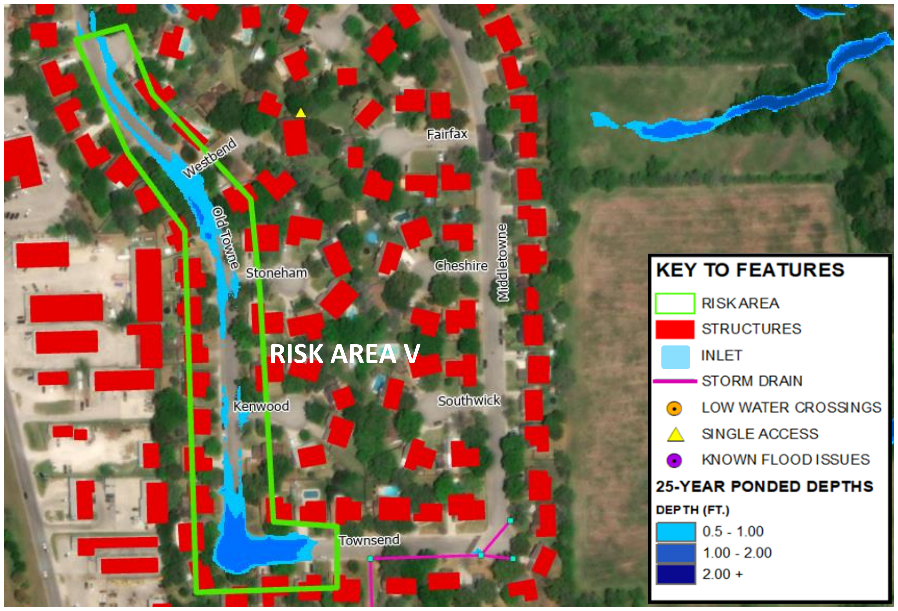


Figure 32. Risk Area V

Risk Area W – Montwood Road

Low water crossing area that becomes inundated with 0.5 – 1.0 ft of water during the 2-Year event. Neighborhood is single access.

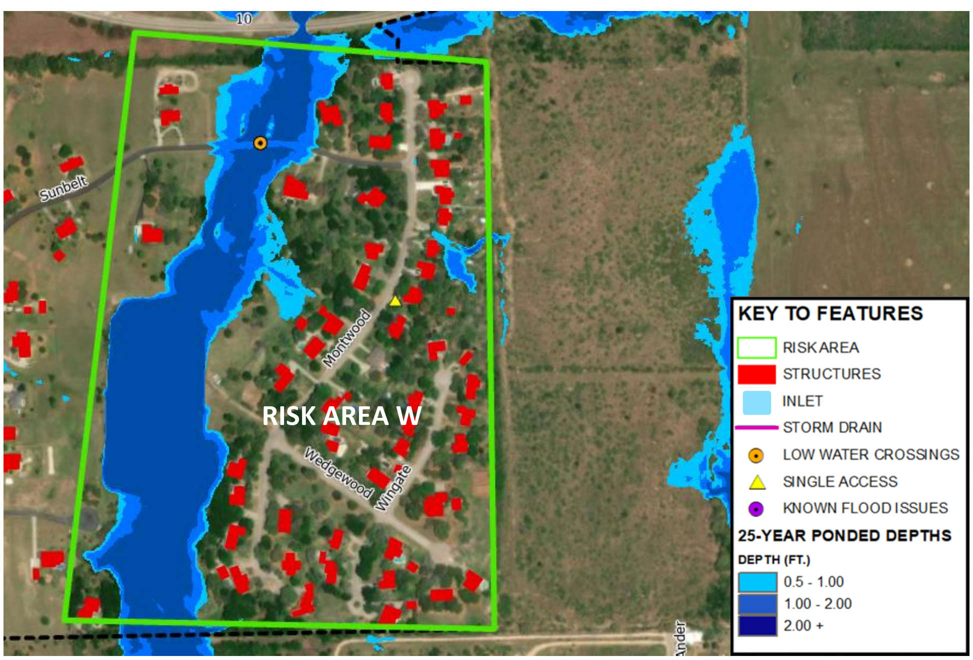


Figure 33. Risk Area W

Risk Area X – Short Avenue

Extensive structural flooding with some homes receiving up to 2.0 feet of water. Short Ave and Elsik St. inundated up to 2.0 ft. Storm drain is present on Short St. that directs stormwater to a storm drain system along Nelda St. Additional flooding is present outside of the road ROW and current capacity of the existing storm drain system along the roadways should be evaluated. This risk area may benefit from a PER and help determine project limits in conjunction with Risk Area K.

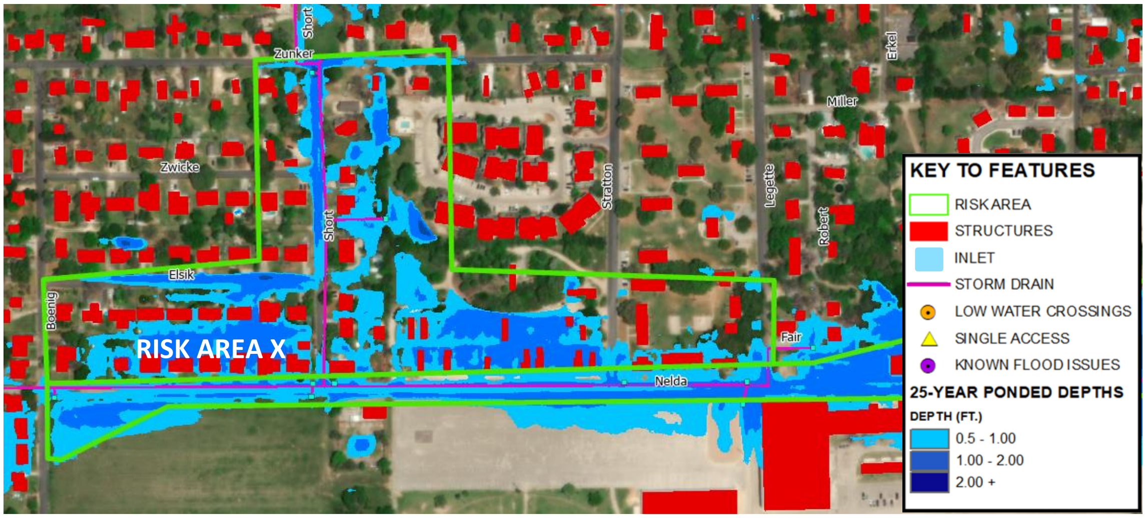


Figure 34. Risk Area X

Risk Area Y – Mesquite and Chapman

Extensive flooding along Chapman St. Some structural damage for several homes with flooding between 0.5 – 1.0 ft. Storm drain present on all sides of the development. Some stormwater conveyed south through Chapman Rd. to an existing storm drain system along Seideman St. Several flood complaints within the risk area with the majority at the intersection of N Camp St. and Mesquite St. Scope of proposed project for this risk area could include both roadway and drainage infrastructure improvements.

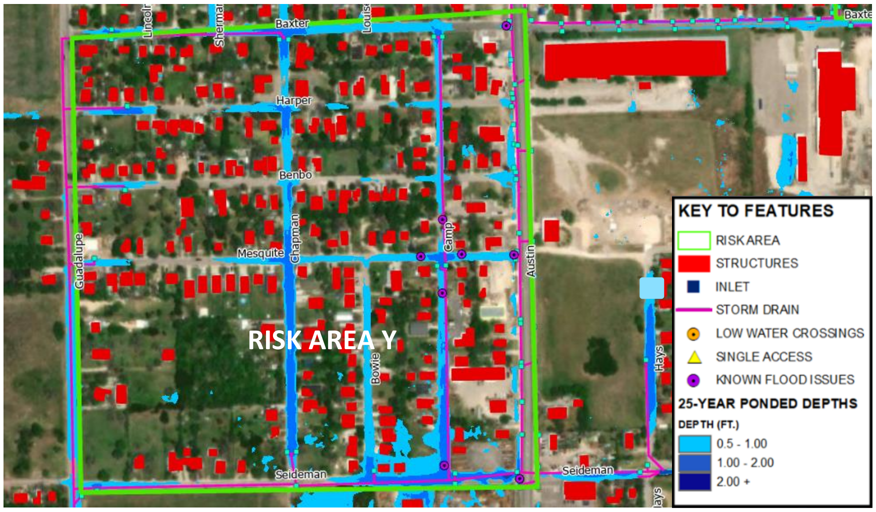


Figure 35. Risk Area Y

Risk Area Z – Vincent Patlan Elementary School

No structural inundation shown within risk area. High flood depths along Breustedt St. cut off access to and from the school. No storm drain present within risk area. Roads likely only form of conveyance for flood waters. Scope of proposed project for this risk area could include extension of Breustedt St. or a newly constructed roadway connection.

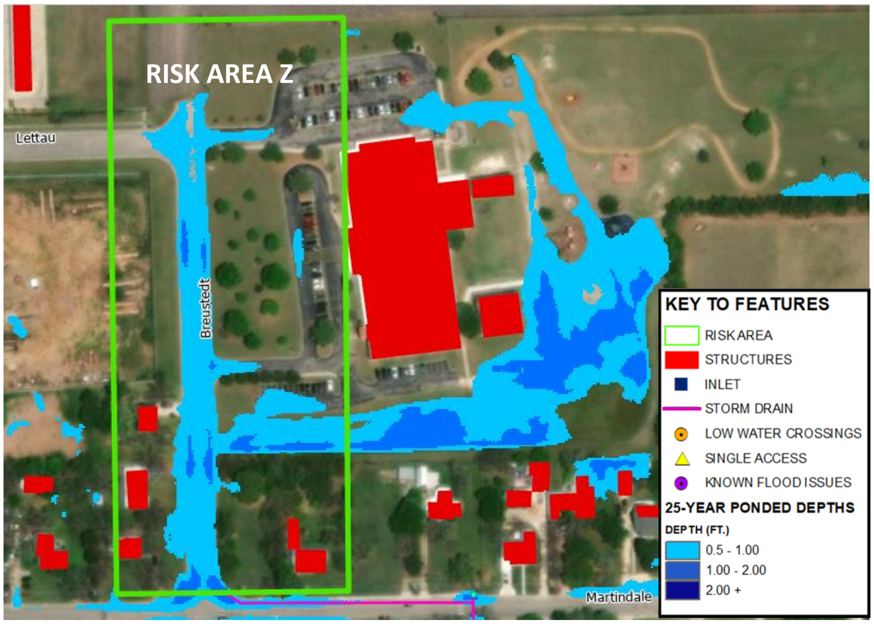


Figure 36. Risk Area Z

5.13 Drainage Capacity Assessment

In addition to the 29 risk areas discussed in Section 2.4, other isolated risk areas were identified for drainage channels. Analysis included assessing channel capacities, presence of new channels through aerial imagery, and accuracy of City GIS data in regard to presence of existing channels and their alignments. Channels assessed are defined in **Table 8** and shown in **Exhibit - Ditches** under **Appendix B**.

Table 8. Drainage Channel Summary

IDENTIFIED CHANNEL	DESCRIPTION
CH01	Channel not matching city channel inventory.
CH02	25yr spillout from open channel.
CH03	25yr spillout from open channel.
CH04	25yr spillout from open channel.
CH05	25yr spillout from open channel.
CH06	25yr WSEL over top of stormwater outlet.
CH07	25yr WSEL over top of stormwater outlet.
CH08	25yr WSEL over top of stormwater outlet.
CH09	Not found in city channel inventory.
CH10	Not found in city channel inventory.
CH11	Not found in city channel inventory.
CH12	Not found in city channel inventory.
CH13	Not found in city channel inventory.

Table 8. Drainage Channel Summary (Continued)

IDENTIFIED CHANNEL	DESCRIPTION
CH14	Not found in city channel inventory.
CH15	Not found in city channel inventory.
CH16	Not found in city channel inventory.
CH17	Not found in city channel inventory. 25-Year at risk of spillover.
CH18	Not found in city channel inventory. 25-Year at risk of spillover.
CH19	Not found in city channel inventory. 25-Year at risk of spillover.
CH20	Channel not matching city channel inventory.
CH21	Open Channel in City GIS data, leading nowhere
CH22	Channel not reflected in current terrain.
CH23	Channel not reflected in current terrain.
CH24	Channel not reflected in current terrain.
CH25	Channel not reflected in current terrain.
CH26	Channel not reflected in current terrain.
CH27	Channel not reflected in current terrain.
CH28	Channel not reflected in current terrain.
CH29	Channel not reflected in current terrain.
CH30	Channel not present in city channel inventory.
CH31	Channel not present in city channel inventory.

6.0 Repetitive Losses

Halff was tasked with assessing repetitive loss structure data provided by the City to determine whether losses were a result of riverine flooding or through localized sheet flow flooding. A majority of the repetitive loss points are located along the Guadalupe River and are a direct result of riverine flooding. Several repetitive loss datapoints did fall outside of the Guadalupe River floodplain and were more closely inspected. Several of these points did not have documented location data corresponding to the actual location of the shapefile point. Several others showed no structure present. An overview of the repetitive loss data and the outlier points not along the Guadalupe River or not a result of riverine flow are shown in **Exhibit 11** below.

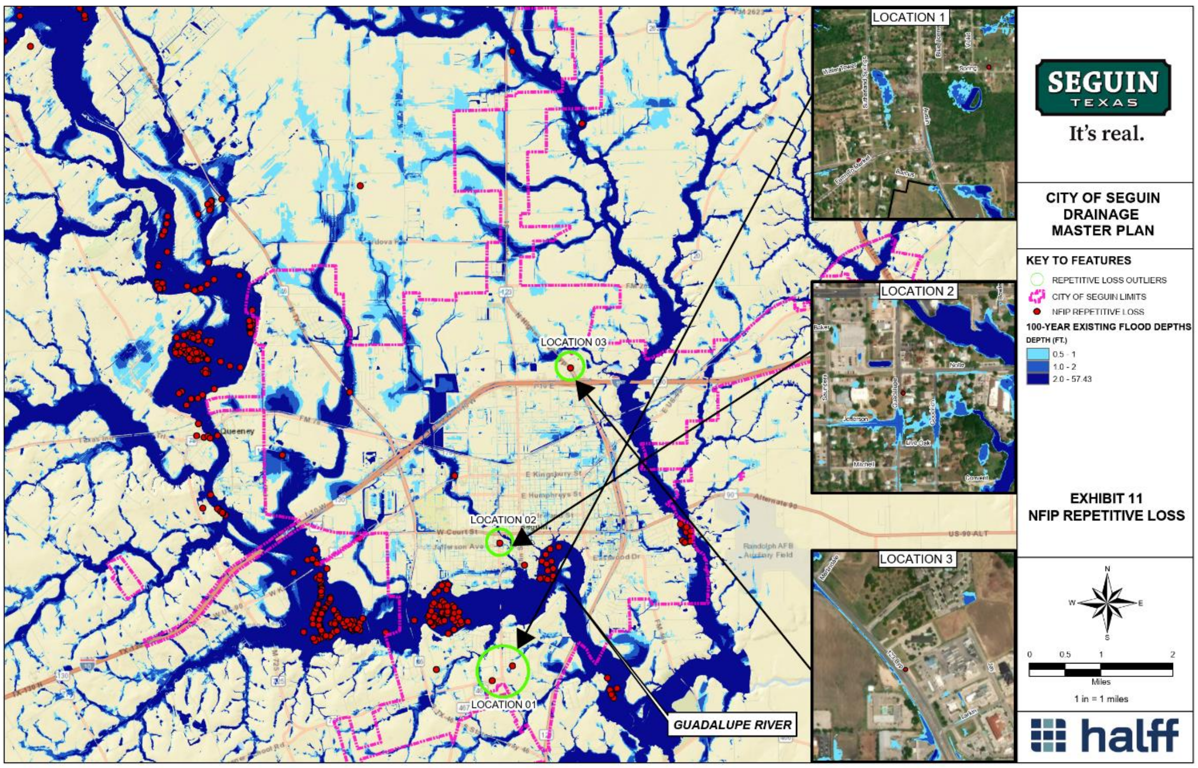


Exhibit 11. NFIP Repetitive Losses

7.0 FEMA Floodplain Comparisons

FEMA floodplains were compared to rapid assessment modeling results. While in some areas modeling results match closely with the 100-Year FEMA floodplain other areas shown discernable differences. Floodplain differences can be attributed to several factors, including Atlas-14 rainfall not being utilized at the time of the FEMA study or modeling methodology differences. Floodplain comparisons are provided in **Exhibit – Floodplain Comparisons** in **Appendix B**.

8.0 Selected Risk Areas

After discussion with the City over identified risk areas, a total of 16 areas were selected for potential project development. While risk area rankings highlighted in **Table 7** of Section 2.11 presented a scored list outlining which projects may be of more interest to the City, multiple risk areas that ranked lower on the list were selected for project development. **Table 9** below outlines both risk areas selected for project development and risk areas excluded.

Table 9. Final Risk Areas

Risk Area	Location	Selected for Project Development
A	N Guadalupe & Humphrey	NOT SELECTED
B	Bauer & Ireland	SELECTED
BB	Baxter and Hiedeke	NOT SELECTED
C	Heideke & Mountain	SELECTED
CC	Matthies Drive	NOT SELECTED
D	Hallmark Rd and E Walnut	SELECTED
DD	Goodrich and Guadalupe	SELECTED
E	Stanley Way	NOT SELECTED
F	Hexel Property & Highway 123	NOT SELECTED
G	New Braunfels St.	NOT SELECTED
H	Kingsbury at Walnut Branch and Aldama at Kingsbury.	SELECTED
I	8th Street	NOT SELECTED
J	Burges St.	SELECTED
K	Nelda and Fair	SELECTED
L	FM 464 & Kingsbury	NOT SELECTED
M	River Oak & FM 725	NOT SELECTED
N	Villa Vista & Highway 46	NOT SELECTED
O	Burr Oak	SELECTED
P	Twin Oak and Red Oak	SELECTED
Q	Woodstone	NOT SELECTED
R	Westgate	NOT SELECTED
S	Friesenhahn	SELECTED
T	Cedar St.	SELECTED
U/V	Middletown and Old Towne	SELECTED
W	Montwood	SELECTED
X	Short Ave.	SELECTED
Y	Mesquite St.	SELECTED
Z	Vincent Patlan Elementary School	SELECTED

9.0 Introduction – Existing System Assessment

A capacity evaluation for 8 of the 10 risk areas selected for Halff to analyze was performed for the existing storm drain networks for the City of Seguin (City) for the 5-Year, 25-Year, and 100-Year storm events. The additional 7 risk areas overseen by Pape Dawson are not undergoing an existing storm drain analysis at this time. This analysis was completed using Rational Method calculations to determine local basin discharges and BENTLEY software StormCAD to model storm drain conduit capacities. Survey data developed by SAM Inc. was utilized to determine conduit locations and parameters such as pipe slopes and sizes, pipe invert elevations, and inlet locations. Additionally, a capacity assessment was conducted for one channelized area using BENTLEY software FlowMaster and Rational Method discharges.

10.0 Identification of Risk Areas for Storm Drain Assessment

A total of 8 risk areas out of the 10 selected by Halff were identified for an existing storm drain assessment. The 2 risk areas not included, Risk Area H and Risk Area P, were excluded from this storm drain assessment as flood issues within these areas are not expected to be a result from inadequate storm drain sizes. A summary of risk areas that include a storm drain assessment are listed in **Table 10** below.

Table 10. Risk Area Storm Drain Assessment

Risk Area	Storm Drain Assessment
B	YES
C	YES
D	YES
DD	NO
H	NO
J	YES
K	YES
O	NO
P	NO
S	NO
T	YES
U	NO
V	NO
W	NO
X	YES
Y	NO
Z	YES

Risk Area H and Risk Area P storm drain networks are shown in **Exhibit 12** and **Exhibit 13** respectively. These 2 risk areas encounter flood issues stemming from riverine flooding and will likely benefit from projects not associated with storm drain improvements such as detention, ditches or channels, cross culverts, or roadway improvements.

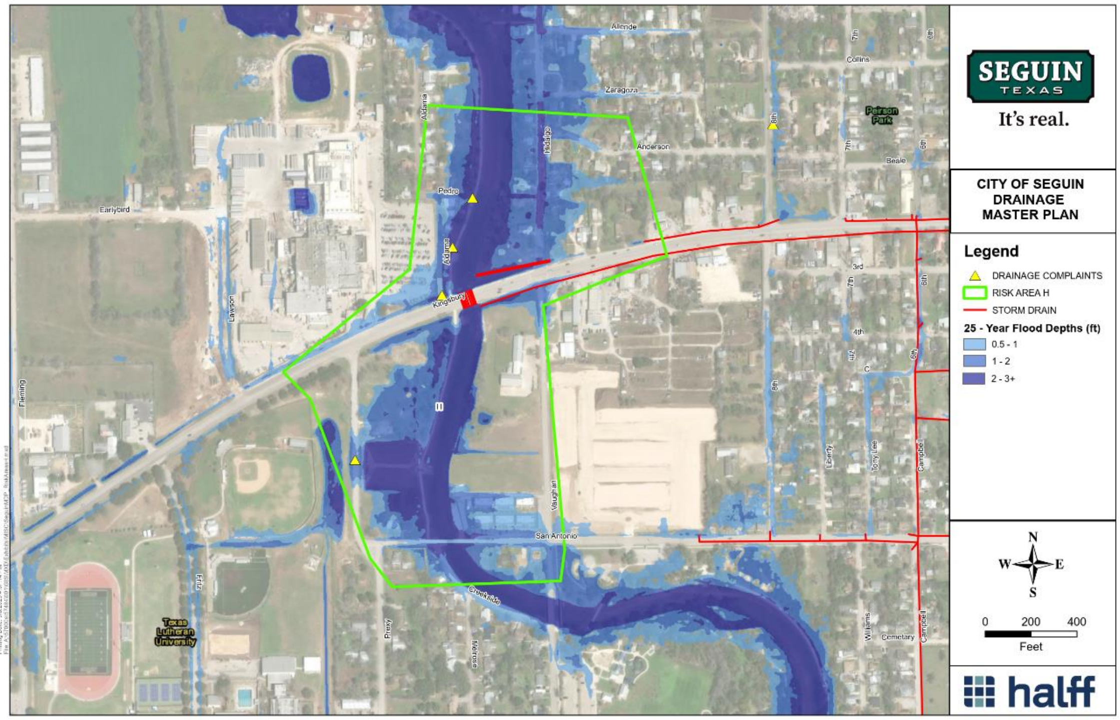


Exhibit 12. Risk Area H Storm Drain

Exhibit 13. Risk Area P Storm Drain

11.0 SAM Inc. Storm Drain Survey Data

The City provided Halff with survey data organized by SAM Inc. to incorporate into this existing storm drain assessment. After careful review, Halff identified areas where data was missing or questionable within the storm drain shapefiles provided. Missing data includes missing pipe inverts or slopes, broken pipe networks that dead end, missing manhole depths and inverts, and missing top of rim elevations for manholes. Halff applied best practices and data retrieved from as-built plansets to fill in these data gaps. A more detailed list of assumptions made to fill in these gaps is provided in Section 5.1 of this report. A revised version of the SAM Inc. data has been created that incorporates some of these assumptions made as well as as-built data provided by the City.

12.0 Rational Method Hydrology

Discharges for subbasins associated with the risk area storm drain networks were calculated using the TR-55 Rational Method. Parameters for rainfall intensities, longest flow paths, and runoff coefficients are in accordance with the Seguin Stormwater Criteria Manual (SSCM). Rational Method discharges for the 5-Year, 25-Year, and 100-Year storm events are summarized in **Table 11**.

Table 11. Rational Method Discharges

Risk Area B Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	2	4	5
Subbasin 02	21	33	48
Subbasin 03	8	13	19
Subbasin 04	72	116	168
Subbasin 05	129	210	310
Risk Area C Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	104	168	244
Subbasin 02	38	62	89
Subbasin 03	39	62	89
Subbasin 04	25	40	57
Subbasin 05	9	14	20
Risk Area D Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	144	234	342
Subbasin 02	156	252	368
Subbasin 03	108	173	249
Subbasin 04	55	87	125

Table 11. Rational Method Discharges (Continued)

Risk Area J/K/X Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	24	38	55
Subbasin 02	14	23	34
Subbasin 03	85	137	200
Subbasin 04	18	29	41
Subbasin 05	169	271	390
Subbasin 06	26	42	61
Subbasin 07	67	109	158
Subbasin 08	20	32	46
Risk Area T Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	6	10	15
Subbasin 02	38	61	89
Subbasin 03	21	33	47
Subbasin 04	15	24	34
Subbasin 05	14	23	33
Subbasin 06	3	5	8
Subbasin 07	3	5	7
Risk Area Z Discharges (cfs)			
Subbasin	5-Year	25-Year	100-Year
Subbasin 01	22	35	51
Subbasin 02	7	12	17
Subbasin 03	144	230	331

12.1 Basin Delineation

Basins for each risk area were delineated at a local watershed level using Geographic Information System software (GIS). The overall city storm drain network was used to assess whether some basins extents should extend further than what would initially be delineated to based on terrain observations. Several risk areas include watershed basins that extend further than what would be anticipated based on natural terrain. Some storm drain networks extend past the natural risk area watershed and collect and drain stormwater further upstream and into the risk area further downstream. In areas where this was apparent, the risk area basins were extended and expanded up to the point where the storm drain system starts. An example of this basin delineation is shown in **Figure 37**.

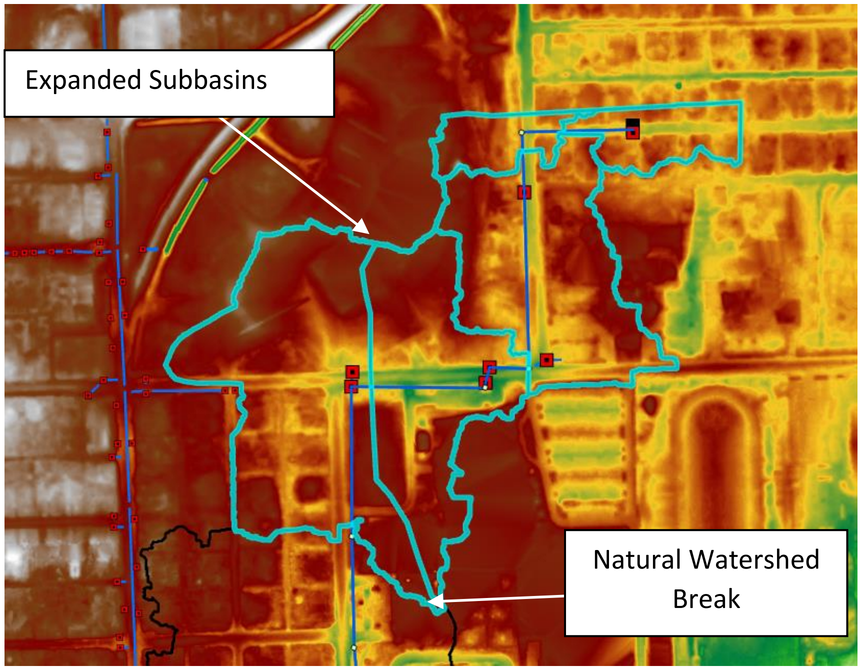


Figure 37. Extended Basin Delineation

12.2 Runoff Coefficients

While Halff is scoped to utilize future landuse data to develop impervious cover and runoff coefficient values, after comparing future landuse data against city zoning data, it was determined that the city zoning data would produce higher impervious values for the risk area subbasins and result in a higher, more conservative runoff coefficient. As a result, city zoning data was used to develop runoff coefficients. *Table 3-7. Maximum Impervious Cover by Land Use Category* from the SWCM was utilized to designate impervious cover per land type. A percent impervious value was developed using the risk area watershed area and the cumulative weighted percent impervious area for each risk area subbasin. The pervious and impervious C-values from the SSCM for each storm event were then weighted based on the calculated percent impervious. **Exhibit 14** below shows city zoning data overlayed with risk area subbasins and the designated impervious classification for each zone type.

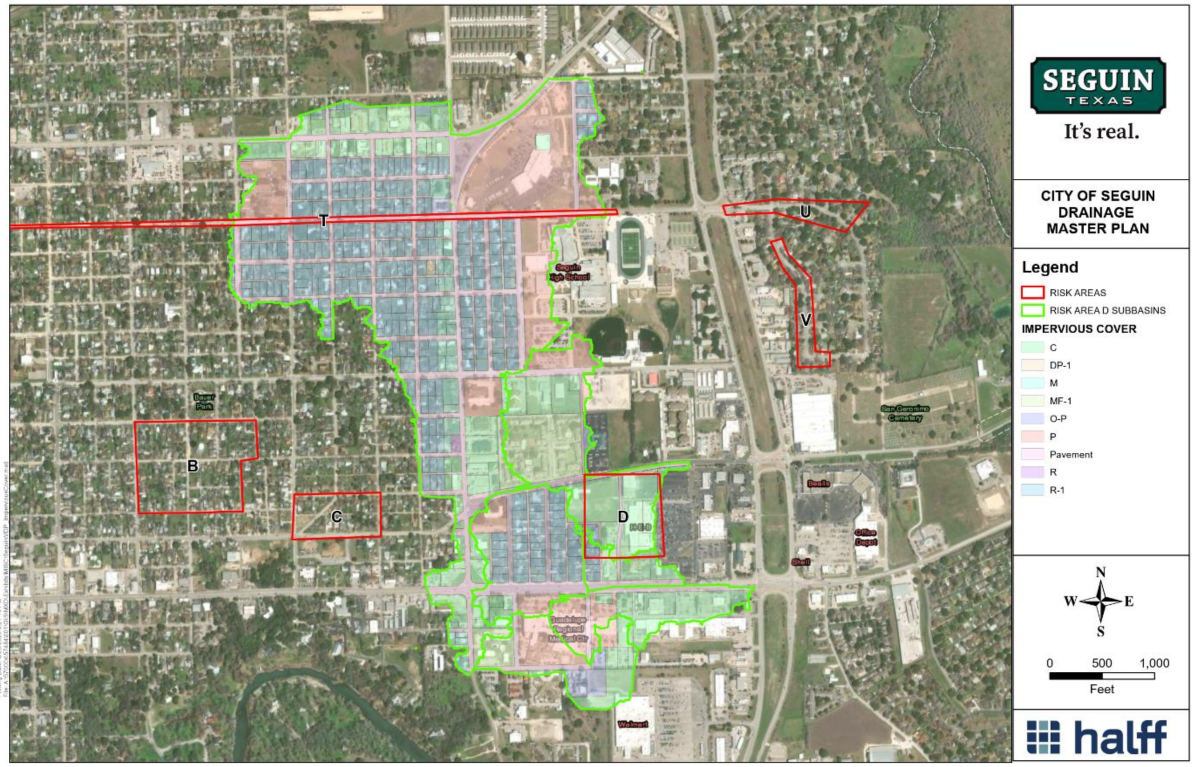


Exhibit 14. Impervious Cover

12.3 Longest Flowpaths

12.3.1 Overland Flow

Longest flow paths were developed for each risk area subbasin and used to calculate time of concentration values. Overland flow was calculated using the first 100 feet of the longest flow path. Manning's n-values for overland flow vary from 0.015 for pavement to 0.41 for Bermuda grass. Overland flows are assumed to have minimums and maximums of 5 and 20 minutes, respectively.

