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# **City of Bellaire**

## **Flood Hazard**

## **Mitigation Report**

**Prepared by ARKK Engineers, LLC.**

**March 2018**

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# Executive Summary

To mitigate future flooding and threats to property and life, the City of Bellaire is updating its flood hazard mitigation plan in accordance with Community Rating System (CRS) credit program through the Federal Emergency Management Agency (FEMA). The City of Bellaire has suffered costly damage from flooding. The geography and climate in the region give rise to conditions conducive to flooding. Most recently Hurricane Harvey inundated the City of Bellaire with flood waters causing extensive damage resulting in more than 29% of Bellaire homes experiencing structural flooding.

The City of Bellaire has been certified with the Community Rating System (CRS) of the National Flood Insurance Program since 1993. Under the CRS, the flood insurance premiums of a community's residents and businesses are discounted to reflect that community's work to reduce flood damage to existing buildings, manage development in areas not mapped by the NFIP, protect new buildings beyond the minimum NFIP protection level, preserve and/or resort natural functions of floodplains, help insurance agents obtain flood data, and help people obtain flood insurance. There are 10 CRS classes<sup>1</sup>. Class 1 requires the most credit points and gives the greatest premium reduction or discount. A community that does not obtain the minimum number of credit points is considered a Class 10 community and receives no discount on premiums. City of Bellaire currently holds a CRS classification of Class 7. This rating provides City residents a 15% reduction on their flood insurance premiums each year.

Bellaire is designated as a Repetitive Loss Community. To maintain its classification of 7, this Floodplain Management Plan must be submitted to the Insurance Services Office (ISO) with sufficient evidence that Bellaire is addressing the floodplain issue.

The purpose of the Floodplain Hazard Mitigation Plan is to provide a blueprint for the development and implementation of activities that will efficiently use public and private resources to reduce flood losses and encourage support for hazard mitigation activities among the public.

The Staff Technical Advisory Team (Staff) contributing to the development of the Plan, includes ChaVonne Sampson; Floodplain Manager, Michael Leech; Director of Public Works, Terrence Beaman; Chief Financial Officer, Darryl Anderson; Fire Chief, William Davidson; Building Official; Karl Miller; Director of Parks, Recreation, & Facilities, Shawn Cox; Administration Services Manager, and Paul A. Hofmann; City Manager. ARKK Engineers, LLC., Bellaire's Consulting

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<sup>1</sup> See Appendix – CRS Summary

Engineers (Technical Advisory Team) prepared the Plan, and include James Andrews and Marcus McRae.

The Flood Hazard Mitigation Task Force on Drainage Issues (Task Force) are performing oversight review and approval of the Plan. Task Force members are all citizens of Bellaire and it includes Chris Canonico, Yana Kristal, Menny Rosenbaum, Winfred Frazier, Michael Ling, Robyn Rosenblatt, Brian Sanford, Millie Hast, Jonathan Reichek, and David Roylance. The Council Liaison Team consists of Mayor Andrew Friedberg, Council Member Trisha Pollard, and Council Member David Montague.

One of the first steps in the planning process was to establish a list of flood hazards that the City encounters. Subsequent planning steps used this list to identify and assess the risks and issues relating to these hazards, and ultimately a set of goals evolved with associated action plans to mitigate the identified hazards. The three primary overarching goals that evolved during this process are:

1. Continue to enforce and establish policies, procedures and activities for the safety and assurance for citizens of City of Bellaire.
2. Develop, fund, design and construct infrastructure improvements to mitigate the effects of flooding.
3. Evaluate and establish the City's position in floodplain regulation in terms of policies and management.

Based on these goals, the Task Force has developed a list of potential activities as part of an Action Plan for the City's consideration. This Action Plan provides the blueprint that will guide the City toward a set of projects, policies, and procedures designed to reduce the severity of flooding and its damaging impacts.

The activities for mitigation of floodwaters envisioned by the City have been driven by determining and assessing risk factors associated with flooding within the City, developing a mitigation plan to reduce potential losses identified in the risk assessment, and implementing an action plan to provide tangible solutions for achieving the goals and objectives outlined in the Mitigation Plan.

The City has made a serious commitment to mitigating the effects of flooding. As part of this commitment, the City will continue to implement several of its ongoing activities, while new activities have been identified to further reduce future flood damage. The City has an ongoing program of maintenance and repair of its existing storm sewer system. The storm sewer system is also updated annually with the construction of new storm sewers. These activities will help reduce flood damage to property and the threat to life and health. Through adoption of this Plan,

the City underscores its commitment to continue to carry out activities to reduce the effects of flooding.

As this Floodplain Management Plan is put into action, progress will be monitored and the Plan will be evaluated periodically so that revisions can be made to keep the Plan current and relevant.

# Purpose

The purpose of this Flood Hazard Mitigation Plan is to review and implement a strategy of programs, projects, and measures that will be adopted to reduce the adverse impacts of the flooding hazards that the City may encounter. This Plan is designed to mitigate damage and loss, establish post-disaster recovery programs, and educate residents on disaster preparedness and risk avoidance.

This Plan will review and develop activities to reduce the effects of flooding in terms of damage and loss, and improving resident safety and awareness as well as the following:

- Provide a comprehensive review of possible activities and mitigation measures that can be conducted to minimize hazards;
- Identify existing and future flood-related hazards and their causes;
- Demonstrate the criteria used in the City land development programs account for the hazards faced by existing and new developments;
- Educate resident and property owners about the hazards, loss reduction measures, and the natural and beneficial functions of the floodplains;
- Assist in building public and political support for activities and projects that prevent new problems, reduce losses, and protect the natural and beneficial functions of floodplains; and
- Assist the City in meeting the goals and objectives of the community.

The Action Plan should provide tangible solutions for achieving the goals and objectives that will be outlined in the Mitigation Plan. Per Resolution No. 17-08, adopted on October 2, 2017 the Mitigation Plan will be outlined by the following focus areas:

- **Local**
  - Assess the Drainage Plan and Recommend Steps Presented by the City Engineer to Council in September 2016.
  - Assess drainage criteria for CIP project selection
  - Assess the hazards and risks related to street and utility flooding
  - Review the hazards and risks related to communications and emergency operations.
  - Review the economic impacts
- **Regulatory**
  - Assess the current Building Code Requirements

- Assess options and develop recommendations concerning whether to pursue property buyouts and potential FEMA funding participation.
- Review the City's Continuing participation in the Community Rating System (CRS) and the National Flood Insurance Program (NFIP)
- **Regionally**
  - Evaluate regional Flood Hazard Management Plans and their impact on the City of Bellaire
  - Recommend additional efforts to improve regional drainage.
  - Recommend ways to facilitate and expedite current regional efforts that benefit the City.

## Plan Organization (CRS Activity 511.1)

Bellaire City Council, by Resolution No. 17-08<sup>2</sup> adopted on October 2, 2017, authorized the City Manager to establish a Flood Mitigation Task Force to update the Mitigation Plan and to develop actionable local, regulatory and regional policy recommendations for the prevention of future flooding. The City is currently adhering to the 2007 CRS Manual. By establishing the Flood Hazard Mitigation Plan Task Force and updating the City's current Flood Hazard Mitigation Plan, Bellaire will maintain compliance with National Flood Insurance program requirements. The Plan was written with the guidance of the City Manager for the Flood Hazard Mitigation Task Force on Drainage Issues (Task Force). Paul A. Hofmann, City Manager for the City of Bellaire, acted as its facilitator for development of the Plan.

Per Resolution No. 17-08 the roles and responsibilities of each group throughout the development of the updated Plan were as follows:

- **Task Force**
  - Identify and assess hazards associated with the problem of flooding and provided recommended solutions for those problems
  - Keep the public informed of its deliberation and recommendations, and any proposed changes to the floodplain structure for the City of Bellaire
  - Prepare a post-flood Hazard Mitigation Plan for the City of Bellaire
- **Council Liaison Team**
  - Monitor the level of citizen engagement
  - Ensure broad and ongoing communication
  - Recommend necessary council action
- **City Staff Technical Advisory Team (Staff)**
  - Provide support/analysis
  - Provide recommendations
  - Keep the team on track
  - Provide history/background information
- **Consulting Advisory Team**
  - Provide initial Risk Assessment & Mitigation Plan
  - Technical support and review
  - Assess effectiveness of recommendations.

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<sup>2</sup> See Appendix – Bellaire City Council Resolution No. 17-08

Members of the Task Force are all citizens of Bellaire. Members of the Task Force consisted of Bellaire Homeowners, builder and developers, utility company representatives and previous board and commissioner members. Members included Chris Canonico, Yana Kristal, Menny Rosenbaum, Win Frazier, Michael Ling, Robyn Rosenblatt, Brian Sanford, Millie Hast, Jonathan Reichek, and David Roylance.

The City Staff Technical Advisory Team (Staff) included ChaVonne Sampson (Floodplain Manager), Michael Leech (Director of Public Works), Terrence Beaman (Chief Financial Officer), Darryl Anderson (Fire Chief), William Davidson (Building Official), Karl Miller (Director of Parks, Recreation, & Facilities), Shawn Cox (Administration Services Manager), and Paul A. Hofmann (City Manager).

ARKK Engineers, LLC., Bellaire's Consulting Engineers (Consulting Advisory Team) prepared the Plan and included James Andrews and Marcus McRae.

The Council Liaison Team consisted of Mayor Andrew Friedberg, Council Member Trisha Pollard, and Council Member David Montague.

## Background

The Flood Hazard Mitigation Task Force was comprised of 10 members all of whom were Bellaire residents. These residents represented the following areas:

- Bellaire Homeowner
- Utility Company Representative
- Local Builder/Developer
- Previous Bellaire Board or Commission Member

Members of the Task Force are all private citizens of Bellaire. Members of the Task Force consisted of Bellaire Homeowners, builder and developers, utility company representatives and previous board and commissioner members. Members include Chris Canonic, Yana Kristal, Menny Rosenbaum, Winfred Frazier, Michael Ling, Robyn Rosenblatt, Brian Sanford, Millie Hast, Jonathan Reichek, and David Roylance.

## Public Notices/Information

In keeping with the charge of “keeping the public informed of its deliberations and recommendations”, the Task Force held a total of eight (8) public meetings. The Task Force also held a Public Hearing to allow the residents to provide input and feedback on the Draft Flood Hazard Mitigation Plan<sup>3</sup>. Each meeting, including the Public Hearing, had an agenda<sup>4</sup> and was posted, in accordance with the Texas Open Meeting Act, at least seventy-two (72) hours prior to the meeting. The following additional steps were also taken for each meeting:

- Posting of the agenda online at <http://bellairecitytx.igm2.com/Citizens/default.aspx>
- Live video stream of the meeting at either <http://bellairecitytx.igm2.com/Citizens/default.aspx>, or through Facebook Live
- “Notify Me”<sup>5</sup> Email Blast sent to over 3,700 subscribers with each Agenda
- Each agenda included a time for Public Comments

<sup>3</sup> See Appendix – Flood Hazard Mitigation Plan/Matrix

<sup>4</sup> See Appendix – Agendas

<sup>5</sup> See Appendix – “Notify Me” Emails

- Posting of an Electronic Notebook<sup>6</sup> to provide pertinent information to Task Force Member and the Public. The Mayor made a blog post<sup>7</sup> on November 2, 2017, which highlighted the Electronic Notebook. The Electronic Notebook includes:
  - Task Force Roster and Contact Information
  - Outline of Final Report
  - Meeting Schedule
  - Local “Focus Area” Topics of Interest
  - Regulatory “Focus Area” Topic of Interest
  - Regional “Focus Area” Topics of Interest
  - FEMA Publications
  - Draft Report
  - Meeting Agendas & Notes
  - Meeting Videos & Presentations

Additional steps, including a “News Flash”<sup>8</sup> posting on the City website and a post on the Mayor’s Blog<sup>9</sup> were taken to market the Public Hearing held on Monday, January 29, 2018.

## Public Meetings

### Monday, October 30, 2017 (Regular Meeting):

The first meeting of the Flood Hazard Mitigation Task Force was held on Monday, October 30, 2017. At this meeting, Paul A. Hofmann, City Manager for the City of Bellaire, introduced the members of the Task Force (including Council Liaisons, City Staff, and Consultants) and gave a presentation<sup>10</sup> which reviewed the Task Force’s purpose and outlined roles and responsibilities. The Task Force was asked to provide feedback on the following before the next meeting:

- What are we trying to accomplish with the City of Bellaire drainage improvements?
- What are we trying to accomplish from a regulatory perspective?
- What are we trying to accomplish with other jurisdictions in the region?

### Tuesday, November 14, 2017 (Regular Meeting):

The November 14 meeting included a review of the responses received from the Task Force concerning the questions asked at the previous meeting, and a presentation on the Draft Hazard

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<sup>6</sup> See Appendix – Electronic Notebook ([www.bellairetx.gov/taskforce](http://www.bellairetx.gov/taskforce))

<sup>7</sup> See Appendix – November 2, 2017 “Mayor’s Musings-Flood Hazard Mitigation Task Force Gets to Work” (<http://cityofbellairemayormusings.blogspot.com/2017/11/flood-hazard-mitigation-task-force-gets.html>)

<sup>8</sup> See Appendix – News Flash – “Flood Hazard Mitigation Task Force Public Hearing”

<sup>9</sup> See Appendix – January 25, 2018 “Mayor’s Musings-Task Force Public Hearing on Draft Flood Hazard Mitigation Plan – Jan. 29, 6:30 pm” (<http://cityofbellairemayormusings.blogspot.com/2018/01/task-force-public-hearing-on-draft.html>)

<sup>10</sup> See Appendix – Task Force Presentations

Mitigation plan. The presentation included a review of previous drainage studies and of the City Engineer's Report on Hurricane Harvey.

#### **Tuesday, December 5, 2017 (Regular Meeting):**

The December 5 meeting included a presentation on the Draft Hazard Mitigation Plan, and provided time for the Task Force to provide input on the current draft, specifically:

- What risks and goals are not yet addressed concerning local drainage improvements?
- What risks and goals are not yet addressed concerning regulatory approach?
- What risks and goals are not yet addressed concerning regional efforts?

The Task Force was also asked to provide staff with a list of 'Overarching Goals' which outlined what the Task Force was trying to accomplish.

#### **Tuesday, December 19, 2017 (Regular Meeting):**

The City Engineer presented to the Task Force an overview of Baseflood Elevations, specifically:

- How is it determined?
- What does it mean?
- How does a 100-year event impact Bellaire?

Additionally, the Task Force discussed the "Overarching Goals" provided to staff, and received a status update on the Draft Hazard Mitigation Plan.

#### **Tuesday, January 9, 2018 (Regular Meeting):**

At their January 9 meeting, the Task Force was presented with review of the City of Bellaire current regulatory approach to mitigate flooding, a review of the "Overarching Goals", and a review of the unfinished draft matrix. Additionally, the Task Force reviewed the plan for the January 29 Public Hearing.

#### **Monday, January 29, 2018 (Public Hearing):**

A Public Hearing was held on January 29, 2018 in the City of Bellaire's Council Chamber to seek public input on the Draft Flood Hazard Mitigation Plan. The Public was presented<sup>11</sup> the Draft Flood Hazard Mitigation Plan and a history of its development. The meeting was then opened for Public comments and questions regarding the Plan and other flood related issues. There were twelve (12) individual speakers who signed up<sup>12</sup> to address the Task Force. Each speaker was granted five (5) minutes to comment and pose questions. Comments and questions from the public were addressed to the Task force, who were able to refer questions to the staff as

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<sup>11</sup> See Appendix – January 29, 2018 Public Hearing Presentation

<sup>12</sup> See Appendix – January 29, 2018 Public Hearing Speaker Sign-Up Sheets

appropriate. The floor was then opened to the Task Force to comment and ask questions to Staff and the Consulting Advisory Team regarding comments from the Public.

**Tuesday, February 6, 2018 (Regular Meeting):**

On February 6, the Task Force met to review the comments received at the Public Hearing on January 29, 2018.

**Tuesday, February 20, 2018 (Regular Meeting):**

The Task Force met to review and finalize the Flood Hazard Mitigation Matrix. Members were asked to provide consensus on the activities listed in the Action/Implementation plan.

**Tuesday, March 6, 2018 (Regular Meeting):**

The primary focus of this meeting was to approve the Flood Hazard Mitigation Plan (Final Draft) that will be presented to Council for approval on March 19<sup>th</sup>, 2018. Also discussed were the next steps of the Flood Hazard Task Force.

# Coordination with Other Agencies (CRS Activity 511.3)

## Background

The City of Bellaire is part of the 137 square mile Brays Bayou watershed<sup>13</sup>. The Brays Bayou watershed is located in southwest Harris County and portions of Fort Bend County and drains parts of the cities of Houston, Missouri City, Stafford, Bellaire, West University Place, Southside Place and Meadows Place. The bayou flows eastward from Fort Bend County to its confluence with the Houston Ship Channel. The Brays Bayou watershed is fully urbanized, although several large urban parks and regions of open space are located within the watershed.

## Coordination

A cooperative effort is currently active between Harris County Flood Control District (HCFCD) and the U.S. Army Corps of Engineers (Corps) to improve Brays Bayou. This \$480 million project will substantially reduce flooding risks in the Brays Bayou watershed. Encompassing more than 75 individual project components, Project Brays will help to reduce flooding risks by widening 21 miles of Brays Bayou, replacing or modifying 32 bridges to accommodate channel modifications and excavating four storm water detention basins that will hold a collective 3.5 billion gallons of storm water.

Upon completion, Project Brays will provide a 1% (100-year) level of protection along the main stem of Brays Bayou upstream of Beltway 8. After the construction of all elements of Project Brays, the area downstream of Beltway 8 will see the removal of the 1% (100-year) floodplain from approximately 15,000 homes and businesses in the watershed. A Conditional Letter of Map Revision (CLOMR) projects that much of the current 100-year floodplain will be removed from the City of Bellaire.

The City of Bellaire is working with HCFD and other state and federal government entities to expedite improvements to Brays Bayou to add capacity and lower the flood stage water surface elevations.

On February 13, 2018 City's Consulting Advisory Team and City Staff met with City of Houston (COH) representatives to present<sup>14</sup> and discuss flooding issues that Bellaire encounters. City of Bellaire arterial street drainage systems service storm water from City of Houston. Bellaire

<sup>13</sup> See Appendix – Map of Brays Bayou Watershed

<sup>14</sup> See Appendix – City of Bellaire presentation to City of Houston

representatives presented that this issue contributes to flooding during localized rain events due to less capacity in the Bellaire system.

City personnel also met with City of Houston personnel to discuss the Richmond Plaza North Drainage and Paving Improvements project<sup>15</sup>. This project is located upstream of Bellaire and it was determined that the City of Bellaire's Chimney Rock drainage system would not be adequate to accommodate runoff from this project. City of Bellaire and City of Houston agreed that a collaborative effort should take place to perform a drainage system study to determine a proposed level of service for the Chimney Rock drainage system as a first step in improving this area.

A Notice<sup>16</sup> to Surrounding Communities and Agencies was prepared and distributed. This Notice notified those communities and agencies of the preparation of the City of Bellaire Flood Hazard Mitigation Report. Those contacted were encouraged to provide comments and information relevant to the proposed Plan and solicited to work with the City to develop partnerships to address the regional problem of flooding.

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<sup>15</sup> See Appendix – Meeting with COH meeting minutes

<sup>16</sup> See Appendix – Notice to Surrounding Communities and Agencies

# Assess the Hazard (CRS Activity 511.4)

## Background

The City of Bellaire participates in the National Flood Insurance Program and the Community Rating System (CRS), a voluntary federal program that rewards communities that implement higher standards by providing discounts on flood insurance policies. Currently, there are approximately 4,783 Bellaire flood insurance policy holders and Bellaire holds a CRS classification of Class 7, which saves policy holders 15% on their flood insurance premiums each year. Bellaire is designated as a Repetitive Loss Community<sup>17</sup> and the current Floodplain map shows most of Bellaire to be within the 1% (100-year) flood plain<sup>18</sup>.

Over the last 24 months, Bellaire experienced three (3) significant flood events:

- April 18, 2016 (Tax Day Flood)
- May 25-27, 2016 (Memorial Day Flood)
- Hurricane Harvey (2017)

Most recently Hurricane Harvey flooded approximately 2318 structures including garages. Approximately 1936 homes experienced water damage to the main house structure. The areas with the most structures flooded were located in the southeast quadrant of the City followed by the south central area of the City. Both areas are in close proximity to Brays Bayou. While the majority of these homes were not in compliance with the elevation requirements enacted after Tropical Storm Allison (one (1) Foot above Base Flood Elevation), the damage was still severe and devastating to our residents.

After the Memorial Day event, the City of Bellaire contracted with ARKK Engineering to conduct a Drainage Study<sup>19</sup>, the report “addressed drainage problems local to Bellaire and those regional to the Bellaire area”. The City Engineer also provided a report<sup>20</sup> after Hurricane Harvey, which outlined the cause and impact of the event. Utilizing the 2004 Flood Hazard Mitigation Plan and these two reports as a starting point, the City began development of its Hazard Assessment.

The process of updating the City’s Flood Hazard Mitigation Plan began before Hurricane Harvey, however the impact of the event on the process was not dismissed. As it concerns the development of the Mitigation Plan, the decision was made, by staff and through consensus of

<sup>17</sup> See Appendix – Map of Repetitive Loss Structures in Bellaire

<sup>18</sup> See Appendix – Map of 1% (100-year) Flood Plain for Bellaire

<sup>19</sup> See Appendix – City Engineer Drainage Study

<sup>20</sup> See Appendix – City Engineer Hurricane Harvey Report

the Flood Hazard Mitigation Task Force to focus on the impact of a 1% (100-year) storm event. It is with this in mind that the hazards were assessed.

## Hazard Assessment

The City of Bellaire experiences shallow floodplain flooding as well as ponding/overland flow flooding.

Shallow floodplains exist throughout much of Harris County and Bellaire is located near the Brays Bayou shallow floodplain. When Brays Bayou's capacity is exceeded and flood waters overtop the bayou banks, flooding occurs in the land areas near the bayou that are located at lower elevations. Land areas can remain flooded for hours until water surface elevations drop in the bayou. This type of flooding was prevalent in southeast portions of Bellaire during Hurricane Harvey.

Bellaire is also subject to ponding and overland flow flooding. Ponding and overland flow flooding occurs when intense local rainfall exceeds storm sewer or roadside ditch capacity, the water can "pond" in the streets deep enough to flood residences that are away from the bayou. This type of flood is not restricted to any one area. The storm water ponds until it eventually seeks a path to the outfall by flowing overland. When residences and other structures are below the surrounding land elevation or in the path of the overland flow, flooding may occur. The probability of this type of flooding is not shown on the floodplain on the Flood Insurance Rate Maps.

Staff met on November 22, 2017 to generate an initial draft of a Hazard Risk Assessment Matrix. One of the first steps was to establish a list of flood hazards that the City encounters. Subsequent planning steps used this list to identify and assess the risks and issues relating to these hazards, and ultimately a set of goals evolved with associated action plans to mitigate the identified hazards. An email was sent out to Task Force members to provide input and comments to be included in the Matrix.

Hazards identified on the Hazard Risk Assessment Matrix were separated in the following categories:

- Public Communication
- Mobility
- Infrastructure (COB & Other)
- Preparedness
- Facilities and Equipment
- Health and Safety
- Economic Impact
- Storms > 100-year
- Representation

The initial draft was presented to the Task Force at the December 5, 2017 meeting for review and comments. The meeting discussion was focused on the development of the Risk/Issues and Mitigation Option/Goals portions of the Matrix. The identified hazards will allow for the development of effective action plans to mitigate flooding.

# Assess the Risk (Problem) (CRS Activity 511.5)

## Background

The City of Bellaire has flooded from various severe storms over the last century. Various degrees of flooding affect the City of Bellaire due to the City being predominantly flat in nature, with soils consisting primarily of flat clay. Heavy rainfall amounts and recent large numbers of severe storms have produced more occasions for flooding. While the City of Bellaire is dedicated to minimizing adverse impacts associated with flood events, there are many factors beyond the City's control that contribute to flooding in Bellaire. Some of these factors are:

- Very high average annual rainfall of approximately 50 inches
- Very flat topography
- Clay soils that do not absorb water very well
- Close proximity to an undersized Brays Bayou
- Large amounts of storm water from the City of Houston flow into Bellaire from the north
- Localized storm water runoff from Bellaire drains into undersized drainage systems owned by the City of Houston
- Below base flood finished floor elevations of homes constructed prior to the National Flood Insurance Rate Standards

The City of Bellaire does control the drainage improvements constructed within the City limits and the finished floor elevation requirements for new residential and commercial development. The City also controls residential lot drainage and fill requirements and requires storm water detention on commercial developments.

## Risk (Problem) Assessment

Utilizing the hazards assessed, Staff members of the Flood Hazard Mitigation Task Force, along with the engineering consultant assessed the risks (problem) associated with each hazard category. The identification of these risk was compiled using historical information based on previous flood events in the City. In many cases there were multiple risks identified for a specific hazard category.

The draft risk assessment was presented to the Task Force, and members were asked to identify any risk which may have been overlooked. Identified risks were incorporated in to the draft matrix under the appropriate hazard category.

The Task Force utilized these identified risks when developing the Mitigation Option and Action/Implementation Plan.

## Community Goals (CRS Activity 511.6)

The Flood Mitigation Task Force has identified a set of goals for which the City's flood mitigation program should strive to achieve. These goals will provide direction to develop means and methods to effectively mitigate flooding hazards. During implementation, the available resources, statutory authority, and staffing may affect the City's level of attainment of stated goals.

The Task Force has established the following overarching goals for the mitigation planning effort. Each overarching goal has subsequent detailed objectives.

**1. Establish policies, procedures and activities for the safety and assurance for citizens of City of Bellaire.**

- Bellaire residents and property owners should not need to unreasonably worry about flooding.
- Bellaire residents and property owners should be prepared and equipped to deal with flooding.
- During a flood event, communication between rescue agencies and residents need to be meaningful and reliable
- Rescue agencies should have sufficient training, equipment, and access to resources.

**2. Develop, fund, design and construct infrastructure improvements to mitigate the effects of flooding.**

- The cost/benefit of level of protection options needs to be determined, and the level of protection to be provided by local drainage improvements needs to be established
- The City of Bellaire needs to be positioned to secure adequate funding for local capital drainage projects.
- The City of Bellaire needs to be positioned to secure funding and implementation of regional projects that benefit the City of Bellaire
- The relationship between drainage maintenance (e.g. sewer repairs, inlet cleaning) and level of protection should be established
- Sufficient resources for ongoing drainage maintenance needs to exist.

**3. Evaluate and establish the City's position in floodplain regulation in terms of policies and management.**

- The current approach to regulating the flood plain needs to be evaluated with regard to future base flood elevation calculations (elevation requirements, impervious cover, management of flood repair permits)
- The feasibility and effectiveness of property acquisition for the purpose of drainage improvements should be evaluated
- The City of Bellaire should be positioned to advocate for strict upstream development standards.

## Review Possible Activities (CRS Activity 511.7)

A list of Possible Activities was developed for the Hazard Risk Assessment Matrix. These Activities were categorized to one of six types of General Mitigation Strategies:

- Preventive activities that keep problems from getting worse
- Floodplain Management Regulatory (current and future conditions)
- Property protection activities that address individual buildings
- Natural resource protection activities
- Emergency services measures taken before, during, and after an occurrence
- Structural projects that control the hazard
- Public information activities that advise property owners and others

The City of Bellaire has a myriad of mitigation activities already established. This Flood Hazard Mitigation Plan also proposes new possible activities to address the Mitigation Strategies listed above.

### **Preventive Activities**

City of Bellaire currently has a program for maintenance and repairs of inlets and storm sewers. The prioritization schedule of this program is regularly reviewed and revised to address problem flooding, combining multiple approaches that include potential flooding risks and event based property damage.

Coordination with neighboring agencies is paramount to the mitigation efforts for the City. Coordination with neighboring agencies (i.e. TxDOT, City of Houston and HCFCD) and the formation of regional partnerships need to be established in order to prevent backflow of local bayous from entering the City's underground drainage systems. Such backflow results in less capacity in the City's drainage system for local rainfall events resulting in flooding.

Brays Bayou is undersized for extreme rain. Harris County Flood Control District (HCFCD) and the U.S. Army Corps of Engineers have teamed up to widen Brays Bayou to substantially reduce flooding risks in the Brays Bayou watershed. These preventative measures will essentially remove Bellaire from the 1% (100-year) flood plain. Additional coordination should continue to determine how the additional widening of Brays Bayou will reduce flooding for the City of Bellaire.

### **Floodplain Management Regulatory Activities (Current and Future)**

City of Bellaire has adopted Planning and Zoning Regulations for residential and commercial properties in order to regulate the development and/or redevelopment of property within the City. The Code strictly enforces the maximum allowable lot coverage and lot fill for each zoning district, regulates the limits of impermeable surface areas per lot to help reduce runoff. Flood Damage Prevention Ordinances also require building slab finished floors to be a minimum of one foot above the base flood elevation.

Single family housing is the primary economic factor for the City and a primary goal of Bellaire is to reduce the number of unsafe structures in the City. Existing regulations need to be routinely reviewed and evaluated to clearly define development guidelines for structures in designated flood areas, as defined by current flood hazard maps. Potential regulatory updates would allow residents to take proactive mitigation efforts on their property.

### **Property Protection Activities**

The City has taken steps to protect public property and encourages residents to protect their personal property. Existing building regulations have already been established to protect property owners from potential flood hazards. This plan will direct the City to determine any additional level of service to be achieved for future flood protection measures.

### **Emergency Service Activities**

Emergency Services response is an integral part of the City's operations. The City has in place an early warning system for Staff to respond to impending emergencies, such as hurricanes or severe storms. The system consists of a graduated level of response based on the relative threat of flooding. Notification of local conditions are broadcast through various broadcasting outlets.

Recent flood events exposed the potential inability to rescue persons trapped in homes where flood inundation makes continued occupation life threatening. The plan seeks to utilize a multi departmental approach to rescue citizens by developing a program to identify, train and utilize citizen rescuers. Flooding also hinders the mobility of specialized response vehicles. This hazard inhibits response vehicles from reaching all residents and moving them to a safe haven. The plan intends to develop a rescue plan which utilizes field-confirmed data to generate dynamic response maps for rescuer pathways.

### **Structural Projects**

An ongoing program has been in place to improve the City's infrastructure. Existing activities include a multi-year plan that evaluates the existing storm sewer system to identify areas requiring improvements. The ongoing improvements aim to prioritize areas based on adequacy of drainage performance.

In 2016 the City engineer prepared a report addressing drainage problems local to Bellaire and those regional to the Bellaire area. The report recommended drainage improvements to help prioritize future street and drainage capital improvements. Among those recommendations is the plan to construct local underground storage systems by increasing the normal two-year design storm sewer system to store the 100-year storm volumes at select strategic locations. It was also recommended to construct backflow prevention systems at several of the City's major drainage system outfalls like the Newcastle and IH 610 system outfalls to Cypress Ditch to prevent back water flow from Brays Bayou backing up into City underground systems during high water flood stages.

## **Public Information Activities**

Public information activities advise and educate residents about the hazards of flooding and how to mitigate its effects. The Plan identifies a number of activities to inform residents of possible flood mitigation measures. The City periodically distributes messages to residents advising them of the dangers of driving in high water, staying abreast of weather conditions and other potential flood hazards.

This plan aims to further public information activities by developing a communication template to be utilized prior to, during and after a flooding even which includes updates on information the City has deemed important based on lessons learned from previous events. It is also a goal of the City to utilize a mass notification system that will reach all residents with relevant hazard warning and evacuation advice.

## **The Problem**

The City of Bellaire lies in a coastal floodplain with a relatively flat topography and clay soils. Close proximity to the Gulf of Mexico and a sub-tropical environment provide an environment of frequent and heavy rainfall. These conditions are conducive to flooding on a regular basis. A significant fraction of the City is currently in the 100-year floodplain because of the nearness to Brays Bayou. All areas of the City are subject to flooding. Historical data from previous floods demonstrate that flooding may be extensive and costly. Being a highly urbanized area, future development in the City is not expected to significantly exacerbate flooding.

## **Program Action Items**

The recommendations made in Section IX and the action/implementation items listed in the Flood Hazard Matrix will become the specific action items proposed below. The action items are organized<sup>21</sup> according to the mitigation strategies outlined in the previous section. The action items have also been prioritized within their respective categories. The City is recommended to continue to implement those action items that are currently being performed. These action items specify what will be done, who is responsible, when it is projected to be done, and how it is expected to be financed.

### **Preventive Activities**

#### **1. Activity**

Establish a desired level of protection versus the cost to implement (cost benefit analysis).

##### **Responsible Person(s)**

Public Works will be responsible for implementing this activity.

##### **Schedule**

Target completion date is End of FY 2020

##### **Financing**

Financing for this activity will be from Operating Budget.

#### **2. Activity**

Establish a comprehensive asset management plan allowing for better short and long-term planning of maintenance and capital improvement costs and needs to address flooding.

##### **Responsible Person(s)**

Public Works will be responsible for implementing this activity.

##### **Schedule**

Target completion date is End of FY 2022

##### **Financing**

Financing for this activity will be from Operating Budget.

<sup>21</sup> See Appendix – Draft Action Plan/Matrix Organization

3. Activity

Develop an educational program/campaign warning residents of dangers of blocked storm sewers, and how they can help mitigate this problem.

Responsible Person(s)

Public Works will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2022

Financing

Financing for this activity will be from Operating Budget.

4. Activity

Develop plan to inform residents of the importance of not filling in the floodplain.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019

Financing

Financing for this activity will be from Operating Budget.

### **Floodplain Management Regulatory Activities (Current and Future)**

1. Activity

Update City Ordinances to clearly define development guidelines for structures in the designated flood areas, as defined by current Special Hazard Flood Area Maps. Review and update City Codes based on the recommended changes to the Special Flood Hazard Area Maps.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing

Financing for this activity will be from Operating Budget.

2. Activity

Research and evaluate regional approach to the 50% rule, for the development of City of Bellaire guidelines.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing

Financing for this activity will be from Operating Budget.

3. Activity

At all stages of infrastructure project development in the floodplain, gather community input strategies to be examined; allowing the public to see the results, costs, and benefits for alternatives studied.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2021.

Financing

Financing for this activity will be from Operating Budget.

4. Activity

Evaluate a buy-out program for properties that have flooded repeatedly.

Responsible Person(s)

City Manager's Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing

Financing for this activity will be from Operating Budget.

5. Activity

Ensure adequate City resources are in place to assist residents when applying for buy-out and elevation grants.

Responsible Person(s)

City Manager's Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2023.

Financing

Financing for this activity will be from Operating Budget.

6. Activity

Develop Bellaire specific commercial drainage requirements.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2023.

Financing

Financing for this activity will be from Operating Budget.

**Property Protection Activities**

1. Activity

Evaluate updates to the Building Code which would allow residents to take proactive mitigation efforts on their property.

Responsible Person(s)

Development Services will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2023.

Financing

Financing for this activity will be from Operating Budget.

## **Emergency Service Activities**

### **1. Activity**

Develop a plan to identify, utilize, and position non-conventional access vehicles for use when weather events dictate.

#### **Responsible Person(s)**

Bellaire Fire Department will be responsible for implementing this activity.

#### **Schedule**

Target completion date is End of FY 2019.

#### **Financing**

Financing for this activity will be from Operating Budget.

### **2. Activity**

Properly budget for rescue oriented persons to make logical purchases for rescue equipment. Develop a program to identify, train, and utilize Citizen Rescuers and create MOU (cover liability of the asses use donation). Evaluate reinstating Citizen Emergency Response Team (CERT).

#### **Responsible Person(s)**

Bellaire Fire/Police Department will be responsible for implementing this activity.

#### **Schedule**

Target completion date is End of FY 2019.

#### **Financing**

Financing for this activity will be from Operating Budget.

### **3. Activity**

Research, develop scope and policies and procedures, and place into effect a mass notification system.

#### **Responsible Person(s)**

City Manager's Office will be responsible for implementing this activity.

#### **Schedule**

Target completion date is End of FY 2020.

#### **Financing**

Financing for this activity will be from Operating Budget.

### **4. Activity**

Develop a rescue plan which utilizes field-confirmed data to generate dynamic response maps for rescuer pathways.

#### **Responsible Person(s)**

Bellaire Fire Department & Public Works will be responsible for implementing this activity.

#### **Schedule**

Target completion date is End of FY 2022.

#### **Financing**

Financing for this activity will be from Operating Budget.

5. Activity

Formalize a mechanism within the scope of EOC operations whereby a team would be responsible for field reconnaissance as well as publication of information for use by the public via the website, social media, local news media, etc.

Responsible Person(s)

Bellaire Fire will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing

Financing for this activity will be from Operating Budget.

6. Activity

Develop a plan to address rescues from one-story homes and older two-story homes.

Develop a plan to evacuate disabled/physically impaired/elderly individuals from homes in advance of anticipated high rainfall events.

Responsible Person(s)

Bellaire Fire Department will be responsible for implementing this activity.

Schedule

Target completion date is FY 2019.

Financing

Financing for this activity will be from Operating Budget.

**Structural Projects**

1. Activity

Coordinate with Harris County Flood Control District (HCFCD) and the U.S. Army Corps of Engineers to determine how additional widening of Brays Bayou will reduce flooding for the City of Bellaire.

Responsible Person(s)

Director of Public Works will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2021.

Financing

Financing for this activity will be from Capital Improvements Budget.

2. Activity

Evaluate increasing the size of existing storm water drainage culverts in Bellaire while continuing to utilize drainage impact when selecting roads to be reconstructed. Lower street level when streets are under construction. Strategically locate undergoing storage pipes within the existing street right-of-way to store 100-year localized rainfall events.

Responsible Person(s)

Director of Public Works will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing

Financing for this activity will be from Capital Improvements Budget.

3. Activity

Determine partners, study alternatives, and develop cost estimates for improvements to increase capacity of the north/south drainage systems and Cypress Ditch.

Responsible Person(s)

Director of Public Works will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing

Financing for this activity will be from Operating Budget

4. Activity

Include design and installation of backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects<sup>22</sup>. Coordinate with neighboring agencies (i.e. TxDOT, City of Houston, and HCFCD) to prevent backflow<sup>23</sup> storm water from entering the City's underground drainage systems.

Responsible Person(s)

Director of Public Works will be responsible for implementing this activity.

Schedule

First phase completion date is End of FY 2020.

Financing

Financing for this activity will be from Capital Improvements Budget.

5. Activity

Identify any and all regional partnership opportunities (elected & appointed). Determine appropriate representatives from the City for regional agencies.

Responsible Person(s)

City Manager's Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing

Financing for this activity will be from Operating Budget.

6. Activity

Identify barriers restricting sheet flow and determine what project could relieve this problem.

Responsible Person(s)

Director of Public Works will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2021.

Financing

Financing for this activity will be from Capital Improvements Budget.

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<sup>22</sup> See Appendix – Bonds for Better Bellaire 2016

<sup>23</sup> See Appendix – Flap Gates Memo

**7. Activity**

Create a proactive approach to repair and maintain drainage systems in desirable development areas and neighborhoods with storm drainage systems. Develop a schedule to perform routine maintenance, inspections, and repairs to storm water infrastructure. Expedite a plan to repair and replace the highly critical local drainage systems in the current Bonds for Better Bellaire 2016. Re-evaluate the priorities annually and aggressively pursue future bond programs.

**Responsible Person(s)**

Director of Public Works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2020.

**Financing**

Financing for this activity will be from Capital Improvements Budget

**8. Activity**

Coordinate with HCFCD to determine steps necessary to increase the size of the outfall of Kilmarnock Ditch. Construct extreme event outfalls at Bellaire Blvd and within the Southdale Subdivision to Kilmarnock Ditch.

**Responsible Person(s)**

Director of Public works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2023.

**Financing**

Financing for this activity will be from Capital Improvements Budget.

**9. Activity**

Contact surrounding municipalities and the agencies that own the storm sewers to consider upgrading their storm sewer and providing more detention. Investigate City of Houston developments north of Bellaire for total runoff.

**Responsible Person(s)**

Director of Public Works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2019.

**Financing**

Financing for this activity will be from Capital Improvements Budget.

**10. Activity**

Evaluate the conversion of Bellaire's Wastewater Treatment Plant, the dog park and soccer fields along Edith into detentions areas. Evaluate the conversion of the trash transfer station at Beltway 8 to a reservoir for Brays Bayou.

**Responsible Person(s)**

Director of Public Works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2021.

**Financing**

Financing for this activity will be from Capital Improvements Budget.

**11. Activity**

Evaluate the feasibility of adding flood stage gauges at strategic locations in the City to provide flood water readings for public safety.

**Responsible Person(s)**

Director of Public Works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2019.

**Financing**

Financing for this activity will be from Capital Improvements Budget.

**12. Activity**

Evaluate the transfer of Wastewater Treatment for the City of Bellaire to the City of Houston Facility, including hazard mitigation funding opportunities.

**Responsible Person(s)**

Director of Public Works will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2023.

**Financing**

Financing for this activity will be from Capital Improvements Budget.

**Public Information Activities**

**1. Activity**

Develop a marketing plan which identifies the City outlets and how to increase participation in them. The plan should list events, stakeholders, etc. Develop and update a list of frequently utilized non-City outlets which the City should use to distribute its messages. This list should include media contacts, etc.

**Responsible Person(s)**

City Manager's Office will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2019.

**Financing**

Financing for this activity will be from Operating Budget.

**2. Activity**

Pre-populate communication outlets with needed information, allowing contacts to "opt-out", instead of having to "opt-in". Develop a communication matrix to outline what messages should be sent through which outlets. Evaluate the implementation of a "local street warden" program to deliver City produced storm related communication to their assigned area.