12.3.2 Shallow Concentrated Flow

Shallow concentrated flow made up the majority of flow type for most of the risk area subbasins. Flow generally followed routes through either residential neighborhood properties or roadways. Flow through properties was classified as unpaved while flow through streets was classified as paved.

12.3.3 Channel and Pipe Flow

Only Risk Area D had channel flow incorporated into its time of concentration calculations, with an upstream channel section occurring just west of 1340 E. Walnut St. and a downstream channel section occurring just east of 1351 E. Walnut St. A typical cross section of the channel was taken for each channel section and the existing slope was used to calculate channel velocity and time of concentration.

In some risk areas where shallow concentrated flow occurs through the streets, some flow paths were assumed to enter existing storm drain networks. Shallow concentrated flow was assumed to go to pipe flow when areas of significant sag were encountered. Time of travel for water entering pipes was calculated using FlowMaster. Pipes were assumed full and pipe slope from the storm drain data provided by SAM Inc. was used to calculate velocity.

Pipe length and calculated velocity was then used to calculate total time of flow from beginning of pipe to the outlet point. Longest flow paths and how they were determined and separated into flow types can be seen in **Exhibit 15**.

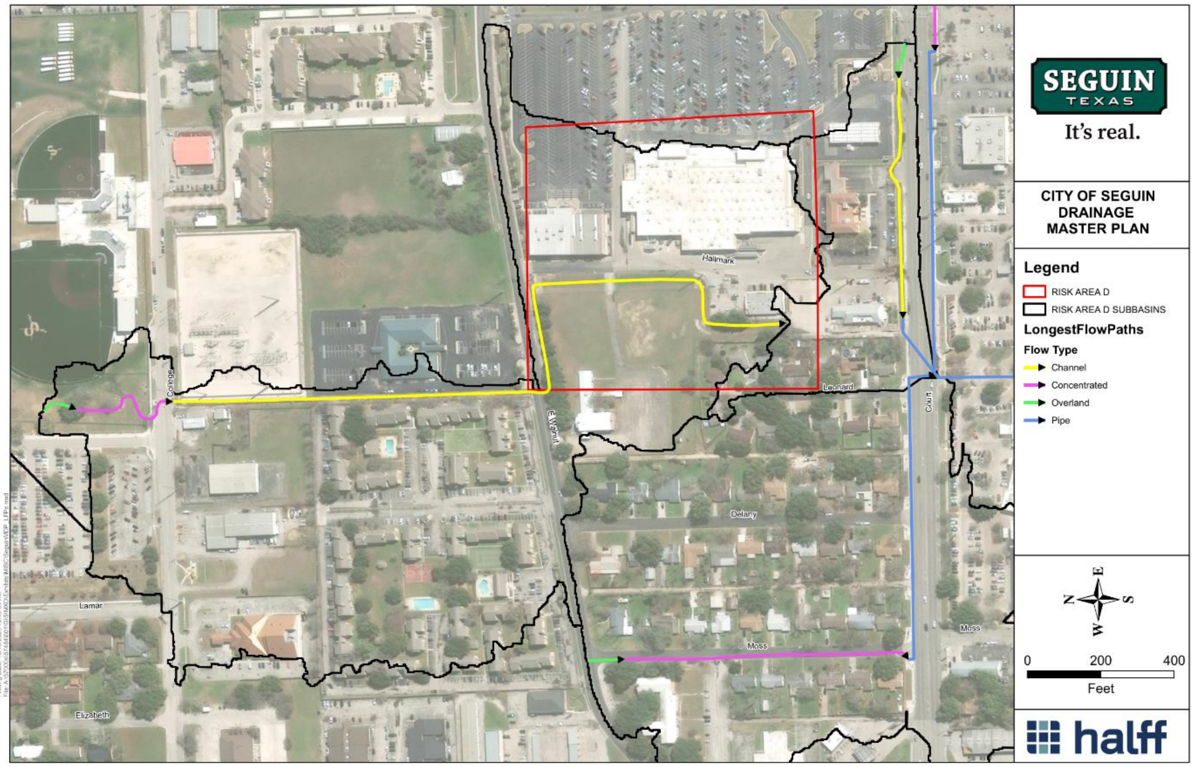


Exhibit 15. Longest Flowpaths

13.0 StormCAD Hydraulic Modeling

Bentley software StormCAD was used to calculate existing capacities of the identified risk area storm drain networks. StormCAD networks were simplified to only focus on the main trunklines of the risk area storm drain network and not adjacent lateral connections.

13.1 Modeling Assumptions

To efficiently model the sections of the identified storm drain networks in StormCAD, several assumptions were made to help minimize the required effort needed for an analysis that would span the entire storm drain network. The assumptions listed are applied to all StormCAD models. Assumptions that are more specific to a risk area are listed in Section 5.2.

StormCAD Modeling Assumptions

- Head loss method is HEC-22 (Third Edition) and utilizes flat benching method.
- Inlets set to sag and assume 100% capture of stormwater discharges.
- Rational Method discharges applied to inlets as continuous flow.
- Junction sizes determined by TXDOT *Guide to the Standard Inlet and Manhole Program – Table 3* procedures document (**Appendix C**).
- Stormdrain outlets set to:
  - Risk Area Z – Water surface elevation (WSEL) at top of crown.
  - All other risk areas – WSEL of Task 4 Rapid Assessment model.
- Manning's roughness values:

- Concrete lined systems: n=0.015
- Corrugated metal pipe systems: n=0.024

13.2 StormCAD Existing Storm Drain Results

StormCAD modeling results help visualize whether existing storm drain systems will surcharge and spill onto the road during a storm event. The three main outputs from the StormCAD software that are used for this assessment are the hydraulic grade line (HGL), Energy Grade Line (EGL), and the ground profile line (GPL). At any point where the HGL becomes higher than the GPL, the storm drain system has exceeded maximum capacity and is now surcharging onto the street.

Risk Area B

Risk Area B shows low capacity for its storm drain network for even the 5-Year storm event. This network experiences surcharging along E Ireland and N Bauer St. for the 5-Year through 100-Year events. The 5-Year event becomes contained at the beginning of E Mountain St. until it outfalls at the tributary of Spring Branch Creek. The 48" reinforced concrete pipe (RCP) running south along N San Marcos St and east along E Mountain St. completely contains the 5-Year event but is exceeded during the 25-Year and 100-Year events. Capacity for the 25-Year storm is seen in the storm drain network beginning at E Mountain St. See **Exhibit 16** for a visual summary of Risk Area B storm drain capacities.

Additional assumptions for Risk Area B include splitting flow at the very northwest corner of the StormCAD network. Rational Method discharges where split evenly for the 5-Year through 100-Year events and applied to separate junction points for the stormdrain draining west to east along E Ireland St. and north to south along N San Marcos St. This diversion is outlined in **Figure 38**.

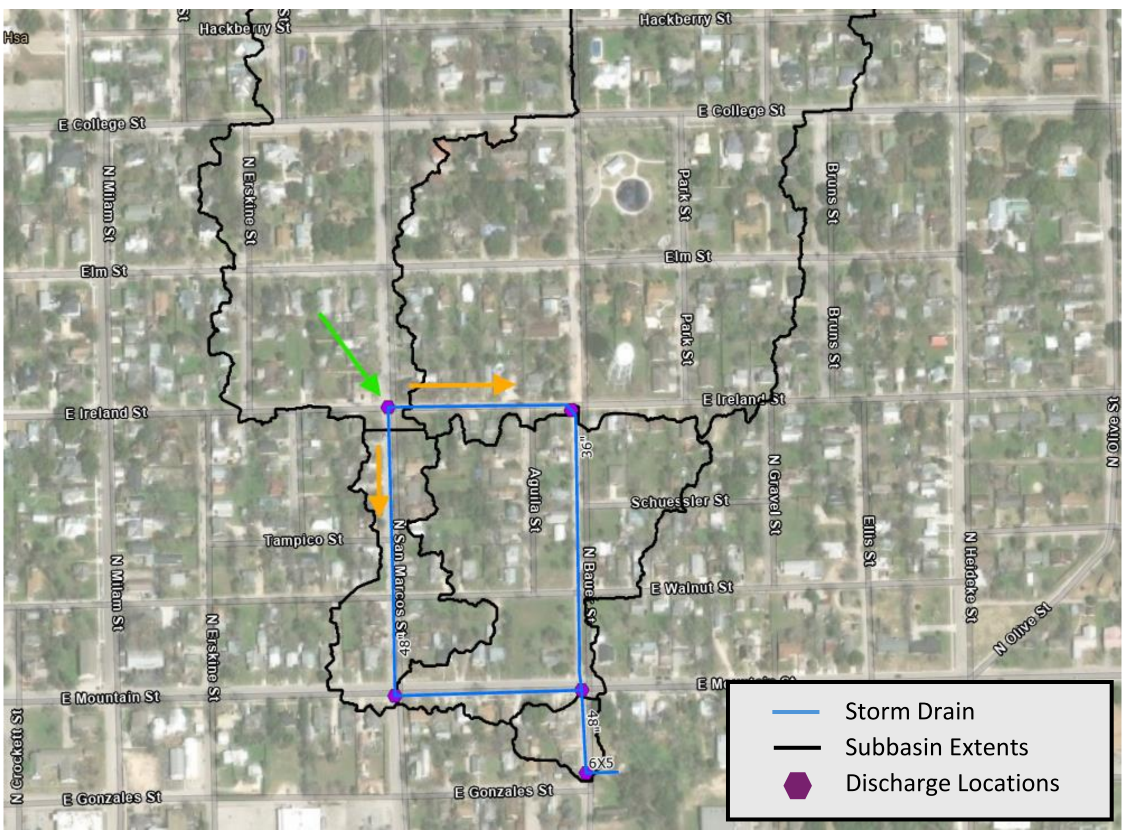


Figure 38. Risk Area B Diversion

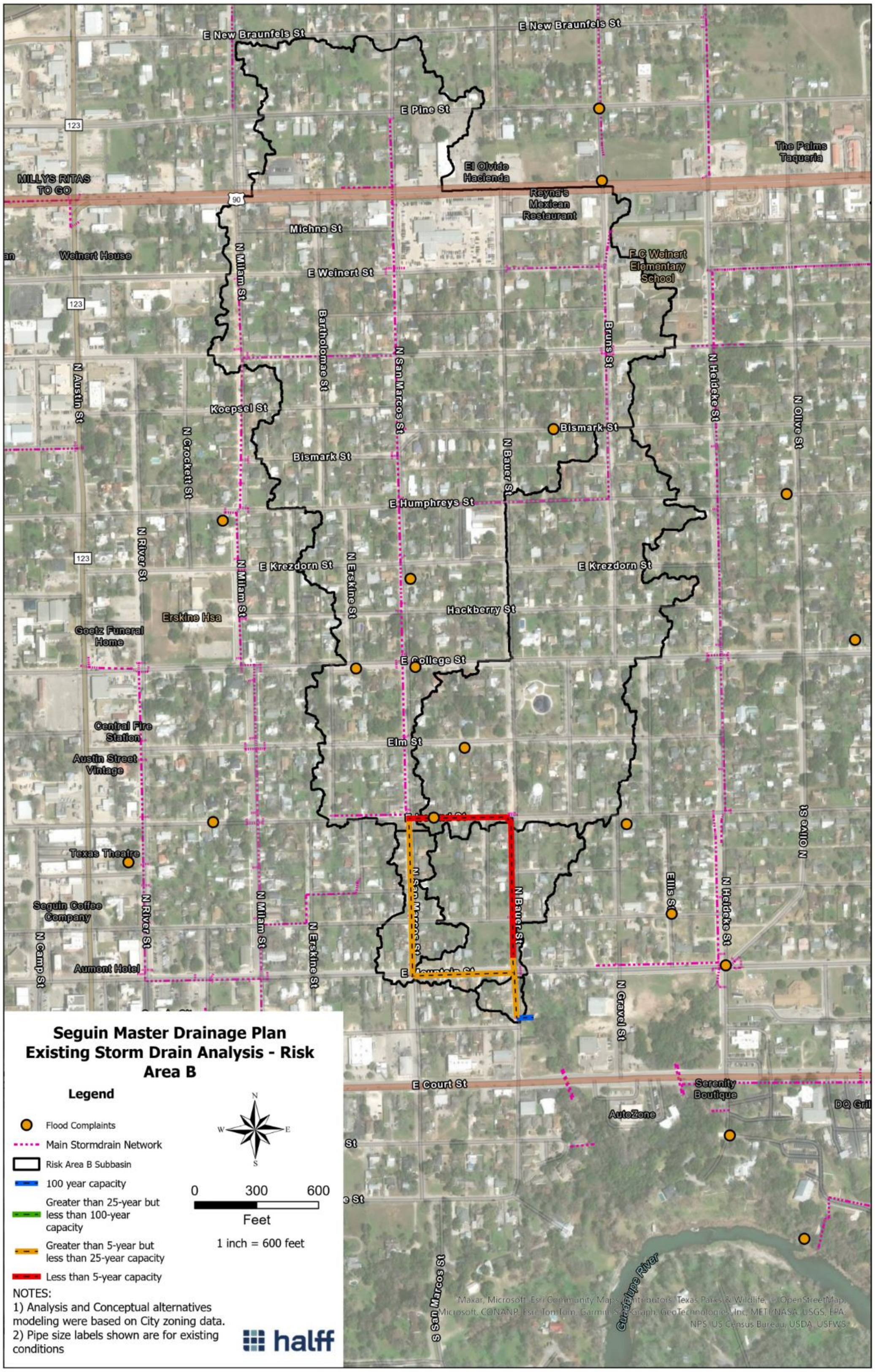


Exhibit 16. Risk Area B Storm Drain

Risk Area C

Risk Area C shows higher capacity for the reinforced concrete box (RCB) along Heideke with no storm event surcharging in this area. The smaller system along the intersection of Olive St and N Heideke St. shows capacity limit exceedance for the 25-Year, 100-Year, and even 5-Year in some areas. See **Exhibit 17** for a visual summary of Risk Area C storm drain capacities.

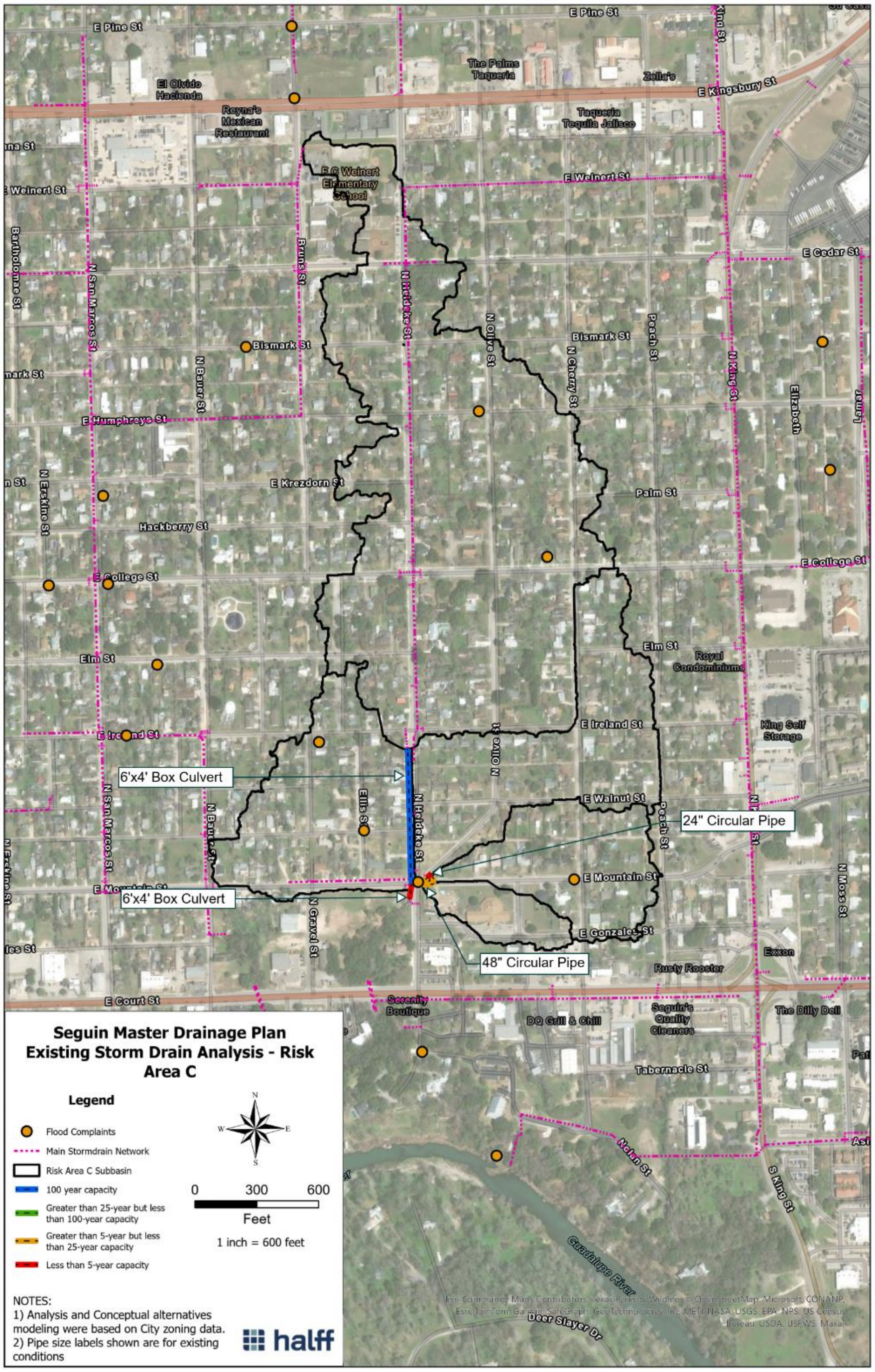


Exhibit 17. Risk Area C Storm Drain

Risk Area D

Risk Area D has presented major flood issues as a result of the undersized storm drain system underneath the Guadalupe Regional Medical Center (GRMC). With a total 25-Year discharge of 746 cfs coming into the network from multiple subbasins, stormwater capacity is reached and exceeded and creates a chokepoint at the downstream end of the channel west of the 1338 E. Court St. Another storm drain network ties into the 78" CMP from N King St. further limiting the capacity of the network underneath the GRMC. The capacity of the storm drain system is further limited due to extremely shallow slopes with a large portion of the network under the GRMC utilizing slopes of 0.1%. Much of the existing network is exceeded during the 5-Year event, with only portions further downstream near the Guadalupe River experiencing some capacity relief. See **Exhibit 18** for a visual summary of storm drain capacities for Risk Area D

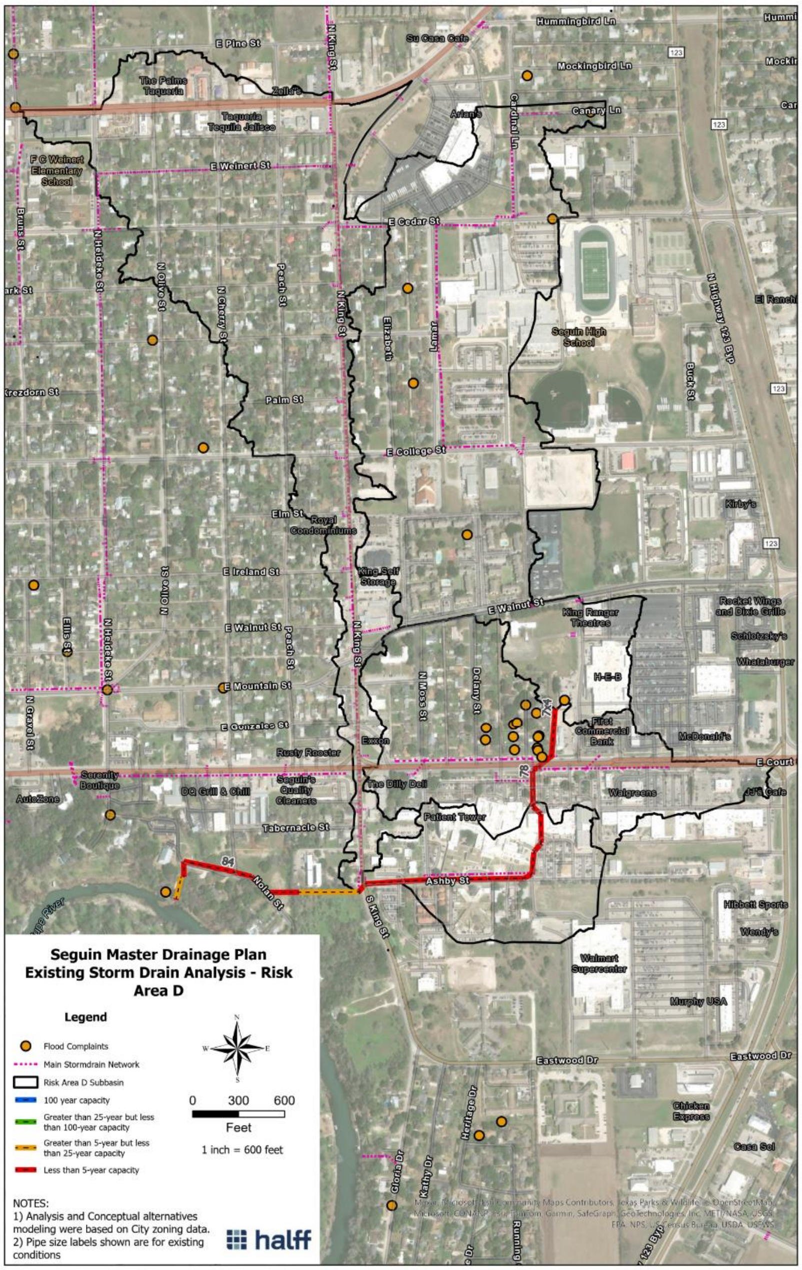


Exhibit 18. Risk Area D Storm Drain

Risk Area J/K/X

Risk areas J, K, and X were combined into one StormCAD model as the three storm drain networks within these risk areas are interconnected. The Risk Area J network shows reasonable capacity and is able to retain discharges for the 5-Year and 25-Year storm events. The 66-inch CMP outlet conduit experiences reduced capacity due to the additional discharges from Risk Areas K and X, resulting in surcharging during the 5-year storm event.

The storm drain network within Risk Area X along Short Ave. shows capacity for the 5-Year through 100-Year events with the 100-Year event being contained up until Elsik St.

The storm drain network in Risk Area J and along Nelda St has capacity limits exceeded for all storm events with discharges from the Risk Area J watershed being significantly higher than those from Risk Area K and Risk Area X. Storm drain capacities can be seen in **Exhibit 19**.

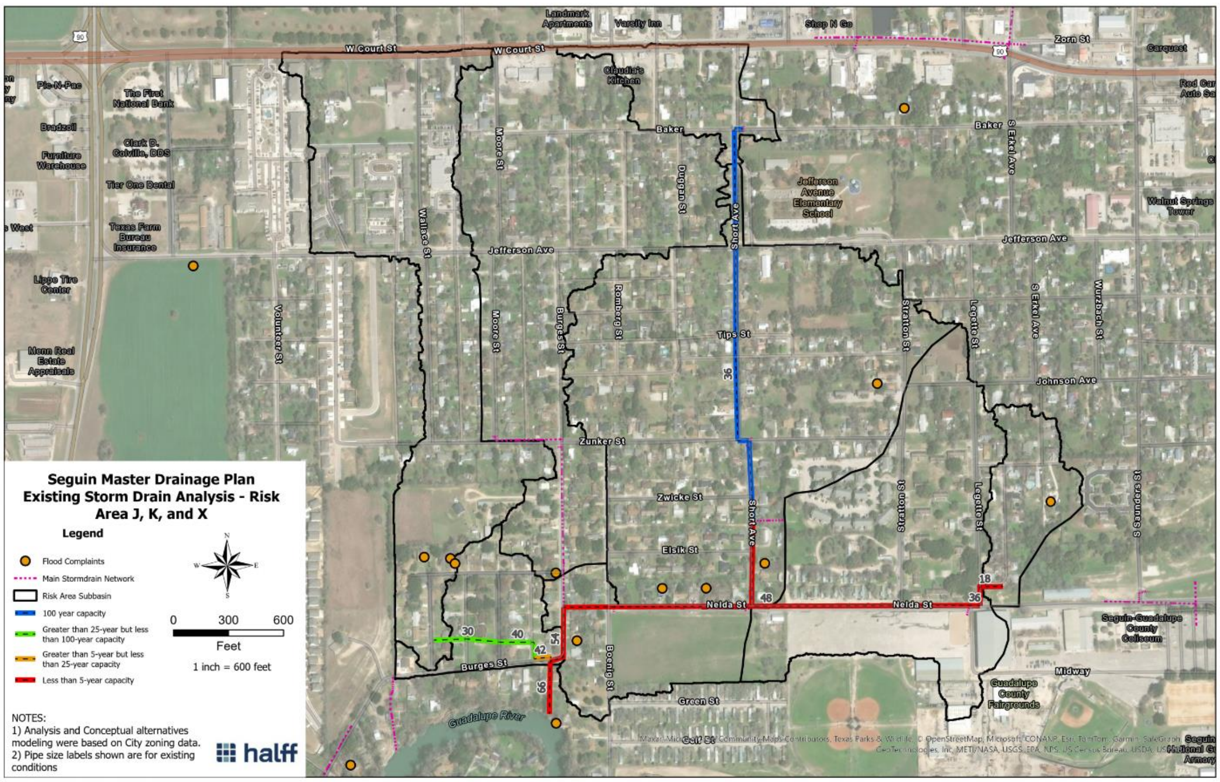


Exhibit 19. Risk Area J/K/X Storm Drain

Risk Area T

Risk Area T storm drain capacity is exceeded for all storm events. Shallower slopes of 0.2% and 0.1% are the main constraint for this network and prevent efficient drainage. **Exhibit 20** highlights the Risk Area T storm drain system and its capacity limitations.

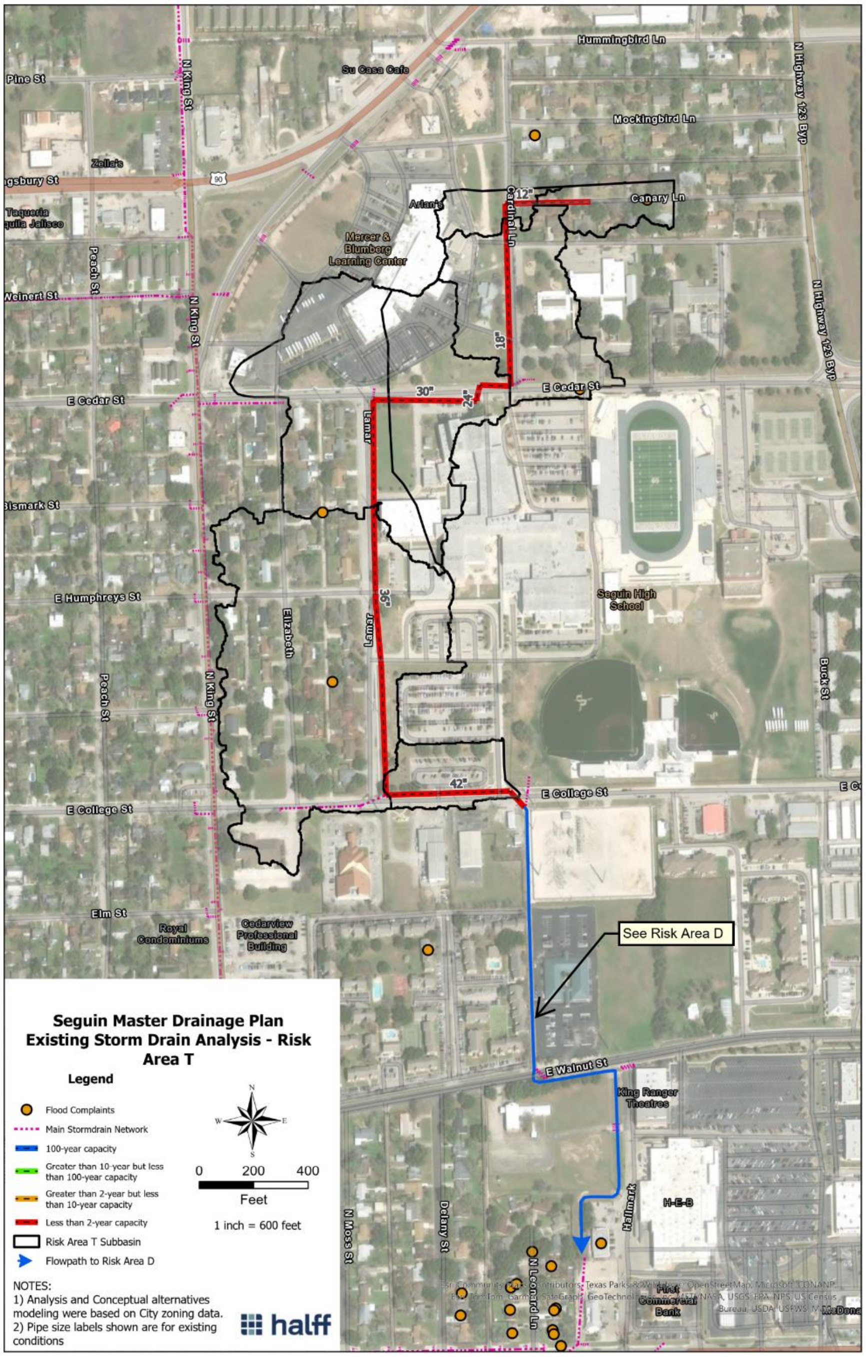


Exhibit 20. Risk Area T Storm Drain

Risk Area Z

Only a small portion of the overall storm drain system was analyzed for Risk Area Z. The section analyzed just south of Patlan Elementary School shows capacity limits for all storm events. Approximately 144 cfs drains from the upstream subbasin and into the existing 15" RCP running east along E Martindale St. Storm drain capacities for Risk Area Z are shown in **Exhibit 21**.

Exhibit 21. Risk Area Z Storm Drain

14.0 Existing Channel and Ditch Capacities

An existing capacity analysis was conducted for existing drainage ditches and channels within the identified risk areas for the 5-Year, 25-Year, and 100-Year storm events. At this time, only one channelized area was selected for analysis as other areas that are within or near selected risk areas are streams or creeks.

14.1 Channel at 1338 E. Court St

Risk Area D is the only risk area with significant channelization. This area is also a higher ranked hot spot with several homes and businesses experiencing significant flooding during past storm events.

During the July 5th storm event in Seguin Texas, heavy and prolonged rainfall occurred within the Seguin and Upper Guadalupe Watershed area. The City saw more than seven inches of rain within a 24-hour period, equating the storm to a 25-Year event. Localized flooding was prominent in much of the city with multiple homes and at least one business experiencing more than 1.0 ft of water within the structures. The drainage channel just east of 1351 E. Walnut St. and north of E Court St. reached and exceeded its capacity resulting in water spilling into the homes along N Leonard Ln. and 1338 E. Court St.

Approximately 99 acres drains to this ditch and is routed downstream into an existing storm drain network that passes under the GRMC and discharges into the Guadalupe River. A typical channel cross section was cut and incorporated in FlowMaster. A slope of 1.1% was calculated from existing terrain and a manning's roughness value of 0.035 for mowed grass was assumed. This channel section is shown in **Figure 39**. Risk Area D with the analyzed channel is shown in **Exhibit 22**.

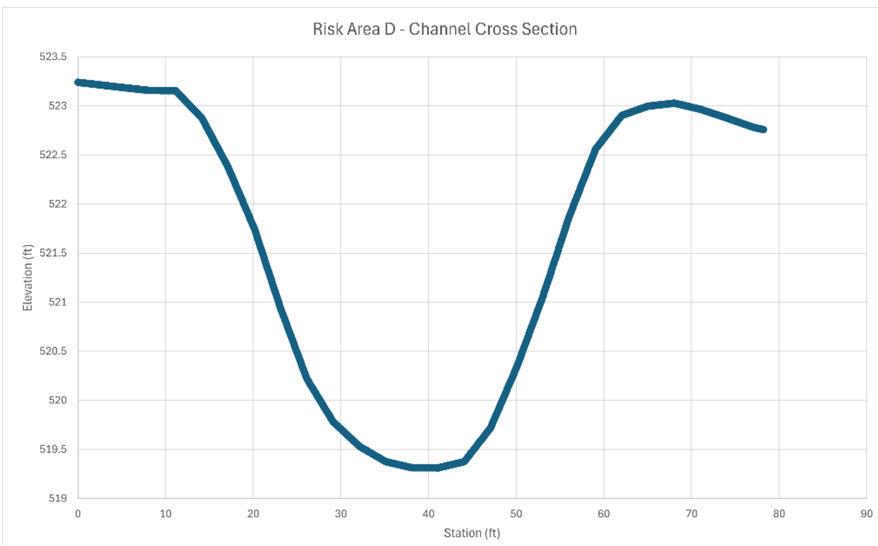


Figure 39. Risk Area D Channel Section

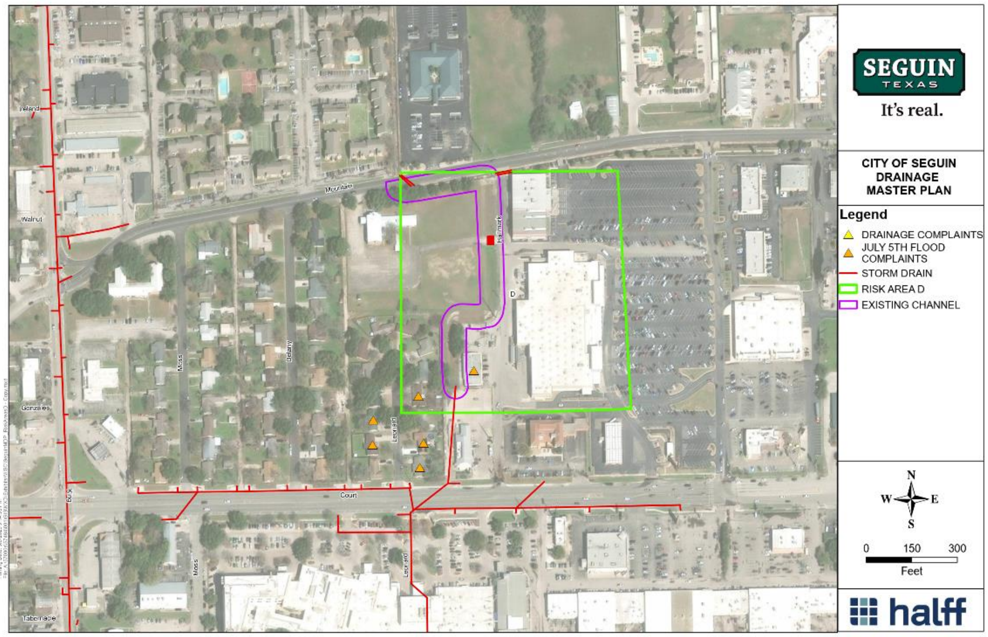


Exhibit 22. Risk Area D Channel

Input parameters and results from FlowMaster are outlined in **Table 12**. FlowMaster depth results are implemented into the channel cross section for each storm event to better visualize channel capacity and are shown in **Figure 40**. Analysis shows the existing channel is capable of handling discharges from the 5-Year through 100-Year storm events. It is important to note that these results are based on the assumption that this channel is free flowing and has no obstructions at the outfall. While this analysis provides a simplified overview of the channel capacity from upstream discharges, it does not reflect true existing conditions resulting from adjacent storm drain networks and the effects they have on the tailwater of this channel area.

Table 12. Risk Area D - Flow Master Parameters

Storm Event Discharges (cfs)		
5-Year	25-Year	100-Year
156	252	368
FlowMaster Results		
5-Year		
Flood Depth (ft)	1.55	
Velocity (ft/s)	4.83	
Freeboard (ft)	2.15	
25-Year		
Flood Depth (ft)	1.97	
Velocity (ft/s)	5.61	
Freeboard (ft)	1.73	
100-Year		
Flood Depth (ft)	2.38	
Velocity (ft/s)	6.29	
Freeboard (ft)	1.32	

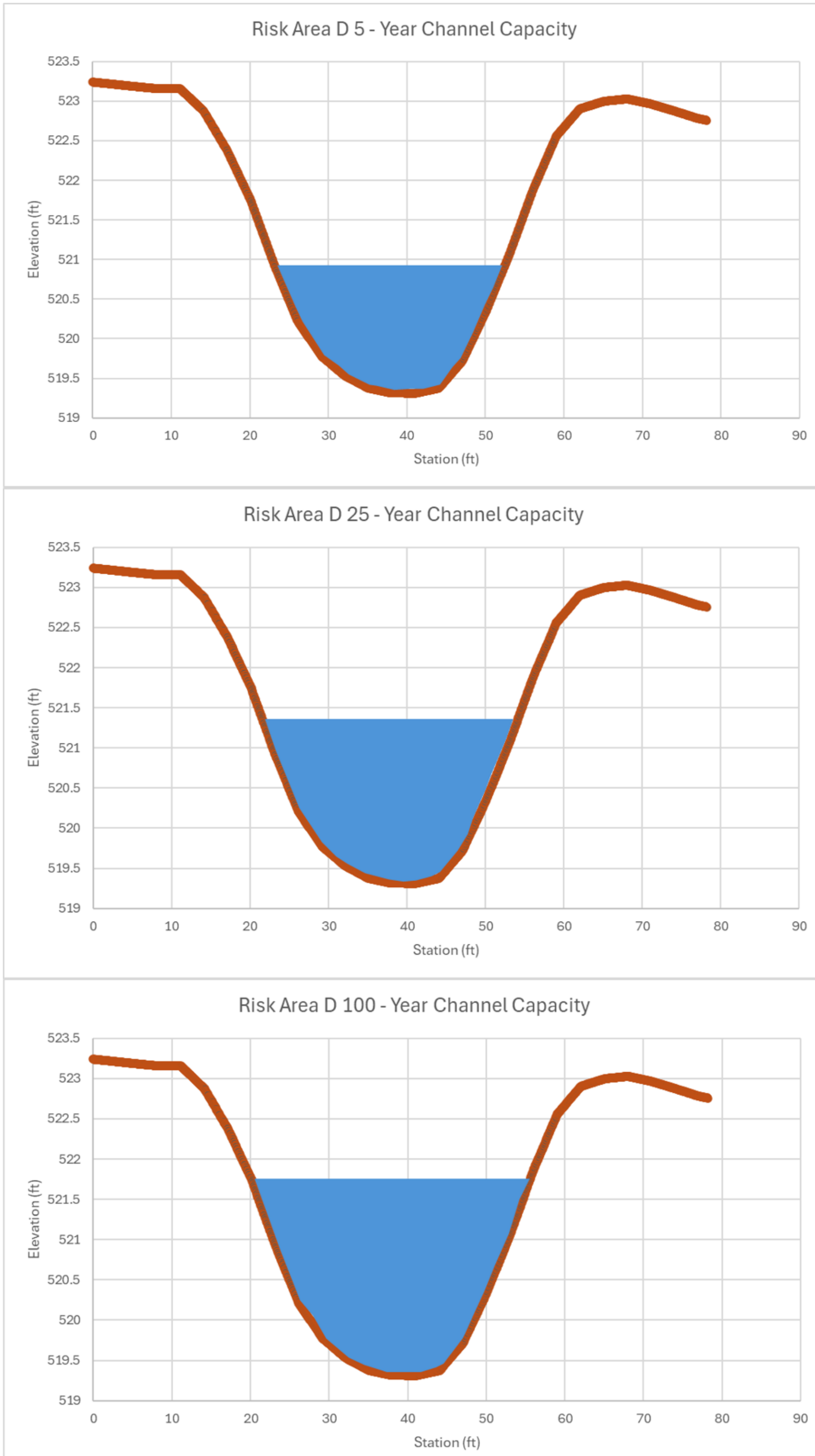


Figure 40. Risk Area D Channel Capacities

15.0 Existing Detention Analysis

No existing detention facilities were located within the designated risk areas and at this time no detention analysis has been conducted. The Walnut Branch detention facility just northeast of the intersection of W Interstate 10 and Huber Rd. has had recent improvements made and the study associated with this detention pond expansion has been provided in **Appendix D** of this submittal.

16.0 Introduction – Project Recommendations

The purpose of this report is to outline proposed flood risk mitigation projects for identified risk areas located in the City of Seguin, Texas. Identified risk areas were developed during the flood risk evaluation phase of the Seguin Drainage Master Plan. Risk areas selected for mitigation project development are outlined in **Exhibit 23** below.

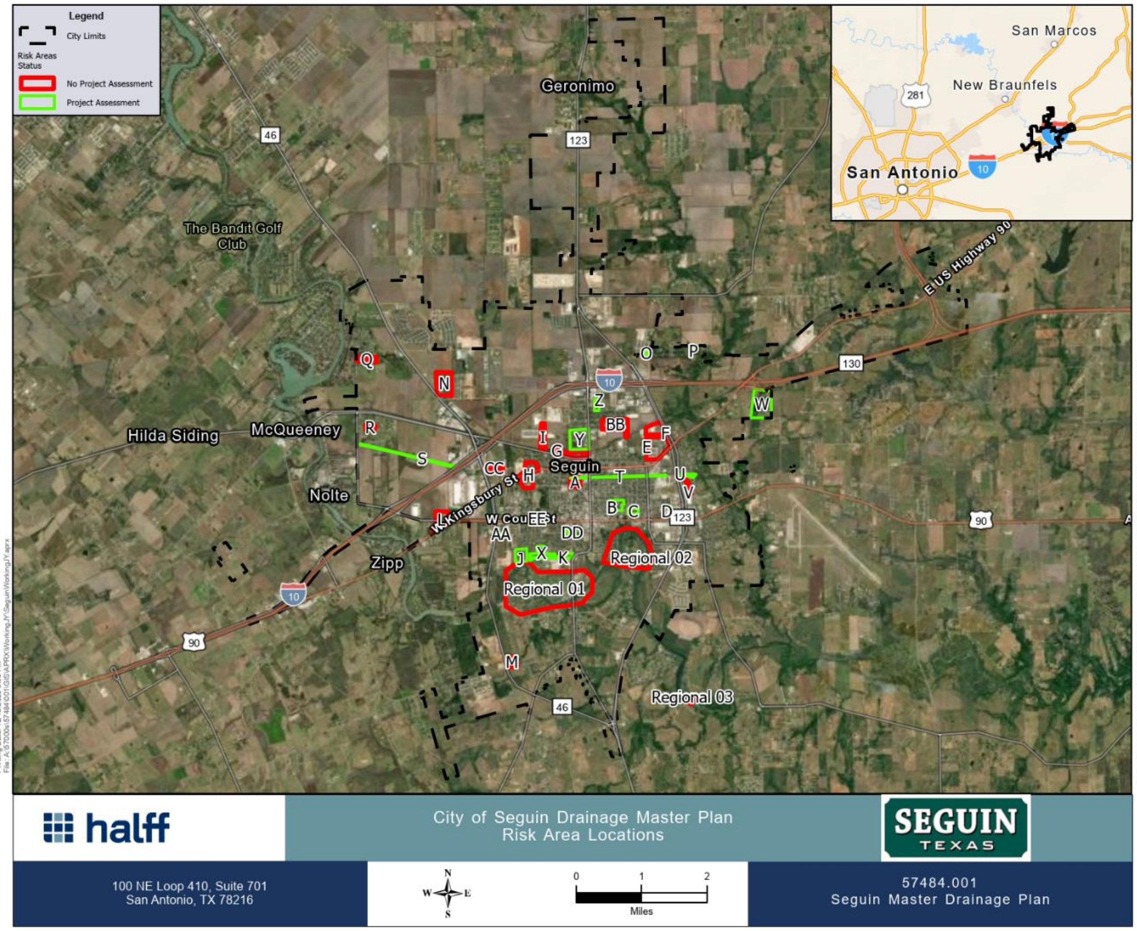


Exhibit 23. Risk Area Locations

17.0 Project Development Approach

Risk Areas were identified based on the rapid assessment results obtained from a HEC-RAS 2-Dimensional (2D) model. These results showed areas where flooding occurs the most frequently within the City of Seguin and from this effort, risk areas were identified. The following report outlines these risk areas and the associated proposed projects to reduce flood risk within these areas and surrounding areas.

Benefits of proposed projects were identified using multiple approaches including Bentley StormCAD modeling and HEC-RAS modeling from a revised rapid assessment model and are designed to mitigate the 25-Year storm event. These benefits are included to show either floodplain reductions from HEC-RAS or hydraulic and energy grade line (HGL and EGL) improvements within the existing storm drain from StormCAD. HEC-RAS storm drain improvements were simulated through “burning” channels into existing terrain to provide conveyance of stormwater. The projects were identified at a conceptual level and will be used to plan for detailed design in the future.

18.0 Proposed Projects

18.1 Risk Area Summary

In total, there are 17 risk areas that were identified by the City. The **Table 13** summarizes the risk areas analyzed within this report. Note that some risk areas have been separated into multiple project areas.

Table 13. Risk Area Summary

Analyzed Risk Areas for Project Development	
Risk Area B – N Bauer St	Risk Area U – Middletowne Rd
Risk Area C – N Olive St	Risk Area U – Oldtowne Rd
Risk Area D – Hallmark Dr	Risk Area U – Park Village Ln
Risk Area J – Sunset Village Neighborhood	Risk Area W – Sunbelt Rd
Risk Area K – Nelda St	Risk Area X – Renee St
Risk Area O – Burr Oak	Risk Area Y – Bowie St
Risk Area P – Twin Oak Rd Low Water Crossing	Risk Area Y – Camp St
Risk Area S – Friesenhahn Rd	Risk Area Z – Breustedt St
Risk Area T – E Cedar St	Risk Area DD – Jefferson Ave
Risk Area AA – Jefferson and Highway 46	Risk Area CC – Court St (Clay to Prexy)

18.2 Risk Area B – N Bauer St

18.2.1 Project Description

Risk Area B is located in a residential neighborhood with localized flooding occurring mainly along Aguila St, Bauer St, and Ireland St between Elm St and E Walnut St. Bauer Park is located immediately to the north of the risk area boundary. Approximately 21 structures experience flood inundation at or above 0.5’ of water during the 25-Year storm event. Elm St experiences flood depths up to 1.0’ while both Aguila and Bauer St experience between 1.0’ to 2.0’ of water.

Stormwater is conveyed underneath Bauer Street through an existing 36” RCP, which transitions into a 48” RCP before discharging into a 6’ x 5’ box culvert. The culvert outfalls into a tributary of the Guadalupe River approximately 280 ft north of Court Street.

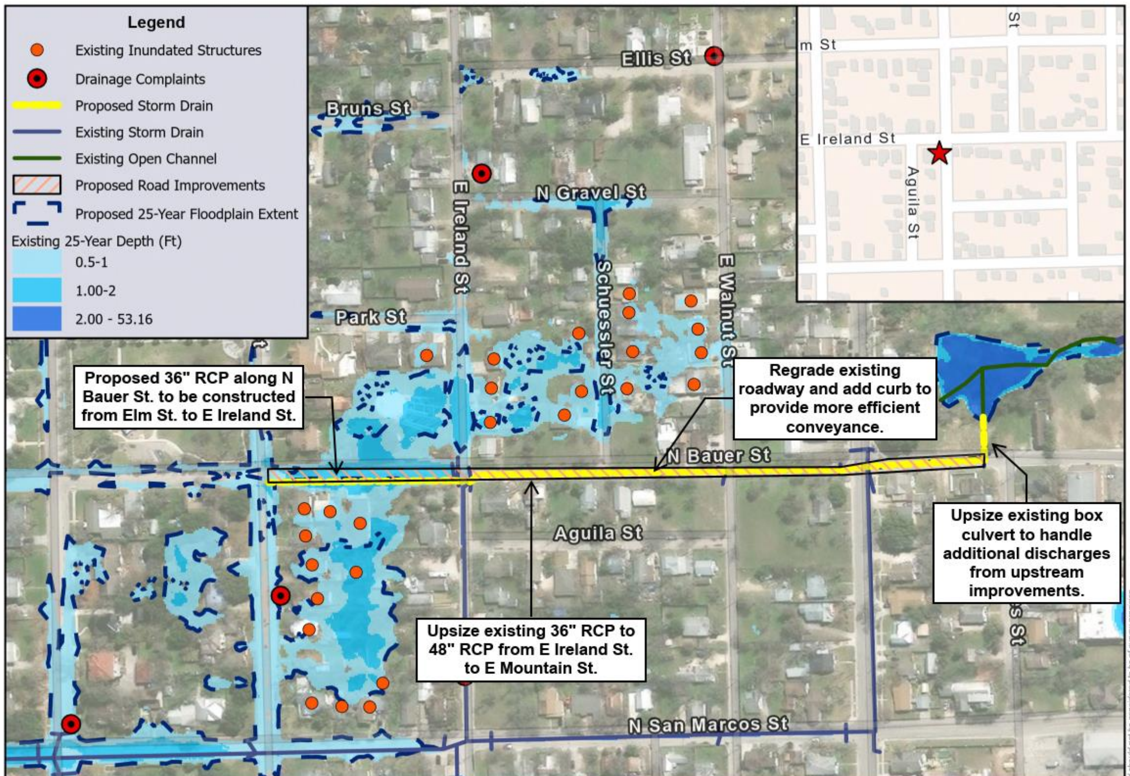
Preliminary results from HEC-RAS 2D modeling show ponding within the neighborhood just north of E Ireland St and throughout much of N Bauer St. Storm drain analysis performed using StormCAD shows most of the 36” RCP along N Bauer St exceeds capacity at the 5-Year storm event. The 48” RCP along N San Marcos and E Mountain St reaches capacity at the 25-Year storm event. Surcharging of the storm drain, combined with localized flooding, results in the surrounding neighborhoods and roadways to become inundated quickly. Relief only occurs when the storm drain network has had sufficient time to drain.

Furthermore, a profile was anallyzed along N Bauer St, and it was apparent that ponding was occurring in locations where the street slope was shallow or flat. Due to this, street improvements, such as regrading to create positive slope and installing curb and gutter along N Bauer St are recommended to convey stormwater to the south more efficiently. Approximate limits of curb and gutter installation would occur between Elm St and E Mountain St.

Project solutions for Risk Area B focus on N Bauer St and the adjacent neighborhood to the west. No physical improvements are proposed for N San Marcos St, but reduction in roadway flood inundation along Aguila St is anticipated with the added storm drain capacity along N Bauer St.

18.2.2 Benefits

The recommended improvements offer benefits to both structural and roadway features within the risk area. StormCAD analysis with the additional proposed RCP's show increased capacity for the network along N Bauer St, E Mountain St, and N San Marcos St. Additional capacity to the storm drain network, along with the proposed roadway regrade and curb improvements allows for more efficient capture of stormwater along N Bauer St. Benefits are realized most within the neighborhoods along Schuessler and E Walnut St. HEC-RAS modeling of proposed improvements are provided in **Exhibit 24** and show 9 structures removed from the 25-Year floodplain. The neighborhood just south of E Elm between N San Marcos and N Bauer St still experiences considerable flooding and is a result of low ground with no efficient drainage path. Additional improvements that could be considered include adding additional inlets to the storm drain along E Ireland St.



PROJECT DESCRIPTION/NOTES

Homes along N Bauer St are at risk of flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Increase the slope of street and install curb & gutter.

2. Add additional storm drain pipe to the north, along N Bauer St and along Elm St.

3. Upsize the existing storm drain pipe for additional capacity, if needed from the above proposed improvements.

BENEFITS

- Reduces flood risk along N Bauer St and surrounding residential properties

- More cost efficient solution

CHALLENGES

- Possible downstream impacts

- Downstream storm drain systems will need to be analyzed for capacity

- Construction impacts to community/traffic

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City of Seguin Drainage Master Plan
Risk Area B
N Bauer St from Elm St to E Gonzales St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

0 150 300
Feet

57484.001
Seguin Master Drainage Plan

Exhibit 24. Risk Area B Project Map

18.2.3 Cost

A tentative project cost was calculated, and a breakdown of the associated costs can be found in **Table 14**.

Table 14. Risk Area B Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.57
ROW/Easement	0.8
Engineering and Testing	0.24
Utility Adjustments	.08
Total	**$2.69**

18.2.4 Constraints

There are several potential constraints associated with the proposed improvements for this risk area. There are likely underground utilities that will need to be relocated due to the implementation of additional storm drain. Additionally, several driveways will need to be reconstructed alongside the proposed roadway re-grading. Property owners would be affected by the construction and phasing would need to occur to reduce impacts. Downstream impacts at the outfall just north of Court St should be evaluated more thoroughly to ensure surrounding structures along E Mountain St and N Bauer St are not affected, and to mitigate possible discharge velocity increases.

18.3 Risk Area C – N Olive St

18.3.1 Project Description

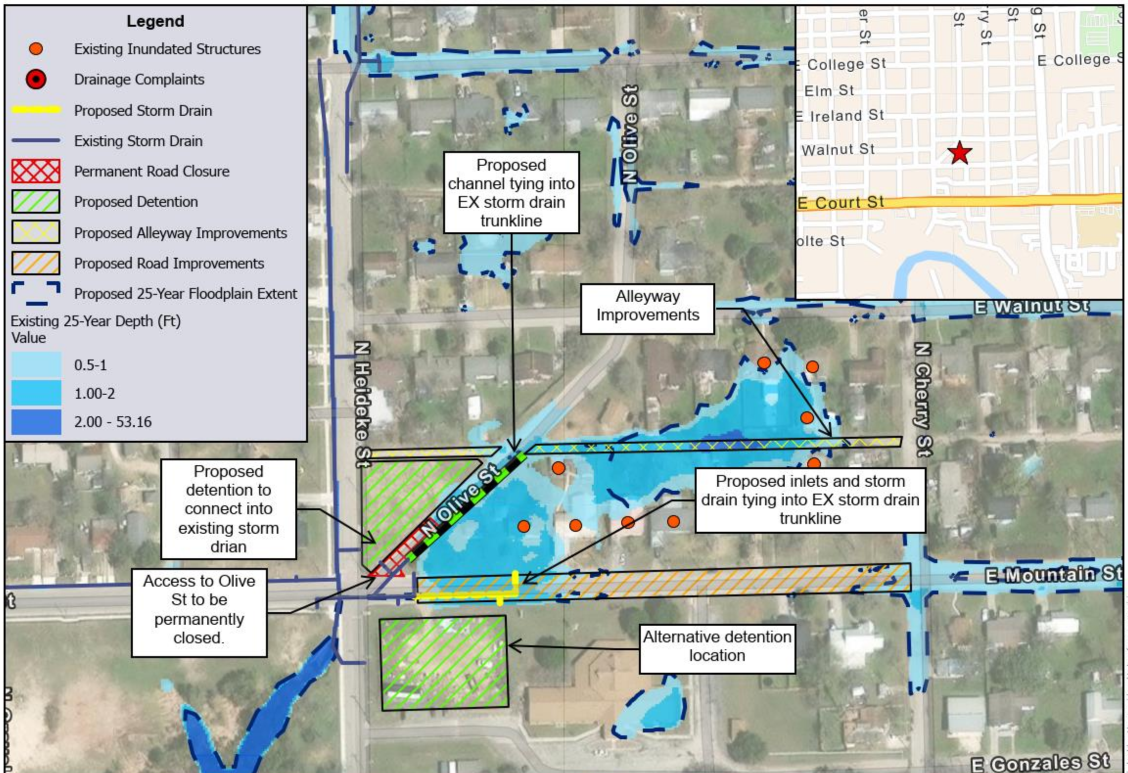
Risk Area C is located two streets to the east of Risk Area B and includes the neighborhood encompassed by N Heideke St to the west, E Walnut St to the north, N Cherry St to the east, and E Mountain St to the south. Approximately 9 structures experience flood inundation at or above 0.5' of water during the 25-Year storm event. Flood depths exceeding 2.0' occur along N Olive St and at the intersection of N Heideke St and E Mountain St. An existing storm drain network captures stormwater at the intersection of these three roads and discharges it through a 6' x 4' box culvert, where it outfalls into an unnamed tributary connecting to the Guadalupe River.

Preliminary results from the HEC-RAS 2D modeling show significant ponding along N Olive St and along the alleyway behind the houses facing E Walnut St. Storm drain analysis using StormCAD show the existing box culvert along N Heideke St has sufficient capacity for the 25-Year storm event, but a significant portion of the existing network at the intersection for E Mountain St, N Olive St, and Heideke St is close to capacity during the 5-Year event.

Project solutions for Risk Area C include improving the alleyway behind the houses along N Olive St and connecting to a proposed roadside ditch running southwest along N Olive St, down to the existing inlet that discharges into the 24" RCP. Additionally, roadway improvements with curb extensions are proposed from E Mountain St to N Cherry St, along with a 24" RCP to connect into the exiting 48" RCP with additional storm drain inlets to capture stormwater before it begins to pond in the intersection to the southeast. A 6.0' deep detention pond is proposed in one of two locations in the vacant lot adjacent to Olive St. to capture additional discharges from both the alleyway and excess flows from the proposed channel. The geometry of the 5-legged intersection of Olive Street, Mountain Street, and Heideke Street does not meet the City's design criteria for street spacing. Therefore, abandoning a portion of Olive Street is recommended for the section of N Olive St starting at E Mountain St to the private alleyway 250 ft northeast.

18.3.2 Benefits

Benefits from the combined improvements are realized along Olive and E Mountain St. with road flooding almost completely removed from along E Mountain and 3 residential structures being removed from the floodplain. **Exhibit 25** shows preliminary modeling results with projects incorporated.



PROJECT DESCRIPTION/NOTES

Homes along N Olive St are at risk of flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Implement alleyway improvements for better drainage in the alley behind the houses along N Olive St.

2. Create a defined channel along N Olive St and tie into the existing storm drain system near the intersection of N Olive St and E Mountain St.

3. Extend the curb & gutter eastward with additional inlets as needed to intercept flow before the intersection.

4. Provide detention facility in open parcel with depths from 5 ft - 9 ft. Facility to drain into existing RCP along N Heideke St.