**Responsible Person(s)**

City Manager's Office will be responsible for implementing this activity.

**Schedule**

Target completion date is End of FY 2020.

Financing for this activity will be from Operating Budget.

3. Activity

Evaluate the implementation of a “local street warden” program to deliver City produced storm related communication to their assigned area.

Responsible Person(s)

City Manager’s Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2022.

Financing for this activity will be from Operating Budget.

4. Activity

Develop public messages to be used prior to and during an event to outline when residents should use 911. The public messages should also include other communication outlets residents can utilized in non-emergency situations.

Responsible Person(s)

Bellaire Fire Department will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing for this activity will be from Operating Budget.

5. Activity

Develop an educational program/campaign to inform residents and stakeholders of regularly utilized communication outlets.

Responsible Person(s)

City Manager’s Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing for this activity will be from Operating Budget.

6. Activity

Develop a communication template to be utilized prior to, during and after a flooding event which includes updates on information the City has deemed important based on lessons learned from previous events.

Responsible Person(s)

City Manager’s Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing for this activity will be from Operating Budget.

7. Activity

Utilize Town Hall meetings to discuss all hazard preparedness. Create a preparedness milestone for families.

Responsible Person(s)

City Manager’s Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing for this activity will be from Operating Budget.

8. Activity

Develop an education program/campaign to inform residents on the level of protection provided by the City's infrastructure. Educate the public that street flooding is preferable to structural flooding.

Responsible Person(s)

City Manager's Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2020.

Financing for this activity will be from Operating Budget.

9. Activity

Periodically distribute messages to residents warning of dangers of walking or playing in floodwaters. Everyone should refrain from walking or riding bicycles in floodwaters. Develop a plan with local schools to educate children to avoid walking, playing, or riding bicycles in floodwaters.

Responsible Person(s)

City Manager's Office will be responsible for implementing this activity.

Schedule

Target completion date is End of FY 2019.

Financing for this activity will be from Operating Budget.



## Implement, Evaluate, & Revise the Plan (CRS Activity 511.9)

This Plan will be implemented by City Staff that have been involved in the development of the plan. As such, Staff is cognizant of the activities required by this Plan and the steps necessary for implementation. Staff has assessed responsibility for activities as outlined in Section X.

The implementation of the Plan will be monitored so that progress may be measured and necessary changes identified. To properly monitor the Plan, Staff and the City Manager will regularly meet throughout the year to report on progress. Staff and the City Manager will also meet at times of flooding events to discuss how the Plan impacts the flooding effects.

The Task Force will meet on a biannual basis to discuss and evaluate updates for the report. An annual evaluation report will be prepared by Staff prior to the City's annual recertification, to be included with the Plan.

The Plan will be updated at least once every five years by the Task Force. This update will include the following:

- A review of hazard and problem assessments
- A revision of the action plan to reflect the status of projects and changes in hazard and problem assessments
- Submittal of the draft update to other agencies for comment
- A public meeting must be held to explain the changes in the Plan
- The update must be adopted by the City Council

1. CRS Summary
2. Bellaire City Council Resolution No. 17-08
3. Flood Hazard Mitigation Plan/Matrix
4. Agendas
5. Notify Me" Emails
6. Electronic Notebook ([www.bellairetx.gov/taskforce](http://www.bellairetx.gov/taskforce))
7. November 2, 2017 "Mayor's Musings-Flood Hazard Mitigation Task Force Gets to Work" (<http://cityofbellairemayormusings.blogspot.com/2017/11/flood-hazard-mitigation-task-force-gets.html>)
8. News Flash – "Flood Hazard Mitigation Task Force Public Hearing"
9. January 25, 2018 "Mayor's Musings-Task Force Public Hearing on Draft Flood Hazard Mitigation Plan – Jan. 29, 6:30 pm"  
(<http://cityofbellairemayormusings.blogspot.com/2018/01/task-force-public-hearing-on-draft.html>)
10. Task Force Presentations
11. January 29, 2018 Public Hearing Presentation
12. January 29, 2018 Public Hearing Speaker Sign-Up Sheets
13. Map of Brays Bayou Watershed
14. City of Bellaire presentation to City of Houston
15. Meeting with City of Houston Meeting Minutes 2/21/2018
16. Notice to Surrounding Communities and Agencies
17. Map of Repetitive Loss Structures in Bellaire
18. Map of 1% (100-year) Flood Plain in Bellaire
19. City Engineer Drainage Study
20. City Engineer Hurricane Harvey Report
21. Draft Action Plan/Matrix Organization
22. Bonds for Better Bellaire 2016
23. Flap Gates Memo
24. Task Force Meeting Minutes

## **Appendix 1**

### **1. CRS Summary**

## **110 PROGRAM OVERVIEW**

### **111 Background**

The National Flood Insurance Program (NFIP) provides federally backed flood insurance within communities that enact and enforce floodplain regulations. Since its inception in 1968, the NFIP has been very successful in helping flood victims get back on their feet. As of October 1, 2016, there were 5.1 million residential and commercial policies in force, with \$1.25 trillion in written coverage with annual premiums of about \$3.6 billion. From 1978 through March 2016, over 2.2 million losses were paid, totaling over \$54 billion.

To be covered by a flood insurance policy (for the structure and/or its contents), a property must be in a community that participates in the NFIP. To qualify for the NFIP, a community adopts and enforces a floodplain management ordinance to regulate development in flood hazard areas. The objective of the ordinance is to minimize the potential for flood damage to future development. Today, over 22,200 communities in 56 states and territories participate in the NFIP.

The NFIP has been effective in requiring new buildings to be protected from damage by a 1% chance flood, also known as the 100-year or base flood. However, flood damage still results from floods that exceed the base flood, from flooding in unmapped areas, and from flooding that affects buildings constructed before the community joined the NFIP.

Under the Community Rating System (CRS), communities can be rewarded for doing more than simply regulating construction of new buildings to the minimum national standards. Under the CRS, the flood insurance premiums of a community's residents and businesses are discounted to reflect that community's work to reduce flood damage to existing buildings, manage development in areas not mapped by the NFIP, protect new buildings beyond the minimum NFIP protection level, preserve and/or restore natural functions of floodplains, help insurance agents obtain flood data, and help people obtain flood insurance.

### **112 Goals**

The goals of the NFIP are to provide flood insurance to property owners, to encourage flood loss reduction activities by communities, and to save taxpayers' money. As a part of the NFIP, the CRS provides both incentives and tools to further these goals.

The CRS recognizes, encourages, and rewards—by the use of flood insurance premium adjustments—community and state activities that go beyond the minimum required by the NFIP to

- Reduce and avoid flood damage to insurable property,
- Strengthen and support the insurance aspects of the NFIP, and
- Foster comprehensive floodplain management.

The purpose of the CRS is to support the NFIP. To do this, the CRS provides flood insurance premium rate reductions to policyholders in recognition of the fact that their communities implement activities that exceed the minimum NFIP requirements and that work toward the three goals of the CRS. Included in this support are measures that credit protection to life and property during a flood. A closer look at how communities can implement these three goals follows.

**Goal 1. Reduce and avoid flood damage to insurable property.**

The CRS supports the NFIP by working to minimize flood losses nationwide, both inside and outside of mapped floodplains. Communities are encouraged to reduce the exposure of existing buildings (and their contents) to flood damage, especially properties that are subject to repetitive flood losses. New buildings and their contents should be protected from known and future local flood hazards. Standards higher than those set out in the minimum criteria of the NFIP may be needed to accomplish these tasks. The CRS encourages communities to map and provide regulatory flood data for all their flood hazards. The data should be used in their regulatory programs and shared with all users and inquirers.

**Goal 2. Strengthen and support the insurance aspects of the NFIP.**

The CRS recognizes communities whose activities generate and contribute data that enable accurate actuarial rating of flood insurance. Communities are encouraged to implement mapping and information programs that help assess individual property risk and reduce repetitive flood losses. To help expand the policy base, communities should make their residents aware of their flood risk so that they purchase and maintain flood insurance policies.

**Goal 3. Foster comprehensive floodplain management.**

The CRS encourages communities to use all available tools to implement comprehensive local floodplain management programs, which ordinarily have concerns beyond the protection of insurable property. The CRS recognizes local efforts that protect lives; further public health, safety, and welfare; minimize damage and disruption to infrastructure and critical facilities; preserve and restore the natural functions and resources of floodplains and coastal areas; and ensure that new development does not cause adverse impacts elsewhere in the watershed or on other properties.

A community's staff should understand the physical and biological processes that form and alter floodplains and watersheds and take steps to deal with flooding, erosion, habitat loss, water quality, and special flood-related hazards. A comprehensive approach includes planning, public information, regulations, financial support, open space protection, public works activities, emergency management, and other appropriate techniques.

## 113 Credit Points and Credited Activities

To be recognized in the insurance rating system, local floodplain management activities must be described, measured, and evaluated by the CRS. The basic document detailing the program is the *CRS Coordinator's Manual*. It sets forth the procedures, creditable activities, and the credit points assigned to each activity, and gives examples of activities and how their credit is calculated.

### 113.a. Credit Points and Classification

A community receives a CRS classification based upon the total credit for its activities. There are 10 CRS classes. Class 1 requires the most credit points and gives the greatest premium reduction or discount. A community that does not apply for the CRS, or does not obtain the minimum number of credit points, is a Class 10 community and receives no discount on premiums. The qualifying community total points, CRS classes, and flood insurance premium discounts are shown in Table 110-1.

**Table 110-1. CRS classes, credit points, and premium discounts.**

CRS Class	Credit Points (cT)	Premium Reduction	
		In SFHA	Outside SFHA
1	4,500+	45%	10%
2	4,000–4,499	40%	10%
3	3,500–3,999	35%	10%
4	3,000–3,499	30%	10%
5	2,500–2,999	25%	10%
6	2,000–2,499	20%	10%
7	1,500–1,999	15%	5%
8	1,000–1,499	10%	5%
9	500–999	5%	5%
10	0–499	0	0

*SFHA: Zones A, AE, A1–A30, V, V1–V30, AO, and AH*

*Outside the SFHA: Zones X, B, C, A99, AR, and D*

*Preferred Risk Policies are not eligible for CRS premium discounts because they already have premiums lower than other policies. Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage.*

*Some minus-rated policies may not be eligible for CRS premium discounts.*

*Premium discounts are subject to change.*

The flood insurance premium discount is based on whether a property is in or out of the Special Flood Hazard Area (SFHA), i.e., the zones beginning with the letter A and V as shown on the community's Flood Insurance Rate Map (FIRM). The premium discount for properties in the SFHA increases according to the community's CRS class. A community's classification is based on the community total points (symbolized as cT in the CRS calculations).

The discount for properties outside the SFHA is lower for Class 1–8 communities because premiums in these areas are already relatively low and can be lowered further through the Preferred Risk Policy. Also, most activities undertaken to qualify for those classes are implemented only in the floodplain. Because areas designated as A99 and AR Zones already receive an insurance premium reduction, these zones get the same premium reduction as non-SFHA areas.

### **113.b. Credited Activities**

There are 19 creditable activities, organized under four categories, which are presented in the 300–600 series of the *Coordinator's Manual*. The *Coordinator's Manual* assigns credit points based upon the extent to which an activity advances the three goals of the CRS.

#### **Public Information Activities (300 Series)**

This series credits programs that advise people about the flood hazard, encourage the purchase of flood insurance, and provide information about ways to reduce flood damage. These activities also generate data needed by insurance agents for accurate flood insurance rating. They generally serve all members of the community.

#### **Mapping and Regulations (400 Series)**

This series credits programs that provide increased protection to new development. These activities include mapping areas not shown on the FIRM, preserving open space, protecting natural floodplain functions, enforcing higher regulatory standards, and managing stormwater. The credit is increased for growing communities.

#### **Flood Damage Reduction Activities (500 Series)**

This series credits programs for areas in which existing development is at risk. Credit is provided for a comprehensive floodplain management plan, relocating or retrofitting flood-prone structures, and maintaining drainage systems.

#### **Warning and Response (600 Series)**

This series provides credit for measures that protect life and property during a flood, through flood warning and response programs. There is credit for the maintenance of levees and for state regulatory programs for dams, as well as for programs that prepare for the potential failure of levees and dams.

Some CRS activities may be implemented by the state or a regional agency rather than by the community. For example, some states have hazard disclosure laws that are creditable under Activity 340 (Flood Hazard Disclosure). A community in those states will receive those credit points when it applies for CRS credit and demonstrates that the law is effectively implemented within its jurisdiction. See also Section 231.c.

### **113.c. Activity Credit Points**

The 19 activities and their credit points are shown in Table 110-2. Each activity has one or more elements. Elements are the basic credit level for the CRS. The element and activity scoring process is covered in Activity 220 (Credit Calculation).

The maximum credit points for each activity are shown in the second column. The maximum credit can be earned when all elements within an activity are being implemented and all credit criteria are met. In some activities, maximum credit cannot be provided unless credit has been earned in other activities. For example, additional credit is provided in some activities if the community has adopted a Program for Public Information under Activity 330 (Outreach Projects).

The third column and fourth columns in Table 110-2 show the estimated maximum credit and average credit points using a conservative model to convert the points received under the 2007 *Coordinator's Manual* to the new scoring in the 2013 and 2017 *Coordinator's Manuals*. The maximums and averages are based upon the number of applicants for each activity, not the total number of applicants for the CRS. The fifth column shows the percentage of all CRS communities that received credit for each activity as of May 2013.

Communities should note the average credits for these activities. They provide a better indication of what an applicant can expect for an activity than do the maximum points available.

A community must have at least 500 verified credit points to become a Class 9 or better. It must also meet the prerequisites for certain classes, as described in Section 211. As explained in Activity 230 (Verification), the final, or verified, credit is calculated by the ISO/CRS Specialist after a review of the documentation provided by the community and the community's implementation of its activities at the verification visit (explained in Section 232).

The CRS "Quick Check" is a tool that a community can use to assess its potential for receiving CRS credit for activities it is undertaking. The Quick Check can be found at [www.CRSresources.org/200](http://www.CRSresources.org/200).

The Quick Check does not estimate credit for a community. However, by reviewing each element and going through the steps explained in Section 220, a community can assess its potentially creditable activities.

**Table 110-2. Credit points awarded for CRS activities.\***

Activity	Maximum Possible Points	Maximum Points Earned	Average Points Earned	Percentage of Communities Credited
<b>300 Public Information Activities</b>				
310 Elevation Certificates	116	116	38	96%
320 Map Information Service	90	90	73	85%
330 Outreach Projects	350	350	87	93%
340 Hazard Disclosure	80	62	14	84%
350 Flood Protection Information	125	125	38	87%
360 Flood Protection Assistance	110	100	55	41%
370 Flood Insurance Promotion <sup>5</sup>	110	110	39	4%
<b>400 Mapping and Regulations</b>				
410 Flood Hazard Mapping	802	576	60	55%
420 Open Space Preservation	2,020	1,603	509	89%
430 Higher Regulatory Standards	2,042	1,335	270	100%
440 Flood Data Maintenance	222	249	115	95%
450 Stormwater Management	755	605	132	87%
<b>500 Flood Damage Reduction Activities</b>				
510 Floodplain Mgmt. Planning	622	514	175	64%
520 Acquisition and Relocation	2,250	1,999	195	28%
530 Flood Protection	1,600	541	73	13%
540 Drainage System Maintenance	570	454	218	43%
<b>600 Warning and Response</b>				
610 Flood Warning and Response	395	365	254	20%
620 Levees	235	207	157	0.5%
630 Dams	160	99	35	35%

\* Figures are based on communities that have received verified credit under the 2013 *CRS Coordinator's Manual* (about 43% of CRS communities), as of October 2016. The maximum possible points are based on the 2013 *Coordinator's Manual*. Growth adjustments are not included.

There are three important things to note when estimating credit:

1. Moving to a Class 6, 4, or 1 depends on both having adequate points AND meeting class prerequisites, as explained in Section 211.
2. Many CRS activities have an impact adjustment associated with them. An impact adjustment means that CRS credit is provided for the portion of the regulatory floodplain to which the creditable element is applied. For example, even though 1,450 maximum points are available for open space preservation (OSP), if a community has 20% of the regulatory floodplain as open space, then the credit will be 20% of the allowable credit, or 290 points. See Section 222.
2. Only the final, verified credit calculated by the ISO/CRS Specialist after the verification visit determines a community's total points. It is important that the community provide correct and complete materials to document its activities. Only through a review of the community's documentation can the ISO/CRS Specialist determine the credit points that should be provided.

A community should apply only for those activities it is actively undertaking and those it knows it can implement in accordance with the *Coordinator's Manual*. For example, no credit is provided for draft ordinances—regulations must have been enacted and enforced. Also, a community should not be overly ambitious in undertaking new activities for CRS credit at the risk of losing the credit later (at annual recertification or cycle verification visits) for activities it is unable to implement or continue.

#### **113.d. Activities not Listed**

The CRS activities are not design standards for local floodplain management. The *Coordinator's Manual* is an insurance tool that describes methods of calculating credit points for various community activities. The fact that the *Coordinator's Manual* does not list a specific credit for some activities does not mean that they should not be implemented by communities that need them.

An activity may deserve credit even if the *Coordinator's Manual* does not include it. The *Coordinator's Manual* cannot predict or list everything that can be done to support the goals of the CRS. Communities are always welcome to request credit for alternate approaches or innovations that are not included in the *Coordinator's Manual*. Similarly, communities can submit alternative approaches to the class prerequisites listed in Section 211.

Requests should be submitted to the ISO/CRS Specialist and should include documentation to support how the alternative approach or innovation meets the intent of, or is equivalent to, the prerequisite or the element and/or activity credited in the *Coordinator's Manual*.

Note that some activities are not directly recognized by the CRS for one of three reasons:

1. They do not directly affect buildings that can be insured under the NFIP (e.g., uninsurable items such as streets and land value);

2. They are recognized by other aspects of the flood insurance rating program (e.g., flood control projects that result in revised FIRMs reduce flood insurance premiums in protected areas); or
3. The impact of an activity cannot be measured for CRS credit (e.g., preserving floodplains for aesthetic reasons).

Credit criteria will change over time as experience is gained in implementing, observing, and measuring the activities and as new concepts in floodplain management come into common practice. As innovations arise, they will be considered for recognition under the CRS.

## **114 The Community's Role**

### **114.a. Community Participation**

Community participation in the CRS is voluntary. Any community in full compliance with the rules and regulations of the NFIP may apply for a CRS classification better than Class 10. A community may apply to participate in the CRS at any time.

The application procedures are simple: the community submits a letter of interest and shows that it is implementing activities that would receive at least 500 credit points. The documents go to the ISO/CRS Specialist for that state. The Regional Office of the Federal Emergency Management Agency (FEMA) must approve the submittal to ensure that the community is in full compliance with the minimum floodplain management criteria of the NFIP. See also Section 212.

Upon receiving FEMA approval, a community verification visit is scheduled by the ISO/CRS Specialist. At this verification visit, the ISO/CRS Specialist reviews all of the community's activities that may deserve credit, even those not in the community's submittal. All CRS credit is verified according to the credit criteria in the *Coordinator's Manual* in effect at the time of the visit. The verification process is discussed in Activity 230.

The ISO/CRS Specialist is an employee of Insurance Services Office, Inc. (ISO), FEMA's CRS management contractor. ISO has many years of experience collecting and processing data for more than 1,000 insurance companies. Among other services, ISO develops and provides advisory classifications for community fire protection and building code programs. ISO reviews CRS submittals, verifies communities' credit points, and performs program improvement tasks for FEMA.

After the verification visit, ISO submits its findings to FEMA. FEMA sets the CRS credit to be granted and notifies the community, the state, insurance companies, and other appropriate parties. The classification is effective on either May 1 or October 1, whichever comes first, after the community's activities are verified.

Each year the community must recertify that it is continuing to perform the activities for which it is receiving CRS credit. Recertification is an annual activity that includes progress reports for certain activities (see Section 213). A “cycle verification visit” takes place every few years and is conducted in the form of another verification visit to the community (see Section 232).

If a community is not properly or fully implementing the credited activities, its credit points, and possibly its CRS classification, will be revised. A community may add credited activities in order to improve its CRS classification. This is called a modification and is explained in Section 214.

Communities are encouraged to call on their ISO/CRS Specialist for assistance at any time. This can be especially helpful when they are considering a change to a credited activity or implementing a new program.

A week-long CRS course for local officials is offered free at FEMA’s Emergency Management Institute and has been field deployed to many states. The ISO/CRS Specialist, NFIP State Coordinator, and FEMA Regional Office have more information on this course, state workshops, and other CRS training opportunities.

## **114.b. Community Responsibilities**

Once a community receives its initial classification in the CRS, it must continue to implement its credited activities to keep its classification. Specifically, a community is responsible for

- Designating a community CRS Coordinator—someone who is familiar with the community offices that implement CRS activities;
- Cooperating with the ISO/CRS Specialist and the verification procedures (Section 230);
- Recertifying each year that it is continuing to implement its activities (Section 213);
- Advising FEMA and its ISO/CRS Specialist of modifications to its activities (Section 214);
- Keeping elevation certificates, old FIRMs, and old Flood Insurance Studies for as long as the community is in the CRS;
- Keeping the records iterated in the activities’ documentation sections until they are reviewed at the verification visit;
- Ensuring that flood protection projects and drainage system maintenance activities are compliant with federal environmental and historic preservation requirements (Section 507); and
- Participating in the cycle verification process (Section 232).

Communities will receive periodic updates to the *Coordinator's Manual* and other CRS materials. They are encouraged to order the background publications (see Appendix C), attend CRS workshops, and ask their ISO/CRS Specialists for help understanding the CRS credit criteria for their current and planned activities.

## **115 Costs and Benefits**

Communities should prepare and implement those activities which best deal with their local problems, whether or not they are creditable under the CRS. Few, if any, of the CRS activities will produce premium reductions equal to or greater than the cost of their implementation. In considering whether to undertake a new floodplain management activity, a community must consider all of the benefits the activity will provide (not just insurance premium reductions) in order to determine whether it is worth implementing.

### **115.a. Costs**

No fee is charged for a community to apply for participation in the CRS. The only costs the community incurs are those of implementing creditable floodplain management activities and the staff time needed to document those activities and prepare for and participate in the recertification process and verification visits.

### **115.b. Benefits**

There are many benefits to participating in the CRS. Most of them cannot be measured in direct dollar terms, so it is impossible to conduct a strict numerical comparison of the benefits with the costs of implementing the credited activities. Listed here are the benefits more commonly mentioned by community officials.

- (1) The benefit that attracts people to the CRS the most is the reduction in flood insurance premiums for their residents and businesses. The dollar savings varies according to the CRS class, the number of policies, and the amount of coverage. A community can obtain the current and potential dollar savings for all 10 classes from its ISO/CRS Specialist. These are known as the "what if" tables (see Figure 110-1).
- (2) Although the premium reduction attracts interest in the CRS, the most important benefits are the enhanced public safety, reduction in damage to property and public infrastructure, avoidance of economic disruption and losses, reduction in human suffering, and protection of the environment provided by the credited activities. Community officials agree that these programs are improved when changes are made to meet the CRS credit criteria.
- (3) Through the CRS a community can evaluate the effectiveness of its flood program against state and nationally recognized benchmarks.
- (4) Training and technical assistance in designing and implementing credited flood protection activities are available through the CRS at no charge.

Community: WATSONVILLE, CITY OF	State: CALIFORNIA			
County: SANTA CRUZ COUNTY	CID: 060357			
<b>Current CRS Class = 7</b> <a href="#">[Printable Version]</a>				
	<b>TOTAL</b>	<b>SFHA *</b>	<b>X- STD/AR/A99 **</b>	<b>PRP ***</b>
PIF	968	852	66	50
PREMIUM	\$1,013,842	\$939,534	\$58,120	\$16,188
AVERAGE PREMIUM	\$1,047	\$1,103	\$881	\$324
CRS Class				
09	Per Policy	\$60	\$65	\$46
	Per Community	\$58,326	\$55,267	\$3,059
08	Per Policy	\$117	\$130	\$46
	Per Community	\$113,592	\$110,533	\$3,059
07	Per Policy	\$174	\$195	\$46
	Per Community	\$168,859	\$165,800	\$3,059
06	Per Policy	\$235	\$259	\$93
	Per Community	\$227,185	\$221,067	\$6,118
05	Per Policy	\$292	\$324	\$93
	Per Community	\$282,451	\$276,333	\$6,118

**Figure 110-1. The “what if” table.**

The table shows the community's current and potential dollar savings in flood insurance premium reductions for various CRS classes. As a Class 7 community, Watsonville officials are saving their flood insurance policy holders nearly \$200 each year.

“PIF” means “policies in force”

- (5) Many communities initiate new public information activities when they join the CRS. These build a knowledgeable constituency within the community—people who become more interested in protecting themselves from flooding and in supporting the community's floodplain management efforts.
- (6) Keeping its CRS credits has proven to be an effective motivator to continue implementing flood protection programs during the “dry years.” The fact that the community's CRS status could be affected by the elimination of a flood-related activity or a weakening of the regulatory requirements for new development has been taken into account by many governing boards when considering such actions.
- (7) There is mutual support among CRS participants. Communities that participate in the CRS are joining the ranks of localities that have demonstrated a serious commitment to the health, safety, and welfare of their residents—and their floodplain and coastal resources. Across the nation, “CRS users groups” of representatives of counties, communities, and regional entities have formed to share

their experiences, support each other in advancing their floodplain management programs, and encourage other communities to participate in the program.

## 116 Other Program Priorities

### 116.a. Natural Floodplain Functions

Floodplains in riverine and coastal areas perform natural functions that cannot be replicated elsewhere. The CRS provides special credit for community activities that protect and/or restore natural floodplain functions, even though some of the activities may not directly reduce flood losses to insurable buildings. There are many reasons to protect floodplains in their natural state.

When kept open and free of development, floodplains provide the necessary flood water conveyance and flood water storage needed by a river or coastal system. When the floodplain is allowed to perform its natural function, flood velocities and peak flows are reduced downstream. Natural floodplains reduce wind and wave impacts and their vegetation stabilizes soils during flooding.

Floodplains in their natural state provide many beneficial functions beyond flood reduction. Water quality is improved in areas where natural cover acts as a filter for runoff and overbank flows; sediment loads and impurities are also minimized. Natural floodplains moderate water temperature, reducing the possibility of adverse impacts on aquatic plants and animals.

Floodplains can act as recharge areas for groundwater and reduce the frequency and duration of low flows of surface water. They provide habitat for diverse species of flora and fauna, some of which cannot live anywhere else. They are particularly important as breeding and feeding areas.

The CRS encourages state, local and private programs and projects that preserve or restore the natural state of floodplains and protect these functions. The CRS also encourages

#### Some Natural Functions of Floodplains

##### WATER RESOURCES

###### *Natural Flood and Erosion Control*

- Provide flood storage and conveyance
- Reduce flood velocities
- Reduce peak flows
- Reduce sedimentation

###### *Water Quality Maintenance*

- Filter nutrients and impurities from runoff
- Process organic wastes
- Moderate temperature fluctuations

###### *Groundwater Recharge*

- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low surface flows

##### BIOLOGICAL RESOURCES

###### *Biological Productivity*

- Rich alluvial soils promote vegetative growth
- Maintain biodiversity
- Maintain integrity of ecosystems

###### *Fish and Wildlife Habitats*

- Provide breeding and feeding grounds
- Create and enhance waterfowl habitat
- Protect habitats for rare and endangered species

*- A Unified National Program for Floodplain Management*  
FEMA-248 (1994)

communities to coordinate their flood loss reduction programs with other public and private activities that preserve and protect natural and beneficial floodplain functions. Credits for doing this are found in the following activities:

- Activity 320 (Map Information Service)—Credits advising people about areas that should be protected because of their natural floodplain functions.
- Activity 330 (Outreach Projects)—Credit is provided for outreach projects that include descriptions of the natural functions of the community's floodplains.
- Activity 350 (Flood Protection Information)—Credit points are available for a website that provides detailed information about local areas that should be protected for their natural floodplain functions and how they can be protected.
- Activity 420 (Open Space Preservation)—Extra credit is provided for open space areas that are preserved in their natural state; have been restored to a condition approximating their pre-development natural state; or have been designated as worthy of preservation for their natural benefits, such as being designated in a habitat conservation plan.
- Activity 430 (Higher Regulatory Standards)—Regulations that protect natural areas during development or that protect water quality are credited.
- Activity 440 (Flood Data Maintenance)—Adding layers to the community's geographic information system (GIS) with natural floodplain functions (e.g., wetlands, designated riparian habitat, flood water storage areas) is credited.
- Activity 450 (Stormwater Management)—Erosion and sediment control, water quality, and low-impact development techniques minimize the impacts of new development. These measures are credited, along with regulations that require the maintenance of natural flow regimes.
- Activity 510 (Floodplain Management Planning)—Extra credit is provided for plans that address the natural resources of floodplains and recommend ways to protect them.
- Activities 520 (Acquisition and Relocation), 530 (Flood Protection), and 540 (Drainage System Maintenance) credit flood loss reduction measures such as capital improvement programs and drainage improvement projects. No such programs or projects can be credited unless a thorough environmental review is conducted and documented.

### **116.b. All-Hazards Mitigation**

All communities are threatened by a variety of natural and technological hazards. The staff and programs that address flooding may also be responsible for protecting the community from damage due to earthquakes, hurricanes, landslides, drought, hazardous materials incidents, and terrorism. Similarly, the staff members that work in programs related to other hazards may be implementing activities that could support floodplain management

programs. Floodplain management programs are synonymous with flood mitigation programs.

FEMA supports an all-hazards approach to mitigation, as does the CRS. It makes economic sense that mitigation programs address as many hazards as are appropriate. An all-hazards approach also ensures that staff, programs, construction standards, and public information messages are consistent and mutually supportive.

The CRS has become an important tool for mitigation as well as a mechanism for integrating mitigation with flood insurance. This is consistent not only with grading systems that have been successfully employed for many years in the insurance industry, but also with industry initiatives for relating insurance premiums to local efforts to reduce losses due to natural hazards. For example, adoption and enforcement of strong building codes as measured by the insurance industry's Building Code Effectiveness Grading Schedule integrates building code enforcement into the industry's premium rates.

The CRS has served as a model for all-hazards, pre-disaster mitigation. Local officials have reported that the CRS was the blueprint for organizing their program to build a more disaster-resistant community.

This edition of the *Coordinator's Manual* highlights many opportunities for expanding a flood-only orientation to address other hazards.

- The 300 series of public information activities credits advising people about the risk of flooding and other hazards and the mitigation measures they can take to protect their property;
- Under Activity 340 (Hazard Disclosure), disclosure of other hazards (DOH) credits advising potential purchasers of property that there may be other hazards that could affect the property, such as erosion, subsidence, or flooding from a dam failure (Section 342.d);
- Section 401 has an overview of the additional credits that are provided for managing seven special flood-related hazards:
  - Uncertain flow paths (alluvial fans, moveable bed streams, and other floodplains within which the channel moves during a flood);
  - Closed-basin lakes;
  - Ice jams;
  - Land subsidence;
  - Mudflow hazards;
  - Coastal erosion; and
  - Tsunamis.
- Activity 420 (Open Space Preservation) encourages communities to keep hazardous areas open and undeveloped;

- Credit is provided for the International Series of building codes (which have improved protection standards for flooding, wind, and other hazards over previous model codes) in Activity 430 (Higher Regulatory Standards), Section 432.h;
- Activity 430 (Higher Regulatory Standards) also credits extending V-Zone standards for coastal storm surge and wind protection farther inland to include coastal A Zones (Section 432.k);
- In Activity 440 (Flood Data Maintenance), additional credit is provided for showing areas subject to other natural hazards, such as landslides and stream migration in the GIS or data base management program;
- Under Activity 450 (Stormwater Management), management of runoff, erosion and sediment control, and water quality and low impact development requirements to minimize the impacts of new development are credited.
- More credit is available for including other hazards in a mitigation plan that qualifies for a floodplain management plan under Activity 510 (Floodplain Management Planning); and
- Local warning and public information activities directed toward storms and tsunamis are credited under the StormReady and TsunamiReady elements in Activity 610 (Flood Warning and Response).

### **116.c. Future Conditions and Impacts of Climate Change**

The CRS recognizes that floodplains and watersheds change over time, driven by many natural and manmade changes. Good floodplain management acknowledges this, and includes thinking about how floodplains might look in the future under different scenarios. Increased impervious surfaces in developing watersheds, new fill in floodways, rising sea levels, changes in natural functions, and many other factors contribute to the character of the future with which floodplain managers must cope.

The *Coordinator's Manual* incorporates additional acknowledgement of—and credit for—community efforts to anticipate the future insofar as it relates to flood risk and natural floodplain functions and climate resilience, and to take actions that can mitigate any adverse impacts that could materialize.

- Credit is provided in Section 322.c for communities that provide information about areas (not mapped on the FIRM) that are predicted to be susceptible to flooding in the future because of climate change or sea level rise.
- To become a Class 4 or better community, a community must (among other criteria) demonstrate that it has programs that minimize increases in future flooding.
- To achieve CRS Class 1, a community must receive credit for using regulatory flood elevations in the V and coastal A Zones that reflect future conditions, including sea level rise.

- Credit is provided in Section 342.d when prospective buyers of a property are advised of the potential for flooding due to climate changes and/or sea level rise.
- Credit is provided in Section 412.d when the community's regulatory map is based on future-conditions hydrology, including sea level rise.
- Credit is provided in Section 432.k when a community accounts for sea level rise in managing its coastal A Zones.
- Credit is provided in Section 452.a if a community's stormwater program regulates runoff from future development.
- Credit is provided in Section 452.b for a community whose watershed master plan manages future peak flows so that they do not exceed present values.
- Credit is provided in Section 452.b for a coastal community whose watershed master plan addresses the impact of sea level rise.
- Credit is provided in Section 512.a, Steps 4 and 5, for flood hazard assessment and problem analysis that address areas likely to flood and flood problems that are likely to get worse in the future, including (1) changes in floodplain development and demographics, (2) development in the watershed, and (3) climate change or sea level rise.

Guidance on the sea level rise projections that are to be used for the purpose of CRS credit can be found in Section 404.

## **Appendix 2**

### **2. Bellaire City Council Resolution No. 17-08**



## **RESOLUTION NO. 17-08**

**AN AMENDING RESOLUTION OF THE CITY COUNCIL OF THE CITY OF BELLAIRE, TEXAS, RESOLVING THAT THE CITY UPDATE ITS FLOOD HAZARD MITIGATION PLAN IN ACCORDANCE WITH A PROCESS PRESCRIBED BY THE COMMUNITY RATING SYSTEM OF THE NATIONAL FLOOD INSURANCE PROGRAM, AND AUTHORIZING THE CITY MANAGER TO ESTABLISH A FLOOD HAZARD MITIGATION TASK FORCE TO UPDATE THE AFOREMENTIONED PLAN AND TO DEVELOP ACTIONABLE LOCAL, REGULATORY AND REGIONAL POLICY RECOMMENDATIONS FOR THE PREVENTION OF FUTURE FLOODING.**

**WHEREAS**, the City of Bellaire, Texas is located within an area of Harris County, which from time to time is negatively impacted by heavy rainfall, storm water run-off, drainage, and occasional flooding; and

**WHEREAS**, the City of Bellaire, Texas has been certified by the Community Rating System since 1993 and currently has a rating of 7; and

**WHEREAS**, properties within the City of Bellaire, Texas have been severely damaged due to the effects of flooding during historical rainfall events, most recently in Hurricane Harvey, in which more than 30% of Bellaire homes experienced structure flooding; and

**WHEREAS**, the City Council of the City of Bellaire, Texas, recognizing the problems associated with poor drainage and potential flooding, did establish a Citizens Advisory Task Force on Drainage Issues, which was charged with the accomplishment of specific objectives to mitigate the hazards associated with flooding; and

**WHEREAS**, the Citizens Advisory Task Force on Drainage Issues, in carrying out its charge, determined that it is in the best interests of the City of Bellaire, Texas, to continue participation in the Community Rating System of the National Flood Insurance Program in order to provide flood insurance premium discounts for its residents; and

**WHEREAS**, a comprehensive planning process resulting in an updated Flood Hazard Mitigation Plan as prescribed by the Federal Emergency Management

Agency will accomplish most of the objectives of the Flood Hazard Mitigation Task Force on Drainage Issues, as well as keep the City of Bellaire, Texas, in good standing with the Community Rating System; and

**WHEREAS**, Hurricane Harvey and its impact on the City of Bellaire has heightened concerns and will require more robust Council and citizen engagement;  
**NOW THEREFORE**,

**BE IT RESOLVED BY THE CITY COUNCIL OF THE  
CITY OF BELLAIRE, TEXAS:**

**1. THAT** it be the policy of the City of Bellaire, Texas, that the City of Bellaire, Texas, engage in a process that results in the update of the Flood Hazard Mitigation Plan in order to identify flood hazards that will limit the impact of flood-related losses to commercial and residential property within the City of Bellaire, Texas, and to remain in good standing in the Community Rating System of the National Flood Insurance Program.

**2. THAT** the City Manager is hereby authorized to establish a Flood Hazard Mitigation Task Force consisting of the following components as outlined in the Community Rating System:

**Flood Hazard Mitigation Task Force**

At least one stakeholder per staff member, to be selected from the following areas:

- Bellaire Homeowner (x2)
- Utility Company
- Builder/Developer
- Previous Board or Commission Member

**Council Liaison Team (Appointed by the Mayor)**

A maximum of three Council members to perform the following:

- Monitor the level of citizen engagement
- Ensure broad and ongoing communication
- Recommend necessary Council action

**Staff Technical Advisory Team**

At least one staff member from the following Departments:

- Development Services
- Public Works
- Parks, Recreation, & Facilities
- Public Safety (Police or Fire)
- City Manager's Office

**Consulting Technical Advisory Team**

- Flood Mitigation Consultant

**3.** **THAT** the Flood Hazard Mitigation Task Force be charged with the following:

- a. Update the City of Bellaire, Texas Flood Hazard Mitigation Plan;
- b. Identify and assess hazards associated with the problem of flooding and provide recommended solutions for those problems;
- c. Keep the public informed of its deliberations and recommendations, and of any proposed changes to the floodplain structure for the City of Bellaire, Texas; and
- d. Prepare a post-flood hazard mitigation plan for the City of Bellaire, Texas, that designates target areas and recommends mitigation measures appropriate for the flood hazard facing the City of Bellaire, Texas. Areas of focus shall include:
  - a. Local:
    - i. Assess the Drainage Plan and recommended steps presented by the City Engineer to Council in September 2016
    - ii. Assess drainage criteria for CIP Project selection
  - b. Regulatory:
    - i. Assess the current Building Code Requirements
    - ii. Assess options and develop a recommendation concerning whether to pursue property buyouts and potential FEMA funding participation
    - iii. Review the City's continuing participation in the Community Rating System and National Flood Insurance Program
  - c. Regional:
    - i. Evaluate Regional Flood Hazard Plans and their impact on the City of Bellaire
    - ii. Recommend additional efforts
    - iii. Recommend ways to facilitate and expedite current efforts

**4.** **THAT** property owners in the City of Bellaire, Texas are encouraged to:

- a. Attend public meetings to review the City of Bellaire, Texas' mitigation planning activities; and
- b. Assist in updating the mitigation plan by providing information on their experiences and damage during extreme storm events.

**5. THAT** this Resolution updates and expands upon Resolution No. 17-07 previously adopted by the City Council on August 21, 2017, which is hereby superseded and replaced in its entirety.

**PASSED, APPROVED, and ADOPTED** by the City Council of Bellaire, Texas, at its Regular Session held on October 2, 2017.