BENEFITS

- Reduces flood risk along N Olive St and surrounding residential properties

- More cost efficient solution

CHALLENGES

- Possible downstream impacts

- Downstream storm drain systems will need to be analyzed for capacity

- Construction impacts to community/traffic

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City of Seguin Drainage Master Plan
Risk Area C
Olive St from E Mountain St to E Walnut St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

N W E S

0 100 200 Feet

57484.001
Seguin Master Drainage Plan

Exhibit 25. Risk Area C Project Map

18.3.3 Cost

A tentative project cost was calculated, and a breakdown of the associated costs can be found in **Table 15**.

Table 15. Risk Area C Expected Project Cost

Cost Type	Amount (in Millions)
Construction	0.26
ROW/Easement	0.01
Engineering and Testing	0.04
Utility Adjustments	0.01
Total	**0.32**

18.3.4 Constraints

Expected constraints include coordination with homeowners along N Olive St and E Walnut St during alleyway and channel improvements, as well as with homeowners along E Mountain St during curb and storm drain improvements. Utility conflicts are also expected within this area. Downstream impacts to the Guadalupe River will need to be assessed as a result of the storm drain improvements to mitigate increases in velocity at the outfalls. Finally, the culvert crossing at the intersection of E Mountain St, N Olive St, and N Heideke St, along with the cross culvert at E Court St, will need to be evaluated for hydraulic capacity and existing scour conditions to determine whether structural upgrades are necessary.

18.4 Risk Area D – Hallmark Dr

18.4.1 Project Description

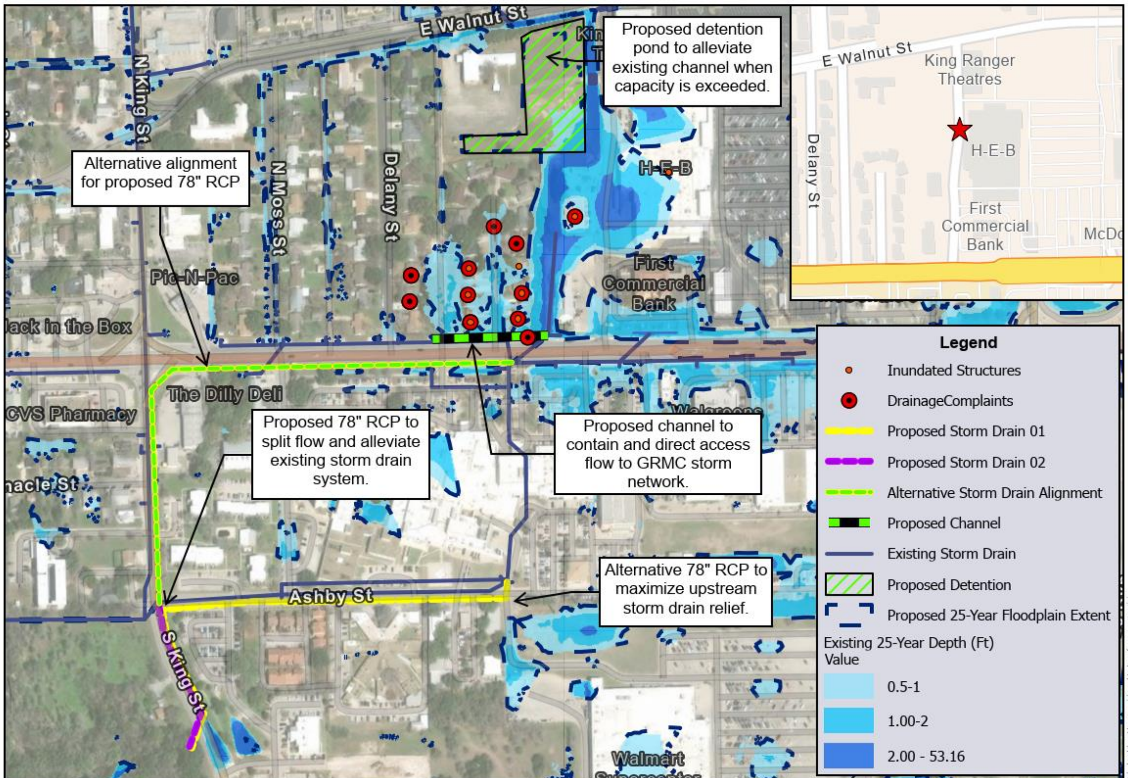
Risk Area D is located south of E Walnut St and north of E Court St, encompassing H-E-B at 1340 E Court St, Hallmark Dr, and the residential properties along N Leonard Ln. Multiple structures within this area encounter flooding issues within and immediately surrounding this risk area to the south and west, with documented damages for multiple homes along N Leonard Ln and the 1838 Grill restaurant located at 1338 E Court St.

Analysis using both HEC-RAS 2D and StormCAD modeling software show that the storm drain system that begins just west of 1838 Grill and passes under the Guadalupe Regional Medical Center (GRMC) and outfalls into the Guadalupe River exceeds capacity for the 5-Year through 100-Year storm events. Shallow slopes within the storm drain network, combined with large stormwater discharges from higher intensity urban and commercial development, result in an inefficient storm drain system that surcharges stormwater upstream into the connecting channel along Hallmark Dr. This also creates a bottleneck that prevents stormwater from upstream drainage basins to properly drain through the channel and into the GRMC storm drain network.

The most cost-efficient solution with the least amount of impact from anticipated construction is a new storm drain outfall located southeast of the current outfall within a small tributary of the Guadalupe River. A proposed 78” RCP will connect from the intersection of S King St and Ashby St and outfall approximately 390 ft south into the unnamed tributary. Additional improvements include a detention pond just east of the Walnut Street Church of Christ (WSCC), located at 1351 E Walnut St, to provide additional storage volume to the adjacent channel, as well as a proposed channel along Court St beginning just west of N Leonard Ln and outfalling into the existing storm drain system near the EZPAWN property at 1332 E Court St. To further expand the capacity limits of the GRMC network, an additional 78” RCP is proposed, flowing from east to west along Ashby St to divert flow from the existing system into the unnamed tributary southwest of King St.

18.4.2 Benefits

Benefits from Risk Area D proposed solutions are marginal when looking at HEC-RAS model results with depth reductions of 0.25’ to 0.5’ around Leonard Ln and E Court St. Flooding along Leonard Ln is improved with inundation mostly contained within the roadway, however, the homes just west of Leonard Ln still experience flood depths up to 1.0’. While initial HEC-RAS modeling results from discussed improvements do not show extensive floodplain reductions, these results do not consider improved tailwater conditions from the storm drain network downstream of the area. The proposed storm drain profile along King St is shown in **Figure 41**. Diverting flow into the proposed storm drain along King St from the existing 78” RCP will attribute to greater capacity limits of the overall storm drain network, allowing more efficient drainage from the proposed channel along E Court St and the existing channel just east of Leonard Ln. The overall project map for Risk Area D is shown in **Exhibit 26** below. Depth reductions are presented in **Figure 42**. It is recommended to pursue a detailed analysis of this area using software that can incorporate both 2D flow and storm drain capabilities.



PROJECT DESCRIPTION/NOTES

Severe flooding along channelized area behind HEB and Court St. Undersized storm drain network with shallow slopes creates a choke point at the upstream end of the storm drain system and backfills into the existing channel and neighborhood along N Leonard Ln. Proposed Improvements include, presented in the order they should be implemented:

1. New 78" RCP from intersection of Ashby and King St to divert flow from existing 78" storm pipe south along King St. and into Guadalupe River (alternative alignment to run west on Court St and south along King St).

2. In addition to Project 1, construct a detention pond just east of Walnut St. Church of Christ (WCC).

3. Combine Projects 1 and 2 along with a proposed U-channel beginning at Delaney St. and ending just north of Court St.

4. Project 3 plus an additional 78" RCP beginning at the east end of Ashby St. and running parallel along the existing 78" RCP. Proposed 78" RCP will discharge into the Guadalupe River.

BENEFITS

- Allows quicker drainage of the storm drain system along Ashby St and the Guadalupe Regional Medical (GRMC) Center and prevents surcharging into the existing channel along H-E-B.

- Proposed pond allows for capture of any additional flood water not contained by the existing channel and can still be used for recreational purposes for the church.

CHALLENGES

- Utility conflicts along Ashby St.

- Impacts to property downstream of proposed RCP's will need analysis

- Traffic routing during construction.

- Coordination with GRMC and and WCC.

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City of Seguin Drainage Master Plan
Risk Area D
Hallmark Drive

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

N W E S

0 250 500 1,000
Feet

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Seguin Master Drainage Plan

Exhibit 26. Risk Area D Project Map

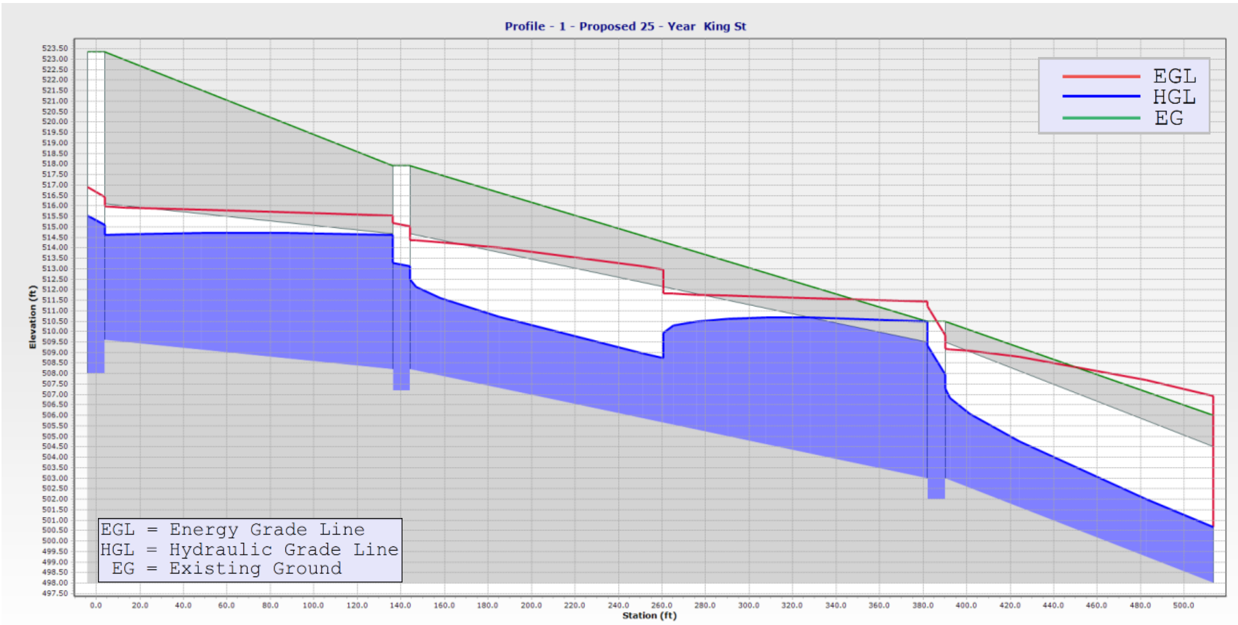


Figure 41. Proposed Storm Drain along King Street

Figure 42. Risk Area D Depth Reductions

18.4.3 Cost

A tentative project cost was calculated, and a breakdown of the associated costs can be found in **Table 16**. An additional cost was calculated for the proposed alternative alignment of the 78” RCP running west then south along Court St and King St.

Table 16. Risk Area D Expected Project Costs

Cost Type	Amount (in Millions)
Construction	4.40
ROW/Easement	0.22
Engineering and Testing	0.66
Utility Adjustments	0.22
Preliminary Engineering Report	.44
Total	**$5.94**
Alternative Alignment	
Construction	5.66
ROW/Easement	0.28
Utility Relocation	0.28
Engineering and Testing	0.85
Preliminary Engineering Report	0.57
Total	**7.64**

18.4.4 Constraints

Expected constraints for the proposed storm drain along S King St and the proposed detention pond adjacent to the WSCC include property acquisition and coordination with property owners, as well as utility relocation along S King St. Traffic impacts are expected along S King St and Ashby St for the storm drain improvements, and Delany St and N Leonard Ln for channel improvements. Coordination with the GRMC may be required for improvements along Ashby St.

18.5 Risk Area J – Sunset Village Neighborhood

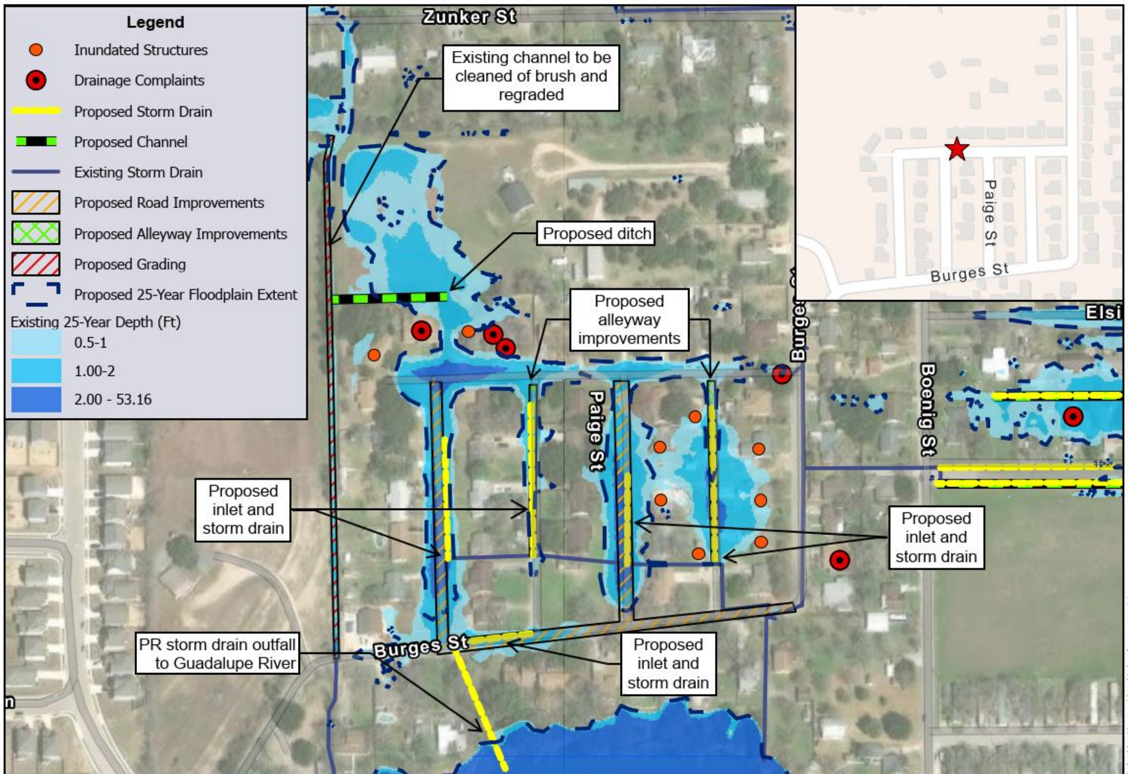
18.5.1 Project Description

Risk Area J includes the neighborhoods along Renee St, Paige St, and Burges St. While structural flooding in this risk area is minimal, much of the area experiences severe flooding along roadways with additional water ponding outside City right-of-way.

StormCAD analysis shows that the existing storm drain running west to east has sufficient capacity for the 25-Year storm event. Proposed improvements include additional 24” RCP laterals along Renee St and Paige St to connect into the existing network to the north and capture water quicker before road inundation occurs downstream during rain events. An additional 24” RCP along Burges St with 2 inlets is proposed to drain water south into the Guadalupe River, relieving some accumulation of stormwater at the south of the neighborhood. Small channelization of the alleyways between Paige St and Renee St were considered to help convey stormwater south and into the proposed storm drain along Burges St. but complications with the adjacent driveways are expected. Instead, 24” RCP’s are proposed along the two alleyways adjacent to Renee and Paige St. to connect to the existing 30” RCP and 40” RCP running east to west. Additional improvements include constructing a channel at the northwest corner of the neighborhood to divert water north of Renee St, behind the houses, and into a regraded, existing channel that drains south into an existing storm drain and outfalls into the Guadalupe River.

18.5.2 Benefits

Benefits of the proposed improvements include a more efficient channel to convey water to the Guadalupe River outside of the neighborhood, to the west. This will decrease the amount of water flowing to Renee St, Paige St, and the alleys from the north. With the additional inlets and storm drain laterals connecting to the existing west to east system, water will be captured quicker, decreasing the amount of water flowing downstream to Burges St. Finally, constructing a separate outfall will drain the water to the Guadalupe River more efficiently from Burges St, providing some relief to the ponding and localized flooding occurring at the intersection of Renee St and Burges St. Initial HEC-RAS model results show considerable depth reductions along Burges St and around the residential structures on the eastern neighborhood. See **Exhibit 27** for the overall project map.



PROJECT DESCRIPTION/NOTES

Homes between Burges St & Renee St are at risk of flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Install a small channel just north of Renee St to capture and drain water into the existing channel running north to south.(PHASE I)

2. Regrade and clean up the existing channel to the west of the neighborhood to convey water to the south more efficiently.(PHASE I)

3. Incorporate 24" RCP storm drain along Renee and Paige St and the adjacent alleyways to connect to existing system running west to east. Roadway and alleyway improvements to be included to provide better storm water conveyance. (PHASE II)

4. Create a new outfall to the Guadalupe and install 2 inlets to capture additional water flowing down Renee and Burges St. (PHASE III)

BENEFITS

- **Reduces flood risk along roadway and residential structures**
- **Water ponding less likely with more efficient conveyance systems**
- **More cost efficient solution**

CHALLENGES

- **Impacts to downstream connection of improved channel system to existing storm drain at Renee and Burges St**
- **Downstream storm drain systems will need to be analyzed for capacity**
- **Construction impacts to community/traffic**

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City of Seguin Drainage Master Plan
Risk Area J
Residential Community Between Burges St & Renee St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

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Seguin Master Drainage Plan

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Exhibit 27. Risk Area J Project Map

18.5.3 Cost

A tentative project cost was calculated, and a breakdown of the associated costs can be found in **Table 17**.

Table 17. Risk Area J Expected Project Costs

Cost Type	Amount (in Millions)
Construction	0.71
ROW/Easement	0.04
Utility Adjustments	0.04
Engineering and Testing	0.11
Total	**$0.90**

18.5.4 Constraints

The main constraints expected for these proposed solutions include traffic impacts, utility relocation and impacts to residential access. Proposed storm drain improvements should be further assessed to ensure no surcharge occurs due to tailwater conditions from the Guadalupe River. Additionally, downstream impacts to the Guadalupe River need to be assessed to confirm there is no rise in water surface elevation. The existing inlet and RCP located at the southwest corner of the neighborhood on Burges St should also be assessed to ensure that there is enough capacity to convey the additional water from channel improvements and will not cause ponding along the roadway where the channel outfalls into the storm drain.

18.6 Risk Area KX – Nelda St

18.6.1 Project Description

Risk Area K and Risk Area X were combined into one risk area due to the proximity and hydraulic interaction they have with each other. These risk areas focus on the streets and surrounding neighborhoods of Short Ave, Elsik St, and Nelda St. Severe flooding occurs along Nelda St between S Austin and Boenig St with flood depths exceeding 2.0'. Residential structures south of Elsik St and to the west of Stratton St and Nelda St experience flooding up to 2.0'.

The shallow roadway and storm drain slope along Nelda St prevents storm water from draining efficiently and results in ponding along much of the street and low-capacity limits for the storm drain. Natural drainage patterns indicate water flows both east and west along Nelda St with the high point separating the drainage direction located at the intersection of Nelda St and Legette St.

Proposed improvements for the residential area south of Elsik St include proposed storm drain along Elsik St connecting to the existing storm drain running south along Short Ave, as well as channelizing the existing alleyway behind the houses along Elsik St to direct stormwater to the existing storm drain network on Short Ave. Additional storm drain improvements are proposed along Nelda St beginning at Legette St and ending at Boenig St. On the north side of Nelda St, roadside ditches are proposed from Stratton St to Short Ave and on the south side of Nelda St, roadside ditches will be constructed from Short Ave to Boenig St. Improvements located at the east end of Risk Area K include a small detention pond on the north side of Nelda St between S Saunders and S Austin St. Additional detention facilities just west of Saunders St and on the west side of Nelda St can be utilized in tandem with the proposed facility along S Austin and Nelda St. Preliminary modeling results from HEC-RAS only utilize the proposed detention facility on the far east side of Nelda St.

Detention at the parking lot just west of the Guadalupe County Expo Center may also provide benefits by providing additional stormwater storage volume for this risk area. Alternative detention for this area may involve either lowering the parking lot to be able to contain larger amounts of water or designating a portion of the parking lot to be utilized as a traditional detention center. Alternatively, underground detention beneath the parking lot may be considered. Existing ground elevations along with the existing storm drain inverts of the 48" RCP along Nelda St were considered for initial sizing of underground detention center dimensions. Maximum height for proposed detention underneath the parking area should not exceed 7.0' and should be routed to drain into the existing 48” RCP along Nelda St. Figure 43 outlines the area proposed for additional detention facility improvements.

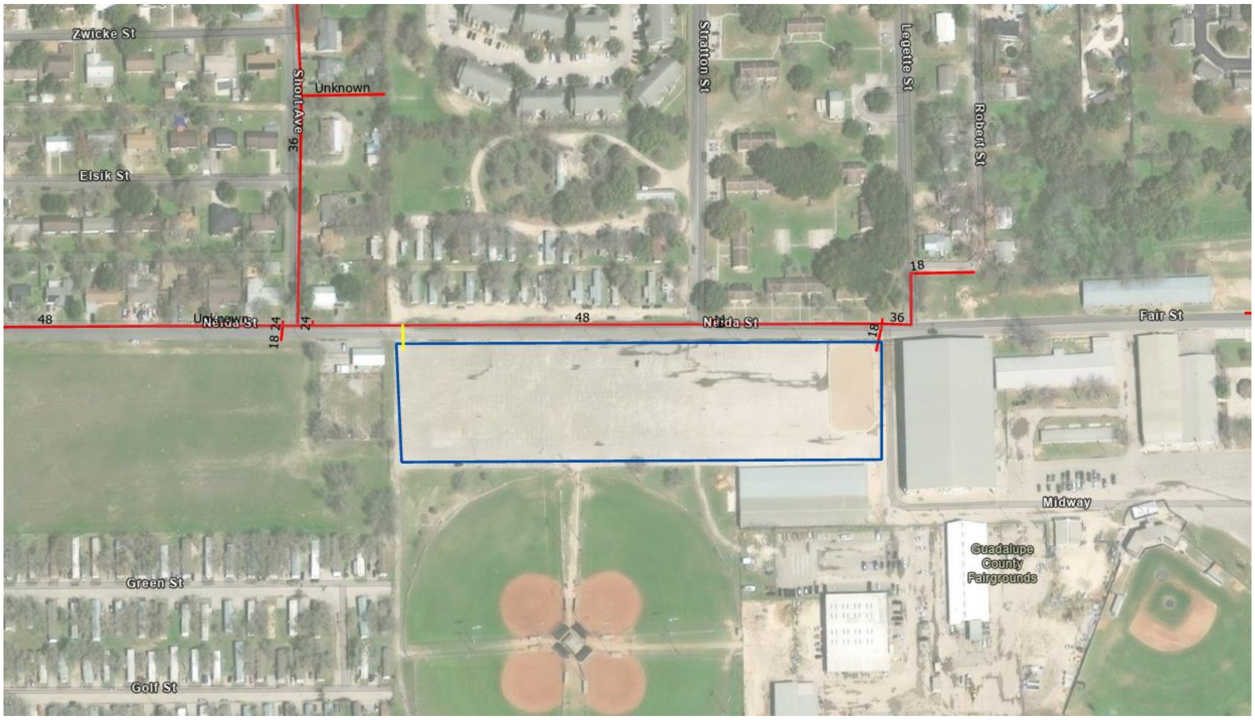


Figure 43. Risk Area KX Additional Detention Area

Another alternative project assessed for this risk area would involve proposed storm drain beginning on the far east side of Nelda St near Nelda and S Austin St and discharging into a proposed detention center within the empty lot near Nelda St and Boenig St. After reviewing existing ground elevations it was determined that this project would not be feasible due to increasing grade running east to west along Nelda St. In order to provide sufficient slope for the proposed storm drain the proposed detention facility would require depths exceeding 10.0 ft. Should this required depth be reached for the detention facility, storm drain cover requirements would constrain proposed storm drain sizes to a 24” or 36” RCP which would provide minimal benefit for this area. **Figure 44** below outlines the proposed storm drain alignment running east to west and the existing ground elevations along the alignment.

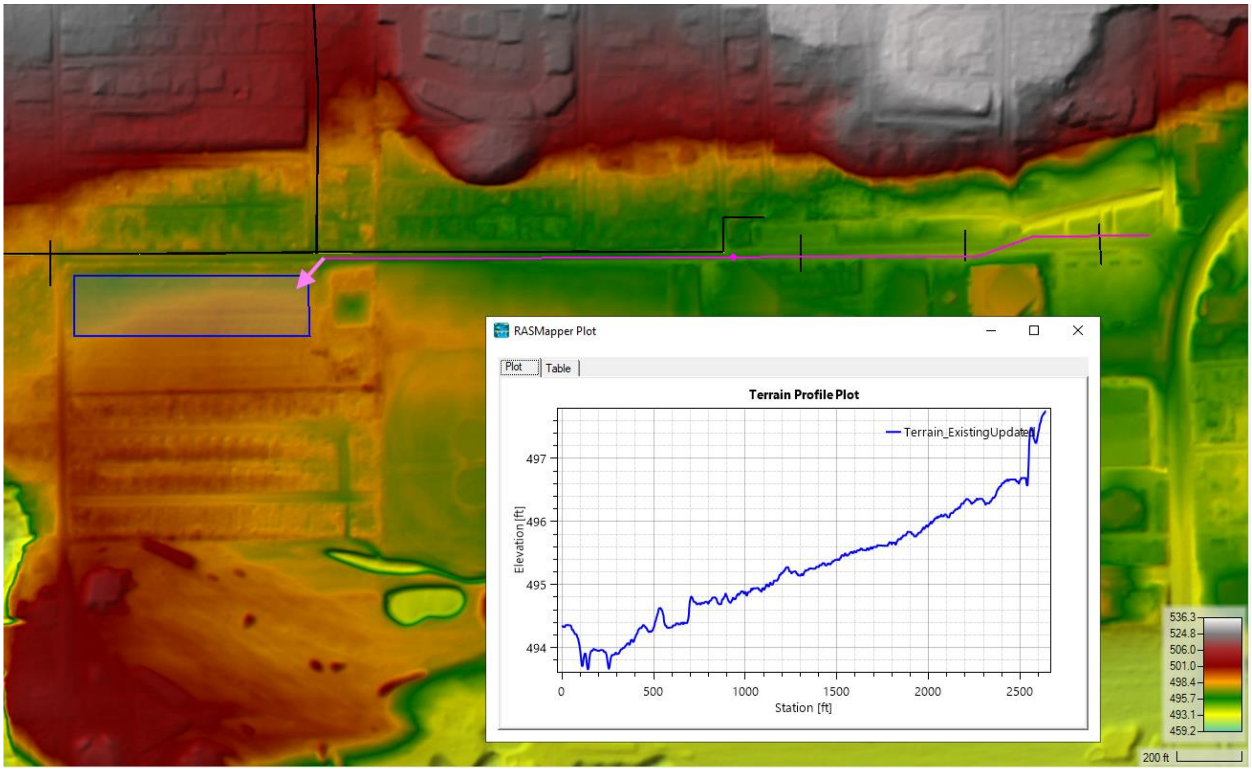
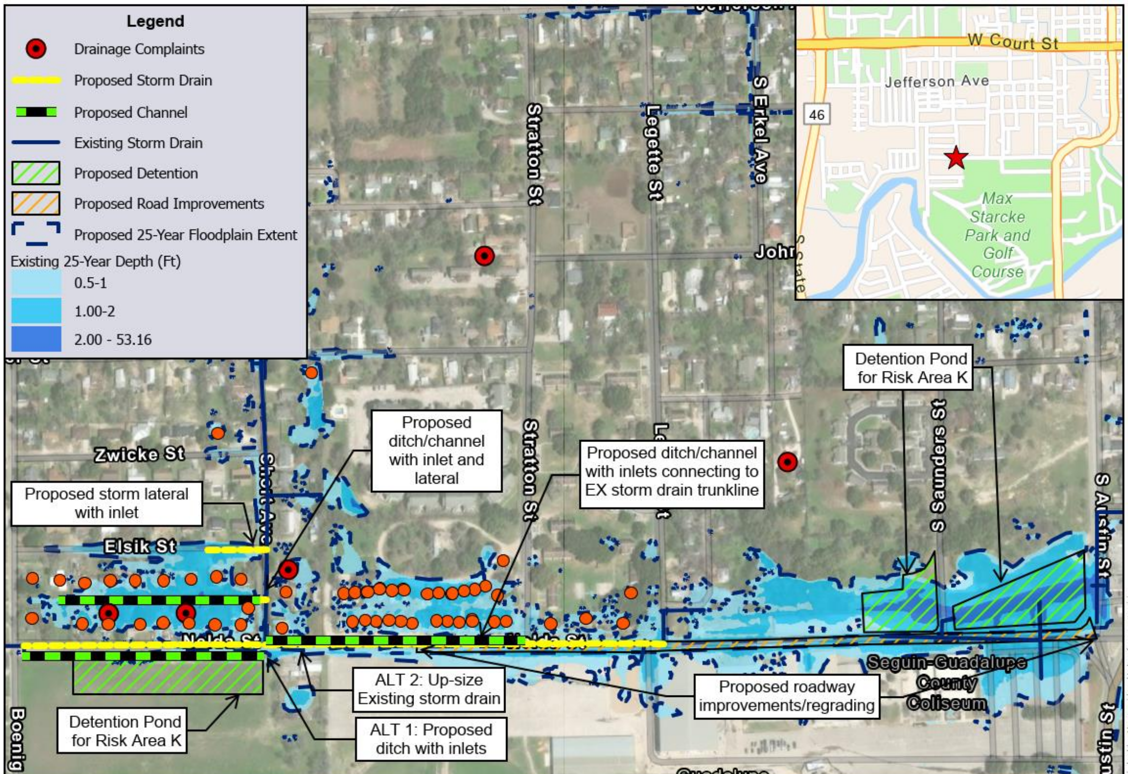


Figure 44. Nelda Sreet Ground Elevations

18.6.2 Benefits

Proposed projects within Risk Area K and Risk Area X serve to alleviate flooding on both the east and west side of Nelda St and the adjacent neighborhoods. Preliminary HEC-RAS modeling of the proposed projects show improvement in flood depths at the intersection of Short Ave and Nelda St. Road improvements including regrading and raising Nelda St 1.0’ – 1.5’ will allow the road to remain dry during the 25 - Year event. Due to the complexity of proposed projects and connection of existing and proposed storm drain systems, it is recommended to apply a more detailed analysis of this area using software capable of both 2D modeling and storm drain modeling, such as Infoworks ICM or XPSWMM. Additionally, HEC-RAS continues to see software updates in storm drain modeling capabilities and is expected to provide more usable and reliable storm drain features in the future. See **Exhibit 28** for an overview of proposed projects for Risk Area K and Risk Area X.



PROJECT DESCRIPTION/NOTES

Homes along Nelda St and Elsik St are at risk for flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Create ditches/channels in the alley behind the houses at Elsik St and Nelda St, with an inlet and lateral pipe connecting into the existing storm drain flowing south along Short Ave. (PHASE I)

2. Install a proposed lateral pipe at Elsik St connecting into the existing storm drain trunkline at Short Ave.
If needed, the following solutions can be included, as well. (PHASE I)

3. Create a ditch within the Nelda St ROW from Short Ave to Stratton Ave with inlets and laterals connecting into the existing storm drain system along Nelda St. Install detention center, or centers, in locations along S Saunders and west along Nelda St. (PHASE II)

4. Raise existing road elevations from S Austin St to 330 ft west of Stratton and Nelda St. Upsize existing storm drain network under Nelda St. (PHASE III)

ALT Channel:
Proposed southern channel along Nelda may extend south along Boenig St to discharge into a proposed conduit at Golf and Boenig St. and outfall into the Gudalupe River.

BENEFITS

- Reduces flood risk for homes along Elsik and Nelda St

- Reduces flood risk within Nelda St for traffic flow improvement during storm events

CHALLENGES

- Possible downstream impacts

- Downstream storm drain systems will need to be analyzed for capacity

- Construction impacts to homeowners

- Adverse impacts to elevating existing roadway will ned to be assessed

- Alternative channel and culvert along Boenig will require property acquisition

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City of Seguin Drainage Master Plan
Risk Area K & X
Nelda St from Boenig St to Legette St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

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Seguin Master Drainage Plan

Exhibit 28. Risk Area KX Project Map

18.6.3 Cost

A tentative project cost was calculated, and a breakdown of the associated costs can be found in **Table 18**.

Table 18. Risk Area K and X Expected Project Costs

Cost Type	Amount (in Millions)
Construction	2.63
ROW/Easement	0.13
Engineering and Testing	0.39
Utility Adjustments	0.13
Preliminary Engineering Report	0.26
Total	**$3.54**

18.6.4 Constraints

The main constraints associated with the proposed projects for these risk areas will include utility relocation and coordination with property owners. Construction phasing may be necessary for work along Nelda St to limit the impacts to traffic. Additionally, property acquisition will be necessary for detention improvements on the eastern side of Risk Area K. Further analysis will also be needed for the proposed storm drain to ensure any additional stormwater routing to existing systems will not cause capacity constraints.

18.7 Risk Area O – Burr Oak

18.7.1 Project Description

Risk Area O consists of the extension of Burr Oak to connect with Jay Rd. This area mainly consists of residential homes and open space. The main contributors to flooding in the area are due to the close proximity of the residential homes on Burr Oak to the floodplain along the unnamed tributary of Geronimo Creek, and the lack of adequate channel and storm drain infrastructure. These restrictions cause the area to flood during the 25-Year storm event and larger storm events.

When the flooding occurs in this area, the residents on Burr Oak have restricted access to their neighborhood due to Martindale Rd. It is recommended that Burr Oak be extended to connect with Jay Rd. The extension consists of approximately 1,075 ft of road extension, with associated curb and gutter, sidewalks, and right-of-way acquisition. A cross culvert with a minimum sizing of 2 - 24” pipes will be required to allow water to flow under the street extension. The recommendations described are shown in **Exhibit 29** below.

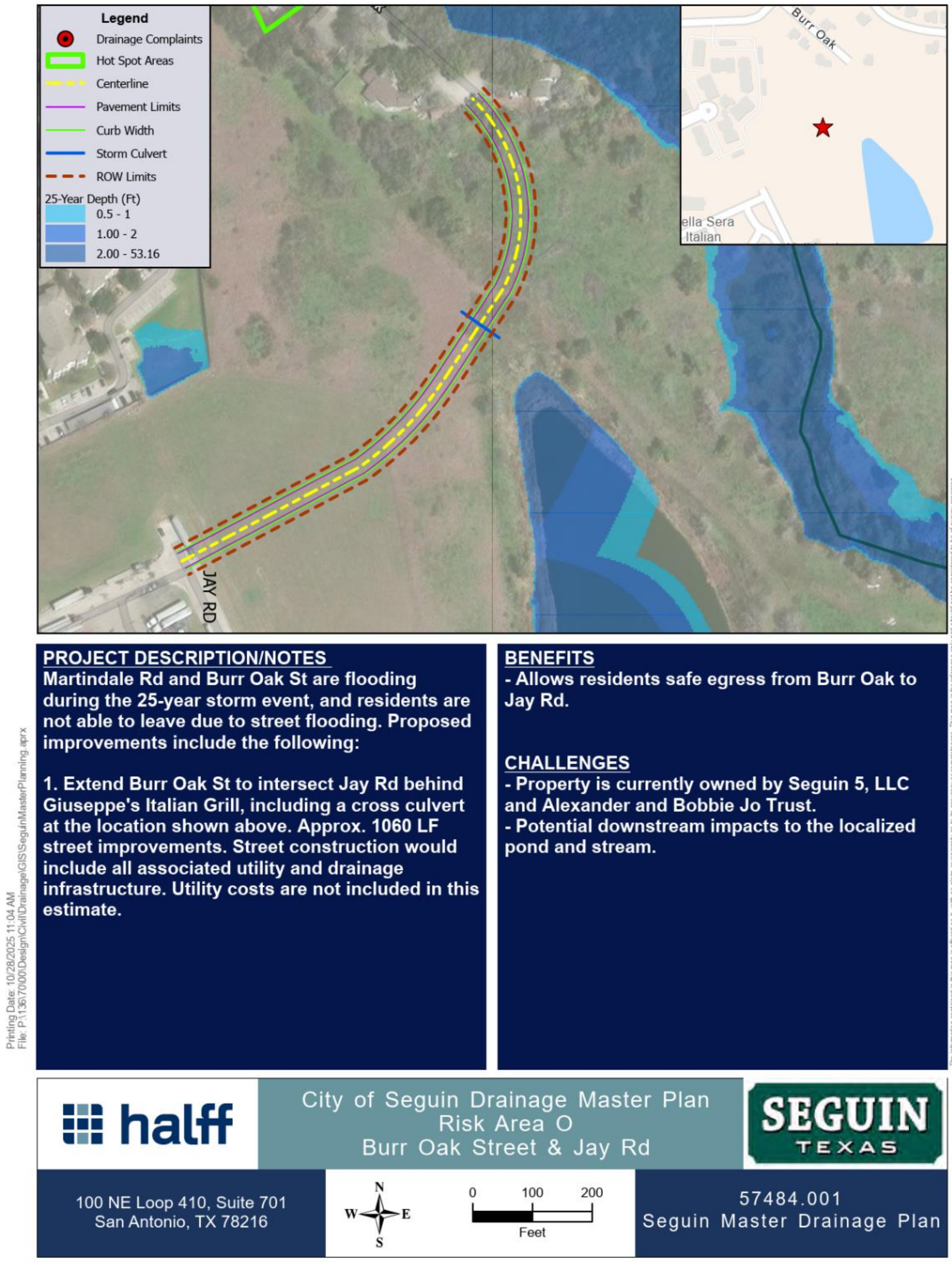


Exhibit 29. Risk Area O Project Map

18.7.2 Benefits

The recommended improvements allow residents egress from the current Burr Oak cul-de-sac to Jay Rd during flooding conditions.

18.7.3 Cost

An approximate opinion of probable cost was calculated, and a breakdown of the associated costs can be found in **Table 19** below.

Table 19. Risk Area O Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.32
ROW/Easements	0.56
Engineering and Testing	0.20
Utility Adjustments	0.70
Total	**$2.78**

18.7.4 Constraints

Construction of the new right-of-way is directly in front of residential structures which may pose a construction constraint. Additionally, the property that this road extension would be built on is currently owned by Seguin 5, LLC and Alexander and Bobbie Jo Trust, so right-of-way acquisition would be required. Associated utility extensions (water, wastewater, gas, electric, telecom) may be required, as well. Potential downstream impacts from the proposed street have not been studied and should be analyzed with detailed design. The improvements also do not improve drainage along Burr Oak from the cul-de-sac to Martindale.

18.8 Risk Area P – Twin Oak Rd Low Water Crossing

18.8.1 Project Description

Risk Area P includes a low water crossing located at Twin Oak Rd and crosses an unnamed tributary of Geronimo Creek. According to the HEC-RAS 2D model, the roadway is overtopped by the 25-Year storm event with water reaching up to 2.0’ encroaching into homeowner’s backyards. Twin Oak Rd serves as the primary access route for the Oak Village North neighborhood, and for several residents, it is the only paved route to their property. Due to this crossing becoming inundated by the 25-Year storm event, access and safety concerns can occur for people who live on the east side of the crossing.

Furthermore, the 25-Year WSEL is encroaching on properties located upstream of the low water crossing. To remedy this, it is recommended to replace the existing 2 – 48” RCPs with 3 – 6’x4’ RCBs and regrade and elevate the existing crossing by 1.5’. In addition, other improvements would include removing the existing stone-lined roadside ditch and HDPE located at the northwest end of the low water crossing and regrade the roadside ditch for more effective drainage to the tributary.

18.8.2 Benefits

The main benefits from proposed projects for Risk Area P are reductions in floodwaters along Twin Oak Rd. Preliminary HEC-RAS modeling results show Twin Oaks Rd to be completely dry for the 25 - Year storm event, allowing residents continued access in and out of the neighborhood.

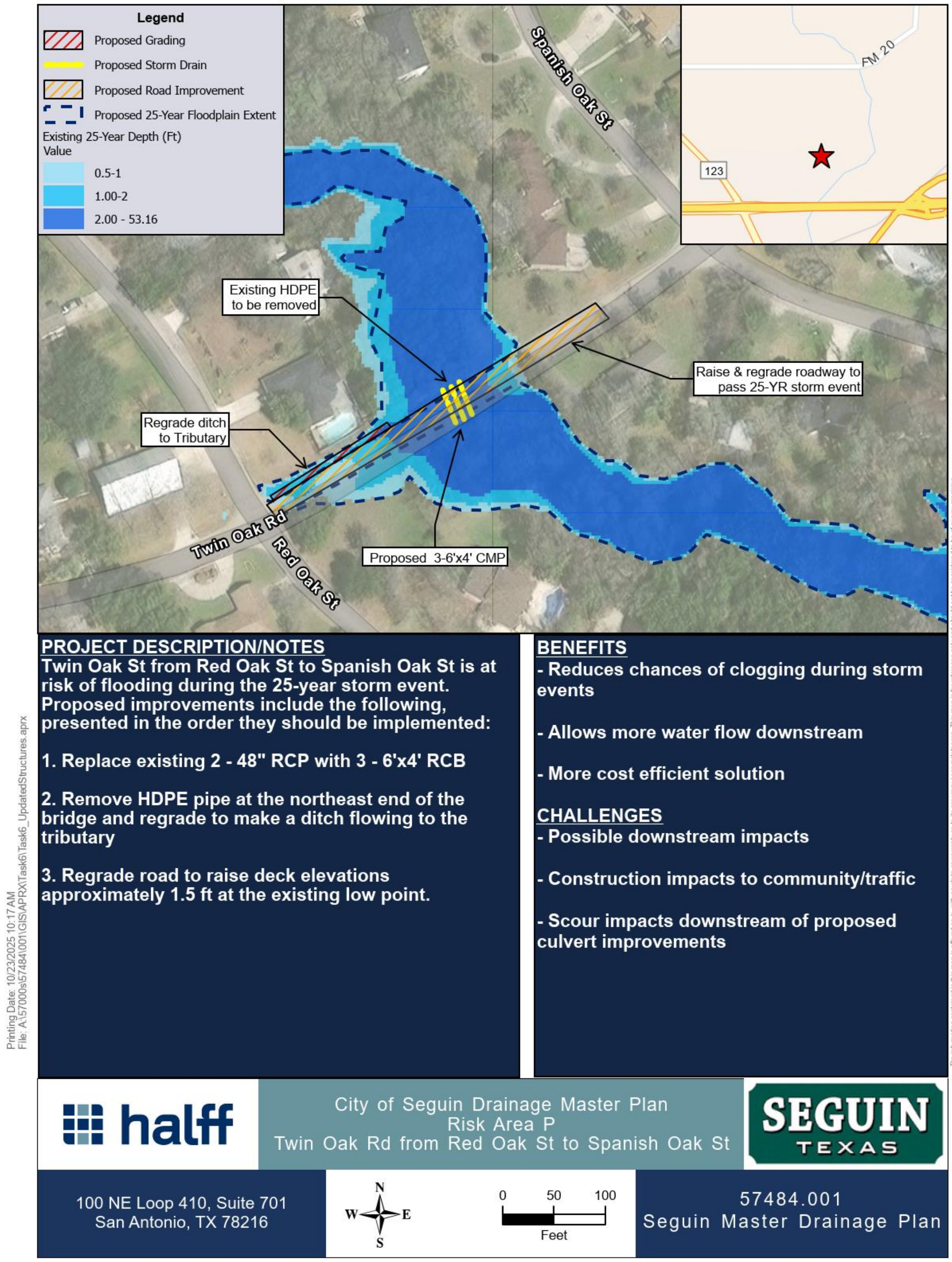


Exhibit 30. Risk Area P Project Map

18.8.3 Cost

An approximate opinion of probable cost was calculated, and a breakdown of the associated costs can be found in **Table 20** below.

Table 20. Risk Area P Expected Project Costs

Cost Type	Amount (in Millions)
Construction	0.19
ROW/Easement	0.01
Engineering and Testing	0.03
Utility Adjustments	0.01
Total	**$0.24**

18.8.4 Constraints

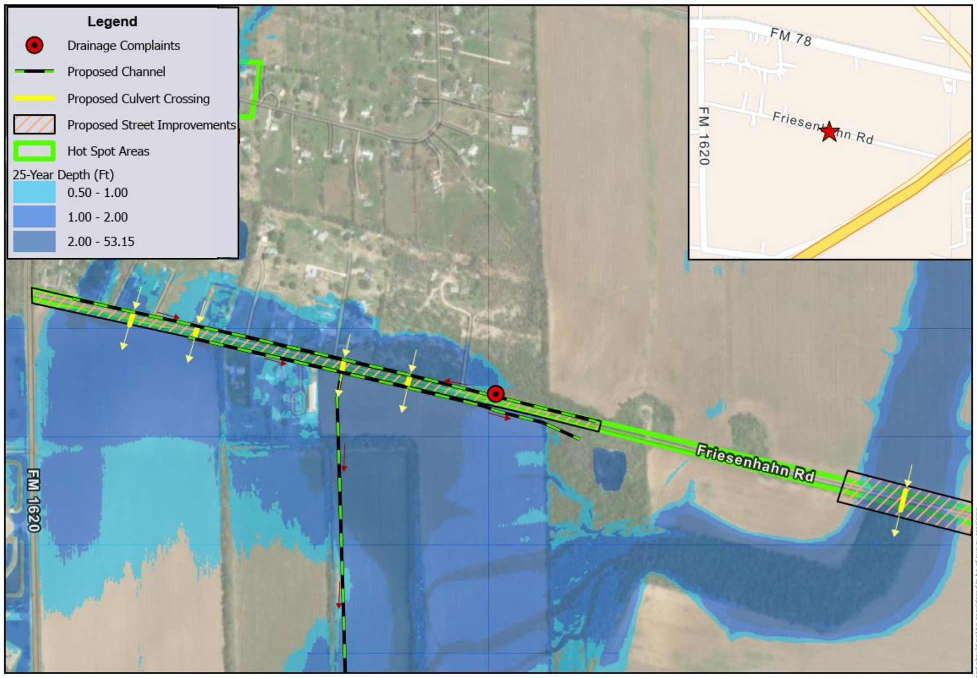
Project constraints will mostly consist of accessibility limitations due to reconstruction of the low water crossing. During construction, residents on the east side of the crossing will not have a direct paved route to their homes. A new temporary route will need to be constructed to the north connecting Red Oak St to Spanish Oak St beforehand if there is not another existing route located to the south of Twin Oak Rd. Additionally, a downstream impacts analysis will need to be performed to ensure there are no impacts to Geronimo Creek due to the proposed drainage improvements upstream. Potential increases in WSEL's and velocities will need additional assessment for impacts to residential properties and to the stream itself from scour and erosion.

18.9 Risk Area S – Friesenhahn Rd

18.9.1 Project Description

The Friesenhahn Road project consists of establishing right-of-way, elevating the roadway, adding channels to both sides of the road, adding multiple culvert crossings, and cutting a relief channel to allow water to flow south. The area consists largely of open space and sparse residential homes. The main contributors to flooding in the area are due to lack of proper grading and drainage. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area the Friesenhahn Roadway must be raised an average of 2.0' for approximately 0.5 miles starting at FM 1620. Additionally, roadside channels need to be added on both sides of the roadway to reduce flood depths from the residential area. The northern channel will have a 12.0' bottom width with 3:1 side slopes and an average depth of 2.5'. The southern channel will have a 10.0' bottom width with 3:1 side slopes and an average depth of 1.5'. A total of five culvert crossings is required to allow water to travel through the roadway. Three of the four western crossings will each be 3 - 6' x 2' box culverts with the remaining crossing consisting of 7 - 6' x 2' box culverts. The eastern crossing will be 12 - 12' x 6' boxes. Finally, the relief channel will be cut to allow flood waters to flow south and consist of a 50' bottom width with 3:1 side slope. The recommendations described are shown in **Exhibit 31** below.



PROJECT DESCRIPTION/NOTES

Friesenhahn Road is flooded during the 25-year storm event, residents have limited access due to street flooding. Proposed improvements include the following:

1. Raise Friesenhahn Roadway an average of 2'

2. Add roadside ditches/channels on western improvements to both sides of Friesenhahn Rd.

3. Add three sets of 3~6'x2' box culverts and one set of 7~6'x2' box culverts to the western portion of improvements

4. Add relief channel flowing south consisting of a 50' bottom width, 3:1 side slopes, and an average depth of 3'.

5. The eastern portion of improvements consist roadway improvements and 12~12'x6' box culverts.

BENEFITS

- Allows residents to have un-flooded access during 25-year storm event, and potential cautionary passage during the 100-year event.

CHALLENGES

- Potential downstream impacts.
- Connecting residential streets and driveways may need improvements or replacement.
- Alternate routes and temporary streets may have to be provided to allow access.
- Right of way acquisition.

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City of Seguin Drainage Master Plan
Risk Area S
Friesenhahn Rd from FM 1620 to the Creek

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

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Seguin Master Drainage Plan

Exhibit 31. Risk Area S Project Map

18.9.2 Benefits

The recommended improvements allow for reduced flood depths and provide cautionary access for residents to evacuate under flooding conditions. These benefits are shown in **Figure 45** below. Colors showing orange, yellow, or red indicate adverse impacts with increased flood depths resulting from proposed improvements. Colors showing blue or green indicate improvements in flooding with reduced water depths.

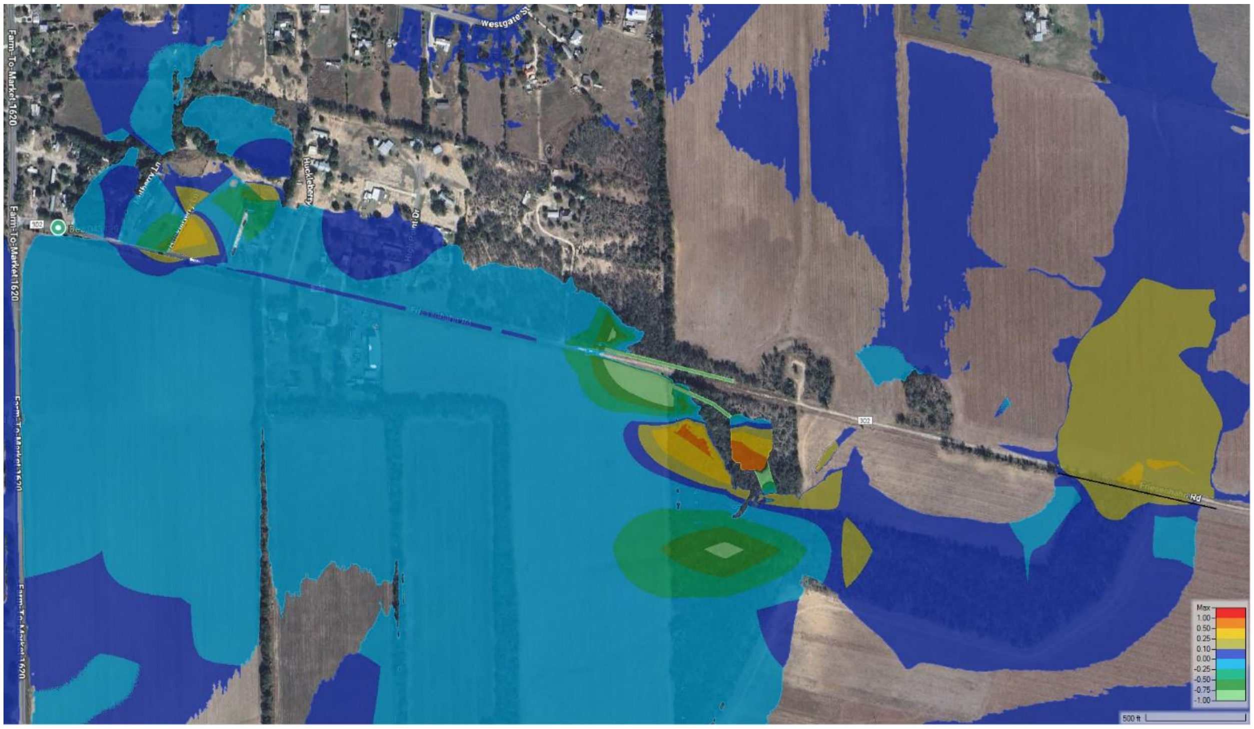


Figure 45. Change in 25-Year Flood Depth (Proposed – Existing) Around Friesenhahn Road

18.9.3 Cost

A cost estimate was calculated, and a breakdown of the associated costs can be found in **Table 21** below.

Table 21. Risk Area S Expected Project Costs

Cost Type	Amount (in Millions)
Construction	5.71
ROW/Easement	1.53
Engineering & Testing	0.86
Utility Adjustments	0.29
Preliminary Engineering Report	0.57
Total	**$8.95**

18.9.4 Constraints

Reconstruction of Friesenhahn Road near residential structures may pose a construction constraint as residents may need alternate routes to access the area. Right-of-way may need to be obtained to account for grading associated with raising the street and cutting relief channels. Utility relocation or replacements for water, wastewater, gas, electric, and telecom may also need to take place. Additionally, connecting residential streets and driveways may need improvement or replacement.

18.10 Risk Area T – E Cedar St

18.10.1 Project Description

Risk Area T focuses on the eastern section of Cedar St near Seguin High School. Structural flooding is of lower concern within this risk area. Flood modeling shows flood depths up to 2-ft at the intersections of E Cedar St and Lamar Dr and E Cedar St and Cardinal Ln. Higher flood depths were also identified in the north parking lot of the Performing Arts Center located at 1315 E Cedar St.

StormCAD and HEC-RAS 2D rapid assessment modeling highlight the section of E Cedar St between Lamar Dr and Cardinal Ln as the most flood prone area within the risk area. Ground elevations within this section of road slope inward from both the east and west creating a low point for water to drain into. StormCAD results show the entire storm drain network beginning at Canary Ln and outfalling into a concreate channel just southwest of the baseball fields at Seguin High School reaches capacity during the 5-Year storm event.

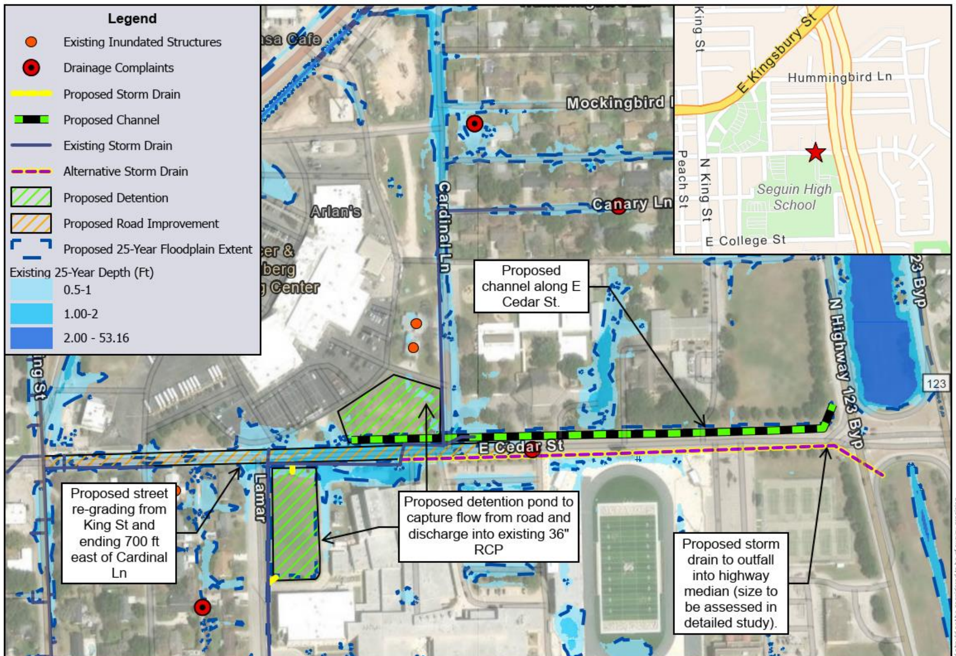
Proposed improvements include a trapezoidal channel along the north side of E Cedar St to capture and drain stormwater east and through N Hwy 123 Bypass and into the existing roadside ditch and a detention center just southeast of E Cedar St and Lamar to relieve and provide additional capacity to the existing storm drain along E Cedar and Cardinal Ln. An additional detention center can also be implemented just south of the Seguin Independent School District office building (SISD). The proposed detention centers will discharge back into the existing storm drain system running south along Lamar or west along E Cedar St. An alternative storm drain conduit running east along Cedar St. and discharging into the median area along the N Highway 123 Bypass could provide considerable flood improvement for the risk area. More detailed analysis for this alternative is needed and should be pursued should project development be considered for this area.

Underground detention along E Cedar St was considered, but due to elevation limitations with the existing storm drain, was determined to be unfeasible. Existing storm drain inverts would allow for box culverts up to 3.0' in height which would not provide enough storage to warrant construction costs and impacts.

Additionaly, another alignment of the alternative storm drain system along Cedar St may be pursued by extending the outfall point to the unnamed tributary just northeast of Middletowne Rd. **Figure 46** outlines this extended alignment.

18.10.2 Benefits

Benefits from proposed projects for Risk Area T focus on reducing flooding along E Cedar St and Cardinal Ln. Preliminary model results from HEC-RAS show floodplain reductions at multiple areas along these two roads but not complete flood depth reductions. Further analysis is needed with more detailed modeling to properly model the interaction these proposed solutions have with one another. The proposed detention north of E Cedar St serves as another potential location for detention improvements. The Proposed storm drain network running east on E Cedar St was not included in the risk area modeling scenario and can be expected to further reduce flooding along the roadway.



PROJECT DESCRIPTION/NOTES

Multiple locations encounter ponding on E Cedar between FM 466 N King St and SH 123 B during the 25-Year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Construct channel to drain west to east along E Cedar St from Mercer & Blumberg Learning Center field to the inlet at N Highway 123 Bypass. Regrade section of E Cedar to convey flow into proposed channel. (PHASE I)

2. Incorporate empty field at Seguin High school as a detention area. Pond will discharge back into 36" RCP along Lamar St. Alternative pond location north east can be added separately or in combination. (PHASE II)

3. Combine Alternatives 1 & 2.

Alternative Storm Drain:
Construct storm drain to drain ponding at Cedar and Lamar and discharge into Highway 123 Bypass median.

BENEFITS

- Reduces flood risk within E Cedar St for traffic flow improvement during storm events

- Improves rate of water leaving area reducing time of ponding

CHALLENGES

- Utility conflicts along E Cedar St.

- Downstream storm drain systems will need to be analyzed for capacity

- Traffic routing during construction.

- Coordination with Seguin High School for detention pond construction.

- Seguin Independent School District outdoor training course will need to be relocated for pond construction

- Alternative drain to require coordinate with TXDOT

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City of Seguin Drainage Master Plan
Risk Area T
E Cedar St from N Hwy 123 Bypass to Lamar St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

N W E S

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Seguin Master Drainage Plan

Exhibit 32. Risk Area T Project Map

Figure 46. Alternative Alignment from East Cedar to Middletown Road

18.10.3 Cost

A cost estimate was calculated, and a breakdown of the associated costs can be found in **Table 22** below. These costs to not take into account the alternative storm drain proposed to route water east along E Cedar St.