(SEAL)



**SIGNED:**

Andrew S. Friedberg  
Mayor

**APPROVED AS TO FORM:**

Alan P. Petrov  
City Attorney

## **Appendix 3**

### **3. Flood Hazard Mitigation Plan/Matrix**

Hazard Category	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
	The assessment and history is the background information which is being used to determine the hazard and severity. This tells us why a particular hazard is relevant in today's environment.	Risks are the individual situations that are created as a result of the hazard.	The Mitigation Plan should develop a strategy for reducing the potential losses identified in the risk assessment, and include goals and objectives.	The Action Plan should provide tangible solutions for achieving the goals and objectives outlined in the Mitigation Plan.
1	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not sufficiently marketing the outlets utilized by the City can limit the reach of the City's messages.</li> <li>- Not providing City messages to outside outlets, can limit their range and effectiveness.</li> </ul>	Residents Utilizing Non-City of Bellaire Outlets to Obtain Information	<p>Outlets should be marketed to stakeholders throughout the year</p> <p>Non-City of Bellaire Outlets Should be Utilized to Distribute Information</p>	<p>Develop a marketing plan which identifies the City outlets and how to increase participation in them. The plan should list events, stakeholders, etc.</p> <p>Develop and update a list of frequently utilized non-City outlets which the City should use to distribute its messages. This list should include media contacts, etc.</p> <p>(Target Completion: End of FY 2019)</p>
2	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not ensuring each communication outlet is being utilized can lead to an information vacuum, where some residents may not receive essential information.</li> </ul>	Communication Efforts Not Reaching Audience	All outlets available should be utilized by the City	<p>Pre-populate communication outlets with needed information, allowing contacts to "opt-out", instead of having to "opt-in".</p> <p>Develop a communication matrix to outline what messages should be sent through which outlets.</p> <p>Evaluate the implementation of a "local street warden" program to deliver City produced storm related communication to their assigned area.</p> <p>(Target Completion: End of FY 2019)</p>
3	History has shown that at the height of a significant event, emergency communication can be diminished resulting in longer wait times or a requirement to queue 911 callers.	Diminished Emergency Communication (911) Capacity	<p>Ensure residents are aware of when to call 911 (what constitutes an emergency)</p> <p>Provide redundancies in 911 communication operations</p>	<p>Develop public messages to be used prior to and during an event to outline when residents should use 911. The public messages should also include other communications outlets residents can utilize in non-emergency situations.</p> <p>(Target Completion: End of FY 2019)</p>
4	During major events access to common communications devices may be unavailable, which impacts the city's ability to regularly update residents.	Failure/Lack of Common Communication Outlets	All outlets available should be utilized by the City	<p>Develop an educational program/campaign to inform residents and stakeholders of regularly utilized communication outlets.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication prior to a flooding event can leave residents unprepared for the possible impact of an event.</li> <li>- Additionally, poor communication can cause confusion or misinformation which could become an issue during an event.</li> </ul>	Lack of Pre-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized prior to an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication during an event can lead to confusion and hinder decisions needing to be made by residents.</li> </ul>	Lack of Communication During an Event	Up-to-date information should continuously be distributed during an event utilizing all outlets available to the City	<p>Develop a communication template to be utilized during an event which includes updates on information the City has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- After an event; residents, employees, business, and numerous other community stakeholders need to have proper information to understand how they and the City are moving forward, post event.</li> </ul>	Lack of Post-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized after an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p>	Reduced mobility can increase emergency response times	Provide regular up-to-date information on local road conditions	<p>Formalize a mechanism within the scope of EOC operations whereby a team would be responsible for field reconnaissance as well as publication of information for use by the public via the website, social media, local news media, etc.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <ul style="list-style-type: none"> <li>- Historic flooding events create impassable roadways where vehicle mobility is limited due to high water areas.</li> </ul>	Bellaire's Public Safety Components will not be able to respond with "normal" first response equipment	Utilize non-conventional vehicles for response	<p>Develop a plan to identify, utilize, and position non-conventional access vehicles for use when weather events dictate.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
10 <b>Mobility</b>	<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <p>- Extreme flood events makes overland mobility impossible</p>	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening. More persons calling for rescue than Bellaire has ability to respond	<p>Utilize a multi departmental approach to rescue which includes training and equipping to help solve issue</p> <p>Utilize Citizen Responders (boat owners &amp; high water vehicles), and mobilizes this group as a force multiplier in flood emergencies</p>	<p>Ensure adequate funding to send rescue oriented persons to hazard specific schools to for information to make logical purchases for rescue equipment (i.e. boats, dry suits, helmets, Coast Guard approved rescue Personal Flotation Devices for flood response).</p> <p>Develop a program to identify, train, and utilize Citizen Responders and create MOU (cover liability of the asset use donation).</p> <p>(Target Completion: End of FY 2019)</p>
11	<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <p>- Extreme flood events makes overland mobility impossible</p>	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening	Utilize a mass notification system that will reach all residents with relevant hazard warning and evacuation advice	<p>Research, develop scope and policies &amp; procedures for, and place into affect a Mass Notification System.</p> <p>(Target Completion: End of FY 2019)</p>
12	Flood events of hinders mobility due to flooding of Bellaire streets	Specialized response vehicles will not be able to reach all residents (water too high for truck, water too low for boat) and move to safe haven	Evacuate rescued persons from deep water inundation, to shallow water vehicle access area, to area of relative safety, to eventual shelter	<p>Develop a rescue plan which utilizes field-confirmed data to generate on-the-fly response maps for rescuer pathways.</p> <p>(Target Completion: End of FY 2019)</p>
13	Storm water from Brays Bayou and Cypress Ditch can backflow into the City's underground drainage system. Backflow from Brays bayou and Cypress Ditch reduces the capacity in the City's underground system.	Storm water that has backflowed into the City's system results in less capacity for local rainfall events resulting in flooding	Utilize backflow devices to prevent storm water from the bayou, during high water surface conditions, from coming back into the City's underground system	<p>Include design and installation of backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects.</p> <p>Coordinate with neighboring agencies (i.e. TxDOT, City of Houston and HCFCD) to prevent backflow stormwater from entering the City's underground drainage systems.</p> <p>(First Phase Completion: End of FY 2020)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
14	Overland sheet flow from areas inside and outside the City collects in low lying areas that do not have adequate storm drainage systems or positive overland flow capabilities to prevent flooding.	Overland sheet flow causes flooding in low lying areas	<p>Strategically locate underground storage pipes within the existing street right-of-way to store 100-year localized rainfall events.</p> <p>(Target Completion: End of FY 2020)</p> <p>Evaluate increasing the size of existing stormwater drainage culverts in Bellaire.</p> <p>(Target Completion: End of FY 2020)</p> <p>Continue to utilize drainage impact when selecting roads to be rebuilt.</p>
15	Inadequate capacity in Brays Bayou has resulted in a cooperative effort between HCFCD and the U.S. Army Corps of Engineers to widen Brays Bayou to substantially reduce flooding risks in the Brays Bayou watershed.	Brays Bayou is undersized for extreme rain events and flood stages prevent local Bellaire drainage systems from adequately serving the area	<p>Lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist</p> <p>Coordinate with HCFCD and the U.S. Army Corps of Engineers to determine how additional widening of Brays Bayou will reduce flooding for the City of Bellaire.</p> <p>(Target Completion: End of FY 2021)</p> <p>Determine if additional improvements to Brays Bayou are possible beyond Project Brays to further increase capacity</p> <p>Provide more flood-hardened rain and flood stage gauges for better flood forecasting</p> <p>Evaluate the feasibility of adding more flood-hardened flood stage gauges at strategic locations in the City, to provide for public safety.</p> <p>(Target Completion: End of FY 2019)</p> <p>Evaluate the conversion the trash transfer station at Beltway 8 to a reservoir for Brays Bayou.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan	
16	Water overflow from the Brays Bayou is a single significant factor for the wide spread flooding in Bellaire and surround areas. The water level at the peak was 4 Ft above the bank on Sunday August 27th 2017.	It flooded many houses South of Bellaire Blvd. Majority of these houses were flooded first time	Move remaining areas (Post Oak Terrace and Southdale ) out of 100 year floor plain even after the completion of the project Brays	Evaluate the conversion of Bellaire's Wastewater Treatment Plat to a retention area
			Reduce or prevent wide spread damage in the events that are as significant as Harvey (beyond 100 year events)	Evaluate the conversion of the dog park and soccer fields along Edith into a detention area.
				Lower street level when streets are under construction
				(Target Completion: End of FY 2019)
17	Major North/South drainage systems and Cypress Ditch are undersized for the large drainage area.	Inability to convey storm water adequately to Brays Bayou, therefore creating additional flooding risks.	Increase capacity of the North/South drainage systems and the Cypress Ditch	Study alternatives and develop cost estimates for improvements. Determine partners.
				(Target Completion: End of FY 2019)
				Educate and inform the public that street flooding is preferable to structural flooding.
				(Target Completion: End of FY 2019)
18	Streets/Roadways are designed to store floodwaters that have overwhelmed the underground storm storage system in order to mitigate structural flooding.	Street Flooding	Increase street storm water storage in order to reduce structural flooding. Assess the advantages and disadvantages of street flooding vs. structural flooding	Expedite a plan to repair and replace the highly critical local drainage systems in the current Bonds for Better Bellaire 2016. Re-evaluate the priorities annually. Aggressively pursue future bond programs.
				(Target Completion: End of FY 2020)
				Develop a schedule to perform routine maintenance, inspections, and repairs to all storm water infrastructure (such as pipes, or open waterway) on a minimum 5-year cycle.
				(Target Completion: End of FY 2019)
				Create a proactive approach to repair and maintain drainage systems in desirable development areas and neighborhoods with storm drainage systems.
				(Target Completion: End of FY 2019)

	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
19	Bellaire is in a flat coastal area with predominately clay soils that are relatively impervious. Additionally, existing elevations and roadway patterns create barriers that trap sheet flow. Flooding occurs more frequently in areas with these conditions.	Existing topography, soils and roadway patterns contribute to flooding. These conditions and barriers trap sheet flow generated by extreme rain events and make flooding worse	Reduce barriers to flow of flood waters  Educate residents on the local topography and why it exacerbate flooding	Identify barriers restricting sheet flow and determine what projects could relieve this problem.  (Target Completion: End of FY 2019)
				Develop communication plan to inform residents of the importance of not filling in the floodplain.  (Target Completion: End of FY 2019)
20	Outfall of Kilmarnock Ditch has proven to be undersized. The undersized outfall causes a backup of floodwaters to the upstream areas and contributes to localized flooding.	Outfall of Kilmarnock Ditch is undersized	Increasing the size of the outfall of Kilmarnock Ditch	Coordinate with HCFCD to determine steps necessary to increase the size of the outfall of Kilmarnock Ditch.
				Construct extreme event outfalls at Bellaire Blvd and within the Southdale Subdivision to Kilmarnock Ditch.
21				(Target Completion: End of FY 2023)
	Debris can clog inlets and storm sewers. This exacerbates localized flooding, since floodwaters cannot drain away quickly.	Blockage of inlets and drainage systems by debris make flooding more severe	Maintain the storm sewer system so that it is free from blockages and operates at its peak efficiency	Develop an educational program/campaign warning residents of the dangers of blocked storm sewers, and how they can help mitigate this problem.
				(Target Completion: End of FY 2019)
22			Ensure adequate staffing to maintain storm sewer system	Establish a comprehensive asset management plan allowing for better short and long-term planning of maintenance and capital improvement costs and needs.
	Storm sewers and overland sheet flow from outside the City flow into the City and contribute to flooding.	Drainage from outside the City	Reduce peak flows of storm water into the City from external storm sewers	(Target Completion: End of FY 2019)
				Eliminate the water Net surplus in Bellaire
				Contact surrounding municipalities and the agencies that own the storm sewers to consider upgrading their storm sewer system and providing more detention.
				Investigate City of Houston developments north of Bellaire for total runoff.
				(Target Completion: End of FY 2019)

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
23 Preparedness	Bellaire is situated in a portion of the country that receives large storm systems and produces and transports hazardous chemicals	Residents will not be adequately prepared for natural and man made disasters	Community outreach to increase preparedness awareness	Utilize Town Hall meetings to discuss all-hazard preparedness.  Create a preparedness milestone for families.  Evaluate reinstating Citizen Emergency Response Team (CERT)  (Target Completion: End of FY 2019)
24 Facilities & Equipment	The Public Works Department is located in the south eastern most portion of the City. To that end, it is among the first to experience flooding from a highwater event on Brays. To limit future damage is challenging. Further the wastewater treatment facility is located in this area as well and serves all Bellaire residents.	Repetitive loss of equipment and or loss of wastewater services to the community	Sell or close the WWTP and contract with Houston for service  Relocate PW facility out of the flood zone	Evaluate the transfer of Wastewater Treatment for the City of Bellaire to the City of Houston facility, including utilizing hazard mitigation funding opportunities.  (Target Completion: End of FY 2023)
25 Health & Safety	Floodwaters may conceal hidden objects that could cause injury. Residents can inadvertently step into manholes or inlets that have lost their lids. Floodwaters carry dangerous diseases that can make people ill due to overflowing sanitary sewers. Snakes and ants can be found floating in floodwaters.	Danger to people walking, playing, or riding bicycles in floodwaters	Prevent injuries to residents due to walking, playing, or riding bicycles in floodwaters  Prevent infiltration into the sanitary sewer so that overflows and contamination of floodwaters will be reduced	Periodically distribute messages to residents warning of dangers of walking or playing in floodwaters. Everyone should refrain from walking or riding bicycles in floodwaters. Develop a plan with local schools to educate children to avoid walking, playing, or riding bicycles in floodwaters.  (Target Completion: End of FY 2019)
26	According to the Harris County Health Department, waters associated with flooding carry numerous ground contaminants such as pesticide, hydrocarbons, and herbicides, as well as household chemicals. Flood water also displace rodents, ants and spiders.	Persons, including rescuers, will come in contact with pests and chemicals that may create health hazard	Ensure rescuers have proper Personal Protective Equipment specific to the hazard	Properly budget for rescue oriented persons to make logical purchases for rescue equipment.  (Target Completion: End of FY 2019)

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
27  <b>Economic Impact</b>	<p>Single family housing is the primary economic factor for the City. The current codes and ordinances adopted have increased the life cycle for compliant structures. Additionally, a lack of established guidelines, and how they effect non-compliant structures, has lead to a negative public perception of the housing stock after significant flood events.</p> <p>Negative public perception of housing stock</p>	<p>Disclosure of Flooding/Flood Variance History</p> <p>Reduce Number of Unsafe Structures in the City</p> <p>Seek community input on development in the floodplain</p>	<p>Ensure adequate City resources are in place to assist residents when applying for buy out and elevations grants.</p> <p>Evaluate updates to the Building Code which would allow residents to take proactive mitigation efforts on their property.</p> <p>Develop Bellaire specific commercial drainage requirements.</p> <p>(Target Completion: End of FY 2023)</p> <p>At all stages of infrastructure project development in the flood plain, gather community input strategies to be examined; allowing the public to see the results, costs, and benefits for alternatives studied.</p> <p>Evaluate a buyout program for properties that have flooded repeatedly.</p> <p>(Target Completion: End of FY 2020)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
28	The frequency of significant rain events in the past three years has called to question the accuracy of the Base Flood Elevations as a predictor of flood risk. Past events, such as Tropical Storm Allison, have lead to updates to the local Special Hazard Flood Area maps. The revision of these maps is not the responsibility of the city of Bellaire. It has historically taken 5 to 7 years to implement recommended map revisions.	Uncertain Base Flood elevations in AE and non-AE zones (100 yr. zones)	Provide clear guidelines for development and redevelopment for non-compliant structures	Update City Ordinances to clearly define development guidelines for structures in the designated flood areas, as defined by current Special Hazard Flood Area Maps.  Review and Update City Codes based on the recommended changes to the Special Flood Hazard Area Maps.  (Target Completion: End of FY 2019)
29	As a participant in the National Flood Insurance Program (NFIP), the City of Bellaire follows the 50% Rule to determine substantial damage. Currently the City only applies previous flood repairs to this rule. As a result, future flood repairs can be limited by previous repairs.	A drop in demand for Bellaire homes, compared to the surrounding area, will lead to lower home values, lower tax revenues, and an overall deteriorated community	Adjust the Community Rating System (CRS) to a cumulative approach to the 50% rule using previous flood events within a 10 year timeframe/look back.  A vocal adherence to a stance consistent with the rest of the metro area will eliminate market value deterioration	Update the cumulative rule to flood related damage sustained by a structure only after two (2) separate flood occasions excluding non-flood related permits.  (Target Completion: FY 2019)
30	Structures who have historically never flooded are being impacted by flooding events. This has lead property owners to evaluate taking extreme mitigation action to limit the impact of future events.	Elevation of new and existing structures improperly meeting future COB codes	Ensure compliance with BFE's are sufficient for known flooding risk	Stay the course collect needed data so that if changes are needed in five years.
31	Many of the mitigation efforts in place hinge on regional projects currently in the works or projected. The city will still be subject to some amount of flooding, therefore even when regional projects are completed the impact of a 500 year events still exist.	False sense of City protection levels	Educate public of flooding risks  Continue to enforce development/redevelopment standards	Develop an education program/campaign to inform residents on the level of protection provided by the City's infrastructure.  (Target Completion: End of FY 2019)  Establish a desired level of protection versus the cost to implement (cost benefit analysis).  (Target Completion: End of FY 2020)
32	Representation  The city may not have proper representation within regional agencies or constituents. This could impact the amount or what projects are funded that could have the greatest amount of impact on our mitigation efforts. Currently it is not clear the exact need for representation on regional platforms or participation regional during the planning process.	Failure of Regional Partners to Keep Promises funding opportunity will be missed	Ensure adequate representation to and relationships with regional partners	Identify any and all regional partnership opportunities (elected & appointed).  Determine appropriate representatives from the City for regional agencies.  (Target Completion: FY 2019)

## **Appendix 4**

### **4. Agendas**

# CITY OF BELLAIRE TEXAS

## FLOOD HAZARD MITIGATION TASK FORCE

OCTOBER 30, 2017

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COUNCIL CHAMBERS

6:00 PM

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7008 S. RICE STREET  
BELLAIRE, TX 77401



### Flood Hazard Mitigation Task Force

Chris Canonico  
Yana Kristal  
Robyn Rosenblatt

Win Frazier  
Michael Ling  
David Roylance

Millie Hast  
Menny Rosenbaum  
Brian Sanford

### Council Liaison Team

Andrew S. Friedberg  
Mayor

Trisha S. Pollard  
Council Position 2

David R. Montague  
Council Position 6

### Staff Technical Advisory Team

Paul A. Hofmann  
City Manager  
Terrence Beaman  
Chief Financial Officer  
Karl Miller  
Director of Parks & Recreation

ChaVonne Sampson  
Floodplain Manager  
Daryl Anderson  
Fire Chief

Mike Leech  
Director of Public Works  
William Davidson  
Building Official  
Shawn Cox  
Administrative Services Manager

### Consulting Technical Advisory Team

ARKK Engineers

#### Mission Statement:

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**REGULAR MEETING – 6:00 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:00 p.m. on Monday, October 30, 2017, in Council Chambers, 7008 S. Rice Ave., Bellaire, Texas 77401, for the following purpose(s):

**A. Call to Order and Announcement of a Quorum – Paul A. Hofmann, City Manager****B. Introduction of Members**

- a. Task Force
- b. Council Liaisons
- c. City Staff
- d. Consultants

**C. Review of Task Force's Purpose****D. Review of Roles and Responsibilities**

- a. Task Force
- b. Council Liaison Team
- c. Staff Advisory Team
- d. Consultant Advisory Team

**E. Review Timeline for Upcoming Meetings****F. Public Comments** – Comments will be limited to 3 minutes per speaker.**G. Adjourn**

**CERTIFICATE**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a of the City of Bellaire, Texas, to be held on Monday, October 30, 2017, was posted on the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, a place convenient and readily accessible to the general public at all times, and was posted on the following date at the stated time: Thursday, October 26, 2017, at \_\_\_\_\_ a.m./p.m.

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Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the City of Bellaire's ADA Coordinator, Yolanda Williams, at (713) 662-8270 or FAX (713) 662-8212.

**CERTIFICATE OF REMOVAL**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas, to be held on Monday, October 30, 2017, was removed by me from the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, on the \_\_\_\_\_ day of \_\_\_\_\_, 2017, at \_\_\_\_\_ a.m./p.m. I hereby certify further that said Notice remained posted continuously for at least 72 hours preceding the scheduled time of said Regular Session.

---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

# CITY OF BELLAIRE TEXAS

## FLOOD HAZARD MITIGATION TASK FORCE

NOVEMBER 14, 2017

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CENTERPOINT ENERGY COMMUNITY CENTER

6:30 PM

7001 FIFTH STREET  
BELLAIRE, TX 77401



### Flood Hazard Mitigation Task Force

Chris Canonico	Win Frazier	Millie Hast
Yana Kristal	Michael Ling	Jonathan Reichek
Menny Rosenbaum	Robyn Rosenblatt	David Roylance
	Brian Sanford	

### Council Liaison Team

Andrew S. Friedberg	Trisha S. Pollard	David R. Montague
Mayor	Council Position 2	Council Position 6

### Staff Technical Advisory Team

Paul A. Hofmann	ChaVonne Sampson	Mike Leech
City Manager	Floodplain Manager	Director of Public Works
Terrence Beaman	Darryl Anderson	William Davidson
Chief Financial Officer	Fire Chief	Building Official
Karl Miller		Shawn Cox
Director of Parks & Recreation		Administrative Services Manager

### Consulting Technical Advisory Team

ARKK Engineers

#### Mission Statement:

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**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, November 14, 2017, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

**A. Welcome** (5 Minutes)

**B. Review of Community Rating System (CRS) Requirements** (10 Minutes)

**C. Review of Task Force Provided Input on the Following:** (30 Minutes)

- a. What are we trying to accomplish with the City of Bellaire drainage improvements?
- b. What are we trying to accomplish from a regulatory perspective?
- c. What are we trying to accomplish with other jurisdictions in the region?

**D. Presentation, Review, and Discussion of the Draft Hazard/Risk Assessment and Mitigation Strategies, to Include a Review of the Following Data:** (60 Minutes)

- a. 2016 Drainage Study
- b. 2017 City Engineer Report on Hurricane Harvey
- c. Utilities Report
- d. Emergency Operations Center Report
- e. Communications Report
- f. Regulatory

**E. Discussion on Upcoming Meetings** (15 Minutes)

**F. Public Comments** – Comments will be limited to 3 minutes per speaker.

**CERTIFICATE**

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---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

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Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

# CITY OF BELLAIRE TEXAS

## FLOOD HAZARD MITIGATION TASK FORCE

DECEMBER 5, 2017

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CENTERPOINT ENERGY COMMUNITY CENTER

6:30 PM

7001 FIFTH STREET  
BELLAIRE, TX 77401



### Flood Hazard Mitigation Task Force

Chris Canonico  
Yana Kristal  
Menny Rosenbaum

Win Frazier  
Michael Ling  
Robyn Rosenblatt  
Brian Sanford

Millie Hast  
Jonathan Reichek  
David Roylance

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Darryl Anderson  
Fire Chief

Mike Leech  
Director of Public Works  
William Davidson  
Building Official  
Shawn Cox  
Administrative Services Manager

### Consulting Technical Advisory Team

ARKK Engineers

#### Mission Statement:

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, December 5, 2017, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

**A. Welcome** (5 Minutes)

**B. Presentation of the Draft Hazard/Risk Assessment Matrix:** (50 Minutes)

**C. Task Force Input on the Draft Matrix:** (50 Minutes)

- a. What risks and goals are not yet addressed concerning local drainage improvements?
- b. What risks and goals are not yet addressed concerning regulatory approach?
- c. What risks and goals are not yet addressed concerning regional efforts?

**D. Discussion on Upcoming Meetings** (15 Minutes)

**E. Public Comments** – Comments will be limited to 3 minutes per speaker.

**CERTIFICATE**

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Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

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---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**DECEMBER 19, 2017**

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**CENTERPOINT ENERGY COMMUNITY CENTER**

**6:30 PM**

**7001 FIFTH STREET**  
**BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonic	Win Frazier	Millie Hast
Yana Kristal	Michael Ling	Jonathan Reichek
Menny Rosenbaum	Robyn Rosenblatt	David Roylance
	Brian Sanford	

**Council Liaison Team**

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**Consulting Technical Advisory Team**

ARKK Engineers

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**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, December 19, 2017, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

**A. Welcome** (5 Minutes)

**B. Overview of Base Flood Elevations :** (40 Minutes)

- a. How is it determined?
- b. What does it mean?
- c. How does a 100 year event impact Bellaire?

**C. Discussion on Task Force Overarching Goals:** (50 Minutes)

**D. Draft Hazard/Risk Assessment Matrix Status Update**(10 Minutes)

**E. Discussion on Upcoming Meetings** (15 Minutes)

**F. Public Comments** – Comments will be limited to 3 minutes per speaker.

## **CERTIFICATE**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a of the City of Bellaire, Texas, to be held on Tuesday, December 19, 2017, was posted on the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, a place convenient and readily accessible to the general public at all times, and was posted on the following date at the stated time: Friday, December 15, 2017, at 3:00 p.m.

Shalen B.

---

Chavonne Sampson  
Interim Director of Development Services  
City of Bellaire, Texas

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the City of Bellaire's ADA Coordinator, Yolanda Williams, at (713) 662-8270 or FAX (713) 662-8212.

**CERTIFICATE OF REMOVAL**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas, to be held on Tuesday, December 19, 2017, was removed by me from the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, on the \_\_\_\_\_ day of \_\_\_\_\_, 2017, at \_\_\_\_\_ a.m./p.m. I hereby certify further that said Notice remained posted continuously for at least 72 hours preceding the scheduled time of said Regular Session.

---

Chavonne Sampson  
Interim Director of Development Services  
City of Bellaire, Texas

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**JANUARY 9, 2018**

---

**CENTERPOINT ENERGY COMMUNITY CENTER**

**6:30 PM**

**7001 FIFTH STREET  
BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonico  
Yana Kristal  
Menny Rosenbaum

Win Frazier  
Michael Ling  
Robyn Rosenblatt  
Brian Sanford

Millie Hast  
Jonathan Reichek  
David Roylance

**Council Liaison Team**

Andrew S. Friedberg  
Mayor

Trisha S. Pollard  
Council Position 2

David R. Montague  
Council Position 6

**Staff Technical Advisory Team**

Paul A. Hofmann  
City Manager  
Terrence Beaman  
Chief Financial Officer  
Karl Miller  
Director of Parks & Recreation

ChaVonne Sampson  
Floodplain Manager  
Darryl Anderson  
Fire Chief

Mike Leech  
Director of Public Works  
William Davidson  
Building Official  
Shawn Cox  
Administrative Services Manager

**Consulting Technical Advisory Team**

ARKK Engineers

**Mission Statement:**

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, January 9, 2018, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

- A. Welcome/Agenda Review (5 Minutes)**
- B. Review of Regulatory Approach: (30 Minutes)**
- C. Review of Overarching Goals (30 Minutes)**
- D. Review of Complete but Unfinished Matrix (20 Minutes)**
- E. Plan for Public Hearing (15 Minutes)**
- F. Future Meeting Schedule (15 Minutes)**
- G. Public Comments**

**CERTIFICATE**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a of the City of Bellaire, Texas, to be held on Tuesday, January 9, 2018, was posted on the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, a place convenient and readily accessible to the general public at all times, and was posted on the following date at the stated time: Thursday, January 4, 2017, at \_\_\_\_\_ a.m./p.m.

---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the City of Bellaire's ADA Coordinator, Yolanda Williams, at (713) 662-8270 or FAX (713) 662-8212.

**CERTIFICATE OF REMOVAL**

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---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**JANUARY 29, 2018**

---

**COUNCIL CHAMBERS**

**6:30 PM**

**7001 FIFTH STREET  
BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonico	Win Frazier	Millie Hast
Yana Kristal	Michael Ling	Jonathan Reichek
Menny Rosenbaum	Robyn Rosenblatt	David Roylance
	Brian Sanford	

**Council Liaison Team**

Andrew S. Friedberg	Trisha S. Pollard	David R. Montague
Mayor	Council Position 2	Council Position 6

**Staff Technical Advisory Team**

Paul A. Hofmann	ChaVonne Sampson	Mike Leech
City Manager	Floodplain Manager	Director of Public Works
Terrence Beaman	Darryl Anderson	William Davidson
Chief Financial Officer	Fire Chief	Building Official
Karl Miller		Shawn Cox
Director of Parks & Recreation		Administrative Services Manager

**Consulting Technical Advisory Team**

ARKK Engineers

**Mission Statement:**

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**PUBLIC HEARING – 6:30 P.M.****A. Welcome/Overview of Public Hearing Procedure****B. Presentation:**

The Flood Hazard Mitigation Task Force is holding this Public Hearing to present and receive feedback on its draft Flood Hazard Mitigation Plan.

**C. Public Comments:**

The Task Force will recognize speakers who have completed a sign-up sheet prior to the commencement of the public hearing. Each speaker shall have a time limit of up to five (5) minutes, with no extension, and with notice after four (4) minutes that one (1) minute is left. Questions from the public shall be addressed to the Task Force, and members of the Task Force may refer such questions to the staff as appropriate.

**D. Questions from the Task Force****E. Close Public Hearing and Adjourn**

**CERTIFICATE**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a of the City of Bellaire, Texas, to be held on Monday, January 29, 2018, was posted on the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, a place convenient and readily accessible to the general public at all times, and was posted on the following date at the stated time: Thursday, January 25, 2018, at \_\_\_\_\_ a.m./p.m.

---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the City of Bellaire's ADA Coordinator, Yolanda Williams, at (713) 662-8270 or FAX (713) 662-8212.

**CERTIFICATE OF REMOVAL**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a Public Hearing before the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas, to be held on Monday, January 29, 2018, was removed by me from the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, on the \_\_\_\_\_ day of \_\_\_\_\_, 2018, at \_\_\_\_\_ a.m./p.m. I hereby certify further that said Notice remained posted continuously for at least 72 hours preceding the scheduled time of said Regular Session.

---

Shawn Cox  
Administrative Services Manager  
City of Bellaire, Texas

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**FEBRUARY 6, 2018**

---

**CENTERPOINT ENERGY COMMUNITY CENTER**

**6:30 PM**

**7001 FIFTH STREET  
BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonico  
Yana Kristal  
Menny Rosenbaum

Win Frazier  
Michael Ling  
Robyn Rosenblatt  
Brian Sanford

Millie Hast  
Jonathan Reichek  
David Roylance

**Council Liaison Team**

Andrew S. Friedberg  
Mayor

Trisha S. Pollard  
Council Position 2

David R. Montague  
Council Position 6

**Staff Technical Advisory Team**

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Director of Parks & Recreation

ChaVonne Sampson  
Floodplain Manager  
Darryl Anderson  
Fire Chief

Mike Leech  
Director of Public Works  
William Davidson  
Building Official  
Shawn Cox  
Administrative Services Manager

**Consulting Technical Advisory Team**

ARKK Engineers

**Mission Statement:**

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, February 6, 2018, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

- A. Welcome/Agenda Review (5 Minutes)**
- B. Review of Public Hearing Comments (50 Minutes)**
- C. Review of Complete but Unfinished Matrix (50 Minutes)**
- D. Future Meeting Schedule (5 Minutes)**
- E. Public Comments**

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**FEBRUARY 20, 2018**

---

**CENTERPOINT ENERGY COMMUNITY CENTER**

**6:30 PM**

**7001 FIFTH STREET  
BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonico  
Yana Kristal  
Menny Rosenbaum

Win Frazier  
Michael Ling  
Robyn Rosenblatt  
Brian Sanford

Millie Hast  
Jonathan Reichek  
David Roylance

**Council Liaison Team**

Andrew S. Friedberg  
Mayor

Trisha S. Pollard  
Council Position 2

David R. Montague  
Council Position 6

**Staff Technical Advisory Team**

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Director of Parks & Recreation

ChaVonne Sampson  
Floodplain Manager  
Darryl Anderson  
Fire Chief

Mike Leech  
Director of Public Works  
William Davidson  
Building Official  
Shawn Cox  
Administrative Services Manager

**Consulting Technical Advisory Team**

ARKK Engineers

**Mission Statement:**

***The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.***

**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, February 20, 2018, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

- A. Welcome/Agenda Review (5 Minutes)**
- B. Finalize Mitigation Matrix (50 Minutes)**
- C. Introduction of Final Flood Hazard Mitigation Plan (Draft) (40 Minutes)**
- D. Future Meeting Schedule (5 Minutes)**
- E. Public Comments**

**CERTIFICATE**

I, the undersigned authority, do hereby certify that the agenda set forth on the preceding pages regarding a of the City of Bellaire, Texas, to be held on Tuesday, February 20, 2018, was posted on the City's official bulletin board located on an outside west wall of City Hall, 7008 South Rice Avenue, Bellaire, Texas, a place convenient and readily accessible to the general public at all times, and was posted on the following date at the stated time: Friday , February 16, 2018, at \_\_\_\_\_ a.m./p.m.

---

ChaVonne Sampson  
Development Services  
City of Bellaire, Texas

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the City of Bellaire's ADA Coordinator, Yolanda Williams, at (713) 662-8270 or FAX (713) 662-8212.

**CITY OF BELLAIRE TEXAS**  
**FLOOD HAZARD MITIGATION TASK FORCE**  
**MARCH 6TH, 2018**

---

**CENTERPOINT ENERGY COMMUNITY CENTER**

**6:30 PM**

**7001 FIFTH STREET  
BELLAIRE, TX 77401**



**Flood Hazard Mitigation Task Force**

Chris Canonico	Win Frazier	Millie Hast
Yana Kristal	Michael Ling	Jonathan Reichek
Menny Rosenbaum	Robyn Rosenblatt	David Roylance
	Brian Sanford	

**Council Liaison Team**

Andrew S. Friedberg	Trisha S. Pollard	David R. Montague
Mayor	Council Position 2	Council Position 6

**Staff Technical Advisory Team**

Paul A. Hofmann	ChaVonne Sampson	Mike Leech
City Manager	Floodplain Manager	Director of Public Works
Terrence Beaman	Darryl Anderson	William Davidson
Chief Financial Officer	Fire Chief	Building Official
Karl Miller		
Director of Parks & Recreation		

**Consulting Technical Advisory Team**

ARKK Engineers

**Mission Statement:**

*The City of Bellaire is dedicated to outstanding quality service and facilities to ensure an open, progressive, and secure community.*

**REGULAR MEETING – 6:30 P.M.**

A Regular Meeting of the Flood Hazard Mitigation Task Force of the City of Bellaire, Texas will be held at 6:30 p.m. on Tuesday, March 6th, 2018, in the CenterPoint Energy Community Center, 7001 Fifth Street, Bellaire, Texas 77401, for the following purpose(s):

- A. Welcome/Agenda Review (5 Minutes)**
- B. Adoption of Final Flood Hazard Mitigation Plan (60 Minutes)**
- C. Next Steps (30 Minutes)**
  - a. Future Meetings Schedule**
- D. Public Comments**

## **Appendix 5**

### **5. “Notify Me” Emails**

## ChaVonne Sampson

---

**Subject:** FW: Upcoming Flood Hazard Mitigation Task Force-Tuesday, March 6 @ 6:30 PM

**To:** ChaVonne Sampson

**Subject:** FW: Upcoming Flood Hazard Mitigation Task Force-Tuesday, March 6 @ 6:30 PM

[View this in your browser](#)

The next meeting of the Flood Hazard Mitigation Task Force will be held on Tuesday, March 6, 2018, at 6:30 PM. The meeting will be held in the CenterPoint Energy Community Center, located above the Bellaire Aquatic Center at 7001 Fifth Street, Bellaire TX. All meeting agendas, notes, support information, and videos are available at [www.bellairetx.gov/taskforce](http://www.bellairetx.gov/taskforce).

\*\*\*\*\*

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Please note, we will not sell or give your e-mail address to any organization without your explicit permission.

You are receiving this message because you are subscribed to Bellaire News and Information on [www.bellairetx.gov](http://www.bellairetx.gov). To unsubscribe, click the following link:

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## **Appendix 6**

- 6. Electronic Notebook ([www.bellairetx.gov/taskforce](http://www.bellairetx.gov/taskforce))**

# Flood Hazard Mitigation Task Force

The City of Bellaire has been certified with the Community Rating System (CRS) of the National Flood Insurance Program since 1993, and currently has a CRS Rating of 7. This rating provides our residents a 15% reduction on their flood insurance premiums.

The City is currently adhering to the 2007 CRS Manual. By establishing the Flood Hazard Mitigation Plan Task Force and updating the City's Current Flood Hazard Mitigation Plan, Bellaire will maintain compliance with National Flood Insurance Program requirements.

On October 2, 2017, the City Council adopted [\*\*Resolution No. 17-08\*\*](#) authorizing the establishment of the Flood Hazard Mitigation Task Force.

## Task Force Notebook

### Sections:

	<a href="#"><b><u>1. Task Force Roster</u></b></a>
	<a href="#"><b><u>6. Regional</u></b></a>
	<a href="#"><b><u>2. Outline of Final Report</u></b></a>
	<a href="#"><b><u>7. FEMA Publications</u></b></a>
	<a href="#"><b><u>3. Meeting Schedule</u></b></a>
	<a href="#"><b><u>8. Draft Report</u></b></a>
	<a href="#"><b><u>4. Local</u></b></a>
	<a href="#"><b><u>9. Meeting Agendas/Notes</u></b></a>
	<a href="#"><b><u>5. Regulatory</u></b></a>
	<a href="#"><b><u>10. Meeting Videos &amp; Presentations</u></b></a>

## **Appendix 7**

### **7. November 2, 2017 “Mayor’s Musings – Flood Hazard Mitigation Task Force Gets to Work**



# Mayor's Musings

Andrew S. Friedberg  
Mayor of Bellaire



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**November 2, 2017**

## Flood Hazard Mitigation Task Force Gets to Work

The Council Chamber was packed Monday night for the first meeting of the Flood Hazard Mitigation Task Force, as appointees and interested residents came together for introductions and orientation. The City Manager provided a detailed overview of the work that lies ahead, but purposely left open the question, for each member of the Task Force to consider individually, what it is we seek to accomplish. With all options on the table, there are no foregone conclusions as to where the process will lead.

The Task Force's membership is a deliberately diverse and inclusive group of residents representing a cross section of the community. Six of the ten flooded in Hurricane Harvey and five of them in hardest-hit Southdale. Their residency in Bellaire ranges from just 5 months to more than 38 years, some in older and some in newer homes. They also draw upon a variety of professional backgrounds and skill sets. A few of those were influenced by the requirements of the National Flood Insurance Program Community Rating System (CRS) for the composition of the Task Force, but we've gone above and beyond that core group to match the increased scope of the task at hand. Following Harvey and with the benefit of the [City Engineer's detailed analysis](#), the City Council expanded the Task Force's charge and its membership reflects that.

While potential solutions and ultimate policy recommendations are left open for the Task Force itself to determine, in addition to its baseline CRS planning function, Council's post-Harvey [amending resolution](#) specifies its charge and structure. The orientation session was therefore organized around those key points in the document. The City Manager emphasized the areas of focus—local, regulatory and regional—and he introduced the Council Liaison Team, City Staff Team and City Engineer, and discussed their respective roles and responsibilities in working with the Task Force. Some structure is necessary to keep things on track and to provide the proper context, but the Task Force is given substantial latitude with little steering by Council and staff. The whole point is to get the best answers with broad community input, and we've set it up that way, favoring substance over excessive formality.

We anticipate the Task Force will present its report to the City Council in March 2018, or at least the portion that addresses the CRS planning component. Future meetings are scheduled with that end date in mind, but we'll make adjustments and schedule additional meetings as needed to get the job done, especially if the Task Force identifies and takes on a more expansive scope. Note that this initial session was held in the Council Chamber because of somewhat limited room availability due to ongoing construction, but future working meetings, the next being November 14, will be conducted in the CenterPoint Energy Community Center.

Residents are encouraged to attend Task Force meetings and provide their input. All proceedings will be recorded and the videos made available online. The Task Force will also be utilizing a [regularly updated electronic notebook](#) accessible to members and the public on the City website.

Posted by [City of Bellaire Texas](#) at **4:18 PM**



[Newer Post](#)

[Home](#)

[Older Post](#)

One of my main goals as Mayor is to enhance our level of citizen and stakeholder engagement, and to introduce new methods of communicating with you on important issues. This "Mayor's Musings" blog is a part of that effort and is updated periodically with timely information. As always, I welcome and encourage your input. Thanks for reading!

*Andrew*

## **Appendix 8**

### **8. News Flash – “Flood Hazard Mitigation Task Force Public Hearing”**



## City of Bellaire

Welcome to the City of Bellaire, Texas Official Nextdoor Page.

The City of Bellaire does not routinely monitor this page and/or comments posted. If you have question or comment, please...

[bellairetx.gov](mailto:bellairetx.gov)

[More info...](#)

### Activity



#### **Flood Hazard Mitigation Task Force Public Hearing - Monday, January 29**

Executive Assistant Raquel Porras from City of Bellaire - 11 Jan

On August 21, 2017, the Bellaire City Council authorized the City Manager to establish a Flood Hazard Mitigation Task Force for the purpose of updating the City's Flood Hazard Mitigation Plan. The Task Force will hold a Public Hearing on Monday, January 29, 2018 at 6:30 PM, in Council Chambers (7008 S. Rice, Bellaire, Texas), to seek public input on the Draft Flood Hazard Mitigation Plan under development. A copy of the draft plan can be found here: <https://www.bellairetx.gov/DocumentCente...>

If you are unable to attend the Public Hearing, but would like your comments to be noted, please email your comments to [scox@bellairetx.gov](mailto:scox@bellairetx.gov).

Since October 2017, the Task Force has met regularly to discuss and develop flood mitigation options for Bellaire. If you are interested in reviewing these previous meetings, and the presentations to the Task Force, you can do so using the Electronic Notebook, provided by the City. This notebook provides links to the documents, videos, and information utilized by the Task Force in their decision making.

<https://www.bellairetx.gov/1416/Flood-Ha...>

If you have questions about the process, draft plan, or Task Force, please call or email Shawn Cox at 713-662-8239 or [scox@bellairetx.gov](mailto:scox@bellairetx.gov).

11 Jan · Subscribers of City of Bellaire in General

[THANK](#)

[REPLY](#)

## **Appendix 9**

**9. January 25, 2018 “Mayor’s Musings – Task Force Public Hearing on Draft Flood Hazard  
Mitigation Plan”**



# Mayor's Musings

Andrew S. Friedberg  
Mayor of Bellaire



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**January 25, 2018**

## Task Force Public Hearing on Draft Flood Hazard Mitigation Plan - Jan. 29, 6:30 pm

The **Task Force** has been hard at work reviewing and updating the City's Flood Hazard Mitigation Plan, both to develop meaningful, actionable solutions to our flooding problem and to satisfy the requirements for our continued participation in the National Flood Insurance Program Community Rating System. The Plan starts with a comprehensive risk assessment to identify and define flood hazards—local, regulatory and regional—and then proposes mitigation strategies to address those hazards, all leading to a tangible action plan. These steps are outlined in the form of a **matrix**, which is the Task Force's principal working draft.

As the Task Force talks through a variety of perspectives on the path to consensus, the matrix is updated to reflect the key points. The meetings are somewhat unstructured, deliberately, to allow the members to see where the discussion leads them. They've made great progress, and are now ready for a formal public hearing. Residents are encouraged to come share their thoughts and ideas for flood prevention generally, and to comment specifically on the current draft of the matrix. The Task Force will consider and incorporate public input as it continues to refine its recommendations.

Those wishing to learn more in preparation for the public hearing can view the matrix and other Task Force materials in the **electronic notebook** on the City website. It includes all reports that have been presented to the Task Force, video recordings and notes of each meeting, and links to other relevant information.