Table 22. Risk Area T Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.45
ROW/Easement	0.07
Engineering & Testing	0.22
Utility Adjustments	0.07
Preliminary Engineering Report	0.15
Total	**$1.96**

18.10.4 Constraints

Expected constraints for proposed projects in this risk area include utility relocation and traffic impacts. Coordination with Seguin High School will likely be required for any detention improvements on the adjacent open parcel along Lamar. The second proposed detention facility will also require relocation of the outdoor training facility south of the SISD office building. Additionally, any improvements developed from the proposed channel will require driveway improvements for the Faith Lutheran Church and Faith Lutheran Church. Further analysis of the proposed channel will be required to ensure no additional stormwater will inundate the roadway at the channel outfall near E Cedar St and N Highway 123 Bypass. Should the proposed storm drain running east along E Cedar St be considered, coordination with TXDOT will be require for and construction occurring on the N Highway 123 Bypass.

Should the storm drain alignment in Figure 6 be pursued, additional coordination will be required with TxDOT. Additionally, adverse impacts within the unnamed tributary as a result of project improvements will need to be assessed.

18.11 Risk Area U – Middletowne Rd

18.11.1 Project Description

The Middletowne Rd project consists of adding storm drains under Middletowne Road from the intersection with Fairfax Circle to Townesend. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are an insufficient number of inlets and undersized storm drain pipe. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area, a series of proposed storm drain pipe improvements should be implemented. The existing 36" pipe on Townesend from the existing 54" to the corner of Middletowne and Townesend should be removed and replaced with a 48" pipe. The 18" pipe traversing the cul-de-sac at the Middletowne and Townesend intersection should be removed and replaced with a 42" pipe. The other 18" pipe traversing the cul-de-sac to the corner should be removed and replaced with a 24" pipe. A 30" pipe should be installed on Middletowne Rd from the existing system at Townesend Rd to Fairfax Circle with a curb inlet at the Fairfax Cir intersection, and possibly additional inlets between Fairfax Circle and Townesend Rd. During detailed design, storm drain sizes can be optimized, including possibly using 24" pipe for a portion of the system. For the purposes of preparing opinions of probable cost, 30" pipe was assumed. Pedestrian sidewalk improvements are also recommended along Middletowne Rd and Townesend Rd. The recommendations described are shown in **Exhibit 33** below.

Exhibit 33. Risk Area U Middletown Project Map

18.11.2 Benefits

The recommended improvements increase inlet capacity and storm drainage capacity, thereby improving drainage along Middletowne. Improved pedestrian mobility is also a benefit. Storm drain profiles are shown in **Figure 47** and **Figure 48** below. Note that the exaggerated hydraulic grade lines at the upstream end of the existing profile indicates the storm drain and is undersized and does not actually indicate that level of surcharge.

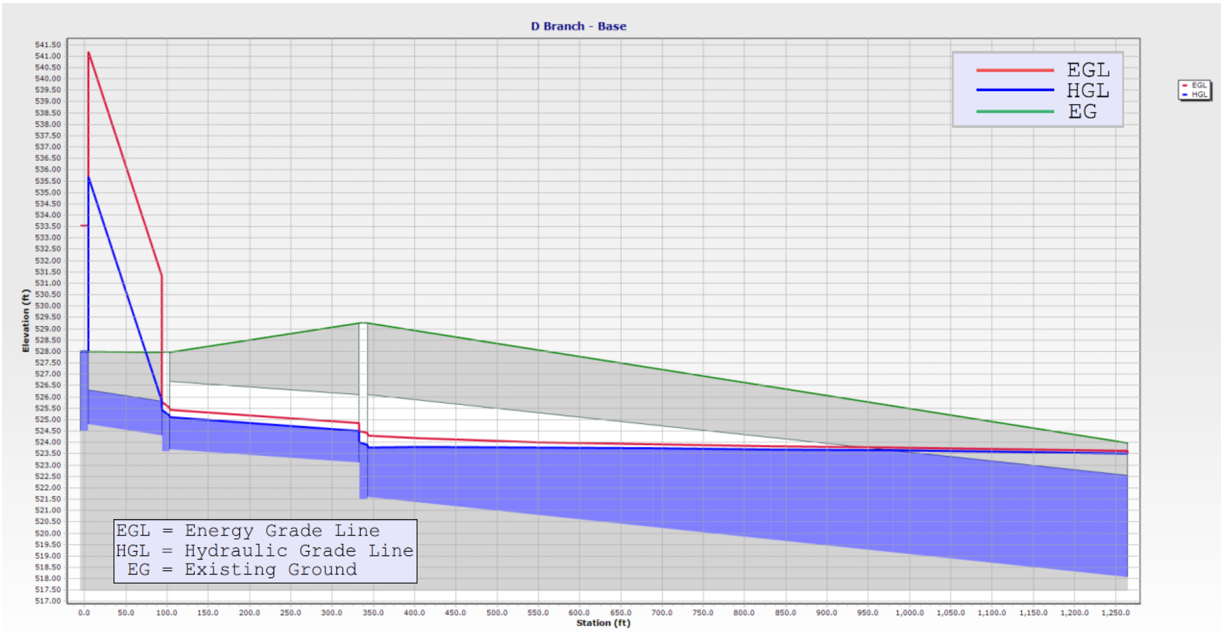


Figure 47. Risk Area U Middletown Road Existing Profile

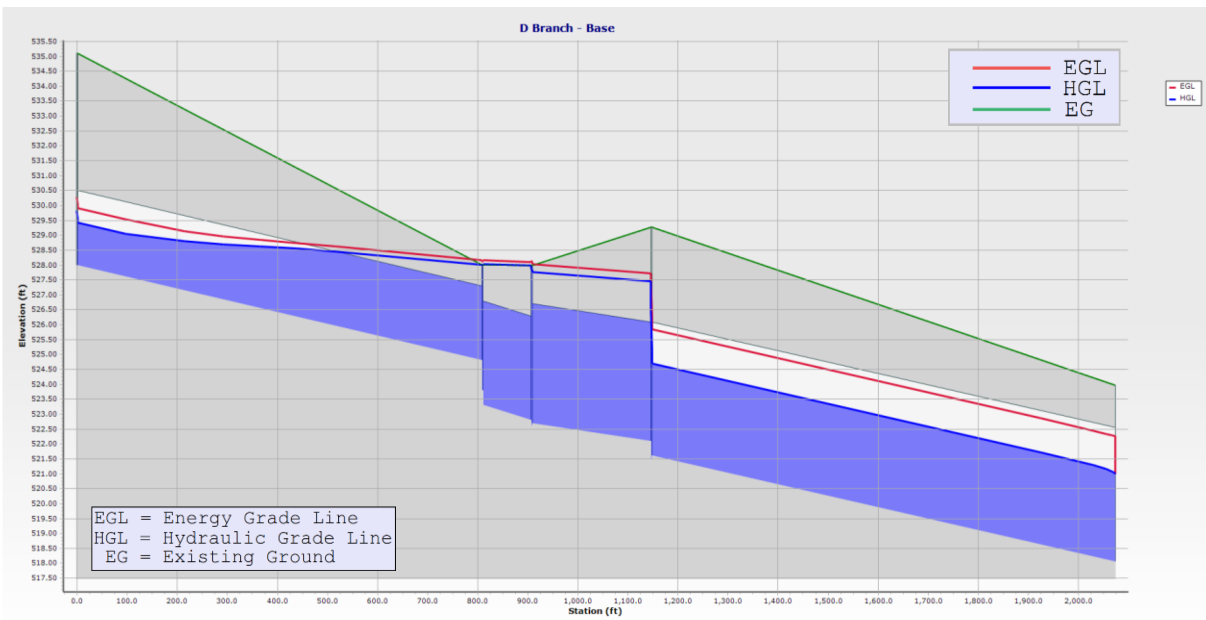


Figure 48. Risk Area U Townsend Road Proposed Profile

18.11.3 Cost

An approximate opinion of probable cost was calculated, and a breakdown of the associated costs can be found in **Table 23** below.

Table 23. Risk Area U Middletowne Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.32

ROW/Easement	0.00
Engineering and Testing	0.20
Utility Adjustments	0.07
Preliminary Engineering Report	0.13
Total	**$1.72**

18.11.4 Constraints

To account for the storm drain upsizing and installation, the streets may need to be reconstructed. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. The proposed construction is in front of residential structures which may pose a construction constraint, to be mitigated during design. This project is further benefited from downstream improvements along Townesend Road. The downstream impact of this project at the outfall in the channel along E Walnut St was not studied and may require additional research as part of detailed design.

18.12 Risk Area U – Oldtowne Rd

18.12.1 Project Description

The Oldtowne Rd project consists of upsized storm drains under Oldtowne Rd and Townesend Rd. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are an insufficient number of inlets and undersized storm drain pipe. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area, a series of proposed storm drain pipe improvements should be implemented. Install a 36" storm drain connecting to the existing system from Townesend Rd to the bend of Oldtowne Rd. Install an additional 30" storm drain from the bend of Oldtowne Rd to across from the knuckle on Oldtowne Rd. Install curb inlets along Oldtowne Rd between Townesend and the Oldtowne knuckle. Pedestrian sidewalk improvements are also recommended. The recommendations described are shown in **Exhibit 34** below.

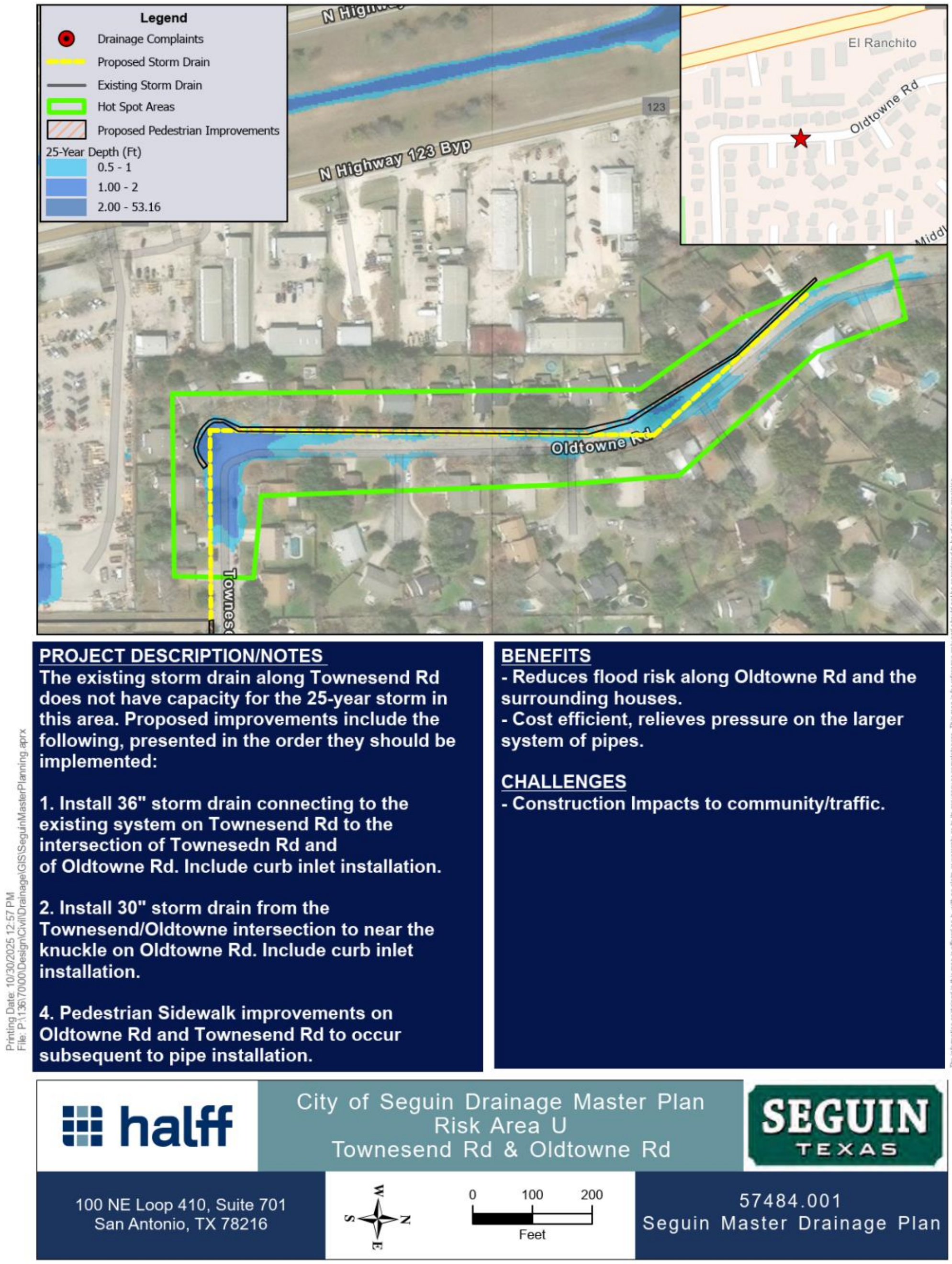


Exhibit 34. Risk Area U Oldtown Project Map

18.12.2 Benefits

The recommended improvements increase inlet capacity and storm drainage capacity, thereby improving drainage along Oldtowne. Pedestrian mobility will be improved with added sidewalks. Storm drain profiles are shown in **Figure 49** and **Figure 50** below.

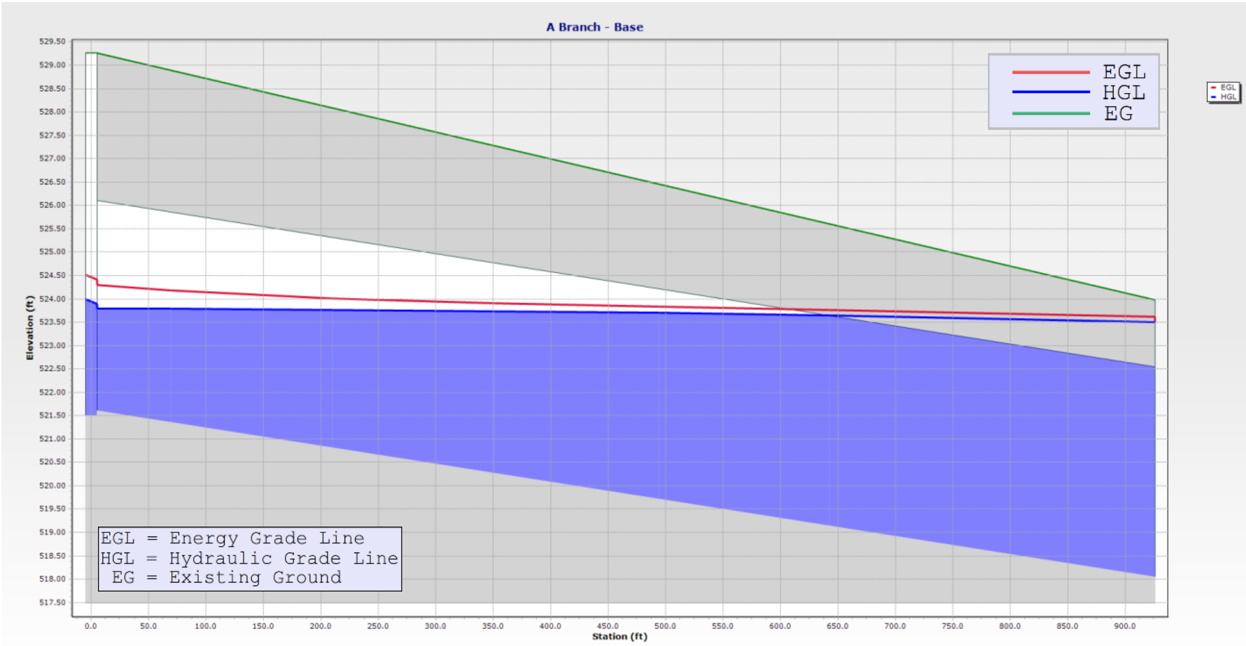


Figure 49. Oldtowne Road Existing Profile (25-YR Storm Event)

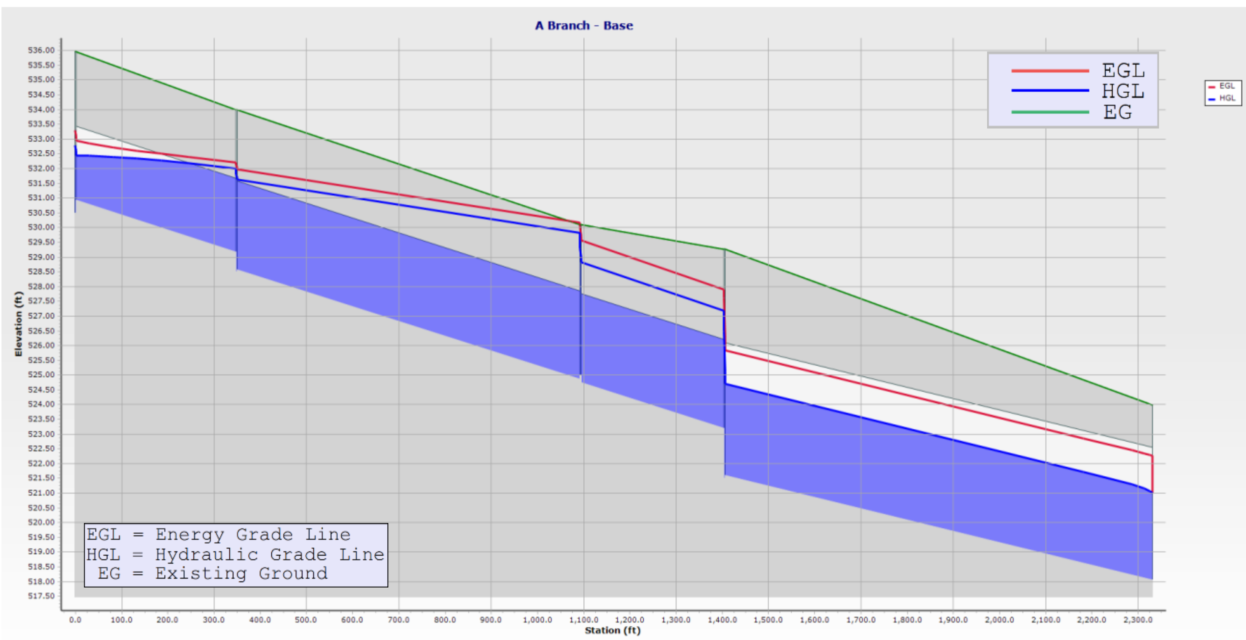


Figure 50. Oldtowne Road Proposed Profile (25-YR Storm Event)

18.12.3 Cost

An approximate opinion of probable cost was calculated, and a breakdown of the associated costs can be found in **Table 24** below.

Table 24. Risk Area U Oldtowne Road Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.47
ROW/Easement	0.00
Engineering and Testing	0.22
Utility Adjustments	0.07
Preliminary Engineering Report	0.15
Total	**$1.91**

18.12.4 Constraints

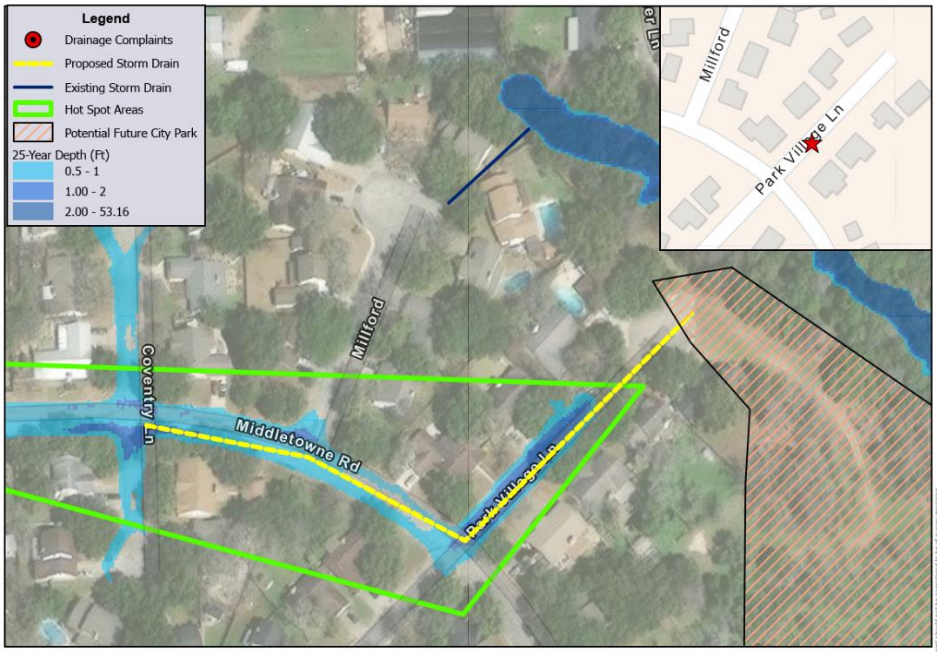
To account for the storm drain installation, the streets will may need to be reconstructed. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. The proposed construction is in front of residential structures which may pose a construction constraint, to be mitigated during design. The downstream impact of this project at the outfall in the channel along E Walnut St was not studied and may require additional research as part of detailed design.

18.13 Risk Area U – Park Village Ln

18.13.1 Project Description

The Park Village Ln project consists of storm drains under Park Village Lane and Middletowne Road. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are due to lack of underground or channel infrastructure along Park Village Lane and relatively minimal slopes on Middletown Road. The street currently drains via an inverted crown from Middletowne Rd to the low area downstream of Park Village. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area, a series of proposed storm drain pipe improvements should be implemented. Improvements considered include installing a 24” storm drain from the intersection of Middletowne Rd and Coventry Ln to the cul-de-sac of Park Village Ln, grading a shallow channel from Park Village Lane to the downstream unnamed Tributary to Walnut Creek, and installing center street grate inlets at each junction for the proposed pipe. An alternate option would be to regrade the street with a crown and curb inlets. The recommendations described are shown in **Exhibit 35** below.



PROJECT DESCRIPTION/NOTES

Middletowne Rd and Park Village Rd are flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Install 24" storm drain from the intersection of Park Village and Middletowne northeast through the cul-de-sac. Grade a shallow channel downstream to the unnamed tributary of Geronimo Creek.

2. Install 24" storm drain on Middletowne from Park Village to Coventry.

3. Install inlets at:
- Coventry Ln and Middletowne Rd.
- Middletowne Rd and Park Village Ln.

BENEFITS
- Reduces flood risk along Middletown Rd, Coventry Ln, and Park Village Ln.
- Cost efficient, mostly isolated solution.
-Connects to Future City of Seguin Park.

CHALLENGES
- Construction Impacts to community/traffic.
- Impacts a small number of houses.

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City of Seguin Drainage Master Plan
Risk Area U
Park Village Lane &
Middletowne Rd to Coventry Ln

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100 NE Loop 410, Suite 701
San Antonio, TX 78216

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Seguin Master Drainage Plan

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Exhibit 35. Risk Area U Park Village Project Map

18.13.2 Benefits

The existing centerline swale on Park Village Ln is undersized and ends in sawtooth curb at the cul-de-sac of the street. The recommended improvements increase positive drainage down Park Village Road to the outfall at a tributary of Geronimo Creek. In turn, this will alleviate flooding potential in and around Risk Area U. The storm drain profile is shown in **Figure 51** below.

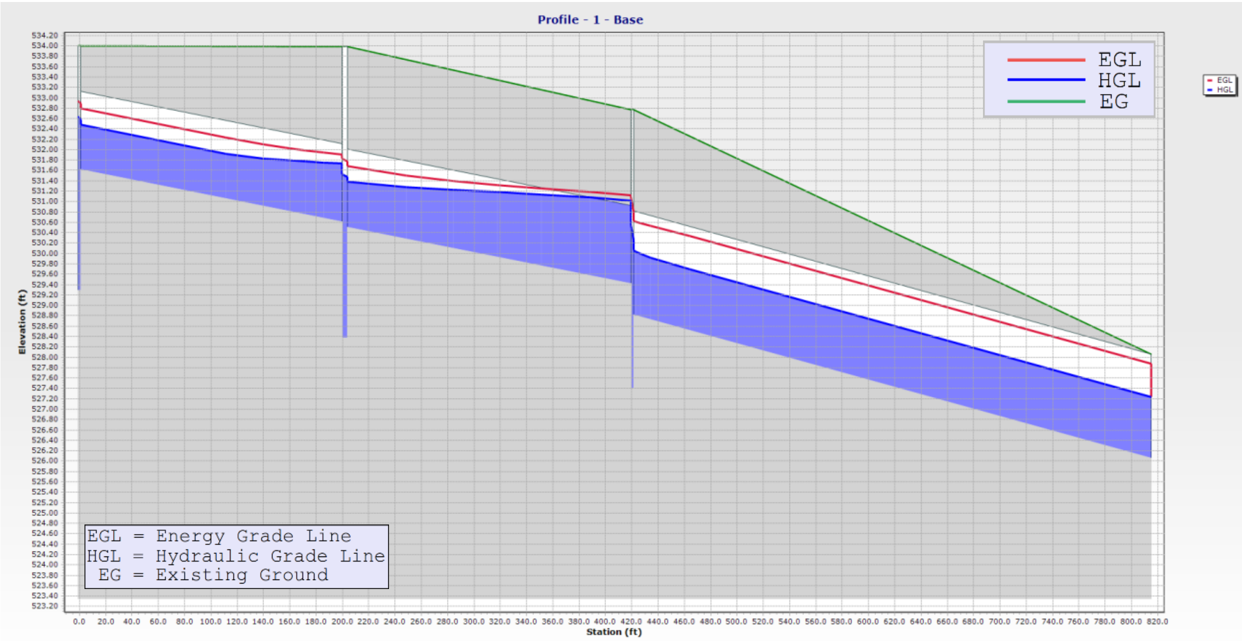


Figure 51. Proposed Park Village Lane Pipe Profile (25-YR Storm Event)

18.13.3 Cost

A tentative cost was calculated, and a breakdown of the associated costs can be found in **Table 25** below.

Table 25. Risk Area U Park Village Expected Project Costs

Cost Type	Amount (in Millions)
Construction	0.55
ROW/Easements	0.06
Engineering and Testing	0.08
Utility Adjustments	0.03
Total	**$0.72**

18.13.4 Constraints

To account for the storm drain installation, the streets may need to be reconstructed. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. The proposed construction is in front of residential structures which may pose a construction constraint, to be mitigated during design. The downstream impact of this project at the outfall in the tributary of Geronimo Creek was not studied and may require additional research as part of detailed design.

18.14 Risk Area W – Sunbelt Rd

18.14.1 Project Description

The Sunbelt Rd project consists of elevating the street, upsizing the culvert crossing, and channel improvements. The area consists largely of open space and sparse residential homes. The main contributors to flooding in the area are due to low street elevations and an undersized culvert crossing relative to the floodplain. These restrictions cause the area to flood during the 25-year storm event.

To maintain unflooded access, the Sunbelt Roadway should be raised to an elevation of 523.40’ from its existing elevation of approximately 519.60’. Additionally, to allow for water to pass and to not cause adverse impact upstream of Sunbelt Rd, the culvert crossing below Sunbelt Rd needs to be upsized from 3 - 42” pipes to 5 - 6’ x

4’ RCBs. Finally, channel improvements around Sunbelt Rd are needed to allow additional flow into and from the proposed box culverts. The recommendations described are shown in **Exhibit 36** below.

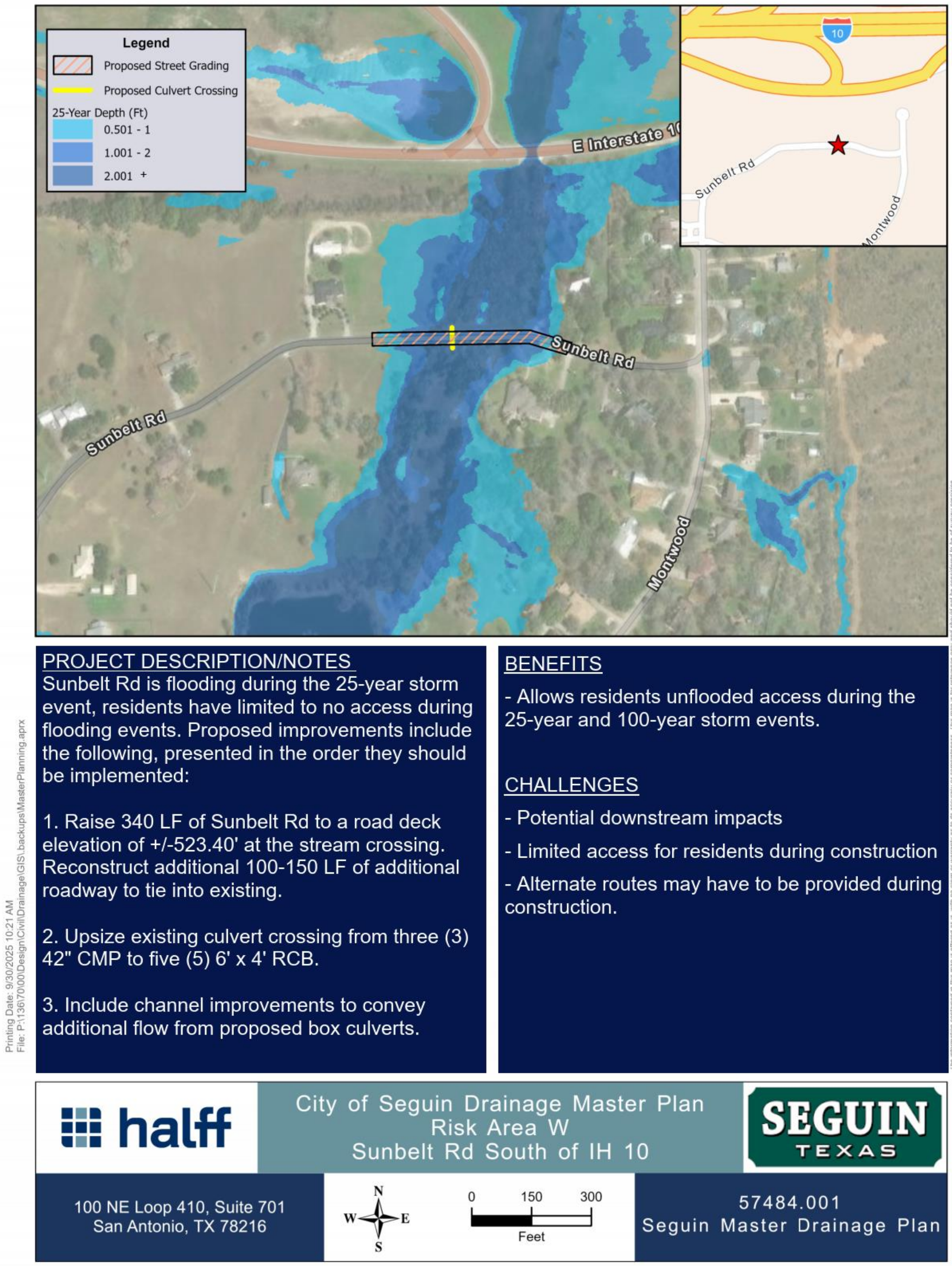


Exhibit 36. Risk Area W Project Map

18.14.2 Benefits

The recommended improvements allow residents to evacuate under flooding conditions. These benefits are shown in **Figure 52** below. Green indicates slight reductions in flood depths while yellow and red colors indicate higher flood depth reductions.

Figure 52. Risk Area W Flood Depth Reductions

18.14.3 Cost

A tentative cost was calculated, and a breakdown of the associated costs can be found in **Table 26** below.

Table 26. Risk Area W Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.13
ROW/Easement	0.17
Engineering & Testing	0.17
Utility Adjustments	0.06
Preliminary Engineering Report	0.11
Total	**$1.64**

18.14.4 Constraints

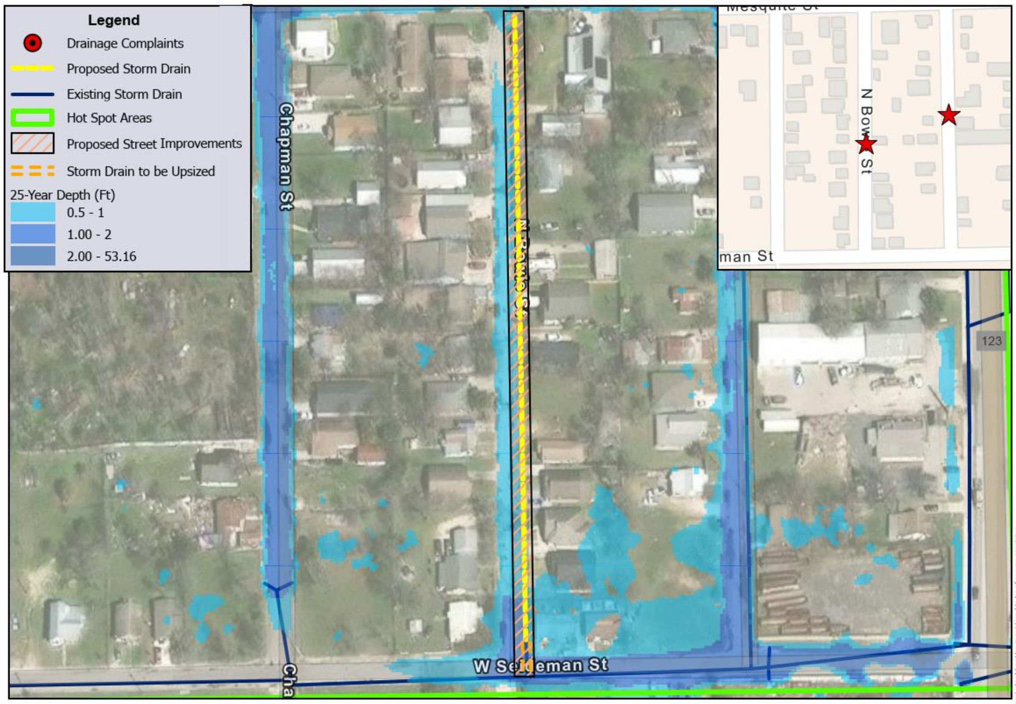
Reconstruction of the street is near residential structures which may pose a construction constraint as residents may need an alternate route. Right-of-way may need to be obtained to account for grading associated with raising the street. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. Additionally, connecting residential streets and driveways may need improvements. Additionally, downstream impacts of the upsized culverts and channel improvements were not studied.

18.15 Risk Area Y – Bowie St

18.15.1 Project Description

The Bowie St project consists of adding storm drains under only Bowie St. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are due to a lack of inlets along Bowie and an undersized curb inlet at the Bowie St and Seideman St intersection. These restrictions cause parts of the area to flood during the 25-year storm event.

To alleviate flooding in the area a series of proposed pipe improvements should be implemented. The existing 18" pipe on Bowie Street should be removed and replaced with a 24" pipe. Install a 24" storm drain pipe along Bowie from Mesquite to Seideman. Street reconstruction is also recommended. Install curb inlets along Bowie from Mesquite to Seideman. The recommendations described are shown in **Exhibit 37** below.



PROJECT DESCRIPTION/NOTES

Bowie St is flooding during the 25-year storm event. Proposed improvements include the following:

1. Upsize existing 18" storm drain pipt to a 24" storm drain along Bowie St from Mesquite St to the existing system at Seideman St, including adding curb inlets.

2. Following pipe installation, construct subsequent street grading to connect to existing asphalt on N Bowie St.

BENEFITS

- Reduces flood risk along Bowie St as well as the surrounding houses.

CHALLENGES

- Construction Impacts to community/traffic.

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City of Seguin Drainage Master Plan
Risk Area Y
N Bowie St from W Seideman St to Mesquite St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

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Seguin Master Drainage Plan

Exhibit 37. Risk Area Y Bowie Street Project Map

18.15.2 Benefits

The recommended improvements allow for runoff to enter the underground storm drain system along Bowie instead of at the Bowie and Seideman intersection. The increased storm drain size along Seideman lowers the hydraulic grade line and adds capacity to the system. Combined, these improvements will help to alleviate flooding potential in and around Risk Area Y. Storm drain profiles are shown in **Figure 53** and **Figure 54** below.

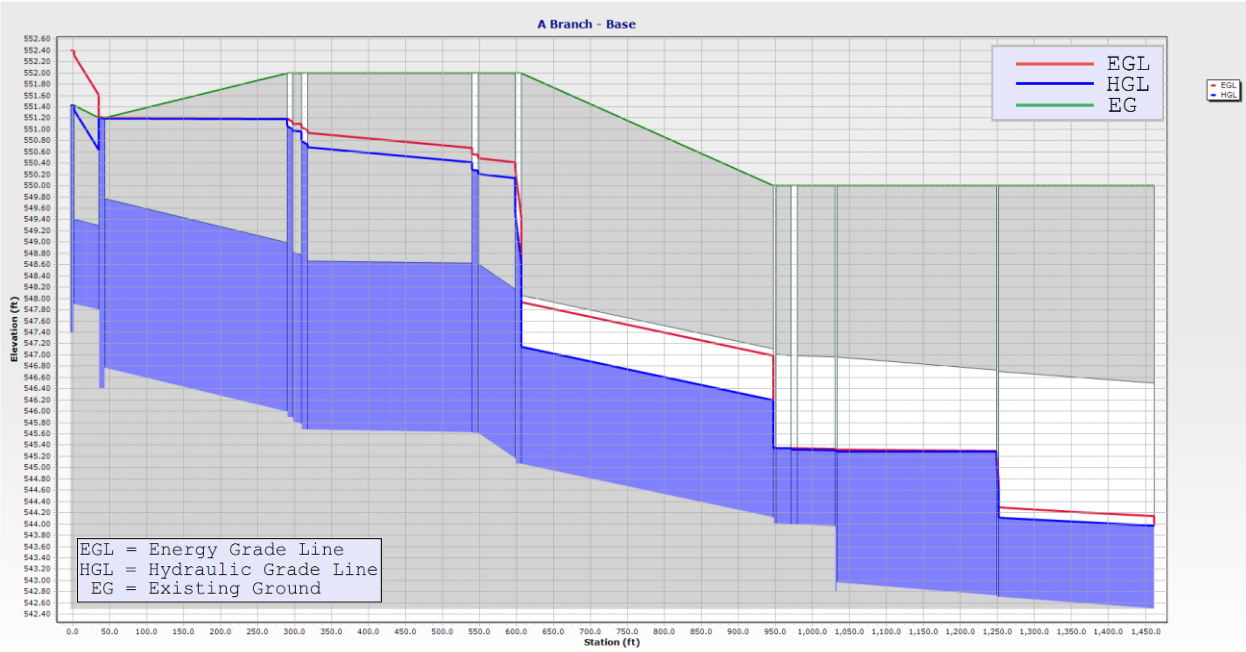


Figure 53. Existing Bowie Street Pipe Profile (25-YR Storm Event)

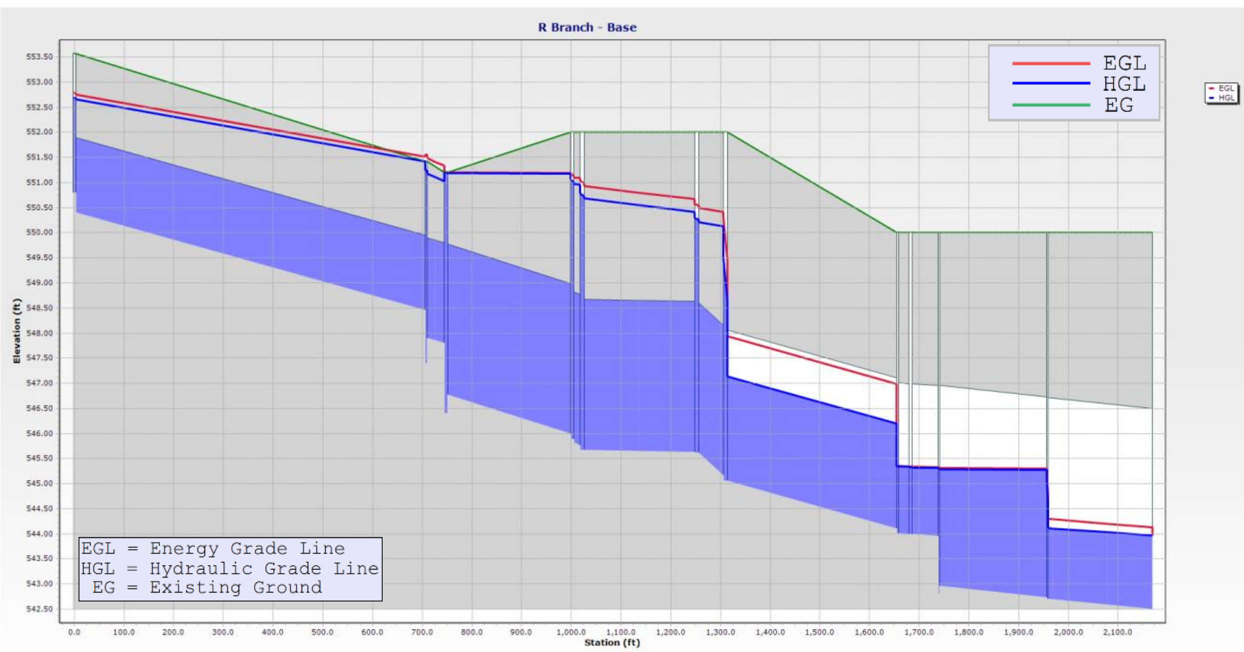


Figure 54. Proposed Bowie Street Pipe Profile (25-YR Storm Event)

18.15.3 Cost

An approximate opinion of probable cost was calculated, and a breakdown of the associated costs can be found in Table 27 below.

Table 27. Risk Area Y Bowie Street Expected Project Costs

Cost Type	Amount (in Millions)
Construction	0.76
ROW/Easement	0.0
Engineering and Testing	0.11
Utility Adjustments	0.0.04
Total	**$0.92**

18.15.4 Constraints

To account for the storm drain installation, the streets may need to be reconstructed. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. The proposed construction is in front of residential structures which may pose a construction constraint, to be mitigated during design. These improvements should not be designed and constructed without considering the adjacent proposed improvements on Camp Street.

18.16 Risk Area Y – Camp St

18.16.1 Project Description

The Camp St project consists of storm drains under only Camp St. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are due to lack of/undersized curb inlets and pipes along Camp St. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area a series of proposed pipe improvements should be implemented. The existing 24" storm drain on Camp St from Baxter St to Seideman St should be removed and replaced with a 7' x 3' box pipe from Seideman St to Mesquite St and a 36" pipe from Mesquite St to Baxter St. Additionally, the existing 18" storm drains to the curb inlets on Baxter St and Mesquite St should be removed and replaced with 24" pipes. Storm drain design may be optimized to include smaller pipes/boxes during detailed design, but for the purposes of determining costs the pipe/box sizes above are assumed. Street reconstruction is also recommended. The recommendations described are shown in **Exhibit 38** below.

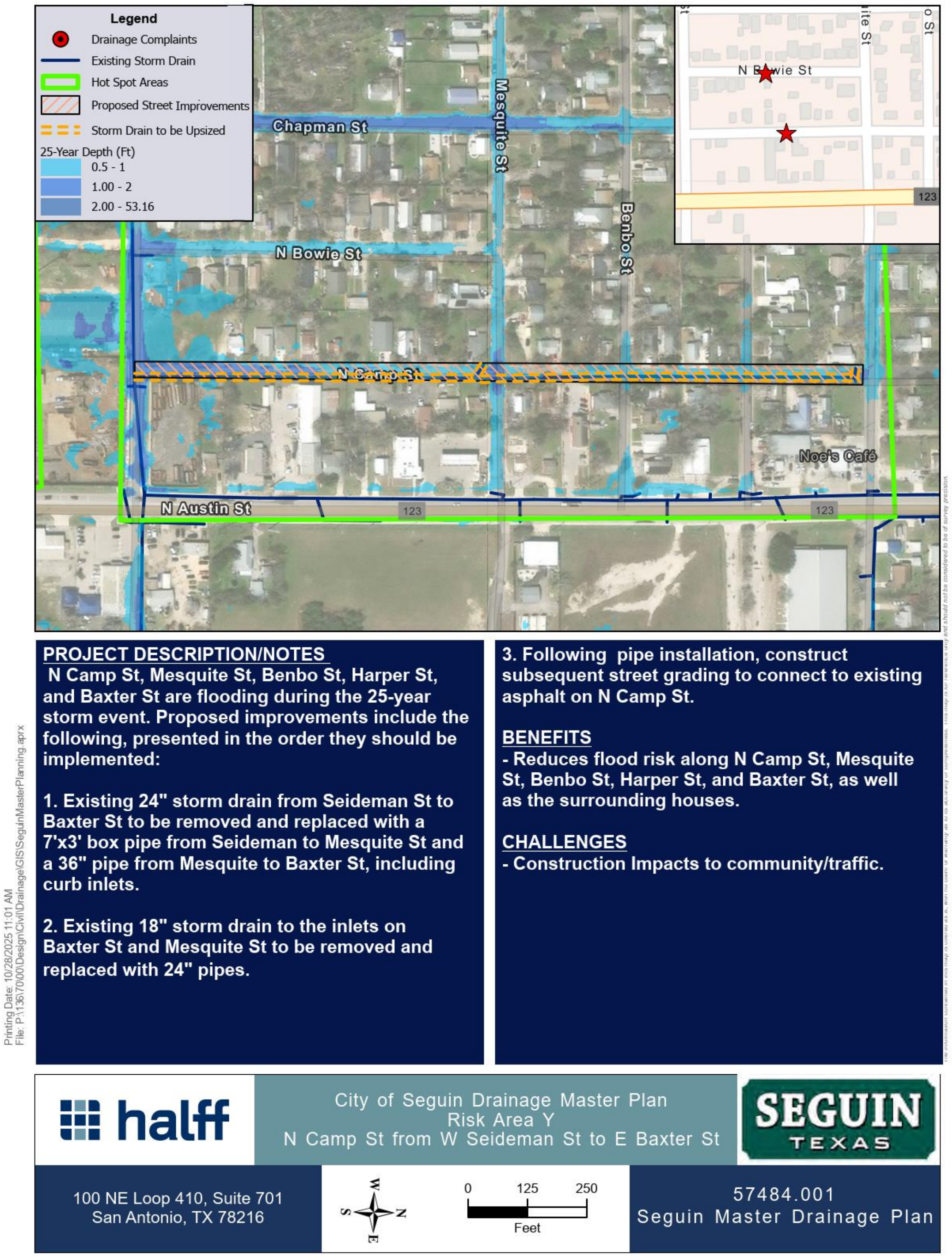


Exhibit 38. Risk Area Y Camp Street Project Map

18.16.2 Benefits

The recommended improvements take storm water runoff underground, helping to alleviate flooding potential in and around Risk Area Y. Storm drain profiles with hydraulic grade line are shown in **Figure 55** below. Note that the existing conditions analysis image was not included because the surcharge calculation greatly exaggerated the hydraulic grade line due to modeling software limitations. The calculations are a good indicator that the system is undersized, but the surcharge is not to the level indicated on the existing conditions profile. The proposed conditions profile is seen below.

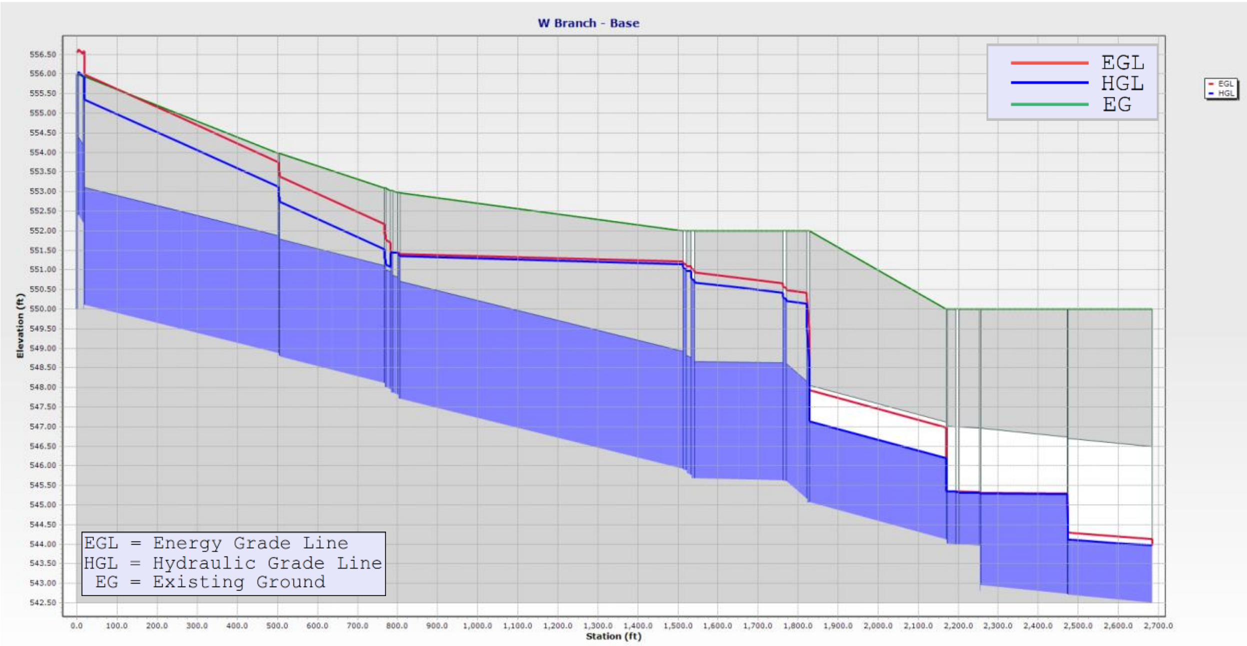


Figure 55. Proposed Camp Street Pipe Profile (25-YR Storm Event)

18.16.3 Cost

A tentative cost was calculated, and a breakdown of the associated costs can be found in **Table 28** below.

Table 28. Risk Area Y Camp Street Expected Project Costs

Cost Type	Amount (in Millions)
Construction	2.5
ROW/Easements	0.00
Engineering and Testing	0.38
Utility Adjustments	0.13
Preliminary Engineering Report	0.25
Total	**$3.26**

18.16.4 Constraints

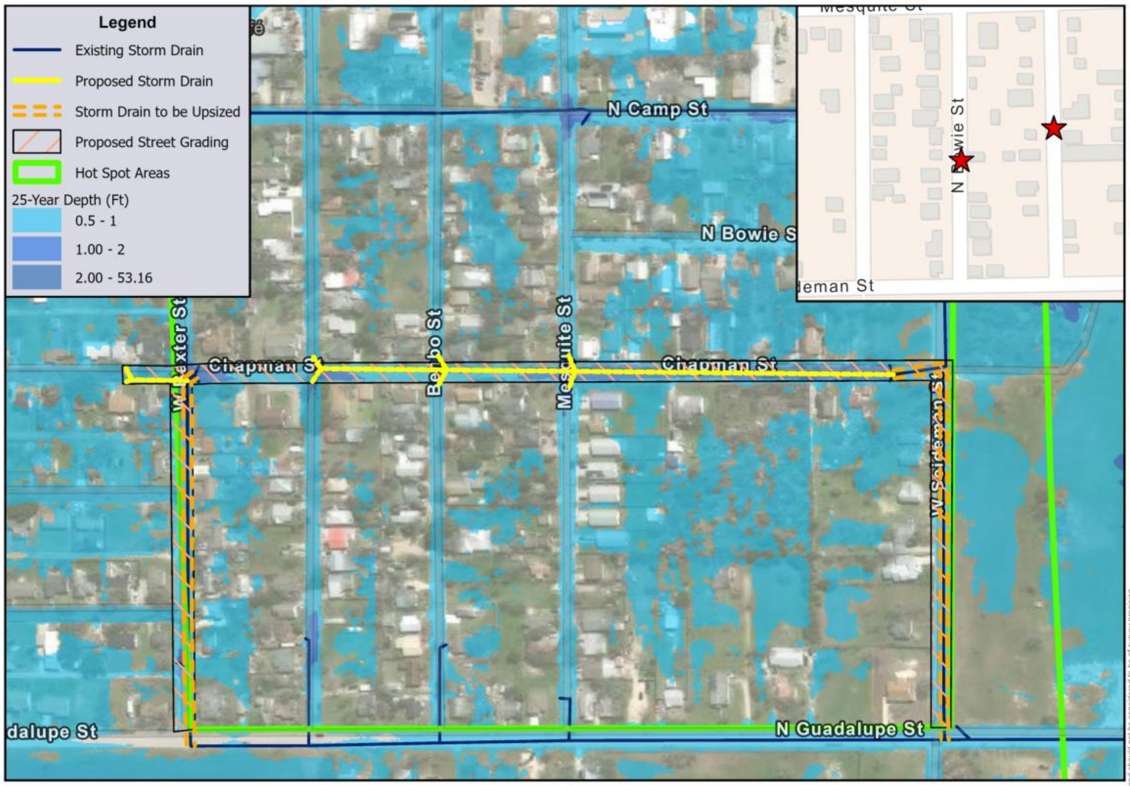
To account for the storm drain installation, the streets will need to be regraded. Additionally, the proposed curb inlets and pipes are right in front of residential structures which may pose a construction constraint. Finally, these improvements should not be done without considering the adjacent proposed improvements on Camp Street.

18.17 Risk Area Y – Chapman St

18.17.1 Project Description

The Chapman St project consists of storm drains under Baxter St, Chapman St, and Seideman St. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are due to lack of/undersized curb inlets and pipes. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area a series of proposed pipe improvements should be implemented. The existing 24" storm drain on Baxter St from Guadalupe St to Chapman St should be removed and replaced with a 7'x3' box pipe and the inlets at the Chapman/Baxter intersection should be removed and replaced with 36" pipes and 15' curb inlets. Additionally, the existing 24" storm drain on Seideman St from Guadalupe St to the curb inlets on Chapman St should be removed and replaced with 7'x3' box pipes and the existing 18" connections to the curb inlets on Chapman and Seideman should be removed and replaced with 24" pipes. A 7'x'3' box pipe along Chapman St between Seideman St and Mesquite St, a 42" pipe between Mesquite St and Benbo St, and a 36" pipe from Benbo to Harper St should be installed with two 10' curb inlets at each intersection. Additionally, a 42" pipe along Chapman St from Baxter St to 100' North of Baxter with two 15' curb inlets should be installed. Storm drain design may be optimized to include smaller pipes/boxes during detailed design, but for the purposes of determining costs the pipe/box sizes above are assumed. Street reconstruction is also recommended. The described recommendations are shown in **Exhibit 39** below.



PROJECT DESCRIPTION/NOTES

The existing storm drains along W Baxter St, Chapman St, and W Seideman St do not have capacity for the 25-year storm in this area. Proposed improvements include the following, presented in the order they should be implemented:

1. Remove existing 24" pipe along Baxter St from Guadalupe St to Chapman St and replace with a 7' x 3' box pipe. Connections to the inlets at Chapman should be removed and replaced with 36" pipes and 15' curb inlets.
2. Remove existing 24" pipe along Seideman St from Guadalupe St to the curb inlets on Chapman St and replace with a 7' x 3' box pipe. Existing 18" connections to curb inlets on Chapman should be removed and replaced with 24" pipes.
3. Install a 7' x 3' box pipe along Chapman St between Seideman St and Mesquite St, a 42" pipe from Mesquite St to Benbo St, and a 36" pipe from Benbo St to Harper St with two curb inlets at each intersection.
4. Install a 42" pipe along Chapman St from Baxter St to 100' north of Baxter with two 15' curb inlets.

BENEFITS

- Reduces flood risk along Baxter St, Chapman St, Seideman St, and the surrounding houses.
- Relieves pressure on the larger system of pipes.

CHALLENGES

- Construction Impacts to community/traffic.

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City of Seguin Drainage Master Plan
Risk Area Y
Chapman St from Seideman St to W Baxter St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

N E S W

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Feet

57484.001
Seguin Master Drainage Plan

Exhibit 39. Risk Area Y Chapman St Project Map

18.17.2 Benefits

The recommended improvements take storm water runoff underground, helping to alleviate flooding potential in and around Risk Area Y. Storm drain profiles with HGL are shown in **Figure 56** and **Figure 57**. Note that the existing conditions analysis image was not included because the surcharge calculation greatly exaggerated the HGL due to modeling software limitations. The calculations are a good indicator that the system is undersized, but the surcharge is not to the level indicated on the existing conditions profile. Please refer to the model for existing conditions analysis. The proposed conditions profile is seen below.

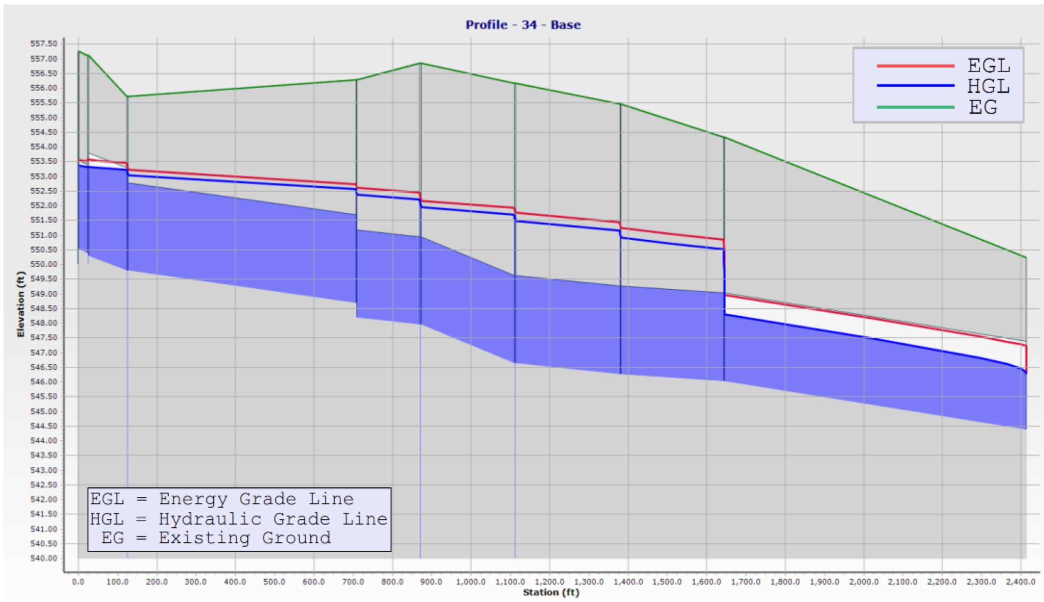


Figure 56. Proposed Baxter St/Guadalupe St Pipe Profile (25-YR Storm Event)

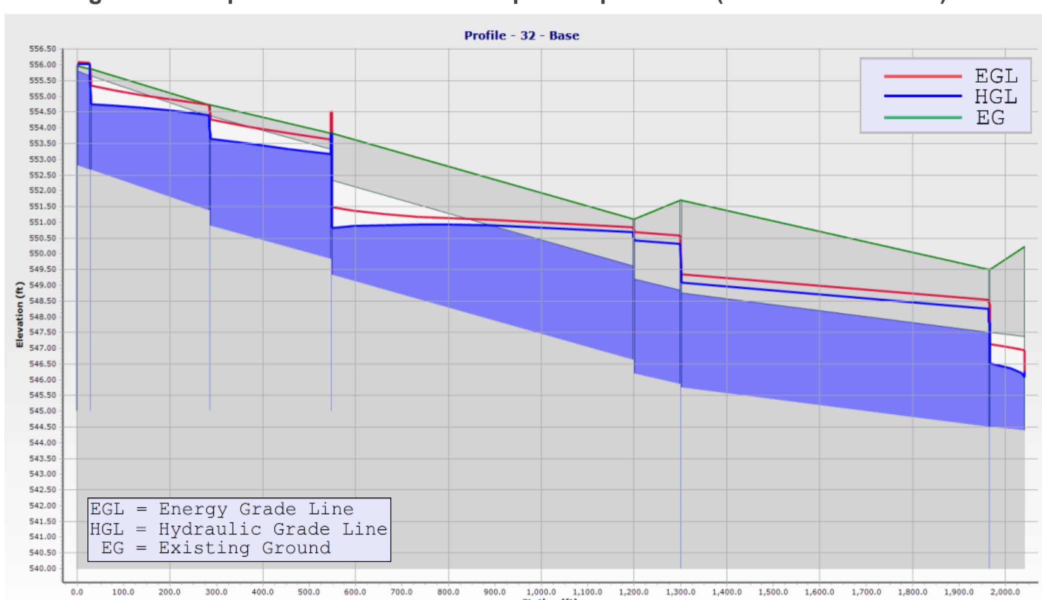


Figure 57. Proposed Chapman St/Seideman St Pipe Profile (25-YR Storm Event)

18.17.3 Cost

A tentative cost was calculated, and a breakdown of the associated costs can be found in **Table 29** below.