Public participation in flood hazard mitigation planning is always important, but it goes without saying that the widespread impact of Hurricane Harvey on Bellaire has only heightened the need for it. The Task Force and its work product will benefit from as much public input as possible. Please make plans to attend the public hearing and let your voice be heard this coming Monday, January 29, at 6:30 pm in the Council Chamber.

Posted by [City of Bellaire Texas](#) at [9:38 AM](#)



[Newer Post](#)

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[Older Post](#)

## **Appendix 10**

### **10. Task Force Presentations**

Monday  
October 30, 2017

# Flood Hazard Mitigation Task Force

# Introduction

What are we trying to accomplish?

# Purpose

Per Resolution No. 17-08, Adopted October 2, 2017

1. Identify flood hazards.
2. Limit the impact of flood related losses to commercial and residential properties.
3. Remain in good standing in the Community Rating System of the National Flood Insurance Program.

# Areas of Focus

## Local

Per Resolution No. 17-08, Adopted October 2, 2017

- Assess the Drainage Plan and Recommend Steps Presented by the City Engineer to Council in September 2016
- Assess Drainage Criteria for CIP Project Selection

## Regulatory

Per Resolution No. 17-08, Adopted October 2, 2017

- Assess the Current Building Code Requirements
- Assess Options and Develop a Recommendation Concerning Whether to Pursue Property Buyouts and Potential FEMA Funding Participation
- Review the City's Continuing Participation in the Community Rating System and the National Flood Insurance Program

# Regional

Per Resolution No. 17-08, Adopted October 2, 2017

- Evaluate Regional Flood Hazard Plans and Their Impact on the City of Bellaire
- Recommend Additional Efforts
- Recommend Ways to Facilitate and Expedite Current Efforts

OLD WESTBROOK  
DETENTION BASH



ARTHUR STOREY PARK  
DETENTION BASIN



#### BRIDGE LEGEND

• [View Details](#) [Edit](#) [Delete](#)



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#### CHANNEL COMPLETION DATES



# Current Thoughts

Why does flooding happen in Bellaire?

# Roles & Responsibilities

# Task Force

Per Resolution No. 17-08, Adopted October 2, 2017

- Update the City of Bellaire Flood Hazard Mitigation Plan;
- Identify and assess hazards associated with the problem of flooding and provide recommended solutions for those problems;
- Keep the public informed of its deliberations and recommendations, and any proposed changes to the floodplain structure for the City of Bellaire; and
- Prepare a post-flood Hazard Mitigation Plan for the City of Bellaire.

# Council Liaison Team

Per Resolution No. 17-08, Adopted October 2, 2017

- Monitor the Level of Citizen Engagement
- Ensure Broad and Ongoing Communication
- Recommend Necessary Council Action

## City Staff

- Provide Support/Analysis
- Provide Recommendations
- Keep Us on Track
- Provide History/Background Information

# Consultant/ City Engineer

- Provide Initial Risk Assessment & Mitigation Plan
- Technical Support & Review
- Assess Effectiveness of Recommendations

# Schedule

Work Plan:	Date:
• Kick Off Meeting (1)	Monday, Oct 30, 17
• Present Risk Assessment & Mitigation Strategy with Task Force (2)	Tuesday, Nov 14, 17
• Address Task Force Comments on Risk Assessment & Mitigation Strategy (3)	Tuesday, Nov 28, 17
• Review Action Plan with Task Force (4)	Tuesday, Dec 12, 17
• 2 <sup>nd</sup> Review of Action Plan with Task Force (5)	Tuesday, Jan 2, 18
• Action Plan Public Hearing	Monday, Jan 29, 18
• Task Force Review of Public Hearing Comments (6)	Tuesday, Feb 6, 18
• Finalize Action Plan (7)	Tuesday, March 6, 18
• Adopt and Implement Action Plan	Monday, March 19, 18

# Electronic Notebook

## Contents:

1. Roster
2. Outline of Final Report
3. Meeting Schedule
4. Local
5. Regulatory
6. Regional
7. FEMA Publications
8. Draft Report
9. Meeting Notes
10. Video Links

We will have this webpage up by the end of the week. An email with a link will be sent to each task force member

## For Next Time

What are we trying to accomplish?

- With the City of Bellaire Drainage Improvements
- From a Regulatory Perspective
- With Other Jurisdictions in the Region

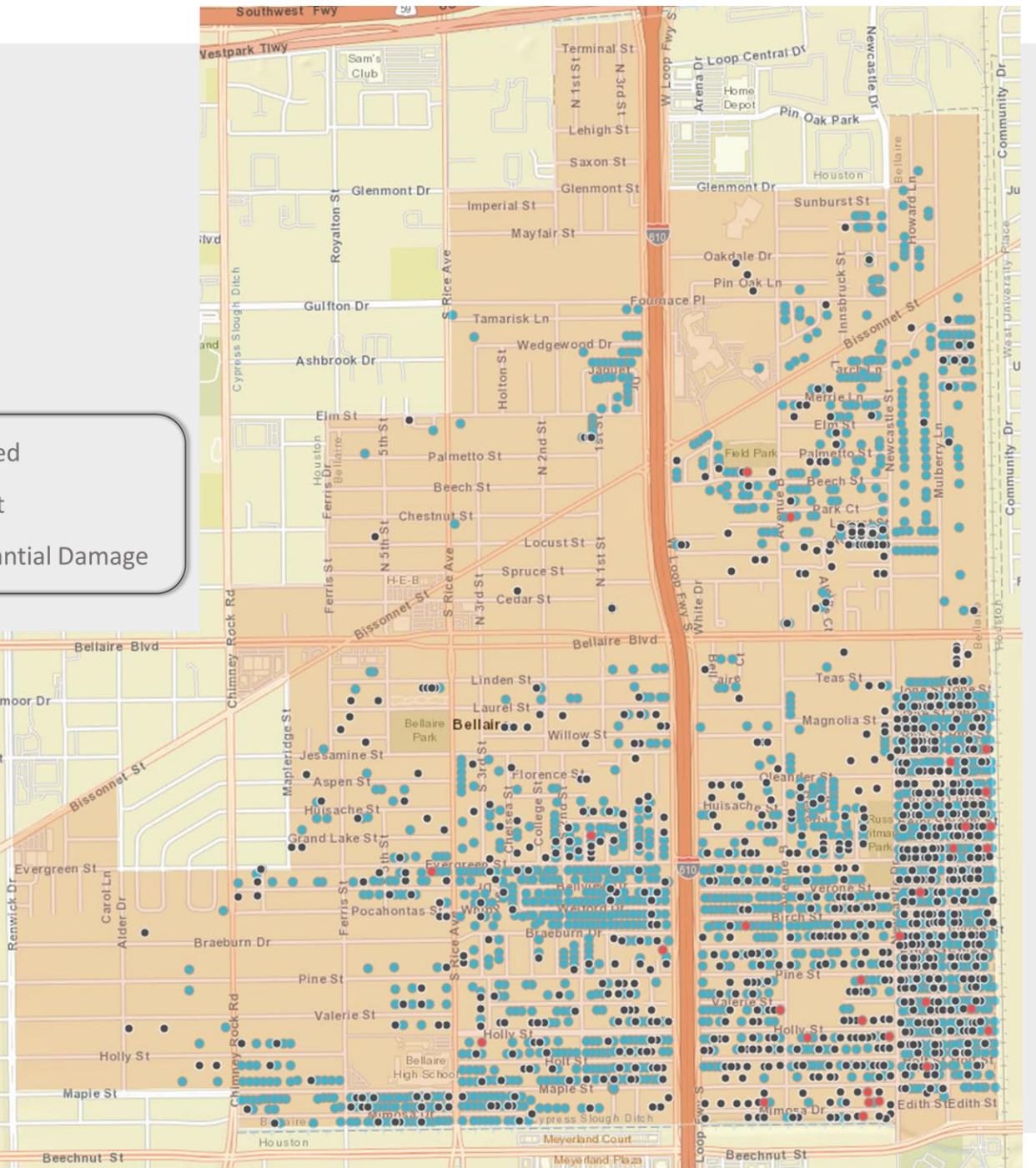
Please email your response to Shawn at

[scox@bellairetx.gov](mailto:scox@bellairetx.gov).

# Hurricane Harvey Flooding Event

## Data as of 11-9-2017

- Flooded
- Permit
- Substantial Damage



Tuesday  
November 14, 2017

# Flood Hazard Mitigation Task Force

# Review of CRS Requirements

## What is CRS?

The National Flood Insurance Program (NFIP) Community Rating System (CRS) was implemented in 1990 as a voluntary program for recognizing and encouraging community floodplain management activities exceeding the minimum NFIP standards.

# City of Bellaire CRS Participation

- The CRS uses a Class rating system that is similar to fire insurance rating to determine flood insurance premium reductions for residents.
- Bellaire CRS Class currently is a 7 as of 2013.
- Bellaire CRS Class trend is improving.

# City of Bellaire CRS Participation

## Facts

- Total Number of Policies: 4,783
- Total amount of premiums: \$4,259,954

## Benefits of Participation

- CRS floodplain management activities provide enhanced public safety, reduced damage to property and public infrastructure, and avoidance of economic disruption and loss.
- Communities can evaluate the effectiveness of their flood programs. The process requires resident involvement based to ensure floodplain plans meets the need of the community.

## Benefits of lower CRS Class scores

- Discounted premiums (Currently 15%)

# City of Bellaire CRS Participation

## How it Relates to FEMA

- Strengthen and support the insurance aspects of the NFIP

## How it Relates to Insurance

- Reduce flood damage to insurable property

## How it Relates to Flood Mitigation Plan

- Encourage a comprehensive approach to floodplain management

# Flood Mitigation Plan and CRS

## Desired Outcome

- Is a part of the needed documentation that shows how the City of Bellaire will implement mitigation activities.
- Develop activities that are not about the CRS ratings but addresses the needs of the community.

How do we take all of the Task Force input and capture it all in one document?

# Flood Mitigation Plan and CRS

	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
Hazard (Categories & Specifics)				

# Responses from Task Force Members

What are we trying to  
accomplish?

# With the City of Bellaire drainage improvements?

- Lower the frequency of both structural flooding and road inundation
- Protect the safety, health, & general welfare of residents
- Ensure development are compliant, which will result in proper storm water drainage & sediment control
- Minimize & mitigate the impact of flooding events
- Prevent future flooding from a Memorial Day type of event
- Systematically modernize drainage to address/replace aging infrastructure
- Reflect the changing residential improvements and commercial development objectives of the City
- Mitigate the adverse impact to residents, businesses and City property from flooding
- Any and all flood prevention measures, within our control, must be considered for implementation to mitigate our ongoing risk

# From a regulatory perspective?

- Review and define minimum level of service for drainage with Bellaire and what regulatory constraints would be borne by private property development as part of this level of service
- Identify FEMA and Hazard Mitigation Grant Program (HMGP) opportunities to bring federal dollars to Bellaire for hardening
- Clarify, either through law or regulation, how to implement flood mitigation
- Need to determine maximum impervious coverage allowed
- New & Redevelopment should have onsite detention
- Discourage or prohibit development in flood prone areas
- Assess current building code requirements with potential upcoming changes of the floodplain
- Reassess participation by the City of Bellaire in the national flood insurance program
- Develop and institutionalize a guideline for the City regarding infrastructure design, code, and investment criteria regarding flood control, e.g. City infrastructure, codes and involvement with regional solutions will be based on ensuring adequate response of XXX year events
- Assess building code requirements relevant to flood mitigation for adequacy
- Review NFIP CRS regulations and make any and all changes needed so that Bellaire's approach is consistent with surrounding jurisdictions

# With other jurisdictions in the region?

- Identify partnership opportunities to improve drainage retention/detention and proposed cost share
- FEMA and HMGP opportunities to bring federal dollars to Bellaire for hardening
- Evaluate pros, cons, and funding streams of Innovative regional solutions with joint benefits, such as wastewater consolidation and hardening with cost effective development of a localized detention pond/amenity park.
- Evaluate Project Brays Impact and Determine Relative Regional Versus Local Drainage Requirements to Improve Level of Service
- Coordination to would include consistency in flood plain studies and flood mitigation plans in the region
- Improved drainage to Cypress Ditch, Railroad, & IH610
- Work together to prevent future flooding
- Develop guidelines as criteria for investments of time and capital in supporting regional solutions that yield favorable progress toward City's outcomes on flood response and mitigation
- Work with jurisdictions to ensure actions do not adversely impact the City of Bellaire

# City Engineer Reports

# City of Bellaire

## Flood Mitigation Task Force

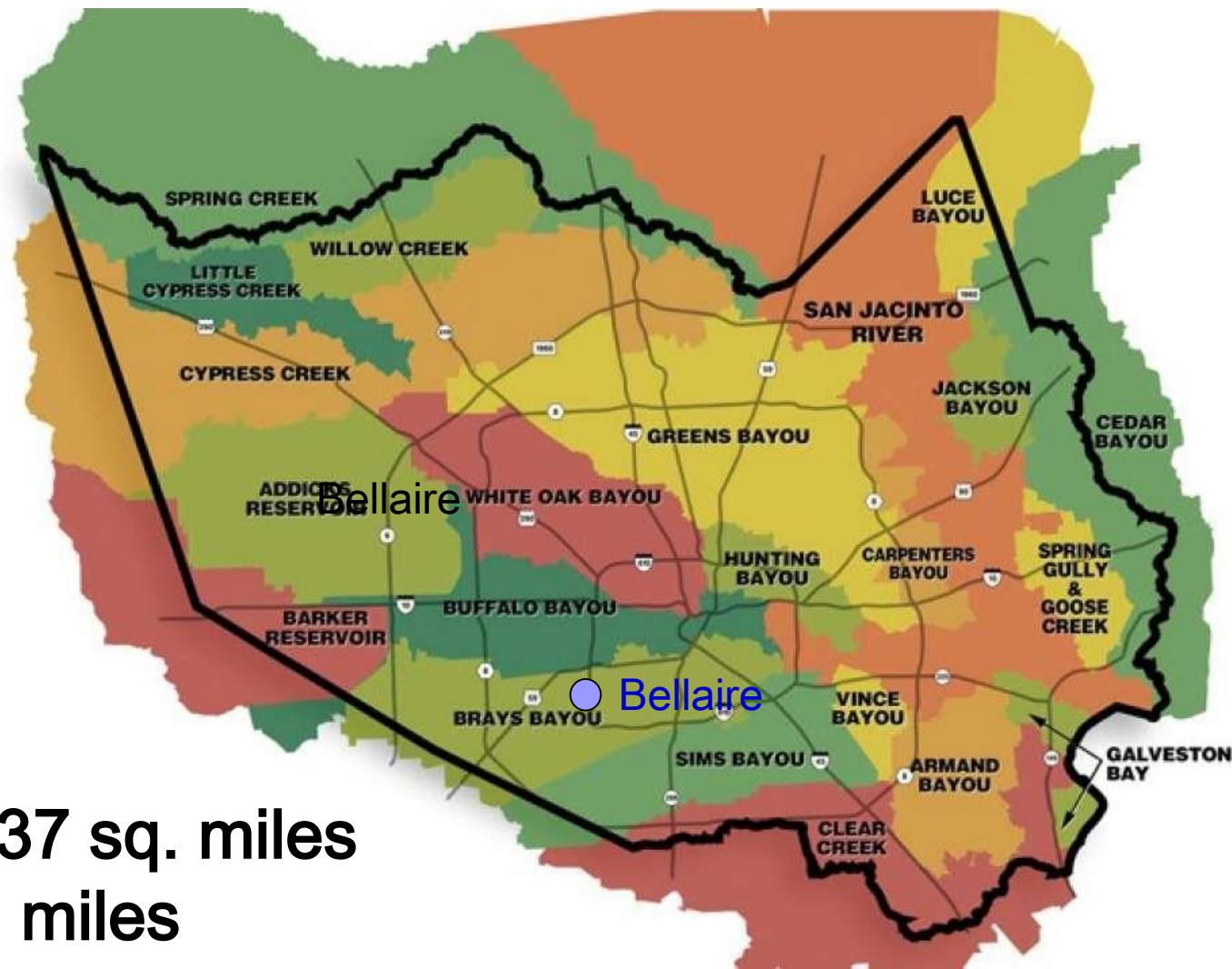
James B. Andrews, P.E.

City Engineer

November 14, 2017

FMTF Meeting







**1955**

**TSA June 2001**



**May 2015**

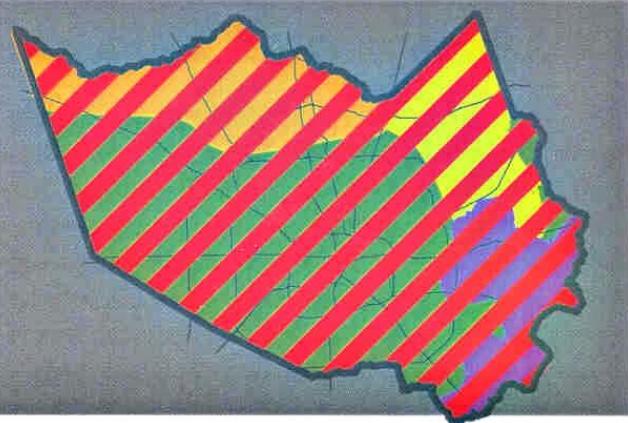
**Why does the Bellaire area flood?**

# Factors Contributing To Flooding

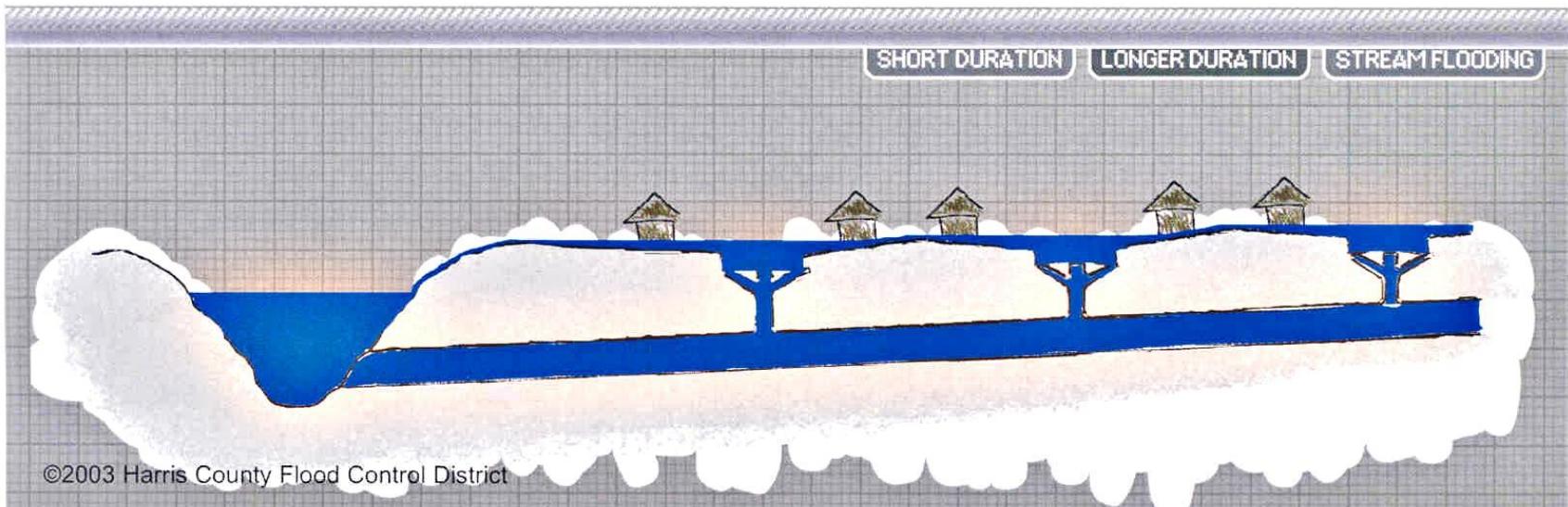
- very high average annual rainfall of about 50 inches
- flat topography
- clay soils that do not absorb water well
- proximity to Brays Bayou
- storm water from the City of Houston flow through Bellaire from the north
- storm water runoff from Bellaire drains into undersized drainage systems owned by the City of Houston
- Below base flood finished floor elevations of homes constructed prior to the National Flood Insurance Rate Standards.
- Neighborhoods developed without a Master Drainage Plan contributing to poor overland flow
- and Extreme rainfall amounts

## PONDING / OVERLAND FLOW

This type of flooding isn't restricted to any one area of the county. It can happen ANYWHERE. When intense local rainfall exceeds storm sewer or roadside ditch capacity, the water can "pond" in the streets deep enough to flood residences that are not even near a creek or bayou. The water will seek a path to the channel by flowing overland (sheetflow). When residences and other structures are in the path, additional flooding occurs. This type of flooding is not identified on Flood Insurance Rate Maps, which is another reason why flood insurance is so important to everyone.

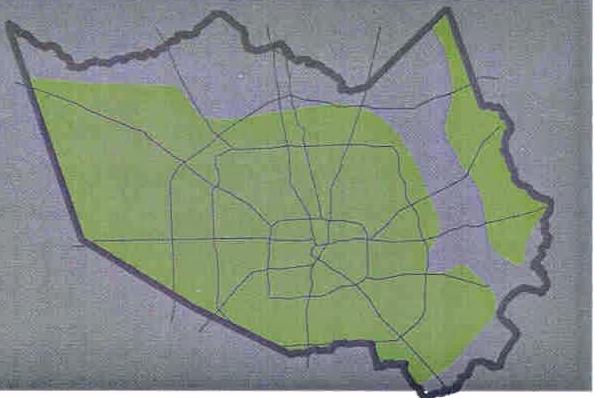


■ VALLEY FLOODPLAIN ■ MAJOR RIVER FLOODPLAIN ■ SHALLOW FLOODPLAIN ■ COASTAL FLOODPLAIN ■ FIFTH FLOODING SCENARIO



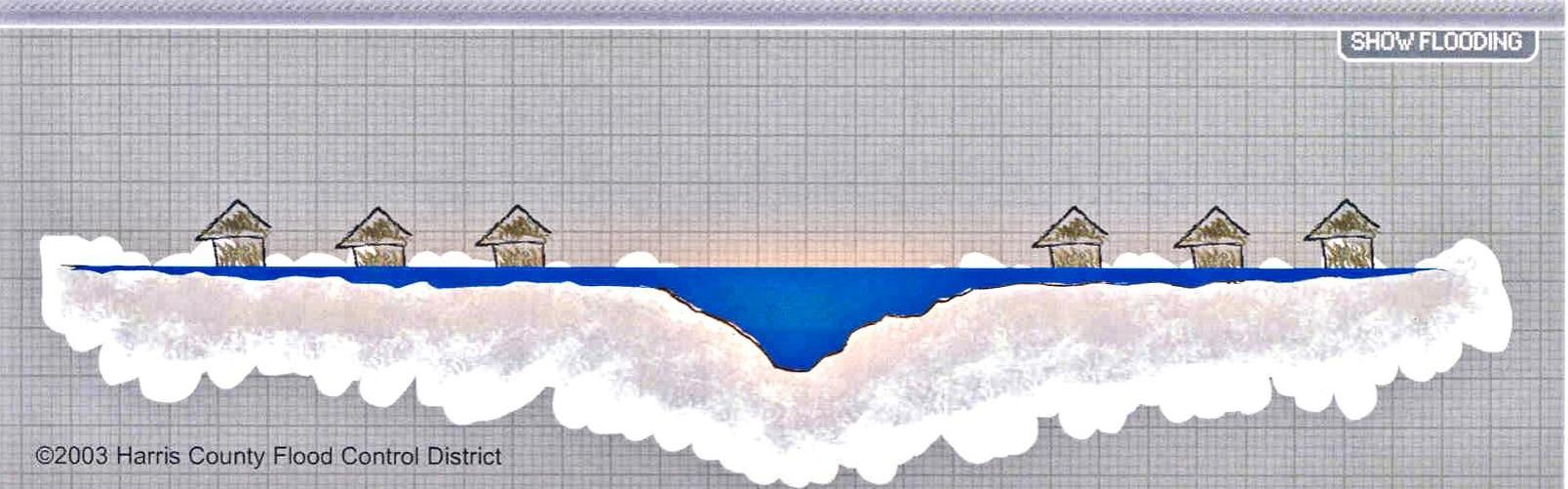
## SHALLOW FLOODPLAIN

Shallow floodplains exist throughout much of the county and affect thousands of residences and businesses. When the channel capacity is exceeded, flooding begins, but usually lasts hours, rather than days.



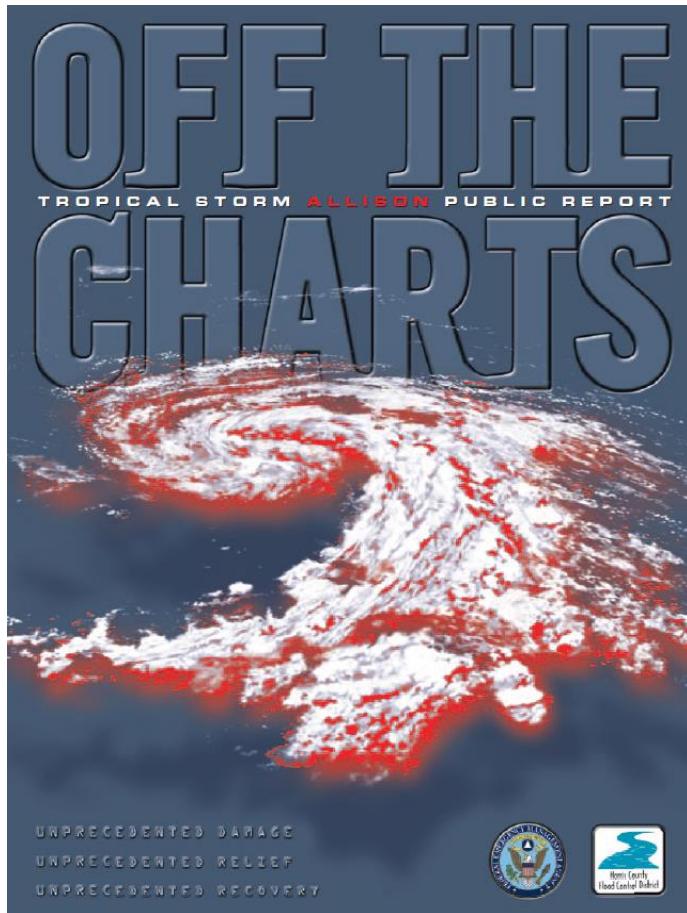
■ VALLEY FLOODPLAIN ■ MAJOR RIVER FLOODPLAIN ■ SHALLOW FLOODPLAIN ■ COASTAL FLOODPLAIN ■ FIFTH FLOODING SCENARIO

SHOW FLOODING

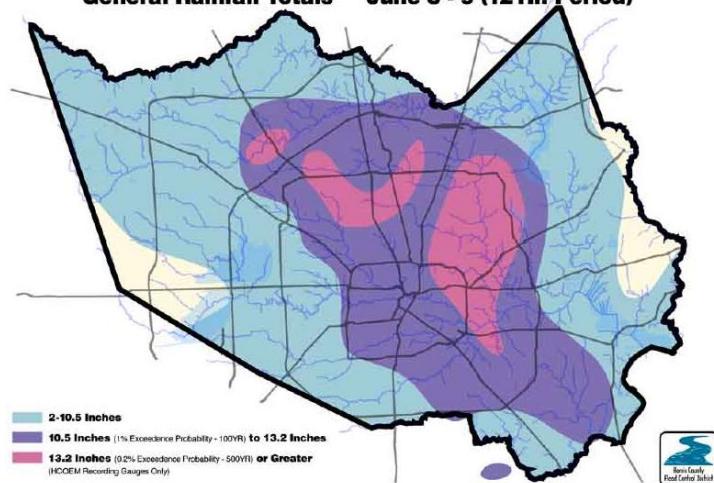


©2003 Harris County Flood Control District

# Tropical Storm Allison - 2001



**Tropical Storm Allison**  
General Rainfall Totals June 8 - 9 (12 Hr. Period)



# Magnitude of Harvey

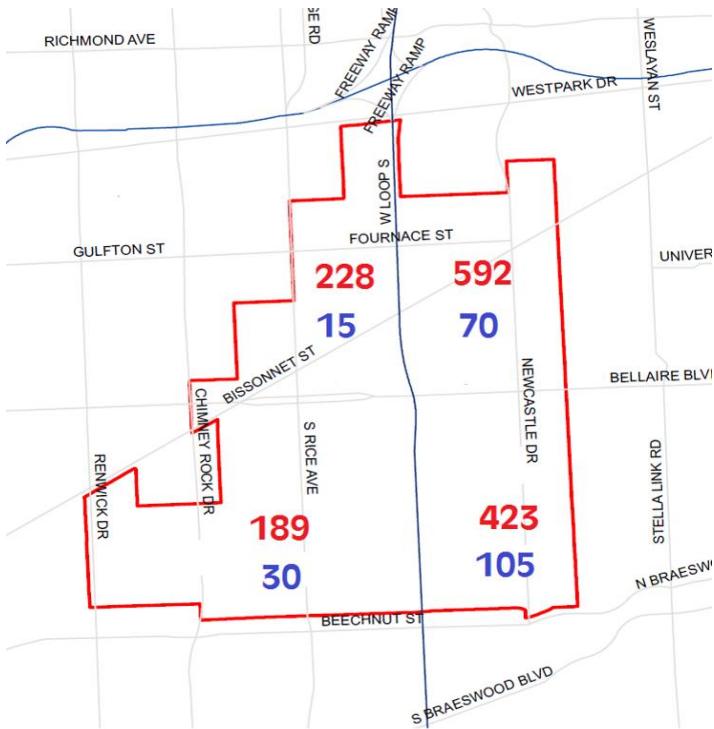
Duration	Rainfall Amount	Return Interval – years
<b>1-Hour</b>		
Maximum	6.8"	1,500 (0.0667%)
Weighted Range	4-5"	50-500 (2.0% - 0.2%)
<b>24-Hour</b>		
Maximum	28.6"	8,000 (0.0125)
Weighted Range	16-20"	200-1,000 (0.5%-0.1%)
<b>2-Day</b>		
Maximum	35.2"	9,000 (0.011%)
Weighted Range	27-33"	2,500-6,000 (0.04%-0.0167%)
<b>4-Day</b>		
Maximum	47.4"	40,000 (0.0025%)
Weighted Range	35-43"	500-20,000 (0.2%- 0.005%)

# Harvey vs Allison vs Tax Day

Duration	Harvey	Allison June 2001	“Tax Day” 2016
1-hr	6.8	5.7	4.7
2-hr	11.9	9.9	7.3
3-hr	14.8	13.5	8.3
6-hr	18.9	21.2	13.9
12-hr	20.9	28.3	16.7
1 day	25.6	28.4	17.4
2 days	34.5	28.5	17.5
4 days	47.4	38.5	N/A

# Allison May 2015 Harvey

## Structures Flooded

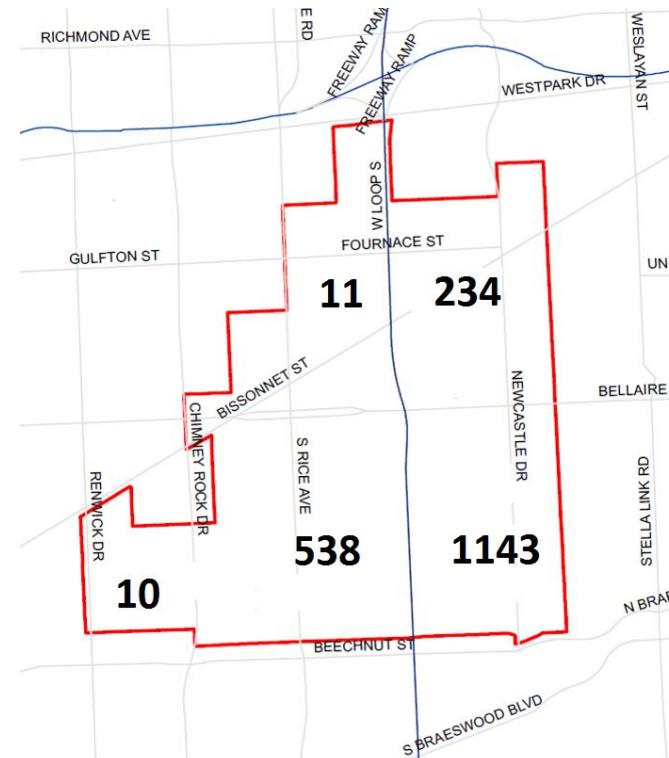


Reported Structures Flooded

**Allison 1432**

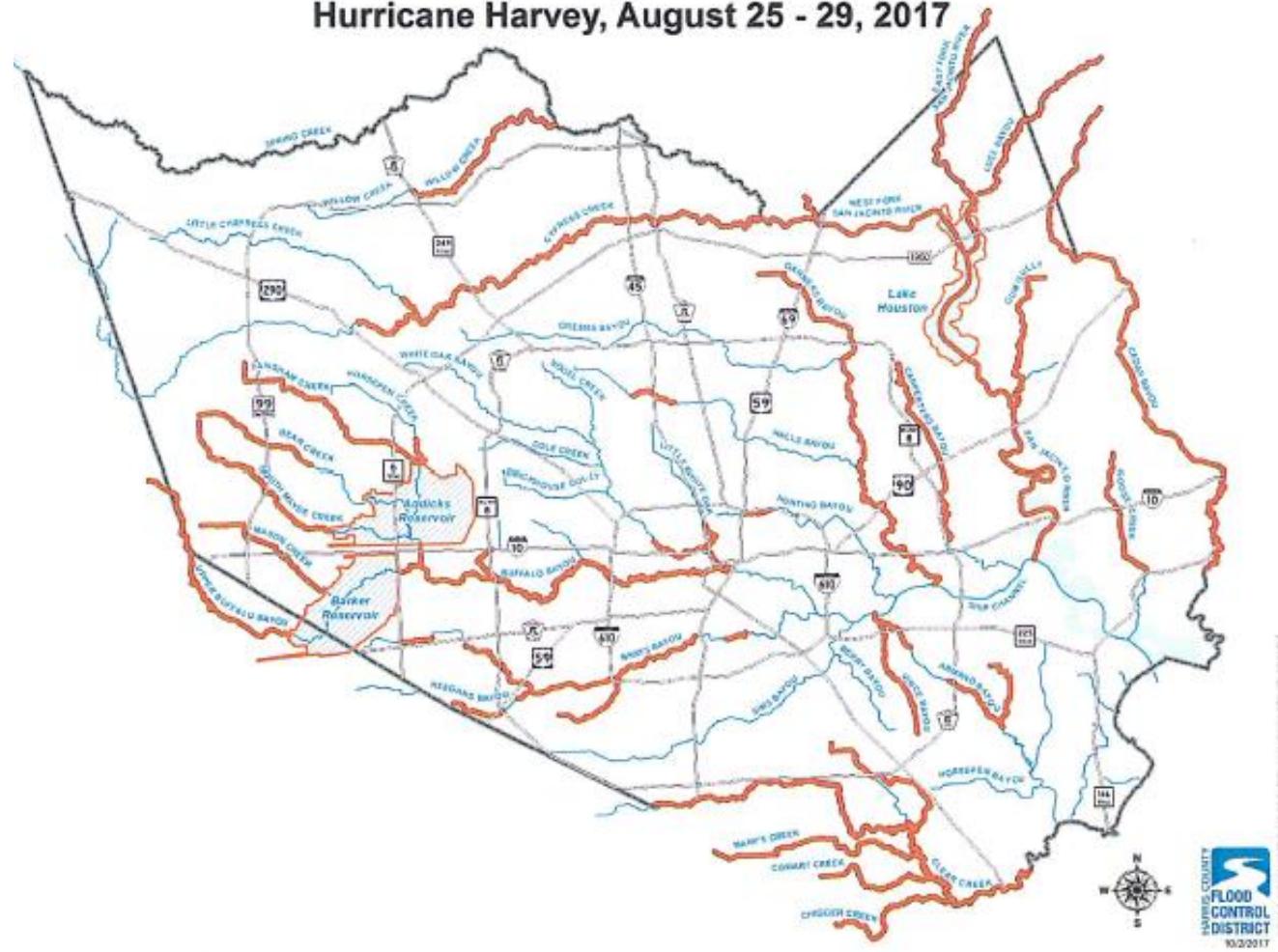
JUNE 9, 2001

**May 2015 220**



**Homes Flooded  
not including garages**

## Record Flood Levels Hurricane Harvey, August 25 - 29, 2017



## SUMMARY SHEET - HCFCD HIGH WATER MARKS

9/19/2017

BRAYS BAYOU D100-00-00 Page 1 of 2

ROAD NAME	STAGE GAGE	BRIDGE BM ELEV	78 TO '01 ADJUST	10.0%	2.0%	1.0%	0.2%	STORM EVENTS																		
								7/30/54	6/18/73	8/31/81	ALICIA 8/18/83	CHANTAL 9/19/83	FRANCES 8/1/89	3/4/92	10/18/94	ALLISON 9/11/98	IKE 6/9/01	11/17/03	9/13/08	4/28/09	1/9/12	5/26/15	4/18/16	1/18/17	HARVEY 8/27/17	
75 TH		20.35	-0.5	14.4	17.1	18.3	21.5				13.4	12.7			11.9	13.6	16.5	8.8	16.8	N/A	10.1	12.4	11.9	8.1	16.1	
LAWNDALE	410	21.97	-0.6	18.1	20.7	21.9	24.7				16.7	17.0	13.9		17.6	17.9	22.8	14.9	17.0	9.2	15.6	18.4	18.0	13.4	20.7	
IH 45 (IN BOUND)		31.49	-0.6	21.7	24.4	25.6	28.3		20.1			20.8			21.7	20.7	27.6	20.0	21.6	N/A	18.4	21.6	18.5	16.9	25.5	
TELEPHONE RD		25.65	-0.6	23.4	26.0	27.3	30.2	22.4	21.7	20.2	18.7				22.1	21.8	27.8	15.7	22.9	14.8	19.9	22.2	21.0	18.2	25.0	
WAYSIDE		32.17	-0.6	24.9	27.8	29.2	32.0		23.5						23.0	16.8	20.4 <sup>1</sup>				14.2	21.0	23.3	22.5	18.2	26.9
OLD SPANISH TRAIL (OST)		28.47	-0.7	25.4	28.3	29.9	32.8								26.3		27.8	16.6	25.0	15.7	20.9	23.8	22.5	16.3	27.3	
MARTIN LUTHER KING		36.47	-0.8	29.7	32.4	33.7	36.1				24.9	26.8			26.0	29.5	32.8	26.6	29.9	20.9	26.2	29.3	26.4	18.2	32.3	
CALHOUN		33.41	-0.8	30.3	32.8	34.0	36.5	31.9	29.2	29.0					29.5	30.1	32.8	27.8	30.7	22.0	28.2	28.9	28.8	26.2	33.7	
SCOTT		37.92	-1.0	31.6	34.4	35.7	37.9								31.3	32.3	32.4	29.7	31.5	24.0	29.4	32.1	30.5	28.4	35.2	
ARDMORE		37.36	-1.1	32.8	35.4	36.6	38.9								33.9		38.0	31.9	32.8	25.8	31.2	34.3	29.1 <sup>1</sup>	30.6	37.4	
SH 288		51.01	-1.2	33.6	36.4	37.8	40.1				30.4				34.8	35.2	39.3	33.9	33.6	26.7	33.0	35.2	34.2	31.7	39.2	
ALMEDA RD		41.10	-1.2	34.4	37.6	39.1	41.9		35.1	34.5					36.2	34.7	37.5	33.9	35.0	27.1	33.7	37.0	36.0	32.3	40.4	
D109 @ MACGREGOR	400	39.11	-1.2	34.9	38.2	39.9	43.0												34.0	N/A	36.1	38.0	37.4	35.3	41.5	
HOLCOMBE BLVD		43.31	-1.2	36.3	39.4	41.1	43.9		37.4	37.3	33.8	38.4			38.2	36.7	40.3	36.7	37.2	30.7	36.5	38.2	37.7	34.9	41.7	
S. BRAESWOOD BLVD.		43.68	-1.2	37.1	40.0	41.9	44.8								39.4		42.9	38.0	38.7	32.0	37.3	39.9	38.2	36.4	42.0	
FANNIN		45.81	-1.3	38.4	41.2	43.3	46.6			38.9	34.7				41.0	38.5	44.0	37.8	39.4	34.0	37.9	40.1	39.5	37.5	43.5	
GREENBRIAR		45.11	-1.3	39.2	41.7	43.8	47.4								40.7		42.2	39.9	39.4	35.0	38.7	41.3	40.4		44.4	
N. BRAESWOOD BLVD.		47.58	-1.4	40.2	42.4	44.9	48.6								41.7		44.5	46.5	40.8	N/A	40.6	42.2	41.0		45.7	
SOUTH MAIN	420	46.53	-1.4	41.0	43.1	45.7	50.0		41.2	41.5	37.4	42.4	38.8		42.2	39.6	42.9	40.6	41.3	36.5	40.5	42.9	42.1		45.7	
S. BRAESWOOD		49.74	-1.3	41.4	43.7	46.6	50.1								42.7		44.3	42.0	41.9	36.3	39.9	43.1	42.4	40.5	45.9	
KIRBY		44.30	-1.3	42.1	44.3	47.1	50.7		41.6	42.5					42.7	40.6	47.2	42.1	41.8	37.4	41.6	43.9	43.0		46.3	
BUFFALO SPEEDWAY		49.48	-1.3	43.7	46.1	48.4	51.1		42.8		40.9				44.4	43.1	47.4	43.7	43.3	39.3	43.7	45.5	44.1	42.7	47.9	
STELLA LINK	430	49.55	-1.7	45.5	47.5	49.6	51.8		45.1	46.1	42.7				45.0	46.0	44.3	48.4	46.4	45.9	43.0	45.7	48.3	47.1	45.7	49.7
SPRR		53.36	-1.7	47.2	49.5	51.3	52.6								47.8	46.3	49.4	47.1	46.5	44.0	47.2	49.1	47.7	46.8	50.7	