Table 29. Camp Street Cost Estimate

Cost Type	Amount (in Millions)
Construction	4.59
ROW/Easements	0.00
Engineering and Testing	0.69
Total	**$5.28**

18.17.4 Constraints

To account for the storm drain installation, the streets will need to be regraded. Additionally, the proposed curb inlets and pipes are right in front of residential structures which may pose a construction constraint. Finally, these improvements should not be done without considering the adjacent proposed improvements on Camp Street and Bowie Street.

18.18 Risk Area Z – Breustedt St

18.18.1 Project Description

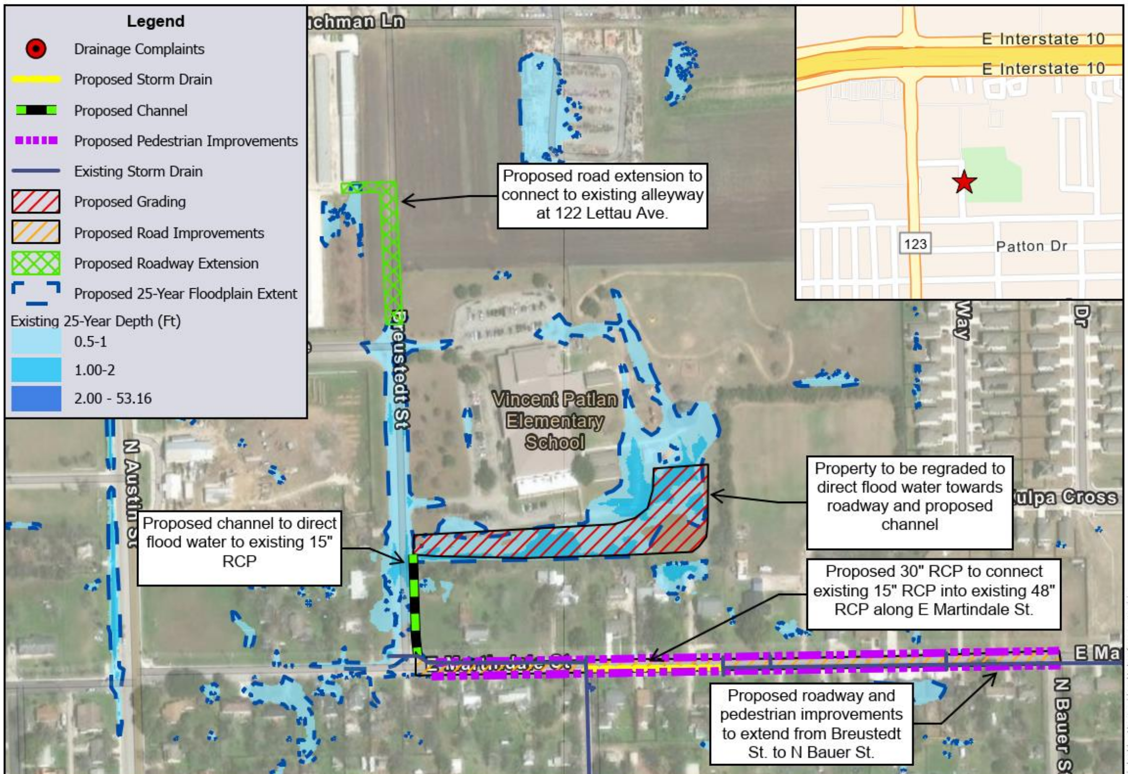
Risk Area Z includes Breustedt St and the open lot just south of Vincent Patlan Elementary School (VPES). Much of Breustedt St experiences flooding up to 1.0’ of water. The area just south and east of VPES encounters issues with ponding with some places seeing up to 2.0’ of water.

Lower ground elevations at Breustedt St and the areas around VPES combined with shallow slopes result in higher ponding depths in these areas. Draining of stormwater in these areas relies on natural topographic slopes as no storm drain or channelized areas are present. Additionally, the storm drain system south of VPES shows low capacity for even the 5-Year storm event and further minimizes the ability for water to drain from Breustedt St.

Proposed improvements include regrading the open parcel south of VPES to direct stormwater into a proposed grass-lined channel running south along Breustedt St and into the existing 15” RCP along E Martindale St. A 30” RCP is proposed to connect the existing 18” RCP running south along Woodland Dr to the existing 48” RCP running east along E Martindale St. Regrading of the open lot adjacent to VPES may not require the entire area to be regraded and a pilot channel collecting and directing water onto Breustedt St. may provide sufficient results. Additional analysis during the design phase should occur to determine grading requirements.

18.18.2 Benefits

Benefits from proposed projects for Risk Area Z focus largely on draining water from the Vincent Patlan Elemntary School and Breustedt St. and street and pedestrian improvements along E Martindale St. The overall project map for Risk Area Z is shown in **Exhibit 40**.



PROJECT DESCRIPTION/NOTES

Multiple locations encounter ponding on West Cedar between FM 466 N King St and SH 123 B during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Channelize east side of Breustedt St and discharge into existing 15" RCP. Regrade field south of Vincent Patlan Elementary school to drain more quickly to proposed channel.

2. Incorporate proposed channel and grading from Alternative 1 and add a new storm drain pipe connecting 30" RCP along Woodland Dr to 48" RCP along E Martindale St Include road and pedestrian improvements from Breustedt St to N Bauer St.

BENEFITS

- Reduces flood risk within Breustedt St for traffic flow improvement during storm events.

- Improves drainage of surrounding area of Vincent Patlan Elementary School.

CHALLENGES

- Ensure proposed channel will not discharge additional flow into adjacent properties

- Downstream storm drain systems will need to be analyzed for capacity.

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The information contained in this map is offered as is, with no claim or warranty as to its accuracy or completeness. This map is for reference only and should not be considered to be of survey precision.

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City of Seguin Drainage Master Plan
Risk Area Z
E Martindale St between Breustedt St & N Bauer St

SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216

N W E S

0 150 300 Feet

57484.001
Seguin Master Drainage Plan

Exhibit 40. Risk Area Z Project Map

18.18.3 Cost

A tentative cost was calculated, and a breakdown of the associated costs can be found in **Table 30** below.

Table 30. Risk Area Z Expected Project Costs

Cost Type	Amount (in Millions)
Construction	1.46
ROW/Easements	0.07
Engineering and Testing	0.22
Utility Adjustments	0.07
Preliminary Engineering Report	0.15
Total	**$1.97**

18.18.4 Constraints

Expected constraints for the discussed project are largely associated with utility relocations along E Martindale St and ensuring the 15” RCP downstream of the proposed channel along Breustedt St.

18.19 Risk Area DD – Jefferson Ave

18.19.1 Project Description

The Jefferson Avenue project consists of storm drains under Jefferson Ave, Guadalupe St, Goodrich St, and the existing storm drain network between Goodrich St and Walnut Branch. The area consists largely of residential homes and public streets. The main contributors to flooding in the area are due to an undersized storm drain from Guadalupe St to the outfall at Walnut Branch, and the overall watershed areas due to minimal inlets. These restrictions cause the area to flood during the 25-year storm event.

To alleviate flooding in the area, a series of proposed underground storm drain improvements should be implemented. The 36” pipe from the Guadalupe St/Jefferson Ave intersection to the outfall at Walnut Branch should be removed and replaced with a 54” pipe from the outfall to Guadalupe St. A 36” pipe should be installed on Jefferson Ave from the existing system at Guadalupe St to Legette St with 2 curb inlets at the Legette St intersection. A 42” pipe should be installed on Guadalupe St from the existing system at Jefferson Ave to Nolte St with a curb inlet across from Nolte St. A 30” pipe should be installed on Guadalupe St from the existing system at Jefferson Ave to Convent St with a curb inlet placed across from Convent St. The existing 36” pipe on Guadalupe St should be removed and replaced with a 48” RCP. A 24” pipe should be installed on Goodrich St from the existing system to Convent St with a Curb Inlet at the Convent St/Goodrich St intersection. It is recommended that any 18” laterals should be removed and replaced with 24” laterals. During detailed design, storm drain sizes can be optimized, including possibly using smaller storm drain pipes for a portions of the system. For the purposes of preparing opinions of probable cost, the pipe sizes shown above were assumed. The recommendations described are shown in **Exhibit 41** below.

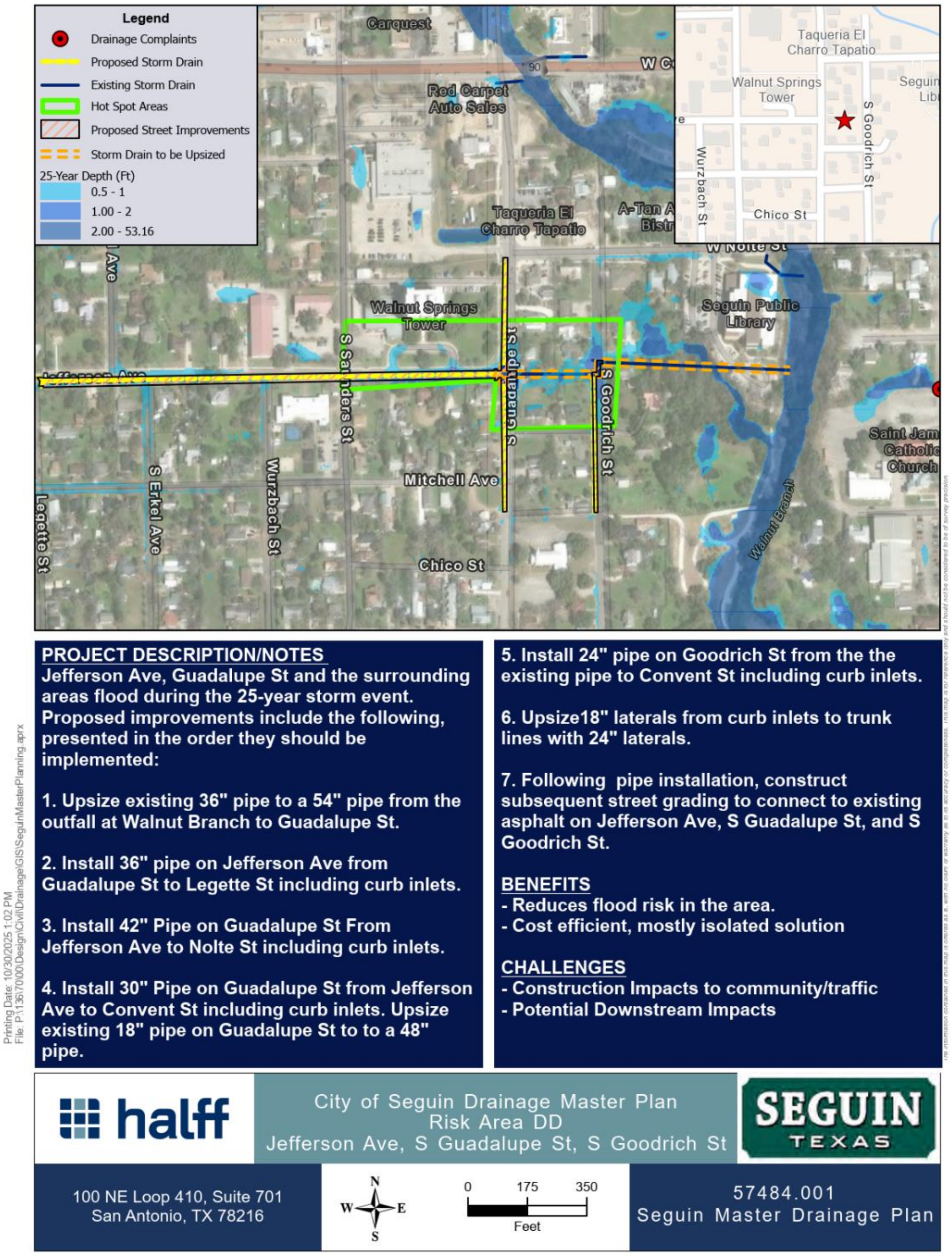


Exhibit 41. Risk Area DD Project Map

18.19.2 Benefits

The recommended improvements reduce the hydraulic grade line of the pipe system and, in turn, alleviate flooding potential in and around Risk Area DD. These benefits are shown in **Figure 58** and **Figure 59** below.

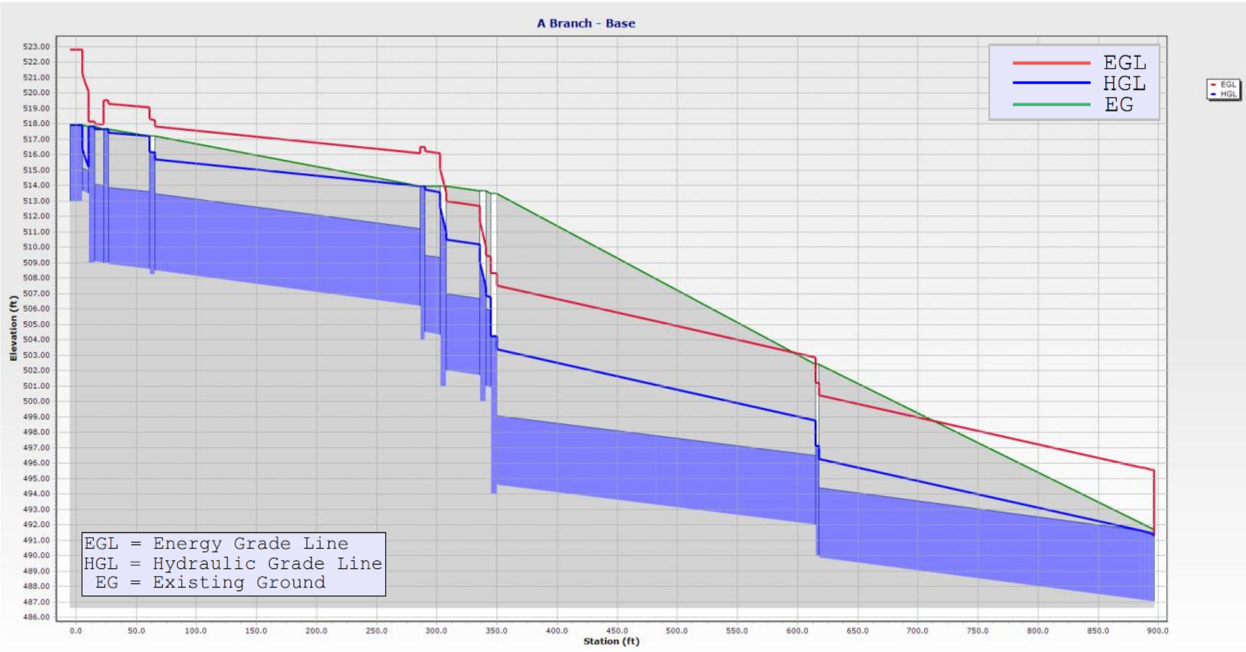


Figure 58. Existing Jefferson Ave Pipe Profile (25-YR Storm Event)

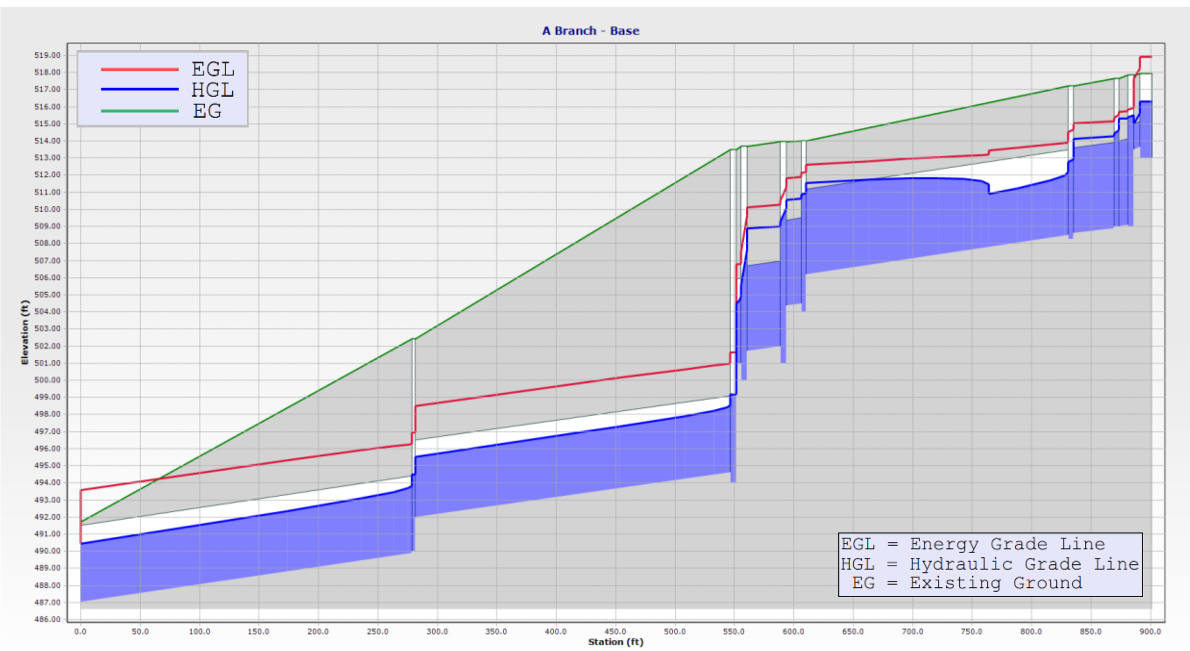


Figure 59. Proposed Jefferson Ave Pipe Profile (25-YR Storm Event)

18.19.3 Cost

An opinion of probable construction cost was calculated, and a breakdown of the associated costs can be found in **Table 31** below.

Table 31. Risk Area DD Expected Project Costs

Cost Type	Amount (in Millions)
Construction	3.34
ROW/Easements	0.14
Engineering and Testing	0.50
Utility Adjustments	0.17
Preliminary Engineering Report	0.33
Total	**$4.48**

18.19.4 Constraints

To account for the storm drain upsizing and installation, the streets will likely need to be reconstructed and potentially regraded, and additional property will need to be accessed for the removal and replacement of pipes in between right-of-ways. Associated street reconstruction costs are included. Water, wastewater, gas, electric, and telecom utility relocations or replacements are likely. The proposed construction is in front of residential structures which may pose a construction constraint, to be mitigated during design. Right-of-way or easement will need to be obtained to construct the downstream-most portion of the project. Finally, the downstream impact of this project in Walnut Branch Creek was not studied and may require additional analysis prior to detailed design.

18.20 Risk Area AA

18.20.1 Project Description

The property at 215 Ermel St #1 has experienced frequent ponding along the property entrance and parking area. Existing topographic features and a lack of storm drain do not allow efficient drainage on the north side of Jefferson St.

Risk Area AA project solutions include a proposed trapezoidal channel along the south side of Jefferson St to drain water west into the existing drainage ditch along Highway 46. Two 24” RCP’s are proposed to drain water from the 315 Ermel St property into an 18” RCP that outfalls into the proposed drainage channel along Jefferson St. Curb improvements are proposed on either side of the property entrance to prevent ponding along the property parking area and entrance. Proposed Improvements for Risk Area AA are shown in **Exhibit 42**.

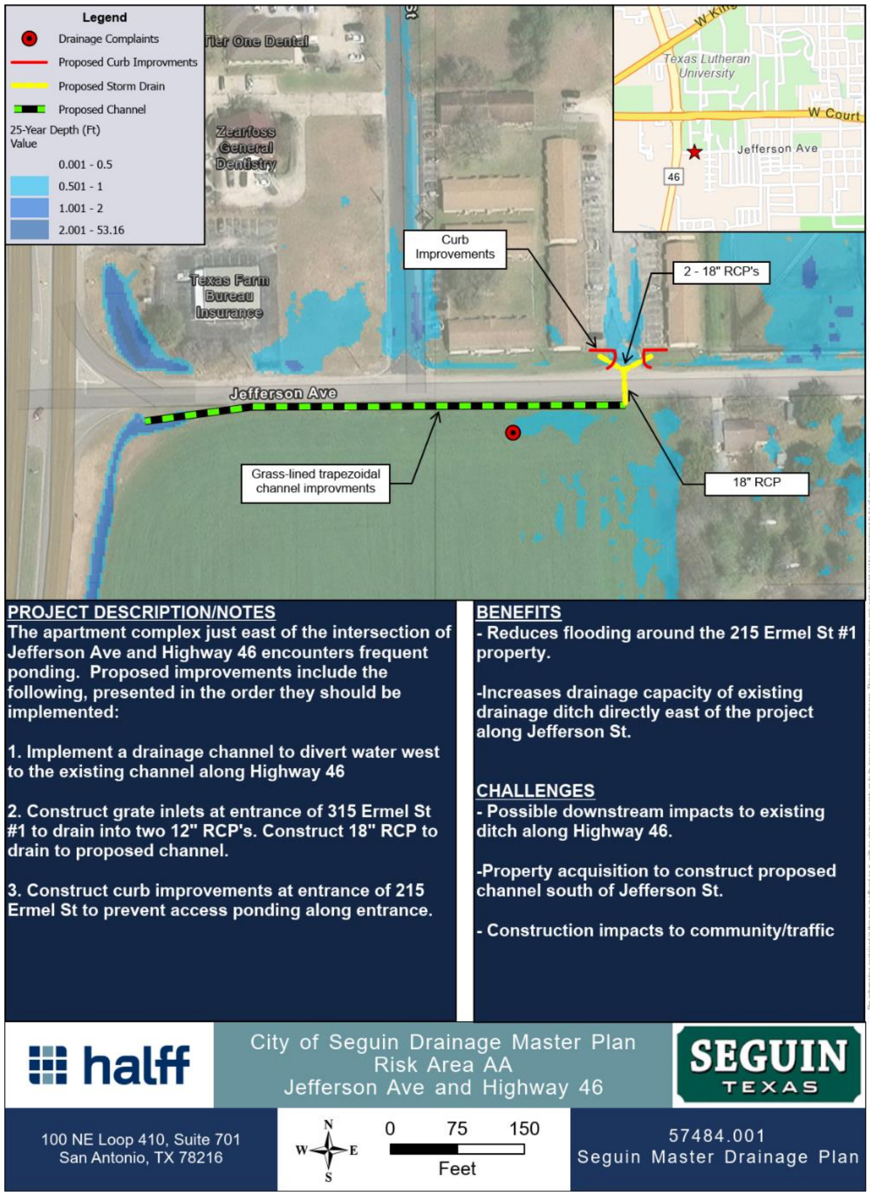


Exhibit 42. Risk Area AA Project Map

18.20.2 Benefits

The main benefit of the proposed improvements for Risk Area AA is improved drainage at the property of 315 Ermel St #1 with reduced ponding at the entrance and parking areas of the property. Drainage capacity of the existing ditches upstream along Jefferson St is also increased as a results of the improved tailwater conditions at the project site.

18.20.3 Cost

An opinion of probable construction cost was calculated, and a breakdown of the associated costs can be found in **Table 32**.

Table 32. Risk Area AA Cost Estimates

Cost Type	Amount (in Millions)
Construction	0.18
ROW/Easements	0.01
Engineering and Testing	0.03
Utility Adjustments	0.01
Total	**$0.23**

18.20.4 Constraints

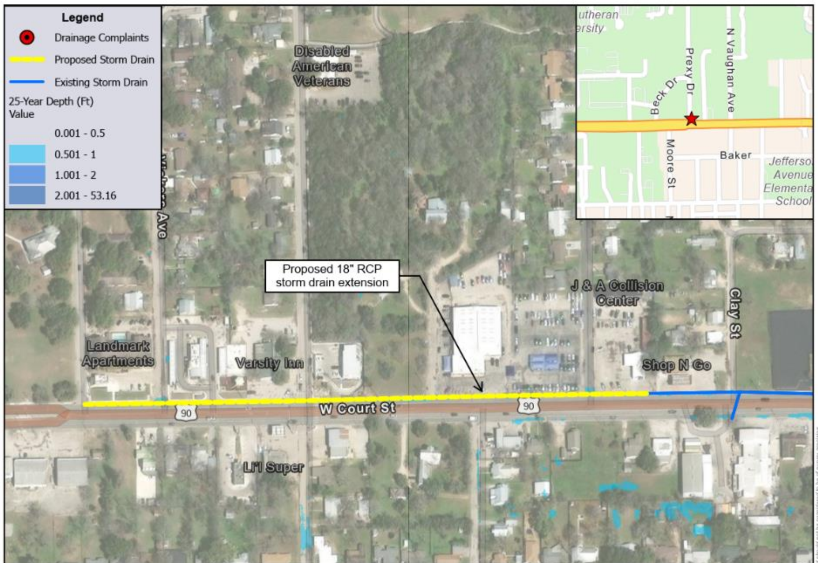
Expected constraints for Risk Area AA improvements are impacts to local traffic and potential adverse impacts to the receiving ditch along Highway 46. Impacts to the downstream ditch from increased discharges from the project area should be assessed to ensure no adverse impacts to the ditch itself through erosion or to the adjacent property.

18.21 Risk Area EE

18.21.1 Project Description

No storm drain network is present along the section of Court St between Prexy Dr and Clay St. Existing grade from connecting streets contribute to ponding along the intersections of court St with no method of directing storm water other than the slope of the existing street.

To mitigate ponding at the intersection of Prexy Dr, an extension of the existing 18” RCP at Clay St is proposed to extend west to Prexy Dr. Risk Area EE improvements are shown in **Exhibit 43**.



PROJECT DESCRIPTION/NOTES

Homes along N Olive St are at risk of flooding during the 25-year storm event. Proposed improvements include the following, presented in the order they should be implemented:

1. Extend existing 18" RCP along Court St. Extension to begin at existing 18" RCP just west of Clay St and extend approximately 1,450 ft west to Prexy Dr.

BENEFITS

- Reduces flood risk at intersection of Prexy and Court St.

- Provides additional locations for storm drain tie-ins at Vickers Ave, Vaughan Ave, and Gordon St (pipe capacity should be assessed).

CHALLENGES

- Downstream storm drain systems will need to be analyzed for capacity

- Construction impacts to community/traffic

halff | City of Seguin Drainage Master Plan
Risk Area EE
Court St (Prexy to Clay) | SEGUIN TEXAS

100 NE Loop 410, Suite 701
San Antonio, TX 78216 | N W E S | 0 75 150 Feet | 57484.001
Seguin Master Drainage Plan

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Exhibit 43. Risk Area EE Project Map

18.21.2 Benefits

Expected benefits from Risk Area CC improvements include added drainage capacity to the storm drain network along Court St and improved drainage at the intersection of Prexy Dr and Court St.

18.21.3 Cost

An opinion of probable construction cost was calculated, and a breakdown of the associated costs can be found in **Table 33**.

Table 33. Risk Area EE Cost Estimates

Cost Type	Amount (in Millions)
Construction	3.57
ROW/Easements	0.18
Engineering and Testing	0.54
Utility Adjustments	0.18
Preliminary Engineering Report	0.36
Total	**$5.83**

18.21.4 Constraints

Constraints from Risk Area EE improvements include impacts to local traffic and potential impacts to the existing 18" RCP system with the addition of flood waters received from Prexy Dr. The existing 18" RCP system should be assessed with proposed improvements to ensure any additional discharges received will not cause surcharging within the existing system on Court St.

19.0 Recently Completed Studies

19.1 Washington and Camp Street PER

A previous study for Camp St was completed in June, 2024. The Washington and Camp Street Preliminary Engineering Report addresses property flooding at Washington St and Camp St near Walnut Branch, as well as erosion concerns along Walnut Branch. This PER report is provide in Appendix D.

Four alternatives were developed from this PER with detailed cost estimates:

1. Scenario 1 - Shelby Outfall ($6,090,268)
2. Scenario 2 – Nolte/Convent Outfalls ($6,190,456)
3. Scenario 3 – Nolte/Shelby Outfalls ($6,090,154)
4. Scenario 4 – Donegan/Shelby Outfalls ($5,242,940)

The final recommendation from the Washington and Camp Street PER outlined Scenario 4 as the most viable option due to its constructability and cost efficiency. **Exhibit 44**. from the PER outlines the Scenario 4 project layout.

Exhibit 44. Washington Street Recommended Improvements

20.0 Conclusion

The proposed projects discussed in the sections above have been assessed to be the most cost-effective solutions while reducing the risk of flooding within the risk areas. While these mitigation concepts provide an initial outline for project development, additional detailed analysis should be conducted for each project solution to fully assess the feasibility of the project and confirm its benefits.

Proposed projects discussed in this report are not final and are subject to change depending on, but not limited to, available funding, realized benefits after detailed analysis, unanticipated utility conflicts, or an inability to obtain private property.

More detailed analysis of these projects should utilize software that can incorporate both 2D and storm drain components into the model simulation to better simulate the complexities of the interdependent hydraulics occurring within these areas.

Furthermore, it is recommended that each outfall to receiving streams and rivers be mapped using GIS technology for management and monitoring of Seguin's drainage areas.