NOTE: BRIDGE AND HIGH WATER ELEVATIONS ARE ON 1988 NAVD; 2001 ADJ

NOTE: D109 @ MacGregor added as a HWM location in summer of 2005

<sup>1</sup> - Suspect elevation, low confidence in field

# High Water Marks

# High Water Marks

## SUMMARY SHEET - HCFCD HIGH WATER MARKS

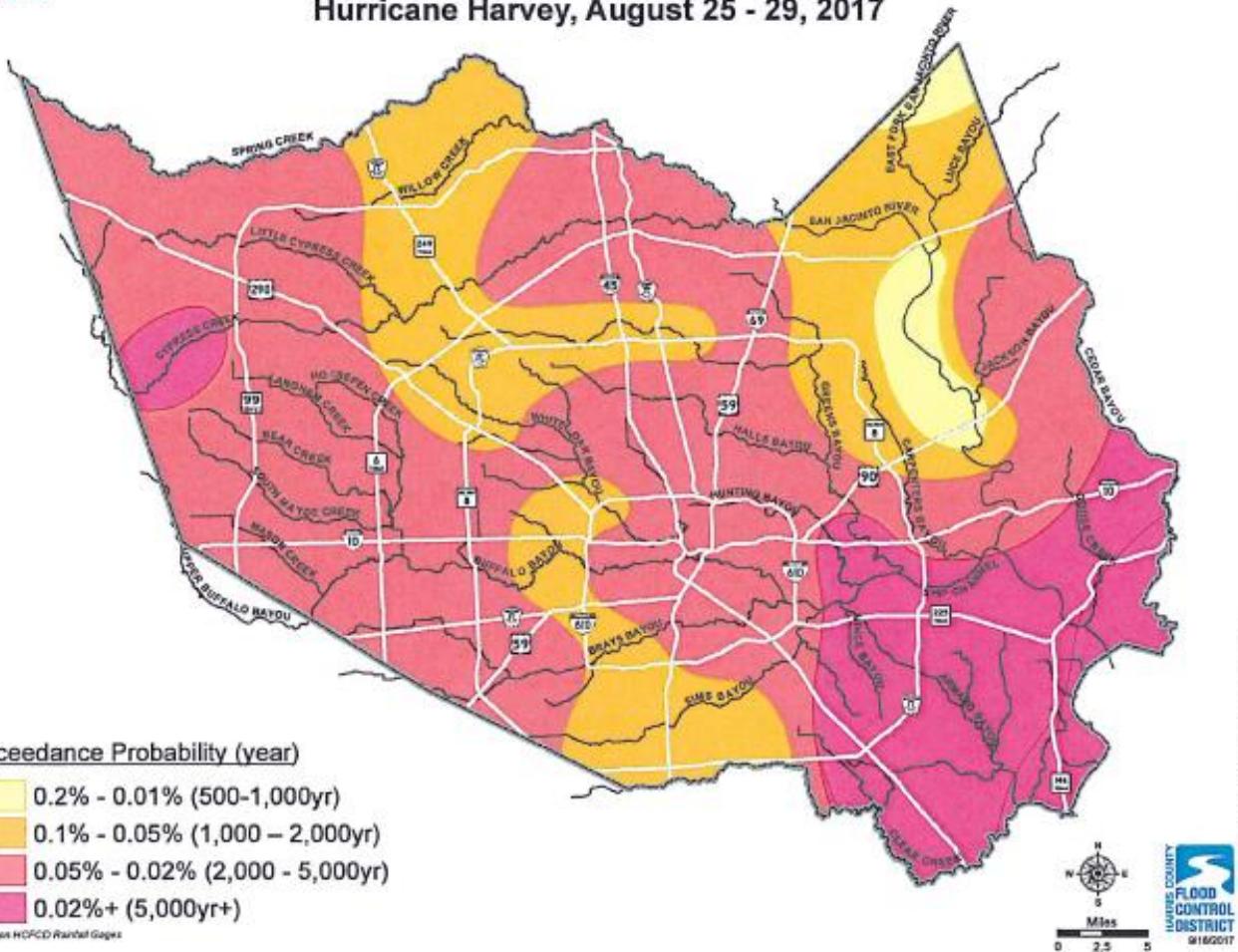
9/19/2017

BRAYS BAYOU D100-00-00 Page 2 of 2

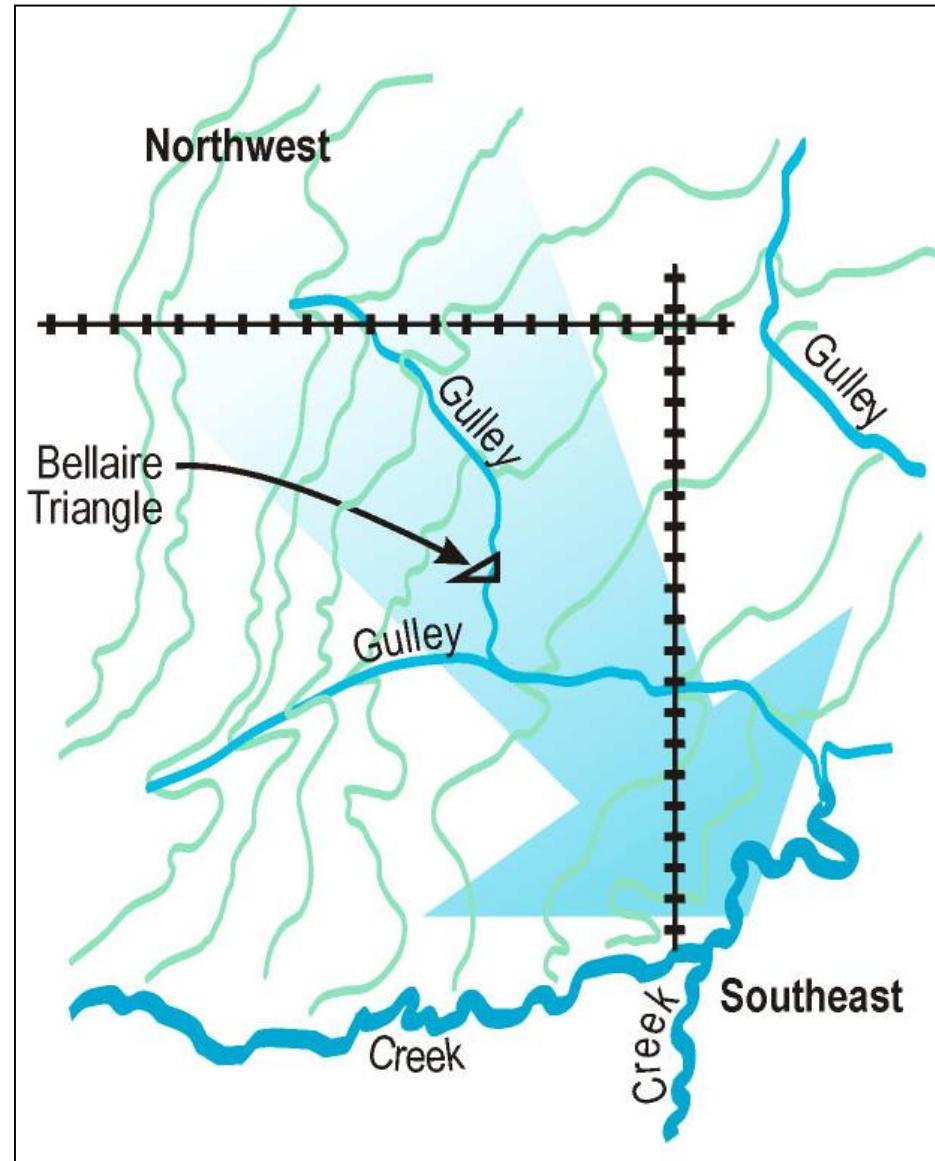
ROAD NAME	STAGE GAGE	BRIDGE BM ELEV	78 TO '01 ADJUST	10.0%	2.0%	1.0%	0.2%	STORM EVENTS																Harvey				
								7/30/54	6/18/73	8/31/81	ALICIA	9/19/83	8/18/83	CHANTEL	8/1/89	3/4/92	10/18/94	9/11/98	FRANCES	ALLISON	11/17/03	9/13/08	4/28/09	1/9/12	5/26/15	4/18/16	1/18/17	
SOUTH POST OAK		50.45	-2.1	49.9	52.1	53.6	55.0							47.4				50.2	46.7	50.8	50.8	47.3	46.3	48.9	51.4	49.6	48.9	53.7
RICE BLVD	440	53.81	-2.0	50.8	52.9	54.3	55.7		49.1		47.4	52.5	49.0			51.5	47.5	50.4	51.0	47.9	47.6	50.3	52.9	51.7	49.8	54.1		
CHIMNEY ROCK		54.05	-2.1	52.4	54.6	55.5	56.8		50.9	50.8		53.7			51.4	52.5	50.6	52.5	53.3	48.4	49.0	51.2	53.6	52.8	50.9	54.9		
HILLCROFT		59.78	-2.2	55.1	57.2	57.4	58.7		52.3	53.3	51.0	56.4				54.5	52.6	53.7	55.1	51.5	51.6	53.8	55.9	47.7 <sup>1</sup>	53.3	57.2		
N. BRAESWOOD		58.37	-2.2	56.2	58.7	59.1	60.5									55.7			56.5	52.8	52.9	55.0	57.1	56.8	54.3	57.9		
FONDREN		59.28	-2.4	58.5	61.1	61.5	62.7		53.7	55.5	52.5	58.4				57.3	52.9	55.4		53.4	54.6	56.5	59.0	55.3	56.0	60.7		
ROCKDALE		51.66	-2.4	50.2	52.4	52.8	53.2									52.6			52.7	52.8	52.9	52.8	52.7	52.8	52.8	52.8		

DRAFT

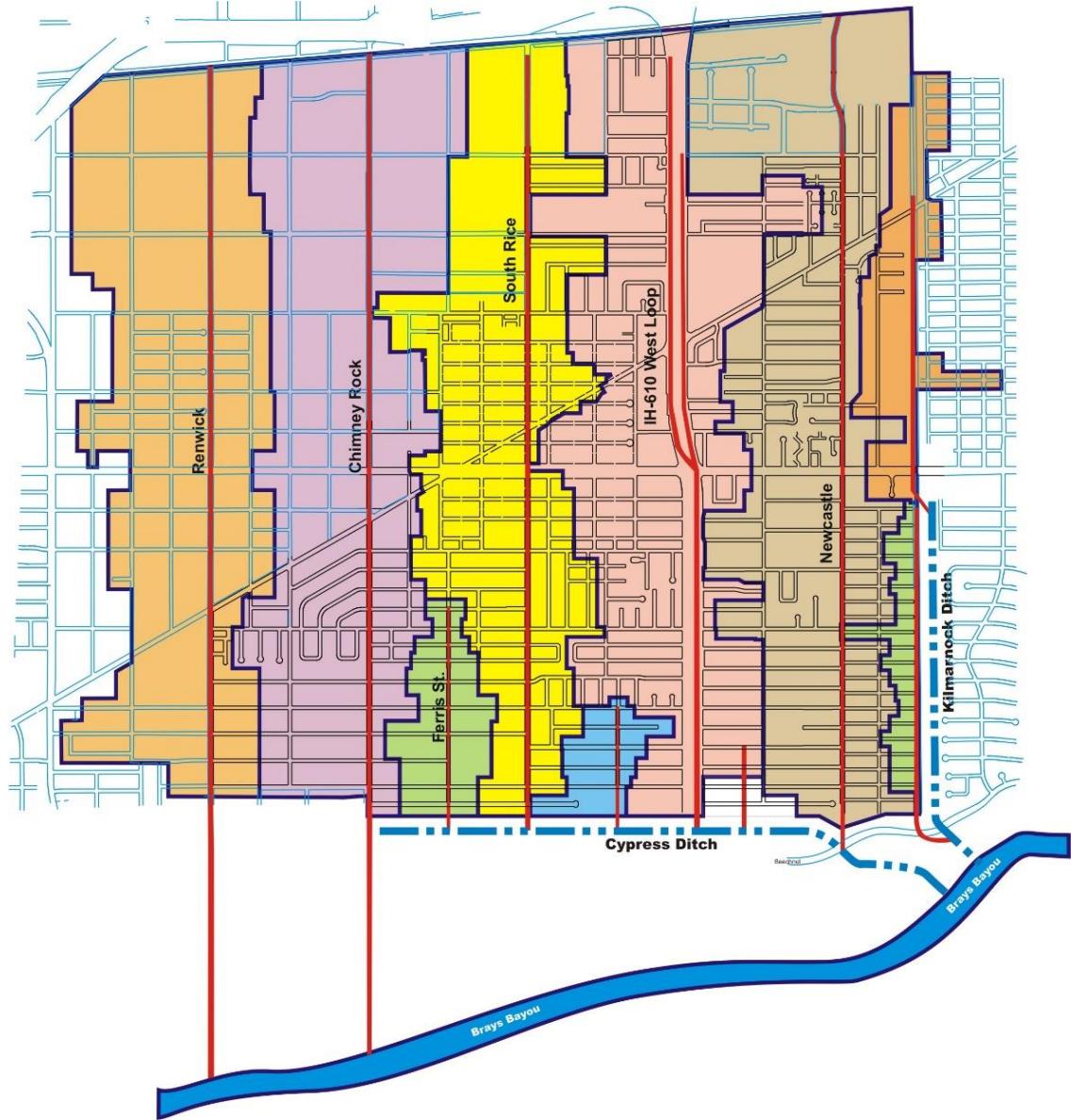
## Two Day Peak Rainfall Frequency Hurricane Harvey, August 25 - 29, 2017



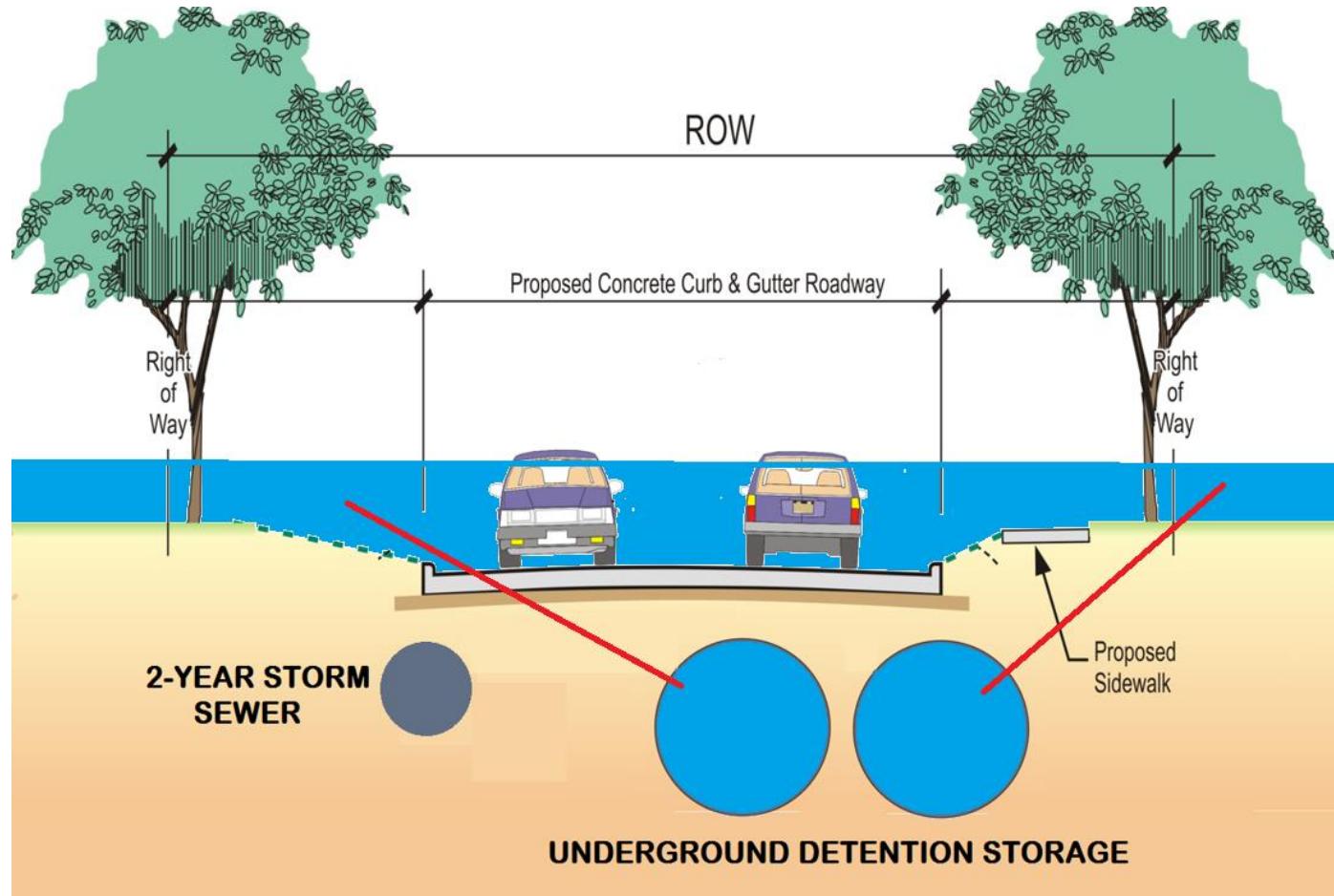
# Early Drainage



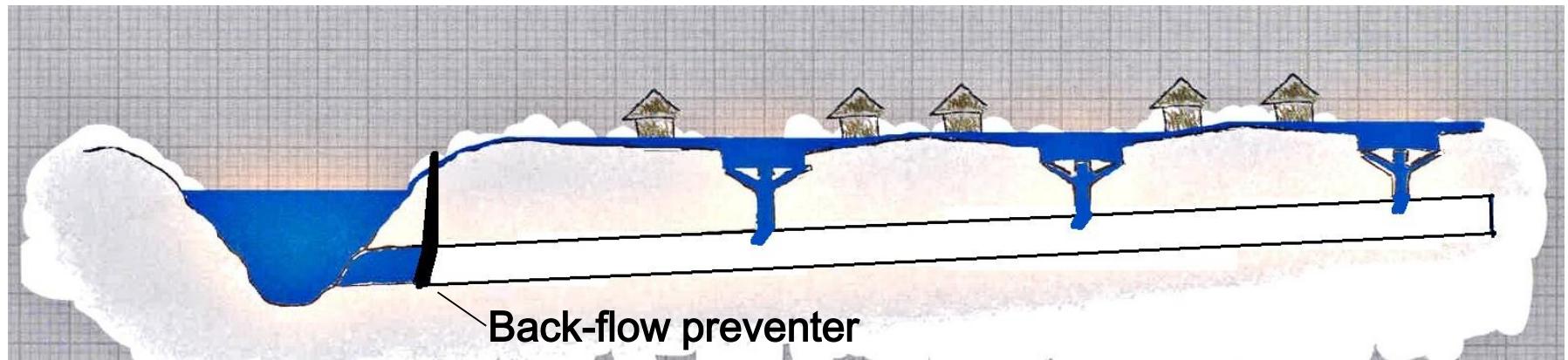
# Major Drainage Systems



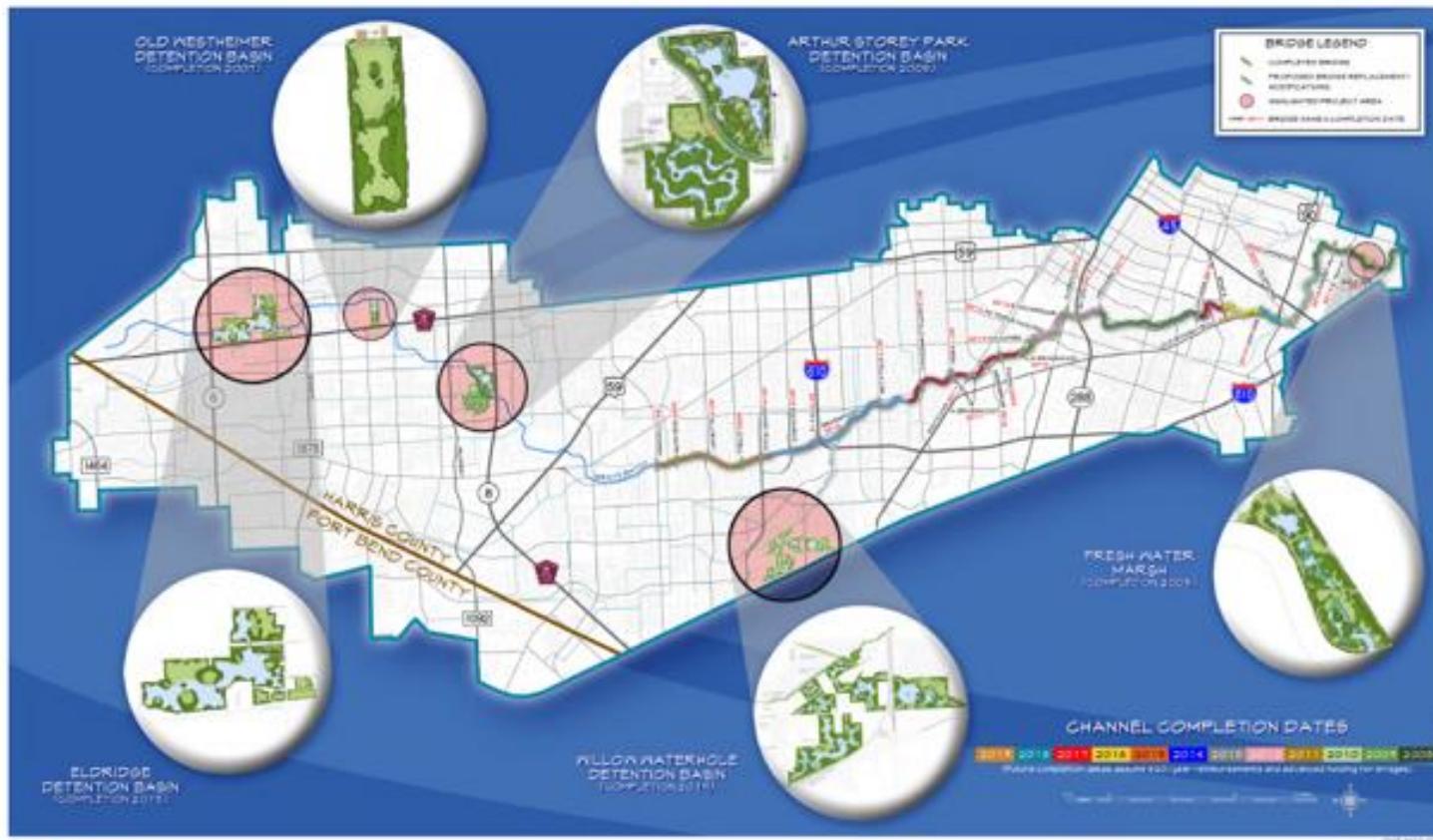
# Bonds for a Better Bellaire 2016



# Back-flow Preventer



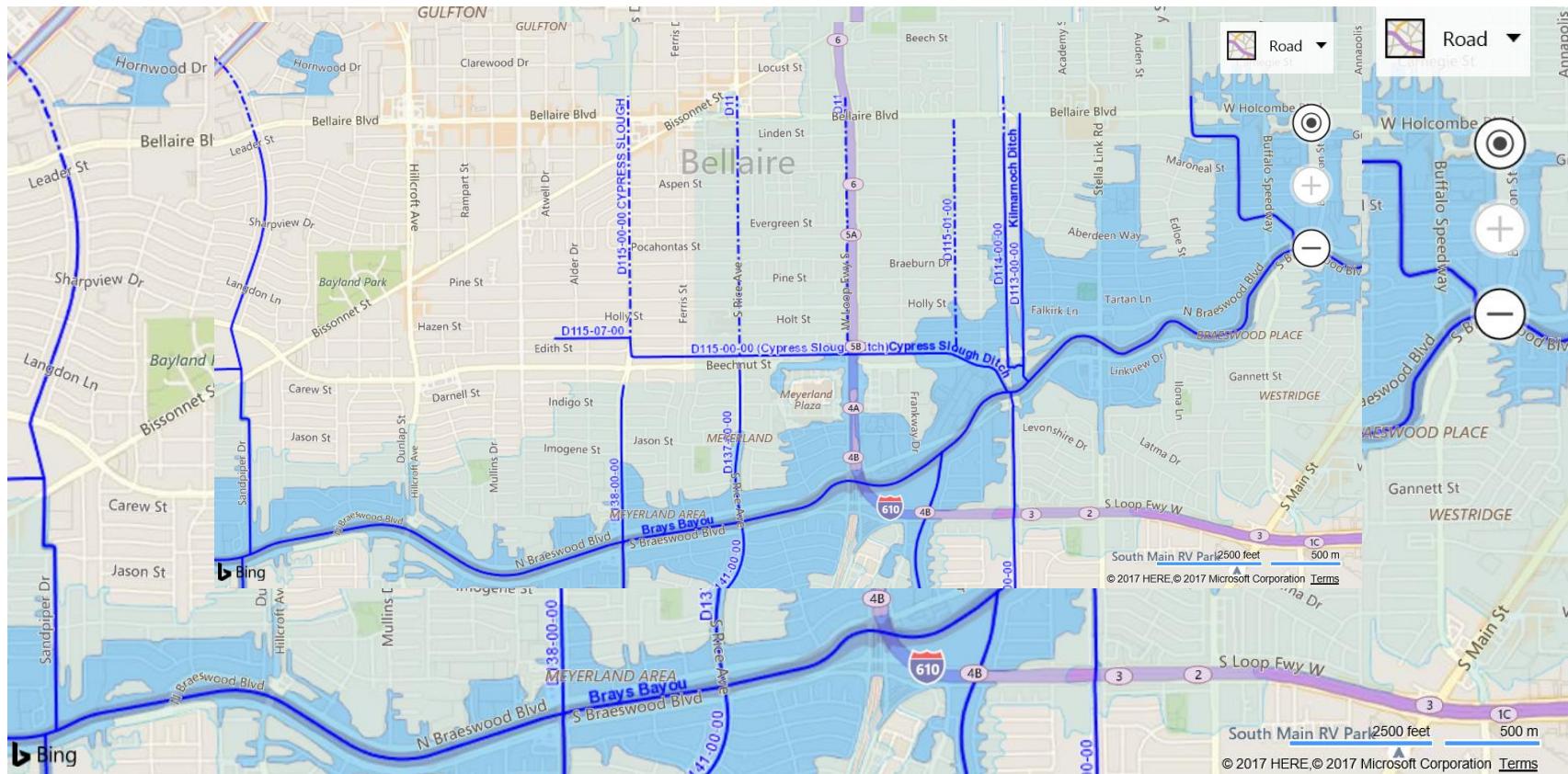
## Brays Bayou Project Locations



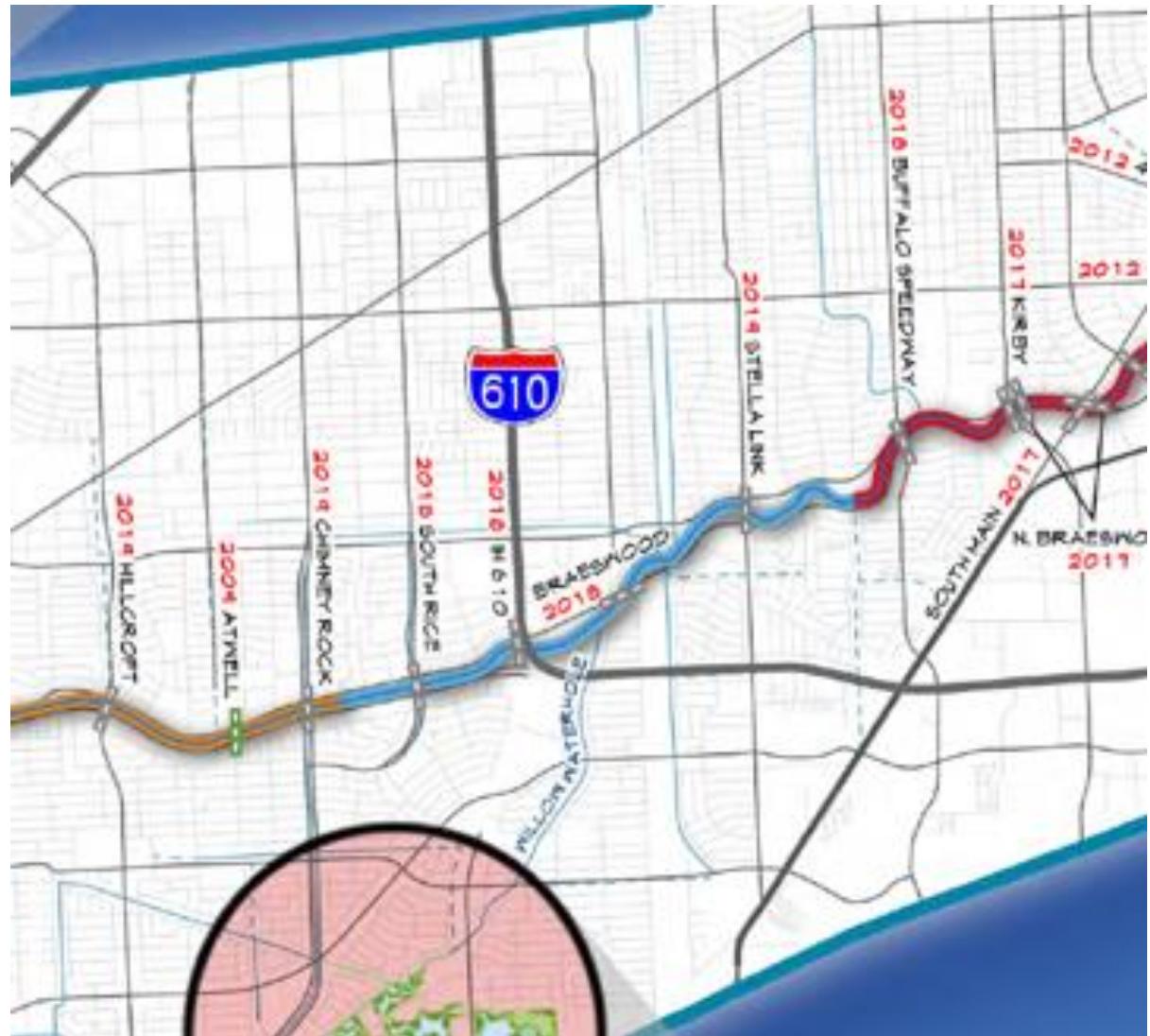
FEDERAL BRIEFING  
April 2013 | Washington, D.C.

# Project Brays

# Conditional Letter Of Map Revision (CLOMR)



# Project Brays to be completed by 2021

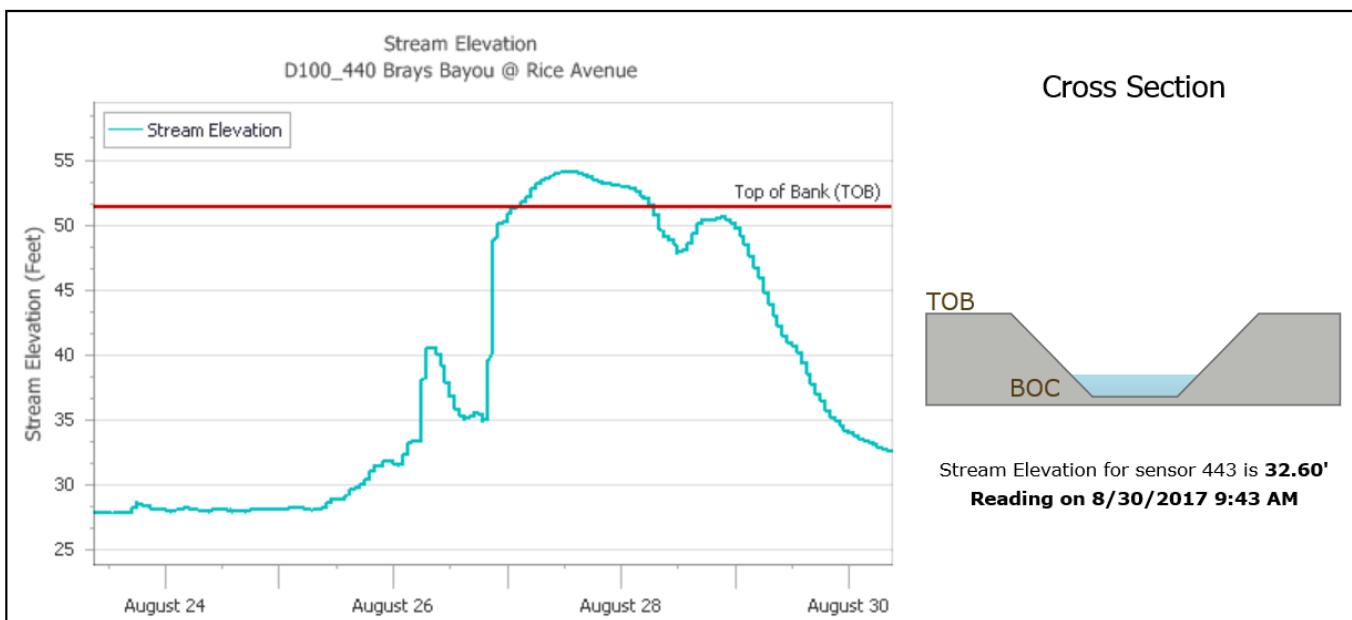


# HCFCDFWS

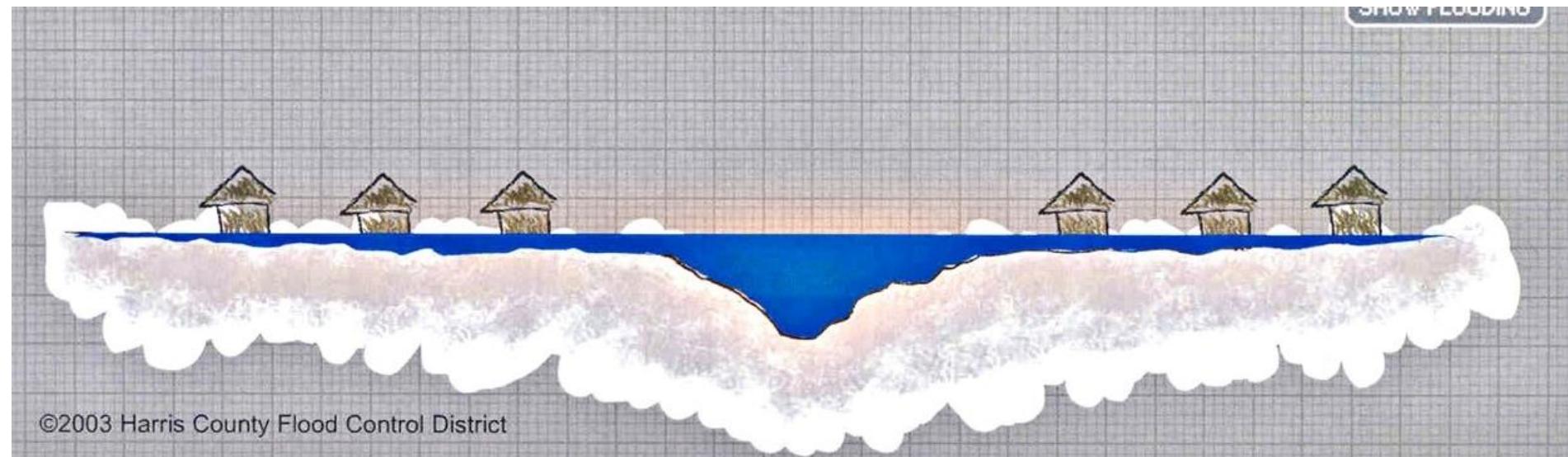
S. Rice Ave. Gage August 2017

Stream Elevation Sensor **443**  
**D100\_440 Brays Bayou @ Rice Avenue**

Key Map	531U
Sensor ID	<b>443</b>
Sensor Type	Bubbler
Installed	8/10/1984
Top of Bank (TOB)	51.30'
Bottom of Stream	25.97'
Tip of Orifice	27.45'
Measuring Plate	54.84'
Benchmark	53.81'
RM 040160 stamped D100 BM 20 located on the downstream sidewalk of northbound bridge at stream centerline, 1988 NAVD, 2001 adjustment. 78 to 01 Adjustment -1.99 As of July 1, 2007, the elevation datum was changed from 1929 NGVD, 1978 adjustment to the 1988 NAVD, 2001 adjustment.	



# Shallow Floodplain Flood





Agency Harris County Flood Control District

Location 440: D100\_440 Brays Bayou @ Rice Avenue

Last 7 Days

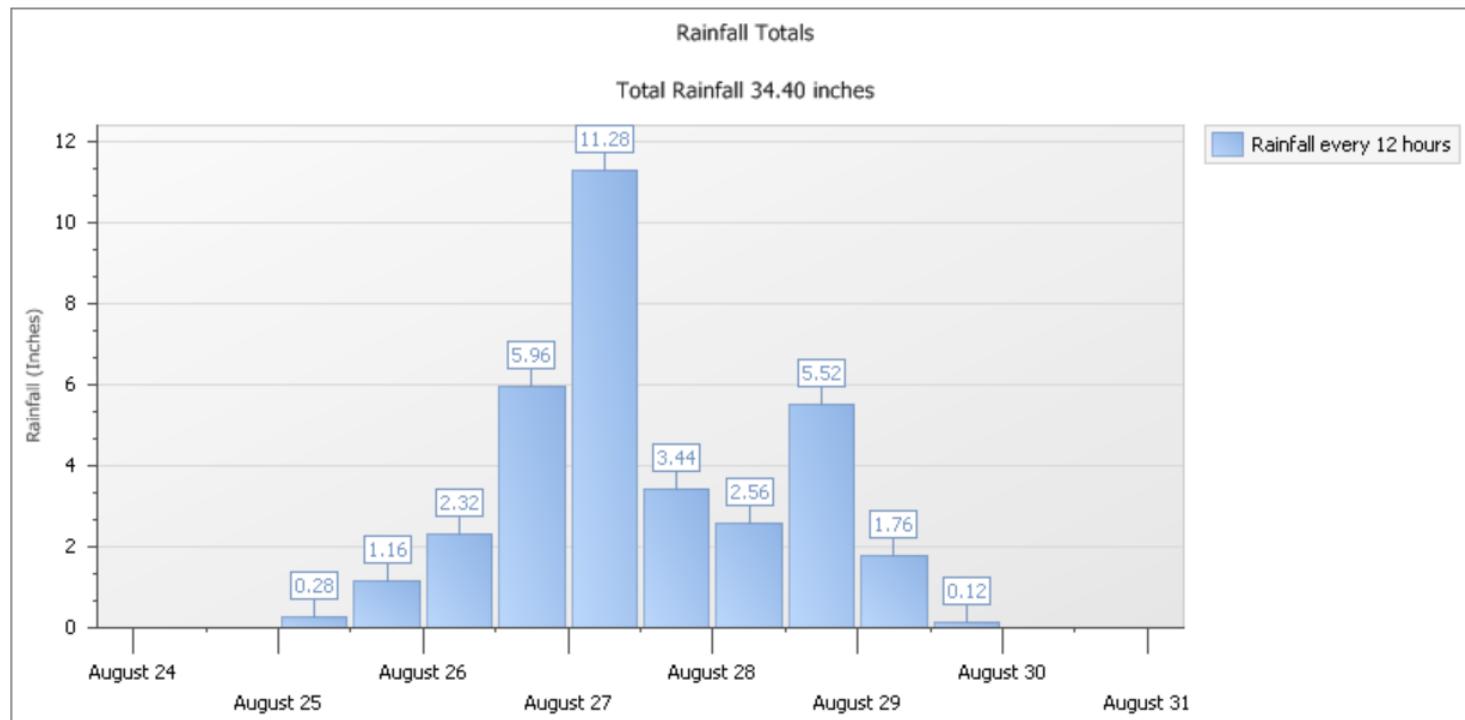
Reported from 8/30/2017 9:46 AM

Show Current Conditions

Stream Elevation

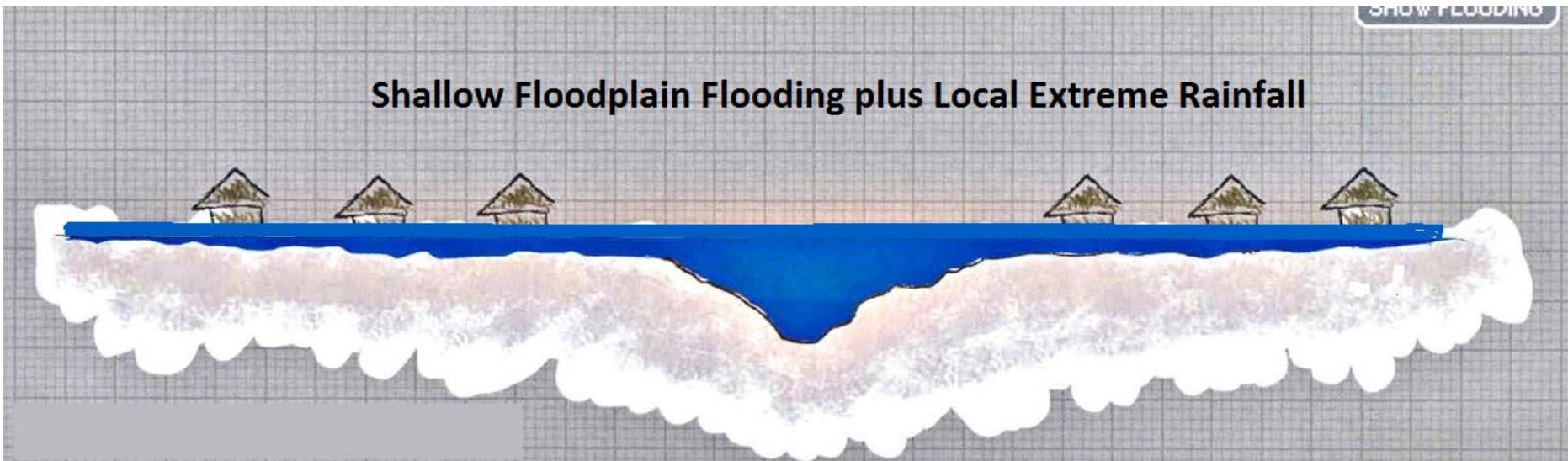
Rainfall

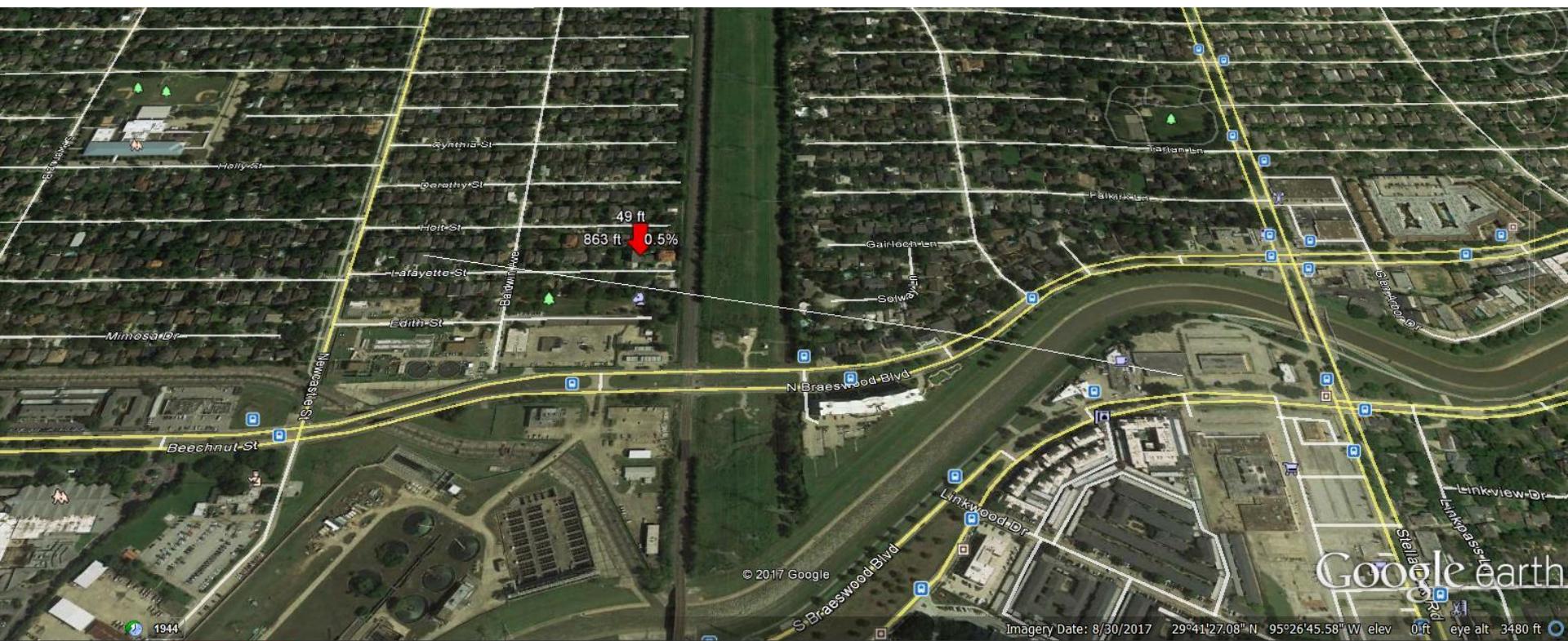
Showing rainfall totals from 8/24/2017 12:00 AM to 8/31/2017 12:00 AM CDT



SHOW FLOODING

**Shallow Floodplain Flooding plus Local Extreme Rainfall**





Graph Min, Avg, Max Elevation 22, 47, 54 ft  
Range Totals: Distance: 0.53 mi Elev Gain/Loss: 76.2 ft, -78.3 ft

Max Slope: 40.7%, -45.9% Avg Slope: 5.5%, -4.9%

Imagery Date: 8/30/2017 29°41'27.08"N 95°26'45.58"W elev 0 ft eye alt 3480 ft



Tour Guide

0.05 mi 0.10 mi 0.15 mi 0.20 mi 0.25 mi 0.30 mi 0.35 mi 0.40 mi 0.45 mi 0.50 mi 0.53 mi

PAGE 18 OF 21

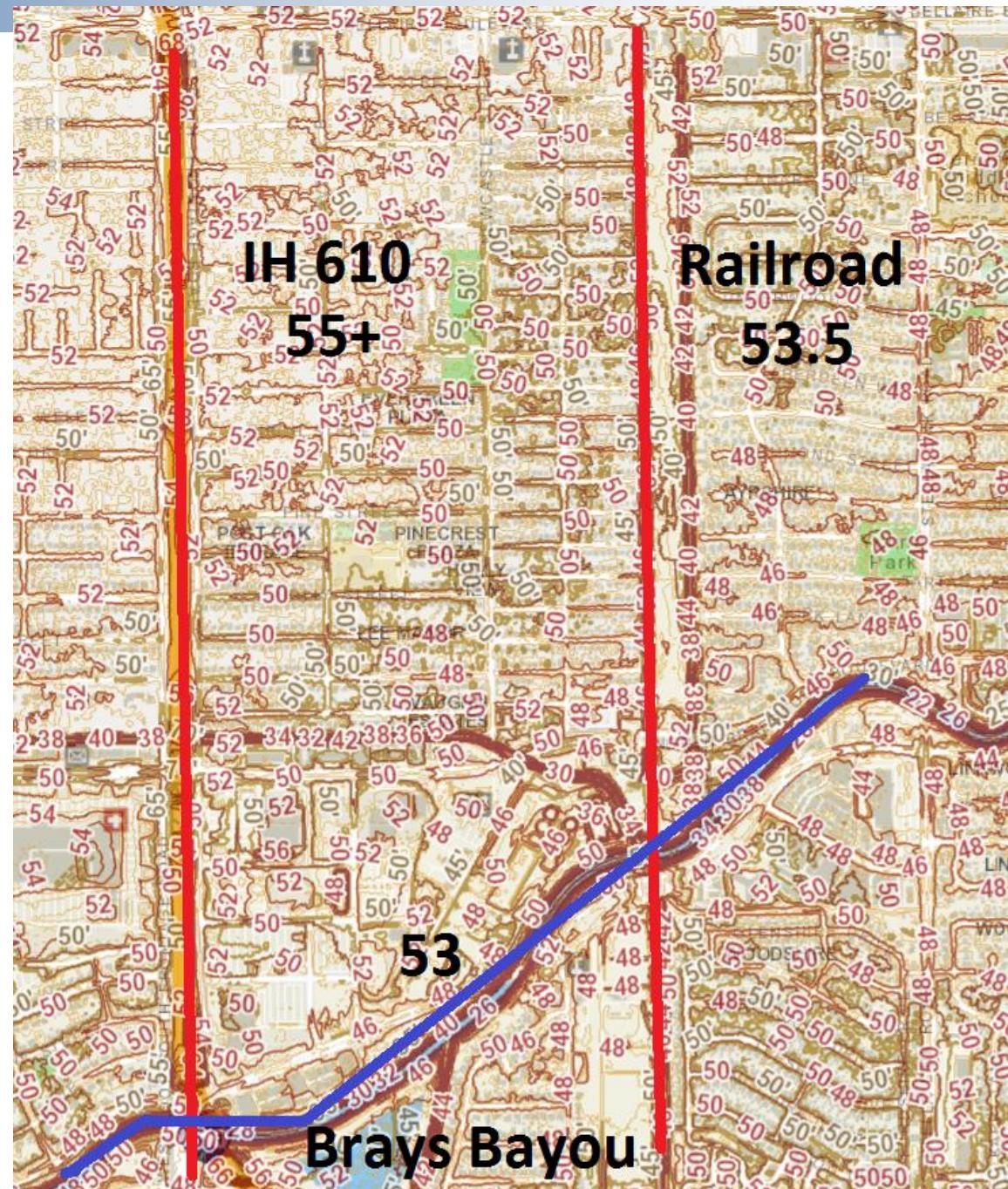
WORDS

LX

0.5%

863 ft

# Potential Overland Flow Obstacles



# Flooded Homes by Building Standard

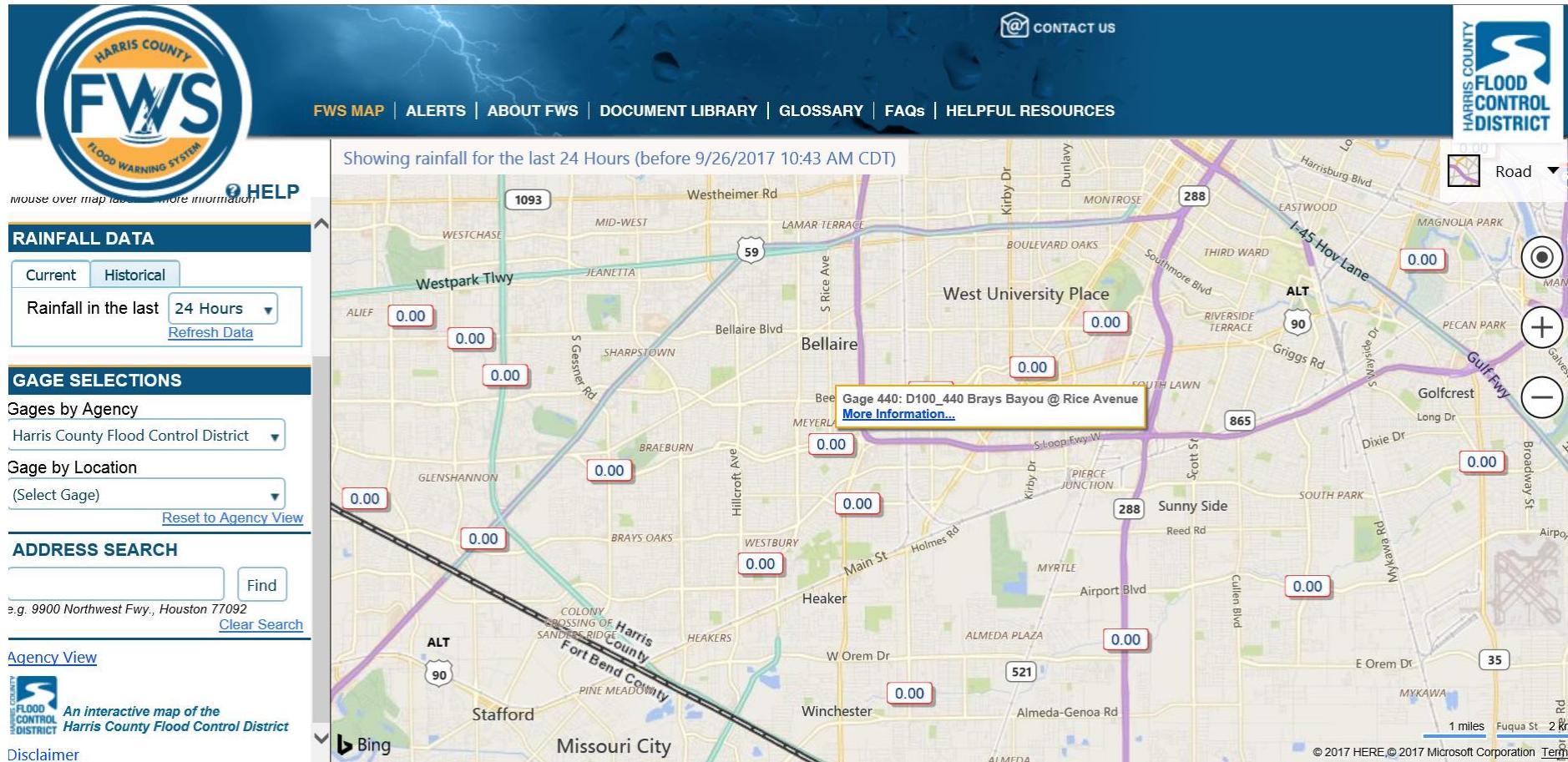
## SUMMARY

Description		Existing Homes	May 2015 Flood		August 2017 Flood		Flooded in Both Storms
			Structural Flooding	% Flooded Homes	Structural Flooding	% Homes w/Structural Flooding	
Tier I	Pre 1980	2313	122	5%	1039	45%	80
Tier II	1980-1993	1087	32	3%	291	27%	12
Tier III	1994-2007	2348	56	2%	554	24%	30
Tier IV	2008-Present	739	16	2%	47	6%	5
	Year Build Unknown	201	2	1%	5	2%	0
<b>TOTAL</b>		<b>6688</b>	<b>228</b>	<b>3%</b>	<b>1936</b>	<b>29%</b>	<b>127</b>

# Newer homes performed better



<https://www.harriscountyfws.org/>



# Utilities

# 100 Year Storm Impact

## Water Production and Distribution

- Three facilities
- Elevation relative to 100 yr.
- 2 of 3 Commercial power
- Central water plant / generator / 72 hours
- Wind events / rain events
- CenterPoint critical facility priority list for power restoration
- Fueling contracts for generators
- Harvey – no service interruption or quality issues

# 100 Year Storm Impact

## Wastewater Collection and Distribution

- Three lift stations and Wastewater Treatment Plant
- Elevation relative to 100 yr.
- 3 of 4 commercial power
- WWTP / generator / 72 hours
- Wind events / rain events
- Harvey - \$300,000 damage, lift station issues (I & I), few in home back ups
- City vehicles – flooded in locations never flooded before
  - Response – manage plant
  - Split asset location – minimize likely hood of total loss

# 100 Year Storm Impact

## Public Utilities

- CenterPoint Gas, Electric
- Fiber, Telecom, etc.
- Coordination Role
- Priority List for Critical Facilities

# Emergency Operations

The City of Bellaire utilizes the National Incident Management System (NIMS) in our All Hazards approach to incidents.

- Allows Bellaire to scale personnel to the incident size
- Brings consistency to training and response approach
- Creates a National Language utilized through the US.
- Important when requesting assets and communicating with counterparts

# Planning

## Historic Perspective on Future Incidents

- Review of past operation and projection to future

Bellaire Office of Emergency Management Holds Annual Exercises to Plan for Events and Incidents

## Table Top Exercise

- Primarily hurricane winds and floods, and hazardous material incidents
- The emphasis is on defining shortcoming and developing situational awareness based on scenarios, leading to a functional exercise

# Training

## Functional Exercise

- An attempt to bring reality into the training regimen.
  - Still scenario based but requires action to external stimuli.
    - Falls short of full scale exercise where units respond to a field based simulation

Adding stressors to decision making simulates the events of an open Emergency Operations Center. While nothing can simulate a “real” incident, increasing decision speed and simulation complexity helps hone the decision making process.

# Responding

Act or behave in reaction to someone or something.

## Normal Response

- Fire
  - Local isolated incidents
- EMS
  - Repetitive, very personal incidents
- Police
  - Local repetitive incidents, Isolated very personal incidents
- Public Works
  - Repetitive personal incidents, broad personal incidents

Everyone responds to major, local incidents affecting broad numbers of citizens.

# Harvey and Similar Incidents

## Historic

- No benchmark to compare
- Planning/Training was held on July 19th with a August 1st exercise follow-up
  - Focus on Hurricane impact and wind preparation

Bellaire did not plan for the scale of Harvey

- Planning did not anticipate the level of water that could fall
- Training did not prepare for the level of water that did fall
- Responding did not anticipate the number of impacted persons.

# What's Next?

## Planning

- Incorporate the unbelievable and use planning as chance to change the paradigm.
  - Nothing is off the table, no potential is too big.

## Training

- Future training will need to utilize the response to Harvey to refine training needs.
  - Specific -- Swift water training will drive future acquisitions for response
    - Rescuer Gear – Victim Safety – Transportation Needs – Refuge After-the-Fact
  - Broad – All Hazard training must continue to train for other, more deadly hazards
    - Incorporate Citizen Training in preparation

# What worked well!?

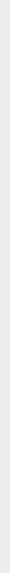
## Responding

- A task force approach
  - Members from Public Works, Police and Fire all working on the same team toward the same immediate action plan
- A community approach-
  - Citizens helping each other
- A regional approach
  - Maximize regional assets when the specific incident allows
    - Boats and High Water Vehicles from surrounding jurisdictions, when available and transportation allows

# Communications

# Harvey Communication Lessons

- The City sent 39 distinct messages between August 24<sup>th</sup> & September 6<sup>th</sup>
- Messages referred to other information sources, Especially Harris County
- Platforms utilized:
  - Notify Me emails, Facebook, Twitter, Nextdoor Bellaire, website updates, Mayor's Blog
- 911 System and Dispatch worked extremely well
- Not everyone who needed the message received it
- All communication platforms require some amount of citizen participation



Regulatory

# Ordinance 04-020

Adopted in March of 2004. This was passed in order to address drainage requirements for residential construction. The highlights of the Ordinance include:

- An approved drainage plan before the issuance of a permit.
- Prohibits water flow from one property unto another
- Set the design requirement for how the water will be carried to the street
- Mandated an engineered sealed plan and statement before Certificate of Occupancy.
- Established a penalty for violation of the ordinance.

# Ordinance 04-032

Adopted in March of 2004. This was passed to establish the Flood Damage Prevention, and Flood Hazard reduction. The highlights of the Ordinance include:

- Prohibits new homes built or Substantial improved/ Substantial *Damaged* in AE zone (100 yr. floodplain) is one foot above Base Flood Elevation (BFE).

## ARTICLE II-A. - FLOOD DAMAGE PREVENTION

- *Substantial damage* means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.
- *Substantial improvement* means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before "start of construction" of the improvement. This includes structures which have incurred "substantial damage," regardless of the actual repair work performed.

# Ordinance 05-024

Adopted in April of 2005. This was passed to establish rules that limit the amount of fill on a lot in the AE zone.

# Ordinances 05-044 & 05-045

Adopted in July of 2005. These were passed to establish rules that limit the amount of fill on a lot in the X zone (500 yr. floodplain) and added a flood vent requirement for new construction.

# Schedule

Work Plan:	Date:
• Kick Off Meeting (1)	Monday, Oct 30, 17
• Present Risk Assessment & Mitigation Strategy with Committee (2)	Tuesday, Nov 14, 17
• Address Task Force Comments on Risk Assessment & Mitigation Strategy (3)	Tuesday, Nov 28, 17
• Review Action Plan with Committee (4)	Tuesday, Dec 12, 17
• 2 <sup>nd</sup> Review of Action Plan with Committee (5)	Tuesday, Jan 2, 18
• Action Plan Public Hearing	Monday, Jan 29, 18
• Committee Review of Public Hearing Comments (6)	Tuesday, Feb 6, 18
• Finalize Action Plan (7)	Tuesday, March 6, 18
• Adopt and Implement Action Plan	Monday, March 19, 18

Before  
November 28

What risks and strategies are not yet addressed concerning:

- Local drainage improvements?
- Regulatory approach?
- Regional efforts?

Tuesday  
December 5, 2017

# Flood Hazard Mitigation Task Force

# Draft Hazard/Risk Assessment Matrix

# Flood Mitigation Plan and CRS

	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
Hazard (Categories & Specifics)				

	Risk/Issues	Mitigation Options/Goal
Public Communication	Residents Utilizing Non-City of Bellaire Outlets to Obtain Information	<ul style="list-style-type: none"> <li>Outlets should be marketed to stakeholders throughout the year</li> <li>Non-City of Bellaire Outlets Should be Utilized to Distribute Information</li> </ul>
	Communication Efforts Not Reaching Audience	<ul style="list-style-type: none"> <li>All outlets available should be utilized by the City.</li> </ul>
	Lack of Pre-Event Communication	<ul style="list-style-type: none"> <li>Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders.</li> </ul>
	Lack of Communication During an Event	<ul style="list-style-type: none"> <li>Up-to-date information should continuously be distributed during an event utilizing all outlets available to the City.</li> </ul>
	Lack of Post-Event Communication	<ul style="list-style-type: none"> <li>Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders.</li> </ul>

	Risk/Issues	Mitigation Options/Goal
Mobility	Reduced mobility can increase emergency response times.	<ul style="list-style-type: none"> <li>It is unlikely that this condition will ever be fully mitigated. Information dissemination would benefit the public to inform them of impassable roads and unsafe conditions.</li> </ul>
	Bellaire's Public Safety Components will not be able to respond with "normal" first response equipment	<ul style="list-style-type: none"> <li>Develop plan, based on predicted weather, to use non-conventional vehicles for response</li> </ul>
	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening. More persons calling for rescue than Bellaire has ability to respond	<ul style="list-style-type: none"> <li>Develop a multi departmental approach to rescue by investigating, training and equipping to help solve issue. Develop a plan that seeks citizen asset owners, develops relationships and trains with Citizen Responders (boat owners &amp; high water vehicles), and mobilizes this group as a force multiplier in flood emergencies. Update the list quarterly.</li> </ul>
	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening	<ul style="list-style-type: none"> <li>Investigate flood warning / mass notification system that will reach all residents with relevant hazard warning and evacuation advice.</li> </ul>
	Specialized response vehicles will not be able to reach all residents (water too high for truck, water too low for boat) and move to safe haven.	<ul style="list-style-type: none"> <li>Develop plan to move rescued persons from deep water inundation, to shallow water vehicle access area, to area of relative safety, to eventual shelter.</li> </ul>

	Risk/Issues	Mitigation Options/Goal
Infrastructure	Storm water that has backflowed into the City's system results in less capacity for local rainfall events resulting in flooding.	<ul style="list-style-type: none"> <li>Include backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects. Coordinate with neighboring agencies (i.e. TxDOT, City of Houston and HCFCD) to prevent backflow stormwater from entering the City's underground drainage systems.</li> </ul>
	Overland sheet flow causes flooding in low lying areas.	<ul style="list-style-type: none"> <li>Lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist.</li> </ul>
	Brays Bayou is undersized for extreme rain events and flood stages prevent local Bellaire drainage systems from adequately serving the area.	<ul style="list-style-type: none"> <li>Determine if additional improvements to Brays Bayou are possible beyond Project Brays to further increase capacity.</li> <li>Provide more flood-hardened rain and flood stage gages for better flood forecasting</li> </ul>
	It flooded many houses South of Bellaire Blvd. Majority of these houses were flooded first time.	<ul style="list-style-type: none"> <li>Beside the Project Brays, local detention facilities are needed. Goals           <ol style="list-style-type: none"> <li>move remaining areas (Post Oak Terrace and Southdale) out of 100 year floor plain even after the completion of the project Brays</li> <li>reduce or prevent wide spread damage in the events that are as significant as Harvey (beyond 100 year events)</li> </ol> </li> </ul>
	Inability to convey storm water adequately to Brays Bayou, therefore creating additional flooding risks.	<ul style="list-style-type: none"> <li>Increase capacity of the North/South drainage systems and the Cypress ditch.</li> </ul>

	Risk/Issues	Mitigation Options/Goal
Infrastructure	Street Flooding	<ul style="list-style-type: none"> <li>• Increase street storm water storage in order to reduce structural flooding. Assess the advantages and disadvantages of street flooding vs. structural flooding.</li> </ul>
	Existing topography, soils and roadway patterns contribute to flooding. These conditions and barriers trap sheet flow generated by extreme rain events and make flooding worse.	<ul style="list-style-type: none"> <li>• Reduce barriers to flow of flood waters. Educate residents on the local topography and why it exacerbates flooding.</li> </ul>
	Outfall of Kilmarnock Ditch is undersized.	<ul style="list-style-type: none"> <li>• Investigate the possibility of increasing the size of the outfall of Kilmarnock Ditch.</li> </ul>
	Blockage of inlets and drainage systems by debris make flooding more severe.	<ul style="list-style-type: none"> <li>• Maintain the storm sewer system so that it is free from blockages and operates at its peak efficiency.</li> <li>• <b>Ensure adequate staffing to maintain storm sewer system</b></li> </ul>
	Drainage from outside the City.	<ul style="list-style-type: none"> <li>• <b>Work with surrounding municipalities and with agencies that own the external storm sewers to reduce peak flows of storm water into the City.</b></li> <li>• <b>Eliminate the water Net surplus in Bellaire</b></li> </ul>
	Attempting to mitigate flooding from a 100-year storm without consulting neighboring agencies and constructing improvements outside the City limits will have limited benefit within the City.	<ul style="list-style-type: none"> <li>• The City must work with, and lead if necessary, TxDOT, Harris County Flood Control, City of Houston, City of West University, Union Pacific Railroad and others towards a workable and reasonable overall floodwater mitigation plan.</li> </ul>

Preparedness	Risk/Issues	Mitigation Options/Goal
	Residents will not be adequately prepared for natural and man made disasters	<ul style="list-style-type: none"><li>Community outreach to increase preparedness awareness.</li></ul>

Facilities & Equipment	Risk/Issues	Mitigation Options/Goal
	Repetitive loss of equipment and or loss of wastewater services to the community.	<ul style="list-style-type: none"> <li>• Sell or close the WWTP and contract with Houston for service. Relocate PW facility.</li> </ul>

Health & Safety	Risk/Issues	Mitigation Options/Goal
	Danger to people walking, playing, or riding bicycles in floodwaters.	<ul style="list-style-type: none"> <li>Prevent injuries to residents due to walking, playing, or riding bicycles in floodwaters.</li> <li>Prevent infiltration into the sanitary sewer so that overflows and contamination of floodwaters will be reduced.</li> </ul>
	Persons, including rescuers, will come in contact with pests and chemicals that may create health hazard	<ul style="list-style-type: none"> <li>Keep citizens out of flood waters and keep rescuers in Personal Protective Equipment specific to the hazards.</li> </ul>

	Risk/Issues	Mitigation Options/Goal
Economic Impact	Negative public perception of housing stock	<ul style="list-style-type: none"> <li>• Explore necessary effort to reduce improvement on repetitive flood structures</li> <li>• Disclosure of Flooding/Flood Variance History</li> <li>• Reduce Number of Unsafe Structures in the City</li> <li>• Seek community input on development in the floodplain</li> </ul>
	Uncertain Base Flood elevations in AE and non-AE zones (100 yr. zones).	<ul style="list-style-type: none"> <li>• Provide clear guidelines for development and redevelopment for non-compliant structures</li> </ul>
	A drop in demand for Bellaire homes, compared to the surrounding area, will lead to lower home values, lower tax revenues, and an overall deteriorated community	<ul style="list-style-type: none"> <li>• Adjust the Community Rating System (CRS) to a non-cumulative approach to the 50% rule</li> <li>• A vocal adherence to a stance consistent with the rest of the metro area will eliminate market value deterioration</li> </ul>
	Elevation of new and existing structures improperly meeting future COB codes	<ul style="list-style-type: none"> <li>• Ensure compliance with BFE's are sufficient for known flooding risk.</li> </ul>

# Schedule

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• Task Force Review of Public Hearing Comments (6)	Tuesday, Feb 6, 18
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• Adopt and Implement Action Plan	Monday, March 19, 18

Before  
December 19

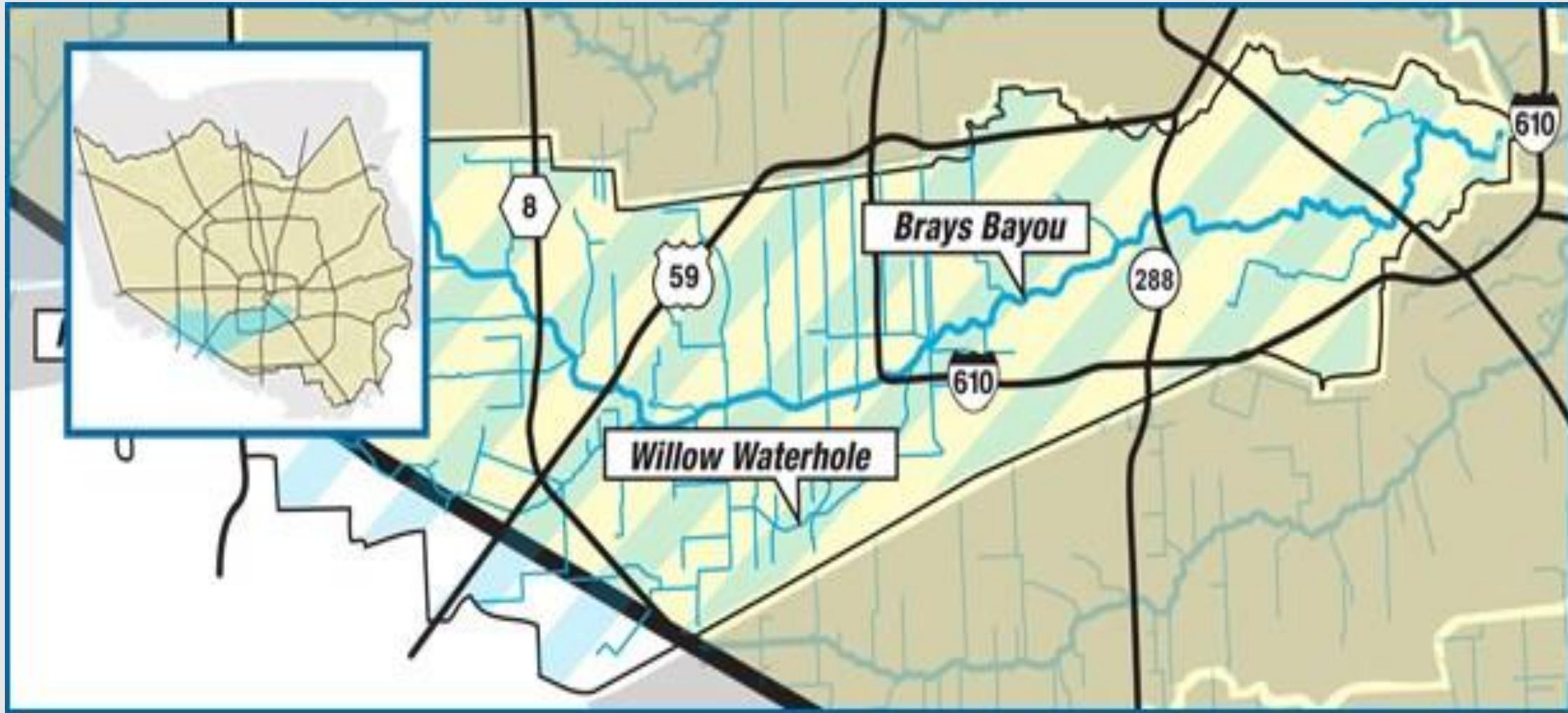


Tuesday  
December 19, 2017

# Flood Hazard Mitigation Task Force

# Overview of Base Flood Elevations

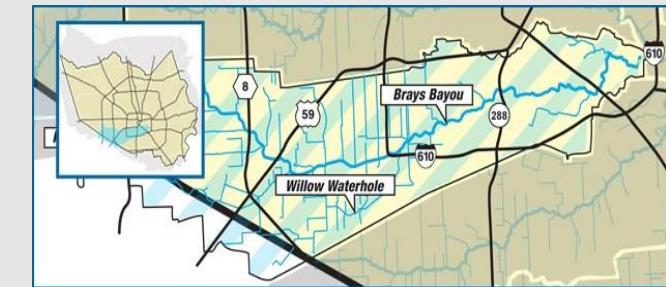
# Brays Bayou Watershed



# Brays Bayou Watershed

The Brays Bayou watershed is located in southwest Harris County and portions of Ft. Bend County and drains parts of the cities of Houston, Missouri City, Stafford, Bellaire, West University, Southside Place and Meadows Place. The bayou flows eastward from Fort Bend County to its confluence with Buffalo Bayou.

This heavily urbanized watershed covers approximately 127 square miles and includes three primary streams: Brays Bayou, Keegans Bayou and Willow Waterhole Bayou. There are about 121 miles of open streams within the watershed, including the primary streams and tributary channels.



## 1% (100-year) Floodplain

The area of land that has a 1% chance of being inundated by flood waters from a bayou, stream or creek in a given year. It is commonly referred to as the 100-year floodplain. This is a regulatory standard used to administer floodplain management programs, the National Flood Insurance Program (NFIP) and to set building requirements for new construction.

The 1% (100-year) floodplain is the Base Flood or Special Flood Hazard Area. It is referred to as Zones AE, AO, A, or VE for insurance purposes on Flood Insurance Rate Maps (FIRMs). Properties located in these mapped zones are required to have flood insurance if the owner has a federally backed mortgage on the property.

## 1% (100-year) Rainfall

An amount of rain having a 1% chance of being equaled or exceeded in any given year. For Harris County this amount of rainfall is just over 13 inches in 24 hours.

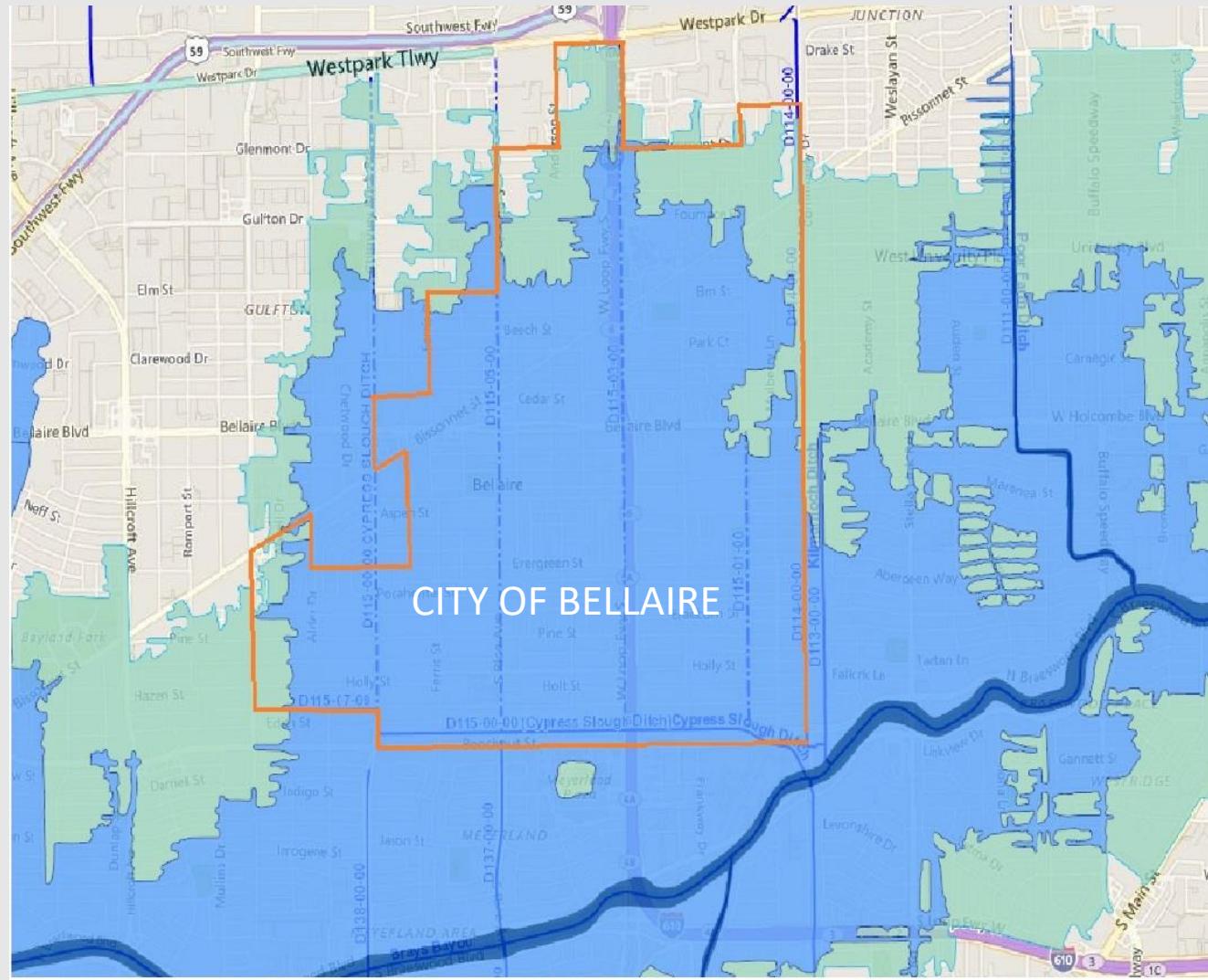
## Base Flood Elevation

The BFE is the regulatory requirement for the elevation or floodproofing of structures. The relationship between the BFE and a structure's elevation determines the flood insurance premium.

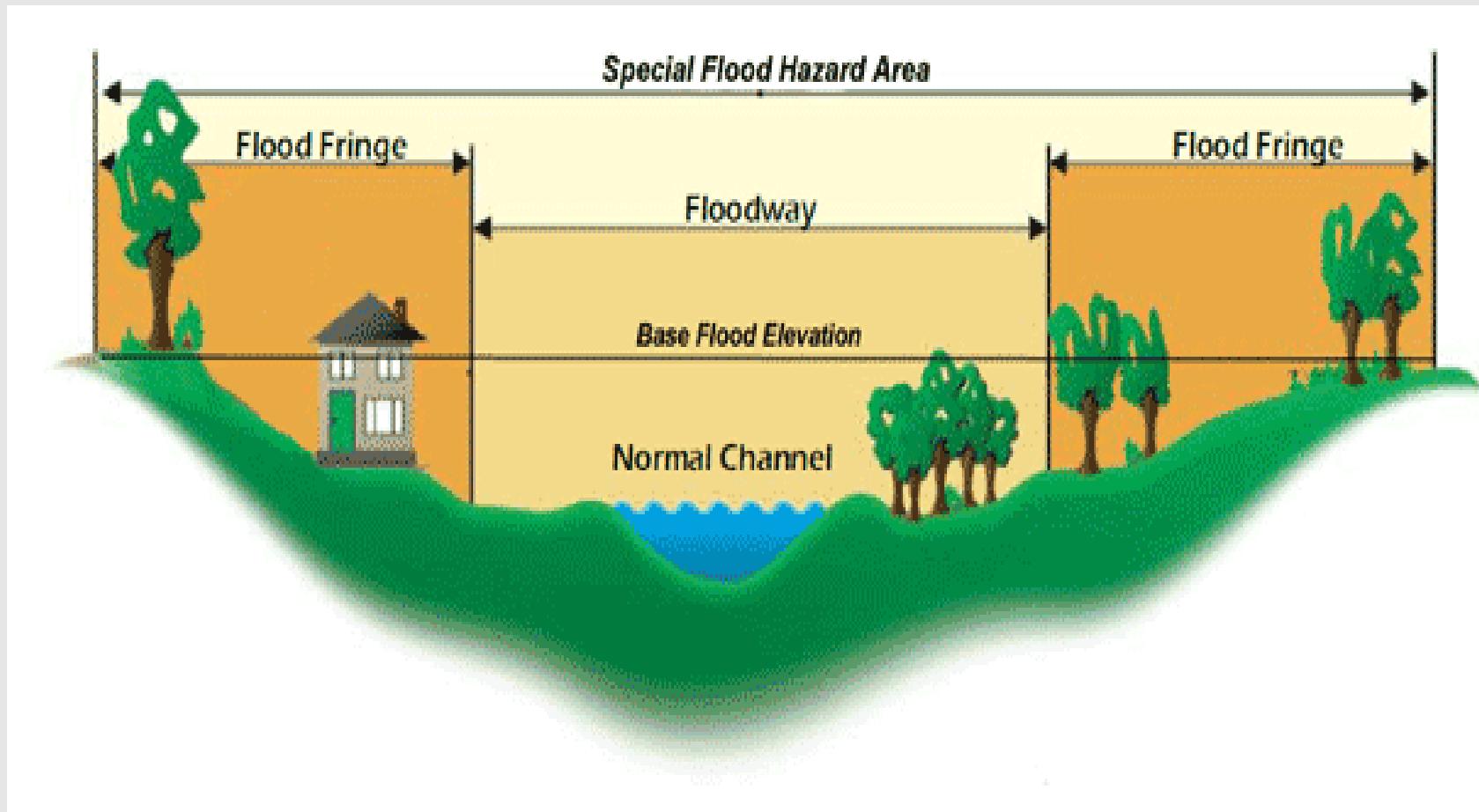
This is the elevation above the average sea level that waters from a 1% (100-year) flood will reach at a given point along a creek or bayou. These elevations are determined by FEMA and its consultants using hydrology and hydraulic computer models. The elevations are then mapped on the topographic data for the agency to produce the 1% (100-year) floodplain.

## 1% (100-year) Floodplain

<http://www.harriscountyfemt.org/>



# Base Flood Elevation



## SUMMARY SHEET - HCFCD HIGH WATER MARKS

9/19/2017

BRAYS BAYOU D100-00-00 Page 1 of 2

ROAD NAME	STAGE GAGE	BRIDGE BM ELEV	78 TO '01 ADJUST					STORM EVENTS															HARVEY 8/27/17			
				10.0%	2.0%	1.0%	0.2%	7/30/54	6/18/73	8/31/81	ALICIA 8/18/63	9/19/83	CHANTAL 8/1/89	3/4/92	10/18/94	FRANCES 9/11/98	ALLISON 6/9/01	11/17/03	IKE 9/13/08	4/28/09	1/9/12	5/26/15	4/18/16	1/18/17		
75 TH		20.35	-0.5	14.4	17.1	18.3	21.5				13.4	12.7			11.9	13.6	16.5	8.8	16.8	N/A	10.1	12.4	11.9	8.1	16.1	
LAWNDALE	410	21.97	-0.6	18.1	20.7	21.9	24.7				16.7	17.0	13.9		17.6	17.9	22.8	14.9	17.0	9.2	15.6	18.4	18.0	13.4	20.7	
IH 45 (IN BOUND)		31.49	-0.6	21.7	24.4	25.6	28.3		20.1			20.8			21.7	20.7	27.6	20.0	21.6	N/A	18.4	21.6	18.5	16.9	25.5	
TELEPHONE RD		25.65	-0.6	23.4	26.0	27.3	30.2	22.4	21.7	20.2	18.7				22.1	21.8	27.8	15.7	22.9	14.8	19.9	22.2	21.0	18.2	25.0	
WAYSIDE		32.17	-0.6	24.9	27.8	29.2	32.0		23.5						23.0	16.8	20.4 <sup>1</sup>				14.2	21.0	23.3	22.5	18.2	26.9
OLD SPANISH TRAIL (OST)		28.47	-0.7	25.4	28.3	29.9	32.8								26.3		27.8	16.6	25.0	15.7	20.9	23.8	22.5	16.3	27.3	
MARTIN LUTHER KING		36.47	-0.8	29.7	32.4	33.7	36.1				24.9	26.8			26.0	29.5	32.8	26.6	29.9	20.9	26.2	29.3	26.4	18.2	32.3	
CALHOUN		33.41	-0.8	30.3	32.8	34.0	36.5	31.9	29.2	29.0					29.5	30.1	32.8	27.8	30.7	22.0	28.2	28.9	28.8	26.2	33.7	
SCOTT		37.92	-1.0	31.6	34.4	35.7	37.9								31.3	32.3	32.4	29.7	31.5	24.0	29.4	32.1	30.5	28.4	35.2	
ARDMORE		37.36	-1.1	32.8	35.4	36.6	38.9								33.9		38.0	31.9	32.8	25.8	31.2	34.3	29.1 <sup>1</sup>	30.6	37.4	
SH 288		51.01	-1.2	33.6	36.4	37.8	40.1			30.4					34.8	35.2	39.3	33.9	33.6	26.7	33.0	35.2	34.2	31.7	39.2	
ALMEDA RD		41.10	-1.2	34.4	37.6	39.1	41.9		35.1	34.5					36.2	34.7	37.5	33.9	35.0	27.1	33.7	37.0	36.0	32.3	40.4	
D109 @ MACGREGOR	400	39.11	-1.2	34.9	38.2	39.9	43.0												34.0	N/A	36.1	38.0	37.4	35.3	41.5	
HOLCOMBE BLVD		43.31	-1.2	36.3	39.4	41.1	43.9		37.4	37.3	33.8	38.4			38.2	36.7	40.3	36.7	37.2	30.7	36.5	38.2	37.7	34.9	41.7	
S. BRAESWOOD BLVD.		43.68	-1.2	37.1	40.0	41.9	44.8								39.4		42.9	38.0	38.7	32.0	37.3	39.9	38.2	36.4	42.0	
FANNIN		45.81	-1.3	38.4	41.2	43.3	46.6			38.9	34.7				41.0	38.5	44.0	37.8	39.4	34.0	37.9	40.1	39.5	37.5	43.5	
GREENBRIAR		45.11	-1.3	39.2	41.7	43.8	47.4								40.7		42.2	39.9	39.4	35.0	38.7	41.3	40.4		44.4	
N. BRAESWOOD BLVD.		47.58	-1.4	40.2	42.4	44.9	48.6								41.7		44.5	46.5	40.8	N/A	40.6	42.2	41.0		45.7	
SOUTH MAIN	420	46.53	-1.4	41.0	43.1	45.7	50.0		41.2	41.5	37.4	42.4	38.8		42.2	39.6	42.9	40.6	41.3	36.5	40.5	42.9	42.1		45.7	
S. BRAESWOOD		49.74	-1.3	41.4	43.7	46.6	50.1								42.7		44.3	42.0	41.9	36.3	39.9	43.1	42.4	40.5	45.9	
KIRBY		44.30	-1.3	42.1	44.3	47.1	50.7		41.6	42.5					42.7	40.6	47.2	42.1	41.8	37.4	41.6	43.9	43.0		46.3	
BUFFALO SPEEDWAY		49.48	-1.3	43.7	46.1	48.4	51.1		42.8		40.9				44.4	43.1	47.4	43.7	43.3	39.3	43.7	45.5	44.1	42.7	47.9	
STELLA LINK	430	49.55	-1.7	45.5	47.5	49.6	51.8		45.1	46.1	42.7				45.0	46.0	44.3	48.4	46.4	45.9	43.0	45.7	46.3	47.1	45.7	49.7
SPRR		53.36	-1.7	47.2	49.5	51.3	52.6								47.8	46.3	49.4	47.1	46.5	44.0	47.2	49.1	47.7	46.8	50.7	

NOTE: BRIDGE AND HIGH WATER ELEVATIONS ARE ON 1988 NAVD; 2001 ADJ

NOTE: D109 @ MacGregor added as a HWM location in summer of 2005

<sup>1</sup> - Suspect elevation, low confidence in field

## SUMMARY SHEET - HCFCD HIGH WATER MARKS

8/19/2017

BRAYS BAYOU D100-00-00 Page 2 of 2

ROAD NAME	STAGE GAGE	BRIDGE BM ELEV	78 TO '01 ADJUST	STORM EVENTS																Harvey					
				10.0%	2.0%	1.0%	0.2%	7/30/54	6/16/73	8/31/81	8/18/83	9/19/83	8/1/89	3/4/92	10/18/94	9/11/98	06/09/01	11/17/03	9/13/08	4/26/09	1/9/12	5/26/15	4/18/16	1/18/17	
SOUTH POST OAK		50.45	-2.1	49.9	52.1	53.6	55.0					47.4			50.2	46.7	50.8	50.8	47.3	46.3	48.9	51.4	49.6	48.9	53.7
RICE BLVD	440	53.81	-2.0	50.8	52.9	54.3	55.7		49.1		47.4	52.5	49.0		51.5	47.5	50.4	51.0	47.9	47.6	50.3	52.9	51.7	49.8	54.1
CHIMNEY ROCK		54.05	-2.1	52.4	54.6	55.5	56.8		50.9	50.8		53.7		51.4	52.5	50.6	52.5	53.3	48.4	49.0	51.2	53.6	52.8	50.9	54.9
HILLCROFT		59.78	-2.2	56.1	57.2	57.4	58.7		52.3	53.3	51.0	56.4			54.5	52.6	53.7	55.1	51.5	51.6	53.8	55.9	47.7	53.3	57.2
N. BRAESWOOD		58.37	-2.2	56.2	58.7	59.1	60.5								55.7			56.5	52.8	52.9	55.0	57.1	56.8	54.3	57.9
FONDREN		59.28	-2.4	58.5	61.1	61.5	62.7		53.7	55.5	52.5	58.4			57.3	52.9	55.4		53.4	54.6	56.5	59.0	55.3	56.0	60.7
REEDWOOD		58.55	-2.2	56.7	58.7	59.5	60.4								55.5			55.7	55.7	55.5	55.5	55.5	55.5	55.5	55.5

## Overarching Goals

What is the Flood Hazard  
Mitigation Task Force  
trying to accomplish?

## Safety & Assurance

- Bellaire residents and property owners should not need to unreasonably worry about flooding
- Bellaire residents and property owners should be prepared and equipped to deal with flooding
- During a flood event, communication between rescue agencies and residents needs to be meaningful and reliable
- Rescue agencies should have sufficient training, equipment, and access to resources

# Planning & Implementation of Drainage Improvements

- The cost/benefit of level of protection options needs to be determined, and the level of protection to be provided by local drainage improvements needs to be established
- The City of Bellaire needs to be positioned to secure adequate funding for local capital drainage projects
- The City of Bellaire needs to be positioned to secure funding and implementation of regional projects that benefit the City of Bellaire
- The relationship between drainage maintenance (e.g. storm sewer repairs, inlet cleaning) and level of protection should be established
- Sufficient resources for ongoing drainage maintenance needs to exist

# Floodplain Regulation: Policy & Management

- The current approach to regulating the flood plain needs to be evaluated with regard to future base flood elevation calculations (elevation requirements, impervious cover, management of flood repair permits)
- The feasibility and effectiveness of property acquisitions for the purpose of drainage improvements should be evaluated
- The City of Bellaire should be positioned to advocate for strict upstream development standards

# Draft Hazard/Risk Assessment Matrix

# Schedule

Work Plan:	Date:
• Kick Off Meeting (1)	Monday, Oct 30, 17
• Present Risk Assessment & Mitigation Strategy with Task Force (2)	Tuesday, Nov 14, 17
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• 2 <sup>nd</sup> Review of Action Plan with Task Force (5)	Tuesday, Jan 9, 18
• Action Plan Public Hearing	Monday, Jan 29, 18
• Task Force Review of Public Hearing Comments (6)	Tuesday, Feb 6, 18
• Finalize Action Plan (7)	Tuesday, March 6, 18
• Adopt and Implement Action Plan	Monday, March 19, 18

Tuesday  
January 9, 2018

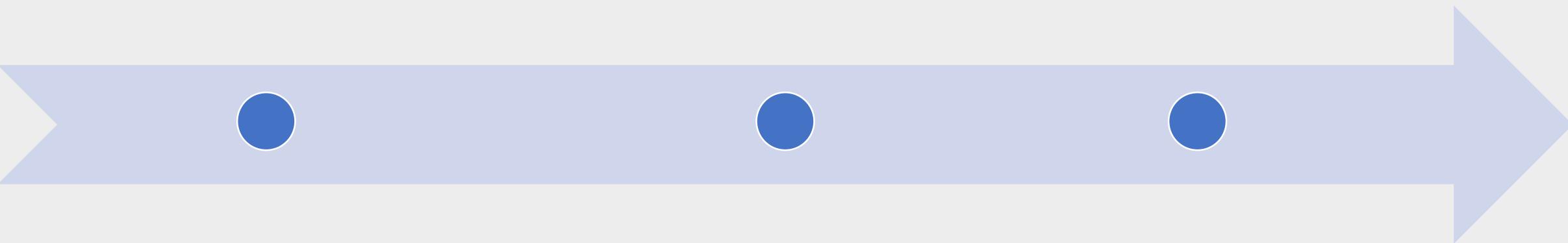
# Flood Hazard Mitigation Task Force

# Review of Regulatory Approach

# Regulations Timeline

1978

2005



2004

# Ordinance 04-020

Adopted in March of 2004. This was passed in order to address drainage requirements for residential construction. The highlights of the Ordinance include:

- An approved drainage plan before the issuance of a permit.
- Prohibits water flow from one property unto another
- Set the design requirement for how the water will be carried to the street
- Mandated an engineered sealed plan and statement before Certificate of Occupancy.
- Established a penalty for violation of the ordinance.

# Ordinance 04-032

Adopted in March of 2004. This was passed to establish the Flood Damage Prevention, and Flood Hazard reduction. The highlights of the Ordinance include:

- Prohibits new homes built or Substantial improved/ Substantial *Damaged* in AE zone (100 yr. floodplain) is one foot above Base Flood Elevation (BFE).

# Ordinance 05-024

Adopted in April of 2005. This was passed to establish rules that limit the amount of fill on a lot in the AE zone.

# Ordinances 05-044 & 05-045

Adopted in July of 2005. These were passed to establish rules that limit the amount of fill on a lot in the X zone (500 yr. floodplain) and added a flood vent requirement for new construction.

## ARTICLE II-A. - FLOOD DAMAGE PREVENTION

- *Substantial damage* means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.
- *Substantial improvement* means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before "start of construction" of the improvement. This includes structures which have incurred "substantial damage," regardless of the actual repair work performed.

# Suggested Approach to Cumulative Rule

**1<sup>st</sup> Flood  
Permit/Claim**  
(No Cumulative Review)

**2<sup>nd</sup> Flood  
Permit/Claim**  
(No Cumulative Review)

**2<sup>nd</sup> Flood  
Permit/Claim with  
RR Permit**  
(Cumulative Review Begins)

**3<sup>rd</sup> Flood  
Permit/Claim with  
RR Permit**

## Overarching Goals

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Mitigation Task Force  
trying to accomplish?

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# Draft Hazard/Risk Assessment Matrix

# Goals

**Safety & Assurance**

**Planning & Implementation of Drainage  
Improvements**

**Floodplain Regulation & Management**

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• Task Force Review of Public Hearing & CRS Comments (7)	Tuesday, February 20, 18
• Finalize Action Plan (8)	Tuesday, March 6, 18
• Adopt and Implement Action Plan	Monday, March 19, 18

Monday  
January 29, 2018

# Public Hearing: Flood Hazard Mitigation Plan

# Public Hearing Procedure

# Public Hearing

- Presentation of the Draft Flood Hazard Mitigation Plan and a History of Its Development
- Public Comments:
  - Each speaker will have five (5) minutes to comment.
  - Questions from the public shall be addressed to the Task Force, who may refer such question to the staff as appropriate.
- Questions from the Task Force

# Background

# Task Force

- City Council took action in August, and October, to authorize the creation of the Flood Hazard Mitigation Task Force
  - The Task Force is charged with recommending to the City Council a Hazard Mitigation Plan
- Comprised of Ten (10) Members, All Residents of Bellaire
  - The Task Force includes Bellaire homeowners, a utility company representative, a builder, and prior members of City Boards/Commissions, as required by the National Flood Insurance Program.
- Three Member Council Liaison Team
  - This team is responsible for monitoring the level of citizen engagement, ensuring broad and ongoing communication, and recommending necessary council action.
- Staff Advisory Team

# Task Force Meetings

- Five (5) Meetings to Date
- Meetings are Public and Allow for Public Comments
- Meetings are Broadcast Live on Facebook Live
- Presentation of Technical Data:
  - Prior drainage studies conducted by the City Engineer
  - The City Engineer's report on the causes and damage from Harvey
  - The City's current approach to the design of flood control projects & how the city regulates flood plain development activity
  - The Harris County Flood Control Project anticipated benefits to Bellaire.
- Task Force Members are Encouraged to Ask Questions, Make Suggestions, & Find Consensus
- Task Force Suggestions to Date are Included in the Draft Flood Hazard Mitigation Plan, Presented in the Form of a Matrix

# Public Information

- An “Electronic Notebook” is Available on the City’s Website
  - [www.bellairetx.gov/TaskForce](http://www.bellairetx.gov/TaskForce)
- The Notebook Includes:
  - Every Presentation and Report Made Available to the Task Force
  - Videos of Each Meeting
  - Notes from Each Meeting
  - The Current Draft Report

# Schedule

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Tuesday  
February 20th, 2018

# Flood Hazard Mitigation Task Force

# Hazard/Risk Assessment Matrix

# Goals

**Safety & Assurance**

**Planning & Implementation of Drainage  
Improvements**

**Floodplain Regulation & Management**

Hazard Category	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
	The assessment and history is the background information which is being used to determine the hazard and severity. This tells us why a particular hazard is relevant in today's environment.	Risks are the individual situations that are created as a result of the hazard.	The Mitigation Plan should develop a strategy for reducing the potential losses identified in the risk assessment, and include goals and objectives.	The Action Plan should provide tangible solutions for achieving the goals and objectives outlined in the Mitigation Plan.
1	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not sufficiently marketing the outlets utilized by the City can limit the reach of the City's messages.</li> <li>- Not providing City messages to outside outlets, can limit their range and effectiveness.</li> </ul>	Residents Utilizing Non-City of Bellaire Outlets to Obtain Information	<p>Outlets should be marketed to stakeholders throughout the year</p> <p>Non-City of Bellaire Outlets Should be Utilized to Distribute Information</p>	<p>Develop a marketing plan which identifies the City outlets and how to increase participation in them. The plan should list events, stakeholders, etc.</p> <p>Develop and update a list of frequently utilized non-City outlets which the City should use to distribute its messages. This list should include media contacts, etc.</p> <p>(Target Completion: End of FY 2019)</p>
2	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not ensuring each communication outlet is being utilized can lead to an information vacuum, where some residents may not receive essential information.</li> </ul>	Communication Efforts Not Reaching Audience	All outlets available should be utilized by the City	<p>Pre-populate communication outlets with needed information, allowing contacts to "opt-out", instead of having to "opt-in".</p> <p>Develop a communication matrix to outline what messages should be sent through which outlets.</p> <p>Evaluate the implementation of a "local street warden" program to deliver City produced storm related communication to their assigned area.</p> <p>(Target Completion: End of FY 2019)</p>
3	History has shown that at the height of a significant event, emergency communication can be diminished resulting in longer wait times or a requirement to queue 911 callers.	Diminished Emergency Communication (911) Capacity	<p>Ensure residents are aware of when to call 911 (what constitutes an emergency)</p> <p>Provide redundancies in 911 communication operations</p>	<p>Develop public messages to be used prior to and during an event to outline when residents should use 911. The public messages should also include other communications outlets residents can utilize in non-emergency situations.</p> <p>(Target Completion: End of FY 2019)</p>
4	During major events access to common communications devices may be unavailable, which impacts the city's ability to regularly update residents.	Failure/Lack of Common Communication Outlets	All outlets available should be utilized by the City	<p>Develop an educational program/campaign to inform residents and stakeholders of regularly utilized communication outlets.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication prior to a flooding event can leave residents unprepared for the possible impact of an event.</li> <li>- Additionally, poor communication can cause confusion or misinformation which could become an issue during an event.</li> </ul>	Lack of Pre-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized prior to an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication during an event can lead to confusion and hinder decisions needing to be made by residents.</li> </ul>	Lack of Communication During an Event	Up-to-date information should continuously be distributed during an event utilizing all outlets available to the City	<p>Develop a communication template to be utilized during an event which includes updates on information the City has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- After an event; residents, employees, business, and numerous other community stakeholders need to have proper information to understand how they and the City are moving forward, post event.</li> </ul>	Lack of Post-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized after an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p>	Reduced mobility can increase emergency response times	Provide regular up-to-date information on local road conditions	<p>Formalize a mechanism within the scope of EOC operations whereby a team would be responsible for field reconnaissance as well as publication of information for use by the public via the website, social media, local news media, etc.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <ul style="list-style-type: none"> <li>- Historic flooding events create impassable roadways where vehicle mobility is limited due to high water areas.</li> </ul>	Bellaire's Public Safety Components will not be able to respond with "normal" first response equipment	Utilize non-conventional vehicles for response	<p>Develop a plan to identify, utilize, and position non-conventional access vehicles for use when weather events dictate.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
10 <b>Mobility</b>	<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <p>- Extreme flood events makes overland mobility impossible</p>	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening. More persons calling for rescue than Bellaire has ability to respond	<p>Utilize a multi departmental approach to rescue which includes training and equipping to help solve issue</p> <p>Utilize Citizen Responders (boat owners &amp; high water vehicles), and mobilizes this group as a force multiplier in flood emergencies</p>	<p>Ensure adequate funding to send rescue oriented persons to hazard specific schools to for information to make logical purchases for rescue equipment (i.e. boats, dry suits, helmets, Coast Guard approved rescue Personal Flotation Devices for flood response).</p> <p>Develop a program to identify, train, and utilize Citizen Responders and create MOU (cover liability of the asset use donation).</p> <p>(Target Completion: End of FY 2019)</p>
11	<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <p>- Extreme flood events makes overland mobility impossible</p>	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening	Utilize a mass notification system that will reach all residents with relevant hazard warning and evacuation advice	<p>Research, develop scope and policies &amp; procedures for, and place into affect a Mass Notification System.</p> <p>(Target Completion: End of FY 2019)</p>
12	Flood events of hinders mobility due to flooding of Bellaire streets	Specialized response vehicles will not be able to reach all residents (water too high for truck, water too low for boat) and move to safe haven	Evacuate rescued persons from deep water inundation, to shallow water vehicle access area, to area of relative safety, to eventual shelter	<p>Develop a rescue plan which utilizes field-confirmed data to generate on-the-fly response maps for rescuer pathways.</p> <p>(Target Completion: End of FY 2019)</p>
13	Storm water from Brays Bayou and Cypress Ditch can backflow into the City's underground drainage system. Backflow from Brays bayou and Cypress Ditch reduces the capacity in the City's underground system.	Storm water that has backflowed into the City's system results in less capacity for local rainfall events resulting in flooding	Utilize backflow devices to prevent storm water from the bayou, during high water surface conditions, from coming back into the City's underground system	<p>Include design and installation of backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects.</p> <p>Coordinate with neighboring agencies (i.e. TxDOT, City of Houston and HCFCD) to prevent backflow stormwater from entering the City's underground drainage systems.</p> <p>(First Phase Completion: End of FY 2020)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
14	Overland sheet flow from areas inside and outside the City collects in low lying areas that do not have adequate storm drainage systems or positive overland flow capabilities to prevent flooding.	Overland sheet flow causes flooding in low lying areas	<p>Strategically locate underground storage pipes within the existing street right-of-way to store 100-year localized rainfall events.</p> <p>(Target Completion: End of FY 2020)</p> <p>Evaluate increasing the size of existing stormwater drainage culverts in Bellaire.</p> <p>(Target Completion: End of FY 2020)</p> <p>Continue to utilize drainage impact when selecting roads to be rebuilt.</p>
15	Inadequate capacity in Brays Bayou has resulted in a cooperative effort between HCFCD and the U.S. Army Corps of Engineers to widen Brays Bayou to substantially reduce flooding risks in the Brays Bayou watershed.	Brays Bayou is undersized for extreme rain events and flood stages prevent local Bellaire drainage systems from adequately serving the area	<p>Lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist</p> <p>Coordinate with HCFCD and the U.S. Army Corps of Engineers to determine how additional widening of Brays Bayou will reduce flooding for the City of Bellaire.</p> <p>(Target Completion: End of FY 2021)</p> <p>Determine if additional improvements to Brays Bayou are possible beyond Project Brays to further increase capacity</p> <p>Provide more flood-hardened rain and flood stage gauges for better flood forecasting</p> <p>Evaluate the feasibility of adding more flood-hardened rain and flood stage gauges at strategic location in the City, to provide for better flood forecasting.</p> <p>(Target Completion: End of FY 2019)</p> <p>Evaluate the development of a levee along the south side of Bellaire, which would prevent water from Brays Bayou from entering the City.</p> <p>(Target Completion: End of FY 2019)</p> <p>Evaluate the conversion the trash transfer station at Beltway 8 to a reservoir for Brays Bayou.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
16   <b>Infrastructure (COB &amp; Other)</b>	Water overflow from the Brays Bayou is a single significant factor for the wide spread flooding in Bellaire and surround areas. The water level at the peak was 4 Ft above the bank on Sunday August 27th 2017.	It flooded many houses South of Bellaire Blvd. Majority of these houses were flooded first time	Evaluate the conversion of Bellaire's Wastewater Treatment Plat to a retention area
		Move remaining areas (Post Oak Terrace and Southdale ) out of 100 year floor plain even after the completion of the project Brays	Evaluate the conversion of the dog park and soccer fields along Edith into a detention area.
		Reduce or prevent wide spread damage in the events that are as significant as Harvey (beyond 100 year events)	Lower street level when streets are under construction
			(Target Completion: End of FY 2019)
17	Major North/South drainage systems and Cypress Ditch are undersized for the large drainage area.	Inability to convey storm water adequately to Brays Bayou, therefore creating additional flooding risks.	Study alternatives and develop cost estimates for improvements. Determine partners.
			(Target Completion: End of FY 2019)
			Educate and inform the public that street flooding is preferable to structural flooding.
			(Target Completion: End of FY 2019)
			Develop a plan to repair and replace the highly critical local drainage systems within five (5) years. If necessary, issue debt instruments every five years until the major local flood mitigation CIPs are completed.
18	Streets/Roadways are designed to store floodwaters that have overwhelmed the underground storm storage system in order to mitigate structural flooding.	Street Flooding	Increase street storm water storage in order to reduce structural flooding. Assess the advantages and disadvantages of street flooding vs. structural flooding
			(Target Completion: End of FY 2020)
			Develop a schedule to perform routine maintenance, inspections, and repairs to all storm water infrastructure (such as pipes, or open waterway) on a minimum 5-year cycle.
			(Target Completion: End of FY 2019)
			Create a proactive approach to repair and maintain drainage systems in desirable development areas and neighborhoods with storm drainage systems.
			(Target Completion: End of FY 2019)

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
19  Bellaire is in a flat coastal area with predominately clay soils that are relatively impervious. Additionally, existing elevations and roadway patterns create barriers that trap sheet flow. Flooding occurs more frequently in areas with these conditions.	Existing topography, soils and roadway patterns contribute to flooding. These conditions and barriers trap sheet flow generated by extreme rain events and make flooding worse	Reduce barriers to flow of flood waters  Educate residents on the local topography and why it exacerbate flooding	Identify barriers restricting sheet flow and determine what projects could relieve this problem.  (Target Completion: End of FY 2019)
			Develop communication plan to inform residents of the importance of not filling in the floodplain.  (Target Completion: End of FY 2019)
20  Outfall of Kilmarnock Ditch has proven to be undersized. The undersized outfall causes a backup of floodwaters to the upstream areas and contributes to localized flooding.	Outfall of Kilmarnock Ditch is undersized	Increasing the size of the outfall of Kilmarnock Ditch	Coordinate with HCFCD to determine steps necessary to increase the size of the outfall of Kilmarnock Ditch. Construct extreme event outfalls at Bellaire Blvd and within the Southdale Subdivision to Kilmarnock Ditch.  (Target Completion: End of FY 2023)
21  Debris can clog inlets and storm sewers. This exacerbates localized flooding, since floodwaters cannot drain away quickly.	Blockage of inlets and drainage systems by debris make flooding more severe	Maintain the storm sewer system so that it is free from blockages and operates at its peak efficiency  Ensure adequate staffing to maintain storm sewer system	Develop an educational program/campaign warning residents of the dangers of blocked storm sewers, and how they can help mitigate this problem.  (Target Completion: End of FY 2019)
			Establish a comprehensive asset management plan allowing for better short and long-term planning of maintenance and capital improvement costs and needs.  (Target Completion: End of FY 2019)
22  Storm sewers and overland sheet flow from outside the City flow into the City and contribute to flooding.	Drainage from outside the City	Reduce peak flows of storm water into the City from external storm sewers  Eliminate the water Net surplus in Bellaire	Contact surrounding municipalities and the agencies that own the storm sewers to consider upgrading their storm sewer system and providing more detention. Investigate City of Houston developments north of Bellaire for total runoff.  (Target Completion: End of FY 2019)
23  Drainage in the City of Bellaire is heavily influenced by factors not directly under the control of the City. These include, but are not limited to, Brays Bayou, IH610 and the elevated railroad east of the City. The City must partner with these agencies as well as with our neighboring cities to develop regional solutions to improve storm water conveyance and remove impediments to drain from the area.	Attempting to mitigate flooding from a 100-year storm without consulting neighboring agencies and constructing improvements outside the City limits will have limited benefit within the City	Establish Regional Drainage Projects Task Force	Evaluate the installation of a separate storm water drainage culverts for Bellaire only, in addition to existing storm water drainage culverts that carry drainage for Bellaire and Houston both.  (Target Completion: End of FY 2020)

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
24 Preparedness	Bellaire is situated in a portion of the country that receives large storm systems and produces and transports hazardous chemicals	Residents will not be adequately prepared for natural and man made disasters	Community outreach to increase preparedness awareness	Utilize Town Hall meetings to discuss all-hazard preparedness.  Create a preparedness milestone for families.  Evaluate reinstating Citizen Emergency Response Team (CERT)  (Target Completion: End of FY 2019)
25 Facilities & Equipment	The Public Works Department is located in the south eastern most portion of the City. To that end, it is among the first to experience flooding from a highwater event on Brays. To limit future damage is challenging. Further the wastewater treatment facility is located in this area as well and serves all Bellaire residents.	Repetitive loss of equipment and or loss of wastewater services to the community	Sell or close the WWTP and contract with Houston for service  Relocate PW facility out of the flood zone	Develop a plan to address rescues from one-story homes and older two-story homes.  Develop a plan to evacuate disabled/physically impaired/elderly individuals from homes in advance of anticipated high rainfall events.  Evaluate the provision of storm shelters in Bellaire.  (Target Completion: End of FY 2019)
26 Health & Safety	Floodwaters may conceal hidden objects that could cause injury. Residents can inadvertently step into manholes or inlets that have lost their lids. Floodwaters carry dangerous diseases that can make people ill due to overflowing sanitary sewers. Snakes and ants can be found floating in floodwaters.	Danger to people walking, playing, or riding bicycles in floodwaters	Prevent injuries to residents due to walking, playing, or riding bicycles in floodwaters  Prevent infiltration into the sanitary sewer so that overflows and contamination of floodwaters will be reduced	Periodically distribute messages to residents warning of dangers of walking or playing in floodwaters. Everyone should refrain from walking or riding bicycles in floodwaters. Develop a plan with local schools to educate children to avoid walking, playing, or riding bicycles in floodwaters.  (Target Completion: End of FY 2019)
27	According to the Harris County Health Department, waters associated with flooding carry numerous ground contaminants such as pesticide, hydrocarbons, and herbicides, as well as household chemicals. Flood water also displace rodents, ants and spiders.	Persons, including rescuers, will come in contact with pests and chemicals that may create health hazard	Ensure rescuers have proper Personal Protective Equipment specific to the hazard	Properly budget for rescue oriented persons to make logical purchases for rescue equipment.  (Target Completion: End of FY 2019)

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
Single family housing is the primary economic factor for the City. The current codes and ordinances adopted have increased the life cycle for compliant structures. Additionally, a lack of established guidelines, and how they effect non-compliant structures, has lead to a negative public perception of the housing stock after significant flood events.	Negative public perception of housing stock	<p>Disclosure of Flooding/Flood Variance History</p> <p>Reduce Number of Unsafe Structures in the City</p> <p>Seek community input on development in the floodplain</p>	<p>Ensure adequate City resources are in place to assist residents when applying for buy out and elevations grants.</p> <p>Evaluate updates to the Building Code which would allow residents to take proactive mitigation efforts on their property.</p> <p>Develop Bellaire specific commercial drainage requirements.</p> <p>(Target Completion: End of FY 2023)</p> <p>At all stages of infrastructure project development in the flood plain, gather community input strategies to be examined; allowing the public to see the results, costs, and benefits for alternatives studied.</p> <p>Evaluate a buyout program for properties that have flooded repeatedly.</p> <p>Evaluate the provision of grants to homeowners for newer houses (1988 to 2001) that flooded only once to elevate their homes. These homes are not eligible for FEMA grants, but are not teardowns.</p> <p>Investigate the City providing incentives for raising height of existing homes or materially increasing permeable land/reduce coverage. Cost of the incentives would be financed through special tax assessment/credit for those participating properties. Essentially finance the upgrades through a tax assessment on those properties. The values should increase so City would also benefit from higher overall taxable value.</p> <p>(Target Completion: End of FY 2020)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
29	The frequency of significant rain events in the past three years has called to question the accuracy of the Base Flood Elevations as a predictor of flood risk. Past events, such as Tropical Storm Allison, have lead to updates to the local Special Hazard Flood Area maps. The revision of these maps is not the responsibility of the city of Bellaire. It has historically taken 5 to 7 years to implement recommended map revisions.	Uncertain Base Flood elevations in AE and non-AE zones (100 yr. zones)	Provide clear guidelines for development and redevelopment for non-compliant structures	Update City Ordinances to clearly define development guidelines for structures in the designated flood areas, as defined by current Special Hazard Flood Area Maps.  Review and Update City Codes based on the recommended changes to the Special Flood Hazard Area Maps.  (Target Completion: End of FY 2019)
30	As a participant in the National Flood Insurance Program (NFIP), the City of Bellaire follows the 50% Rule to determine substantial damage. Currently the City only applies previous flood repairs to this rule. As a result, future flood repairs can be limited by previous repairs.	A drop in demand for Bellaire homes, compared to the surrounding area, will lead to lower home values, lower tax revenues, and an overall deteriorated community	Adjust the Community Rating System (CRS) to a non-cumulative approach to the 50% rule  A vocal adherence to a stance consistent with the rest of the metro area will eliminate market value deterioration	Research and evaluate regional approach to the 50% rule, for the development of City of Bellaire guidelines.  (Target Completion: FY 2019)
31	Structures who have historically never flooded are being impacted by flooding events. This has lead property owners to evaluate taking extreme mitigation action to limit the impact of future events.	Elevation of new and existing structures improperly meeting future COB codes	Ensure compliance with BFE's are sufficient for known flooding risk	Stay the course collect needed data so that if changes are needed in five years.  Review and revise the prioritization methods used to address problem flooding, combining multiple approaches that would include risk and event-based, as well as individual property damage and clustered property damage.
32 <b>Storms &gt;100year</b>	Many of the mitigation efforts in place hinge on regional projects currently in the works or projected. The city will still be subject to some amount of flooding, therefore even when regional projects are completed the impact of a 500 year events still exist.	False sense of City protection levels	Educate public of flooding risks  Continue to enforce development/redevelopment standards	Develop an education program/campaign to inform residents on the level of protection provided by the City's infrastructure.  (Target Completion: End of FY 2019)  Establish a desired level of protection versus the cost to implement (cost benefit analysis).  (Target Completion: End of FY 2020)
33 <b>Representation</b>	The city may not have proper representation within regional agencies or constituents. This could impact the amount or what projects are funded that could have the greatest amount of impact on our mitigation efforts. Currently it is not clear the exact need for representation on regional platforms or participation regional during the planning process.	Failure of Regional Partners to Keep Promises funding opportunity will be missed	Ensure adequate representation to and relationships with regional partners	Identify any and all regional partnership opportunities (elected & appointed).  Determine appropriate representatives from the City for regional agencies.  (Target Completion: FY 2019)

#### Goals

#### Safety & Assurance

#### Planning & Implementation of Drainage Improvements

#### Floodplain Regulation & Management

# Suggested Approach To Cumulative Rule

A Cumulative approach for improvements or damages to structures in special flood hazard areas ensures that flood protection measures are incorporated in the permitting process.

The cumulative rule would be applied to flood related damage sustained by a structure only after two (2) separate flood occasions

# Suggested Approach to Cumulative Rule

**1<sup>st</sup> Flood  
Permit/Claim**

(No Cumulative Review)

**2<sup>nd</sup> Flood  
Permit/Claim**

(No Cumulative Review)

**2<sup>nd</sup> Flood  
Permit/Claim with  
RR Permit**

(Cumulative Review Begins)

**3<sup>rd</sup> Flood  
Permit/Claim with  
RR Permit**

# Scenario 1-Home Market Value \$100,000

2015 Flood Permit  
\$10,000

2017 Flood Permit  
\$20,000

3<sup>rd</sup> Flood Permit/Claim  
with RR Permit  
\$20,000 Only

3<sup>rd</sup> Flood Permit/Claim  
with RR Permit  
NO PERMIT

# Scenario 2-Home Market Value \$100,000

2017 Flood 1<sup>st</sup>  
Permit  
\$50,000

2025 Flood 2<sup>nd</sup>  
Permit  
\$50,000

3rd Flood  
Permit/Claim or RR  
Permit  
No Permit Issued

# Scenario 3-Home Market Value \$100,000

2017 Flood Permit  
\$50,000

2020 Remodel  
Permit  
\$50,000

2027 2nd Flood  
Permit/Claim or RR  
Permit  
\$50,000

3<sup>rd</sup> Flood Permit/Claim  
or RR Permit  
No Permit Issued

# Review of Final Plan Draft Narrative

# Schedule

Work Plan:	Date:
• Kick Off Meeting (1)	Monday, Oct 30, 17
• Present Risk Assessment & Mitigation Strategy with Task Force (2)	Tuesday, Nov 14, 17
• Address Task Force Comments on Risk Assessment & Mitigation Strategy (3)	Tuesday, Dec 5, 17
• Review Action Plan with Task Force (4)	Tuesday, Dec 19, 17
• Review of Action Plan with Task Force (5)	Tuesday, Jan 9, 18
• Action Plan Public Hearing	Monday, Jan 29, 18
• Task Force Review of Public Hearing Comments (6)	Tuesday, Feb 6, 18
• Finalize Action Plan (Matrix) (7)	Tuesday, February 20, 18
• Approve Action Plan (8)	Tuesday, March 6, 18
• Adopt and Implement Action Plan	Monday, March 19, 18

## **Appendix 11**

**11. January 29, 2018 Public Hearing Presentation**

Hazard Category	Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
	The assessment and history is the background information which is being used to determine the hazard and severity. This tells us why a particular hazard is relevant in today's environment.	Risks are the individual situations that are created as a result of the hazard.	The Mitigation Plan should develop a strategy for reducing the potential losses identified in the risk assessment, and include goals and objectives.	The Action Plan should provide tangible solutions for achieving the goals and objectives outlined in the Mitigation Plan.
1	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not sufficiently marketing the outlets utilized by the City can limit the reach of the City's messages.</li> <li>- Not providing City messages to outside outlets, can limit their range and effectiveness.</li> </ul>	Residents Utilizing Non-City of Bellaire Outlets to Obtain Information	<p>Outlets should be marketed to stakeholders throughout the year</p> <p><b>Non-City of Bellaire Outlets Should be Utilized to Distribute Information</b></p>	<p>Develop a marketing plan which identifies the City outlets and how to increase participation in them. The plan should list events, stakeholders, etc.</p> <p>Develop and update a list of frequently utilized non-City outlets which the City should use to distribute its messages. This list should include media contacts, etc.</p> <p>(Target Completion: End of FY 2019)</p>
2	<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- Not ensuring each communication outlet is being utilized can lead to an information vacuum, where some residents may not receive essential information.</li> </ul>	Communication Efforts Not Reaching Audience	All outlets available should be utilized by the City	<p>Pre-populate communication outlets with needed information, allowing contacts to "opt-out", instead of having to "opt-in".</p> <p>Develop a communication matrix to outline what messages should be sent through which outlets.</p> <p>Evaluate the implementation of a "local street warden" program to deliver City produced storm related communication to their assigned area.</p> <p>(Target Completion: End of FY 2019)</p>
3	History has shown that at the height of a significant event, emergency communication can be diminished resulting in longer wait times or a requirement to queue 911 callers.	Diminished Emergency Communication (911) Capacity	<p>Ensure residents are aware of when to call 911 (what constitutes an emergency)</p> <p>Provide redundancies in 911 communication operations</p>	<p>Develop public messages to be used prior to and during an event to outline when residents should use 911. The public messages should also include other communications outlets residents can utilize in non-emergency situations.</p> <p>(Target Completion: End of FY 2019)</p>
4	During major events access to common communications devices may be unavailable, which impacts the city's ability to regularly update residents.	Failure/Lack of Common Communication Outlets	All outlets available should be utilized by the City	<p>Develop an educational program/campaign to inform residents and stakeholders of regularly utilized communication outlets.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication prior to a flooding event can leave residents unprepared for the possible impact of an event.</li> <li>- Additionally, poor communication can cause confusion or misinformation which could become an issue during an event.</li> </ul>	Lack of Pre-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized prior to an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- A lack of communication during an event can lead to confusion and hinder decisions needing to be made by residents.</li> </ul>	Lack of Communication During an Event	Up-to-date information should continuously be distributed during an event utilizing all outlets available to the City	<p>Develop a communication template to be utilized during an event which includes updates on information the City has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Previous events have shown that good communication prior to, during, and after an event can reduce the amount of damage to property and individuals.</p> <ul style="list-style-type: none"> <li>- After an event; residents, employees, business, and numerous other community stakeholders need to have proper information to understand how they and the City are moving forward, post event.</li> </ul>	Lack of Post-Event Communication	Provide regular up-to-date information through each of the City's communication outlets to residents, employees, and community stakeholders	<p>Develop a communication template to be utilized after an event which includes updates on information the City's has determined is important based on lessons learned from previous events.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p>	Reduced mobility can increase emergency response times	Provide regular up-to-date information on local road conditions	<p>Formalize a mechanism within the scope of EOC operations whereby a team would be responsible for field reconnaissance as well as publication of information for use by the public via the website, social media, local news media, etc.</p> <p>(Target Completion: End of FY 2019)</p>
<p>Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.</p> <ul style="list-style-type: none"> <li>- Historic flooding events create impassable roadways where vehicle mobility is limited due to high water areas.</li> </ul>	Bellaire's Public Safety Components will not be able to respond with "normal" first response equipment	Utilize non-conventional vehicles for response	<p>Develop a plan to identify, utilize, and position non-conventional access vehicles for use when weather events dictate.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
<b>Mobility</b>  Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.  - Extreme flood events makes overland mobility impossible	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening. More persons calling for rescue than Bellaire has ability to respond	Utilize a multi departmental approach to rescue which includes training and equipping to help solve issue  Utilize Citizen Responders (boat owners & high water vehicles), and mobilizes this group as a force multiplier in flood emergencies	Ensure adequate funding to send rescue oriented persons to hazard specific schools to for information to make logical purchases for rescue equipment (i.e. boats, dry suits, helmets, Coast Guard approved rescue Personal Flotation Devices for flood response).  Develop a program to identify, train, and utilize Citizen Responders and create MOU (cover liability of the asset use donation).  (Target Completion: End of FY 2019)
Drainage systems, including those in Bellaire rely on the street infrastructure for detention during high intensity rain events. Because drainage capacity is difficult to come by it is unlikely that this will ever change. To that end during high intensity rain events, some City of Bellaire streets will hold water for varying periods of time.  - Extreme flood events makes overland mobility impossible	Inability to rescue persons trapped in home, where flood inundation makes continued occupation life threatening	Utilize a mass notification system that will reach all residents with relevant hazard warning and evacuation advice	Research, develop scope and policies & procedures for, and place into affect a Mass Notification System.  (Target Completion: End of FY 2019)
Flood events of hinders mobility due to flooding of Bellaire streets	Specialized response vehicles will not be able to reach all residents (water too high for truck, water too low for boat) and move to safe haven	Evacuate rescued persons from deep water inundation, to shallow water vehicle access area, to area of relative safety, to eventual shelter	Develop a rescue plan which utilizes field-confirmed data to generate on-the-fly response maps for rescuer pathways.  (Target Completion: End of FY 2019)
Storm water from Brays Bayou and Cypress Ditch can backflow into the City's underground drainage system. Backflow from Brays bayou and Cypress Ditch reduces the capacity in the City's underground system.	Storm water that has backflowed into the City's system results in less capacity for local rainfall events resulting in flooding	Utilize backflow devices to prevent storm water from the bayou, during high water surface conditions, from coming back into the City's underground system	Include design and installation of backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects.  Coordinate with neighboring agencies (i.e. TxDOT, City of Houston and HCFCD) to prevent backflow stormwater from entering the City's underground drainage systems.  (First Phase Completion: End of FY 2020)

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
14	Overland sheet flow from areas inside and outside the City collects in low lying areas that do not have adequate storm drainage systems or positive overland flow capabilities to prevent flooding.	Overland sheet flow causes flooding in low lying areas	<p>Strategically locate underground storage pipes within the existing street right-of-way to store 100-year localized rainfall events.</p> <p>(Target Completion: End of FY 2020)</p> <p>Evaluate increasing the size of existing stormwater drainage culverts in Bellaire.</p> <p>(Target Completion: End of FY 2020)</p> <p>Continue to utilize drainage impact when selecting roads to be rebuilt.</p>
15	Inadequate capacity in Brays Bayou has resulted in a cooperative effort between HCFCD and the U.S. Army Corps of Engineers to widen Brays Bayou to substantially reduce flooding risks in the Brays Bayou watershed.	<p>Brays Bayou is undersized for extreme rain events and flood stages prevent local Bellaire drainage systems from adequately serving the area</p> <p><b>DRAFT</b></p>	<p>Lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist</p> <p><b>DRAFT</b></p> <p>Coordinate with HCFCD and the U.S. Army Corps of Engineers to determine how additional widening of Brays Bayou will reduce flooding for the City of Bellaire.</p> <p>(Target Completion: End of FY 2021)</p> <p>Evaluate the feasibility of adding more flood-hardened rain and flood stage gauges at strategic location in the City, to provide for better flood forecasting.</p> <p>(Target Completion: End of FY 2019)</p> <p>Evaluate the development of a levee along the south side of Bellaire, which would prevent water from Brays Bayou from entering the City.</p> <p>(Target Completion: End of FY 2019)</p> <p>Evaluate the conversion the trash transfer station at Beltway 8 to a reservoir for Brays Bayou.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
16   Infrastructure (COB & Other)	Water overflow from the Brays Bayou is a single significant factor for the wide spread flooding in Bellaire and surround areas. The water level at the peak was 4 Ft above the bank on Sunday August 27th 2017.	It flooded many houses South of Bellaire Blvd. Majority of these houses were flooded first time	<p>Move remaining areas (Post Oak Terrace and Southdale ) out of 100 year floor plain even after the completion of the project Brays</p> <p>Reduce or prevent wide spread damage in the events that are as significant as Harvey (beyond 100 year events)</p>	<p>Evaluate the conversion of Bellaire's Wastewater Treatment Plat to a retention area</p> <p>Evaluate the conversion of the dog park and soccer fields along Edith into a detention area.</p> <p>Lower street level when streets are under construction</p> <p>(Target Completion: End of FY 2019)</p>
	Major North/South drainage systems and Cypress Ditch are undersized for the large drainage area.	Inability to convey storm water adequately to Brays Bayou, therefore creating additional flooding risks.	<p>Increase capacity of the North/South drainage systems and the Cypress Ditch</p>	<p>Study alternatives and develop cost estimates for improvements. Determine partners.</p> <p>(Target Completion: End of FY 2019)</p>
	Streets/Roadways are designed to store floodwaters that have overwhelmed the underground storm storage system in order to mitigate structural flooding.	Street Flooding	<p>Increase street storm water storage in order to reduce structural flooding. Assess the advantages and disadvantages of street flooding vs. structural flooding</p>	<p>Educate and inform the public that street flooding is preferable to structural flooding.</p> <p>(Target Completion: End of FY 2019)</p> <p>Develop a plan to repair and replace the highly critical local drainage systems within five (5) years. If necessary, issue debt instruments every five years until the major local flood mitigation CIPs are completed.</p> <p>(Target Completion: End of FY 2020)</p> <p>Develop a schedule to perform routine maintenance, inspections, and repairs to all storm water infrastructure (such as pipes, or open waterway) on a minimum 5-year cycle.</p> <p>(Target Completion: End of FY 2019)</p> <p>Create a proactive approach to repair and maintain drainage systems in desirable development areas and neighborhoods with storm drainage systems.</p> <p>(Target Completion: End of FY 2019)</p>

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
19 Bellaire is in a flat coastal area with predominately clay soils that are relatively impervious. Additionally, existing elevations and roadway patterns create barriers that trap sheet flow. Flooding occurs more frequently in areas with these conditions.	Existing topography, soils and roadway patterns contribute to flooding. These conditions and barriers trap sheet flow generated by extreme rain events and make flooding worse	Reduce barriers to flow of flood waters Educate residents on the local topography and why it exacerbates flooding	Identify barriers restricting sheet flow and determine what projects could relieve this problem. (Target Completion: End of FY 2019)  Develop communication plan to inform residents of the importance of not filling in the floodplain. (Target Completion: End of FY 2019)
20 Outfall of Kilmarnock Ditch has proven to be undersized. The undersized outfall causes a backup of floodwaters to the upstream areas and contributes to localized flooding.	Outfall of Kilmarnock Ditch is undersized	Increasing the size of the outfall of Kilmarnock Ditch	Coordinate with HCFCD to determine steps necessary to increase the size of the outfall of Kilmarnock Ditch. Construct extreme event outfalls at Bellaire Blvd and within the Southdale Subdivision to Kilmarnock Ditch. (Target Completion: End of FY 2023)
21 Debris can clog inlets and storm sewers. This exacerbates localized flooding, since floodwaters cannot drain away quickly.	Blockage of inlets and drainage systems by debris make flooding more severe	Maintain the storm sewer system so that it is free from blockages and operates at its peak efficiency Ensure adequate staffing to maintain storm sewer system	Develop an educational program/campaign warning residents of the dangers of blocked storm sewers, and how they can help mitigate this problem. (Target Completion: End of FY 2019)  Establish a comprehensive asset management plan allowing for better short and long-term planning of maintenance and capital improvement costs and needs. (Target Completion: End of FY 2019)
22 Storm sewers and overland sheet flow from outside the City flow into the City and contribute to flooding.	Drainage from outside the City	Reduce peak flows of storm water into the City from external storm sewers Eliminate the water Net surplus in Bellaire	Contact surrounding municipalities and the agencies that own the storm sewers to consider upgrading their storm sewer system and providing more detention. Investigate City of Houston developments north of Bellaire for total runoff. (Target Completion: End of FY 2019)
23 Drainage in the City of Bellaire is heavily influenced by factors not directly under the control of the City. These include, but are not limited to, Brays Bayou, IH610 and the elevated railroad east of the City. The City must partner with these agencies as well as with our neighboring cities to develop regional solutions to improve storm water conveyance and remove impediments to drain from the area.	Attempting to mitigate flooding from a 100-year storm without consulting neighboring agencies and constructing improvements outside the City limits will have limited benefit within the City	Establish Regional Drainage Projects Task Force	Evaluate the installation of a separate storm water drainage culverts for Bellaire only, in addition to existing storm water drainage culverts that carry drainage for Bellaire and Houston both. (Target Completion: End of FY 2020)

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
24 Preparedness	Bellaire is situated in a portion of the country that receives large storm systems and produces and transports hazardous chemicals	Residents will not be adequately prepared for natural and man made disasters	Community outreach to increase preparedness awareness	Utilize Town Hall meetings to discuss all-hazard preparedness.  Create a preparedness milestone for families.  Evaluate reinstating Citizen Emergency Response Team (CERT)  (Target Completion: End of FY 2019)
25 Facilities & Equipment	The Public Works Department is located in the south eastern most portion of the City. To that end, it is among the first to experience flooding from a highwater event on Brays. To limit future damage is challenging. Further the wastewater treatment facility is located in this area as well and serves all Bellaire residents.	Repetitive loss of equipment and or loss of wastewater services to the community	Sell or close the WWTP and contract with Houston for service  Relocate PW facility out of the flood zone	Evaluate the transfer of Wastewater Treatment for the City of Bellaire to the City of Houston facility, including utilizing hazard mitigation funding opportunities.  (Target Completion: End of FY 2023)
26 Health & Safety	Floodwaters may conceal hidden objects that could cause injury. Residents can inadvertently step into manholes or inlets that have lost their lids. Floodwaters carry dangerous diseases that can make people ill due to overflowing sanitary sewers. Snakes and ants can be found floating in floodwaters.	Danger to people walking, playing, or riding bicycles in floodwaters	Prevent injuries to residents due to walking, playing, or riding bicycles in floodwaters  Prevent infiltration into the sanitary sewer so that overflows and contamination of floodwaters will be reduced	Periodically distribute messages to residents warning of dangers of walking or playing in floodwaters. Everyone should refrain from walking or riding bicycles in floodwaters. Develop a plan with local schools to educate children to avoid walking, playing, or riding bicycles in floodwaters.  (Target Completion: End of FY 2019)
27	According to the Harris County Health Department, waters associated with flooding carry numerous ground contaminants such as pesticide, hydrocarbons, and herbicides, as well as household chemicals. Flood water also displace rodents, ants and spiders.	Persons, including rescuers, will come in contact with pests and chemicals that may create health hazard	Ensure rescuers have proper Personal Protective Equipment specific to the hazard	Properly budget for rescue oriented persons to make logical purchases for rescue equipment.  (Target Completion: End of FY 2019)

Assessment/History	Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
28  <b>Economic Impact</b>	<p>Single family housing is the primary economic factor for the City. The current codes and ordinances adopted have increased the life cycle for compliant structures. Additionally, a lack of established guidelines, and how they effect non-compliant structures, has lead to a negative public perception of the housing stock after significant flood events.</p> <p>Negative public perception of housing stock</p> <p><b>DRAFT</b></p>	<p>Disclosure of Flooding/Flood Variance History</p> <p>Reduce Number of Unsafe Structures in the City</p> <p>Seek community input on development in the floodplain</p>	<p>Ensure adequate City resources are in place to assist residents when applying for buy out and elevations grants.</p> <p>Evaluate updates to the Building Code which would allow residents to take proactive mitigation efforts on their property.</p> <p>Develop Bellaire specific commercial drainage requirements.</p> <p>(Target Completion: End of FY 2023)</p> <p>At all stages of infrastructure project development in the flood plain, gather community input strategies to be examined; allowing the public to see the results, costs, and benefits for alternatives studied.</p> <p>Evaluate a buyout program for properties that have flooded repeatedly.</p> <p>Evaluate the provision of grants to homeowners for newer houses (1988 to 2001) that flooded only once to elevate their homes. These homes are not eligible for FEMA grants, but are not teardowns.</p> <p>Investigate the City providing incentives for raising height of existing homes or materially increasing permeable land/reduce coverage. Cost of the incentives would be financed through special tax assessment/credit for those participating properties. Essentially finance the upgrades through a tax assessment on those properties. The values should increase so City would also benefit from higher overall taxable value.</p> <p>(Target Completion: End of FY 2020)</p>

Assessment/History		Risk/Issues	Mitigation Options/Goal	Action/Implementation Plan
29	The frequency of significant rain events in the past three years has called to question the accuracy of the Base Flood Elevations as a predictor of flood risk. Past events, such as Tropical Storm Allison, have lead to updates to the local Special Hazard Flood Area maps. The revision of these maps is not the responsibility of the city of Bellaire. It has historically taken 5 to 7 years to implement recommended map revisions.	Uncertain Base Flood elevations in AE and non-AE zones (100 yr. zones)	Provide clear guidelines for development and redevelopment for non-compliant structures	Update City Ordinances to clearly define development guidelines for structures in the designated flood areas, as defined by current Special Hazard Flood Area Maps.  Review and Update City Codes based on the recommended changes to the Special Flood Hazard Area Maps.  (Target Completion: End of FY 2019)
30	As a participant in the National Flood Insurance Program (NFIP), the City of Bellaire follows the 50% Rule to determine substantial damage. Currently the City only applies previous flood repairs to this rule. As a result, future flood repairs can be limited by previous repairs.	A drop in demand for Bellaire homes, compared to the surrounding area, will lead to lower home values, lower tax revenues, and an overall deteriorated community	Adjust the Community Rating System (CRS) to a non-cumulative approach to the 50% rule  A vocal adherence to a stance consistent with the rest of the metro area will eliminate market value deterioration	Research and evaluate regional approach to the 50% rule, for the development of City of Bellaire guidelines.  (Target Completion: FY 2019)
31	Structures who have historically never flooded are being impacted by flooding events. This has lead property owners to evaluate taking extreme mitigation action to limit the impact of future events.	Elevation of new and existing structures improperly meeting future COB codes	Ensure compliance with BFE's are sufficient for known flooding risk	Stay the course collect needed data so that if changes are needed in five years.  Review and revise the prioritization methods used to address problem flooding, combining multiple approaches that would include risk and event-based, as well as individual property damage and clustered property damage.
32 Storms >100year	Many of the mitigation efforts in place hinge on regional projects currently in the works or projected. The city will still be subject to some amount of flooding, therefore even when regional projects are completed the impact of a 500 year events still exist.	False sense of City protection levels	Educate public of flooding risks  Continue to enforce development/redevelopment standards	Develop an education program/campaign to inform residents on the level of protection provided by the City's infrastructure.  (Target Completion: End of FY 2019)  Establish a desired level of protection versus the cost to implement (cost benefit analysis).  (Target Completion: End of FY 2020)
33 Representation	The city may not have proper representation within regional agencies or constituents. This could impact the amount or what projects are funded that could have the greatest amount of impact on our mitigation efforts. Currently it is not clear the exact need for representation on regional platforms or participation regional during the planning process.	Failure of Regional Partners to Keep Promises funding opportunity will be missed	Ensure adequate representation to and relationships with regional partners	Identify any and all regional partnership opportunities (elected & appointed).  Determine appropriate representatives from the City for regional agencies.  (Target Completion: FY 2019)

#### Goals

#### Safety & Assurance

#### Planning & Implementation of Drainage Improvements

#### Floodplain Regulation & Management

## Appendix 12

### 12. January 29, Public Hearing Speaker Sign-up Sheets

## SPEAKER SIGN-UP SHEET

(For All Persons Who Wish to Address the **Flood Hazard  
Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: CINDY MERRILL

Address (Optional)\*: \_\_\_\_\_

City/State (Optional)\*: \_\_\_\_\_

Email Address\*  
(Optional): \_\_\_\_\_

Written Comment (if preferred):

① West Bay connects up  
have heard about flooding  
in Bellair & the Medical Center  
② Flooding at houses on canals

As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

\*The City of Bellaire is subject to the *Texas Public Information Act*. This form and the information herein may be released to the public upon request, with the exception of an email address. Your email address, if provided, is not releasable and will be redacted under state law.

**SPEAKER SIGN-UP SHEET**  
(For All Persons Who Wish to Address the **Flood Hazard  
Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: Tom Burrough

Address (Optional)\*: 4613 Holt

City/State (Optional)\*: Bellaire Tx 77401

Email Address\*  
(Optional): tomburrough@shoebill.net

Written Comment (if preferred):

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As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

\*The City of Bellaire is subject to the *Texas Public Information Act*. This form and the information herein may be released to the public upon request, with the exception of an email address. Your email address, if provided, is not releasable and will be redacted under state law.

**SPEAKER SIGN-UP SHEET**  
(For All Persons Who Wish to Address the **Flood Hazard**  
**Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: DANIEL KARP

Address (Optional)\*: 4500 MERRIE LANE

City/State (Optional)\*: BELLAIRE

Email Address\*

(Optional): \_\_\_\_\_

Written Comment (if preferred):

As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

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**SPEAKER SIGN-UP SHEET**  
(For All Persons Who Wish to Address the **Flood Hazard  
Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: David Swenson

Address (Optional)\*: 5293 Maple

City/State (Optional)\*: \_\_\_\_\_

Email Address\*  
(Optional): \_\_\_\_\_

Written Comment (if preferred):

Question

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As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

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## **SPEAKER SIGN-UP SHEET**

**(For All Persons Who Wish to Address the **Flood Hazard Mitigation Task Force**)**

Date of Meeting: January 29, 2018 (Public Hearing)

Name: \_\_\_\_\_

Helen Ross

### Address

4442 *Scutellaria*

City/S

木

Email Address\*

(Optional):

Written Comment (if preferred):

As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

\*The City of Bellaire is subject to the *Texas Public Information Act*. This form and the information herein may be released to the public upon request, with the exception of an email address. Your email address, if provided, is not releasable and will be redacted under state law.

## **SPEAKER SIGN-UP SHEET**

**(For All Persons Who Wish to Address the Flood Hazard Mitigation Task Force)**

Date of Meeting: January 29, 2018 (Public Hearing)

Name: \_\_\_\_\_

William Durbin

Address (Optional)\*:

4535 Sunburst

City/State (Optional)\*:

Bellaria

Email Address\*

(Optional):

Written Comment (if preferred):

As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

\*The City of Bellaire is subject to the *Texas Public Information Act*. This form and the information herein may be released to the public upon request, with the exception of an email address. Your email address, if provided, is not releasable and will be redacted under state law.

# **SPEAKER SIGN-UP SHEET**

(For All Persons Who Wish to Address the **Flood Hazard Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: \_\_\_\_\_

Mark THIE

Address (Optional)\*:

4824 Bellavue Blvd

City/State (Optional)\*:

Bellair, Blvd

Email Address\*

(Optional):

Written Comment (if preferred):

Subject: Backflow preventers  
in storm sewer pipes(s)

As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

\*The City of Bellaire is subject to the *Texas Public Information Act*. This form and the information herein may be released to the public upon request, with the exception of an email address. Your email address, if provided, is not releasable and will be redacted under state law.

## SPEAKER SIGN-UP SHEET

(For All Persons Who Wish to Address the **Flood Hazard  
Mitigation Task Force**)

Date of Meeting: January 29, 2018 (Public Hearing)

Name: Robert & Deborah Gardner

Address (Optional)\*: 4703 Maple St

City/State (Optional)\*: Bellaire TX 77401

Email Address\*  
(Optional): ddgardner@mdanderson.org

Written Comment (if preferred):

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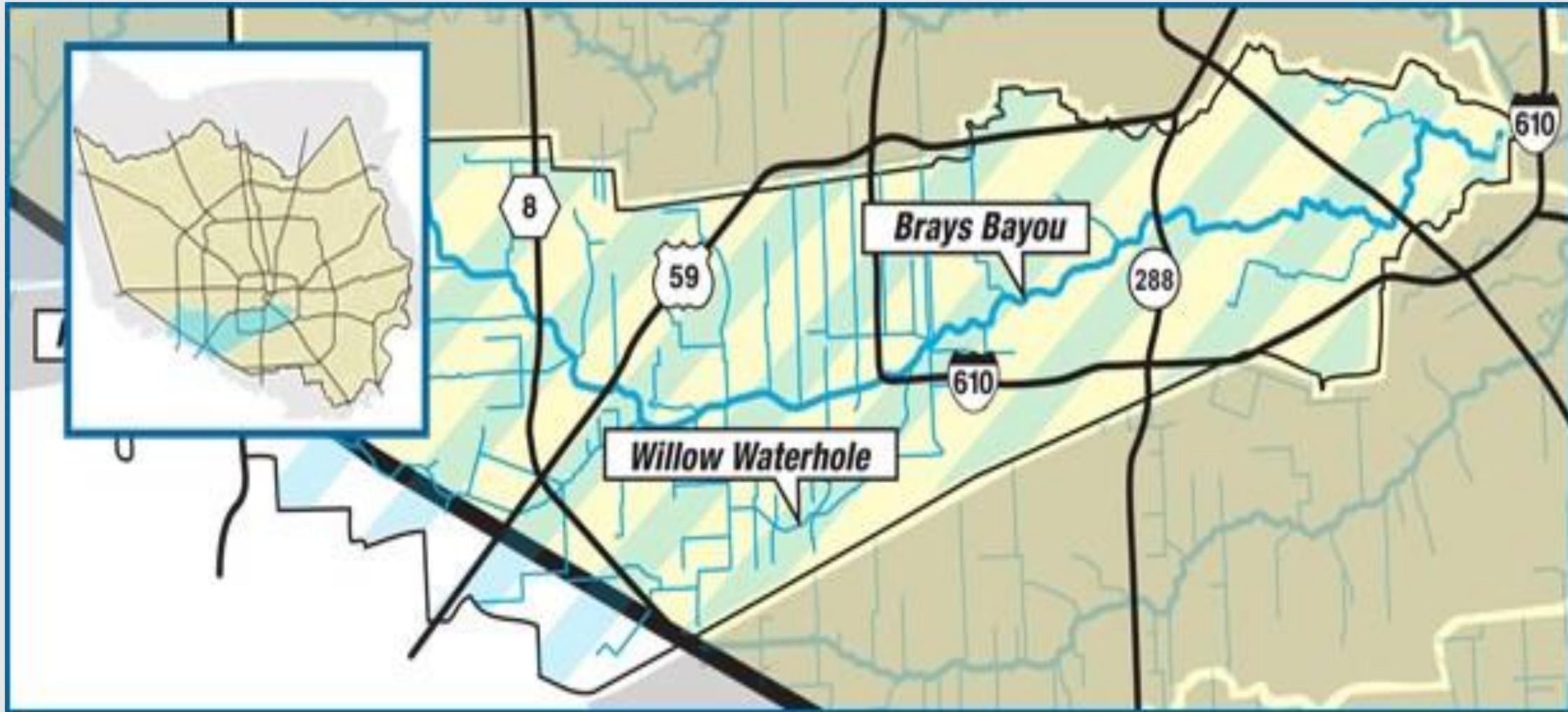
As soon as you are recognized by the Chair, please state your name before beginning your presentation. **Each speaker is limited to five (5) minutes.**

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## Appendix 13

### 13. Map of Brays Bayou Watershed

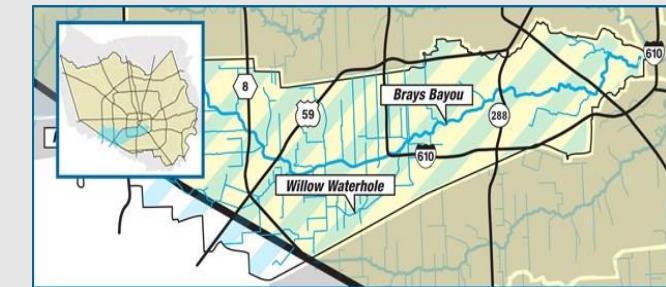
# Brays Bayou Watershed



# Brays Bayou Watershed

The Brays Bayou watershed is located in southwest Harris County and portions of Ft. Bend County and drains parts of the cities of Houston, Missouri City, Stafford, Bellaire, West University, Southside Place and Meadows Place. The bayou flows eastward from Fort Bend County to its confluence with Buffalo Bayou.

This heavily urbanized watershed covers approximately 127 square miles and includes three primary streams: Brays Bayou, Keegans Bayou and Willow Waterhole Bayou. There are about 121 miles of open streams within the watershed, including the primary streams and tributary channels.



## **Appendix 14**

### **14. City of Bellaire Presentation to City of Houston**

# Houston/Bellaire Drainage Meeting

February 13, 2018





1955

TSA June 2001



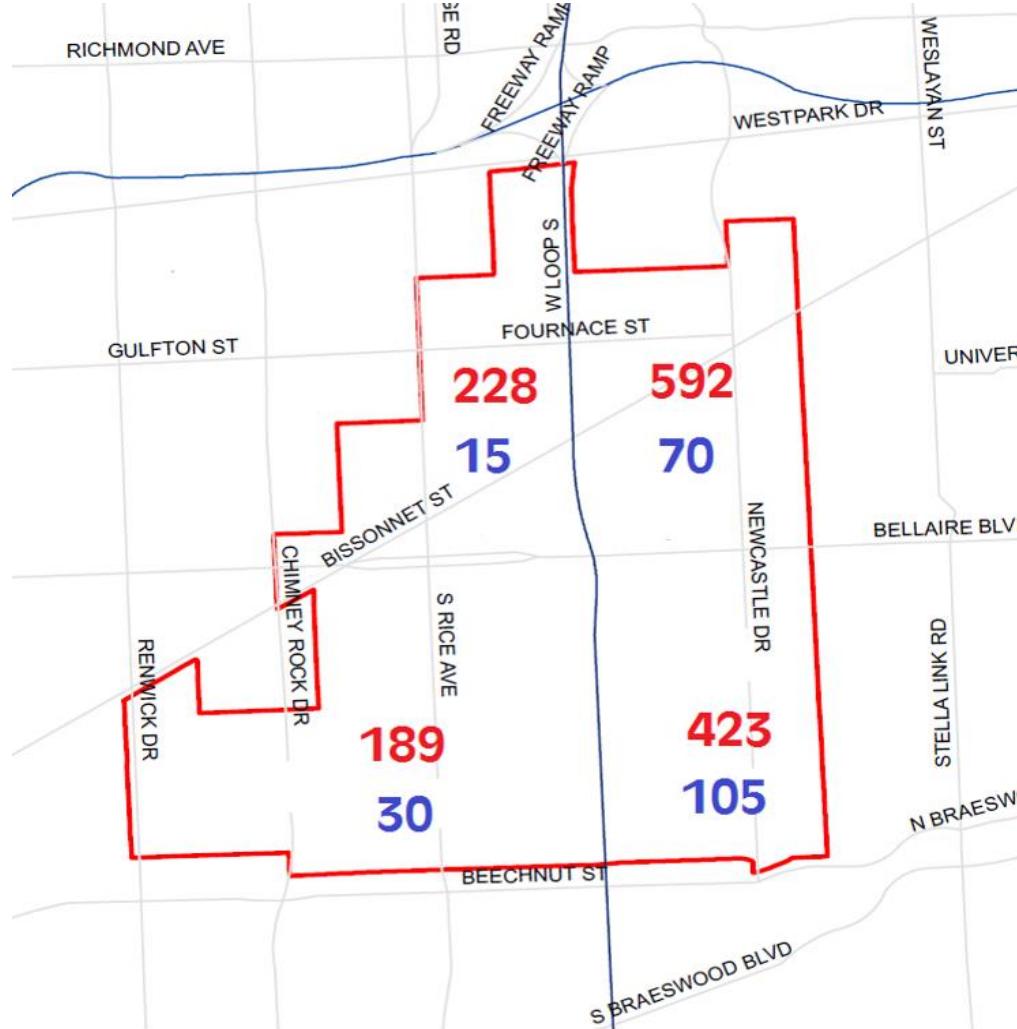
May 2015

**Why does the area flood?**

# Flooded structures by area during Tropical Storm Allison & the May 2015 storm

Public Works Service Center flooded in both storms

No access across Loop 610

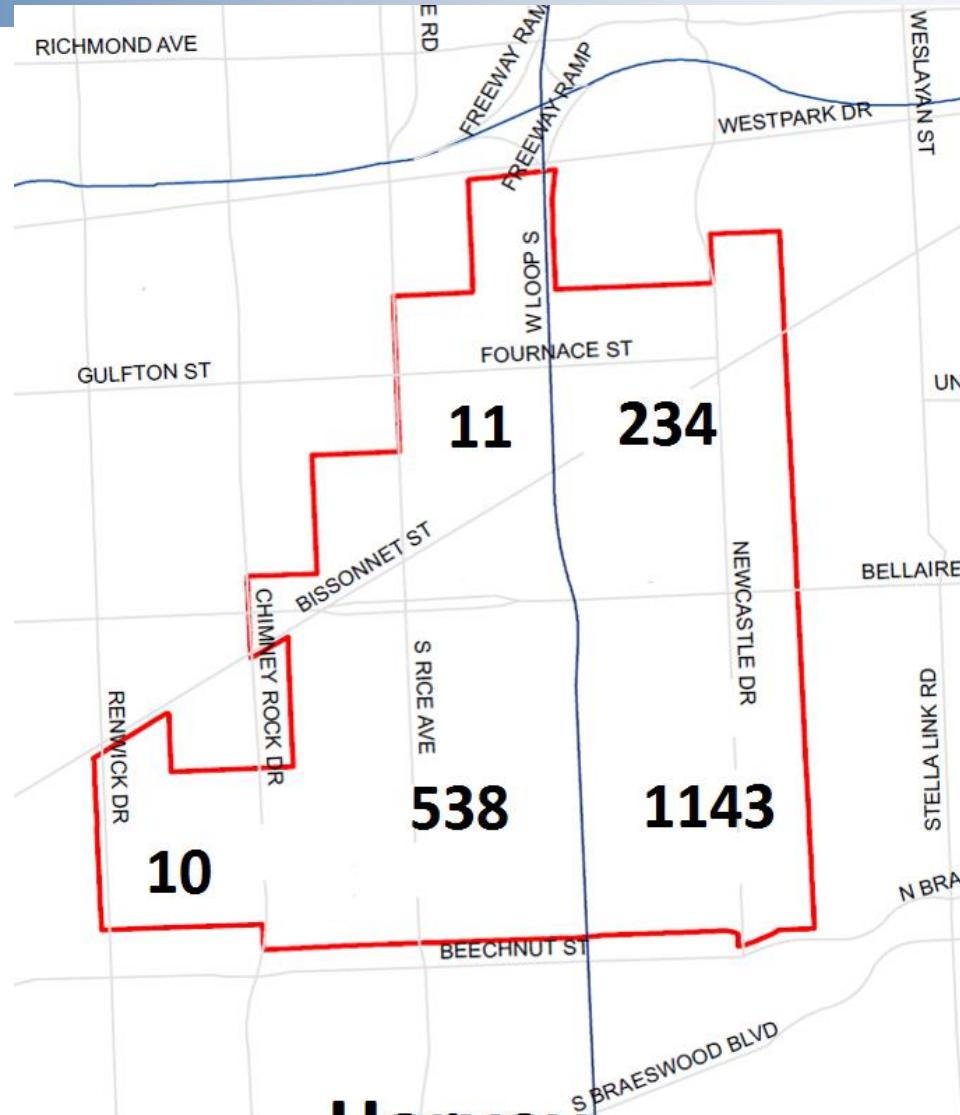


Reported Structures Flooded

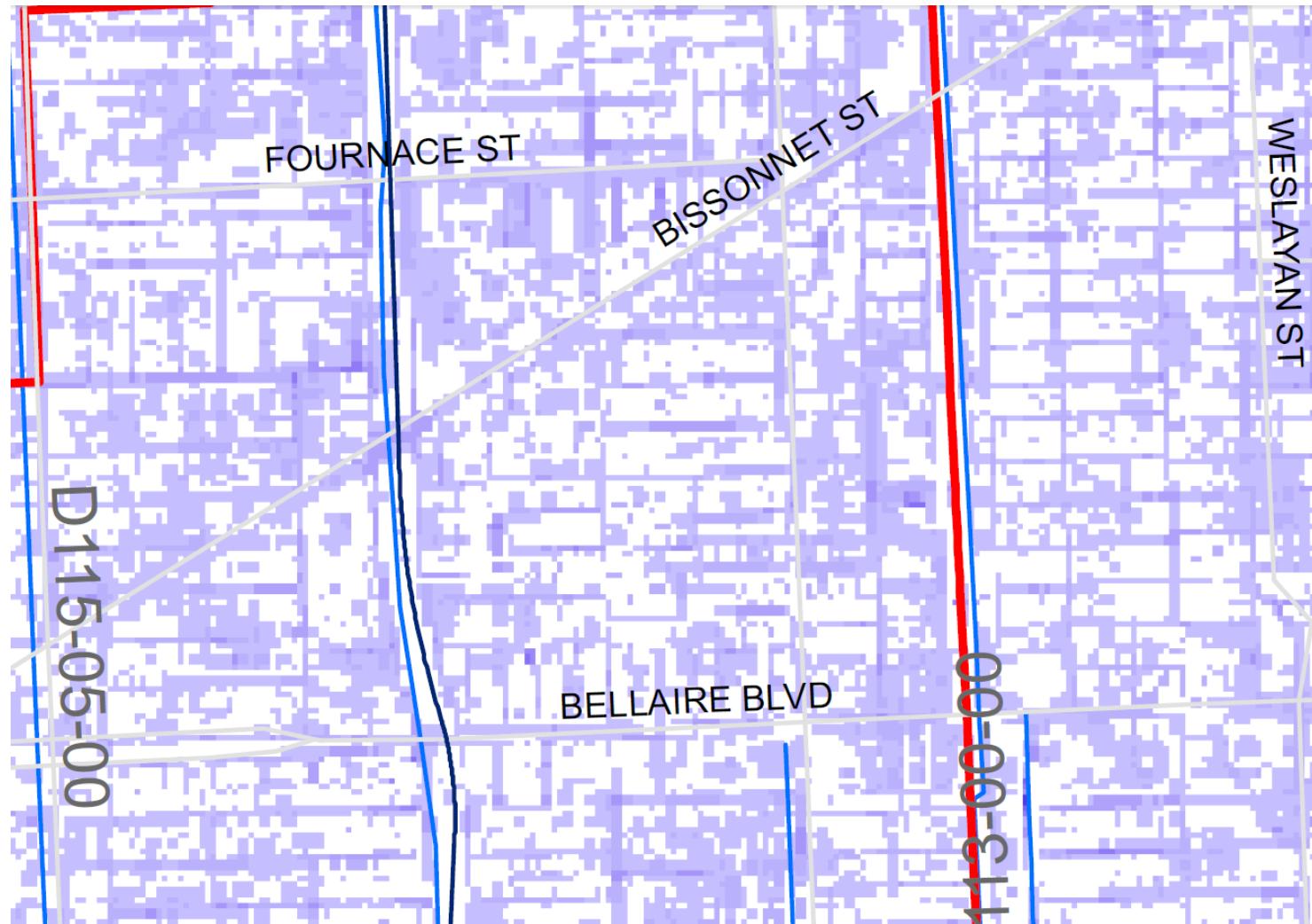
Allison 1432

JUNE 9, 2001

May 2015 220

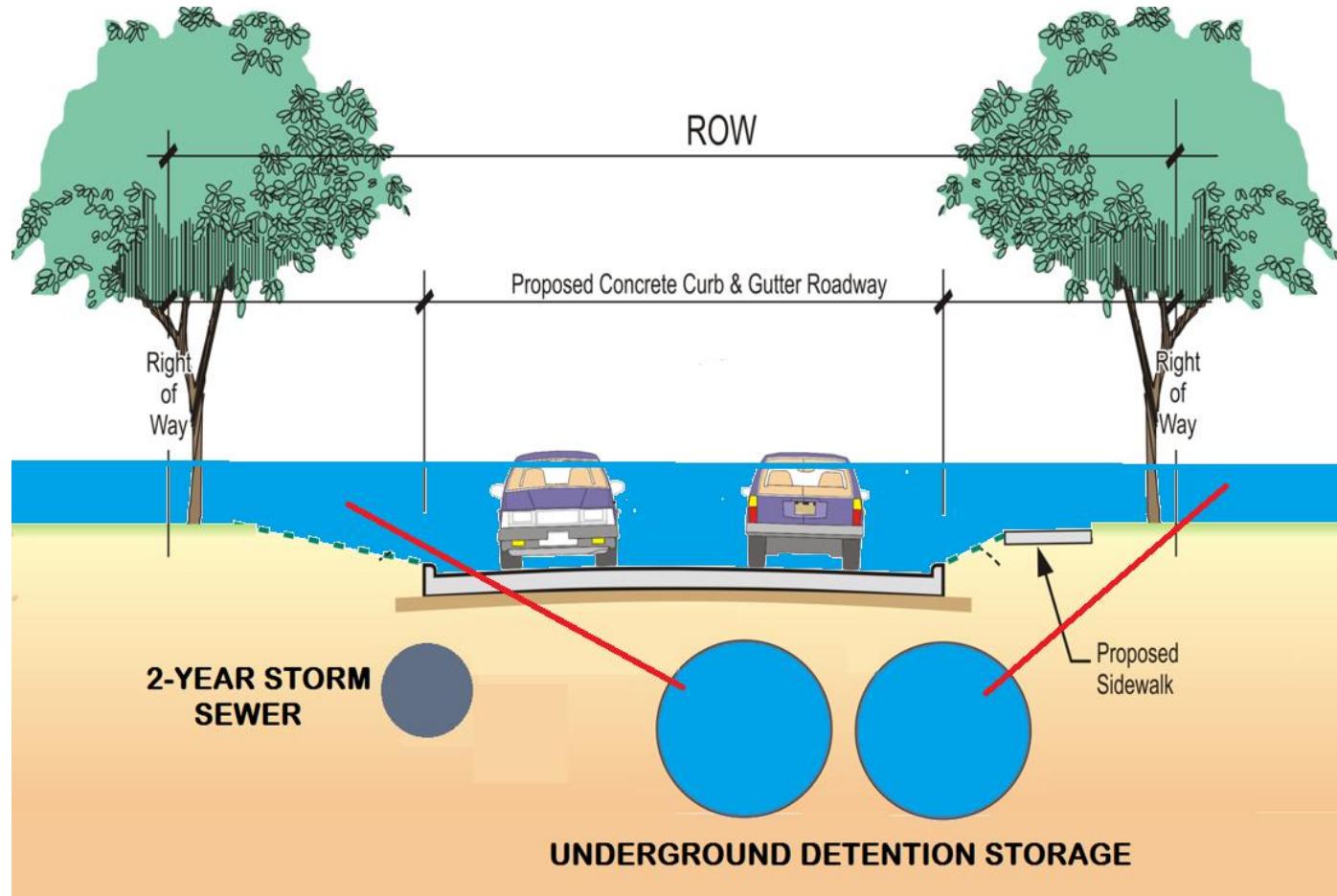


**Harvey**  
**Homes Flooded**  
**not including garages**



**Ponding/Flooding areas identified**

# Bonds for a Better Bellaire 2016

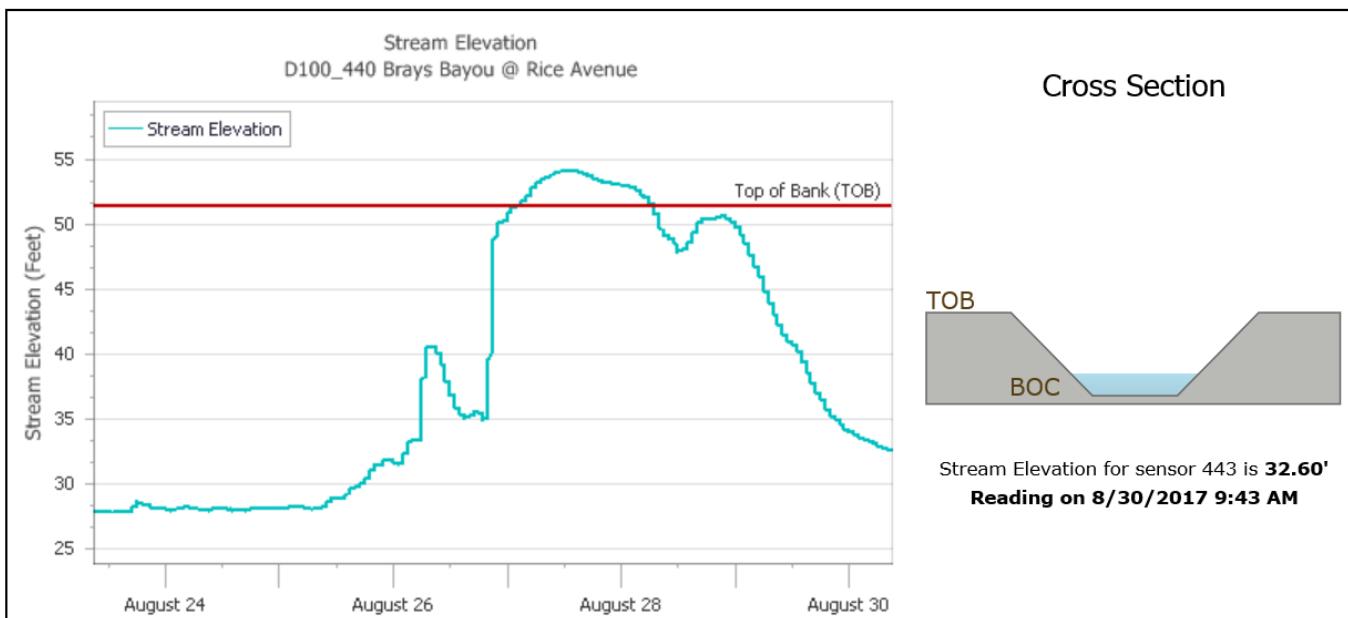


# HCFCDFWS

S. Rice Ave. Gage August 2017

Stream Elevation Sensor **443**  
**D100\_440 Brays Bayou @ Rice Avenue**

Key Map	531U
Sensor ID	<b>443</b>
Sensor Type	Bubbler
Installed	8/10/1984
Top of Bank (TOB)	51.30'
Bottom of Stream	25.97'
Tip of Orifice	27.45'
Measuring Plate	54.84'
Benchmark	53.81'
RM 040160 stamped D100 BM 20 located on the downstream sidewalk of northbound bridge at stream centerline, 1988 NAVD, 2001 adjustment. 78 to 01 Adjustment -1.99 As of July 1, 2007, the elevation datum was changed from 1929 NGVD, 1978 adjustment to the 1988 NAVD, 2001 adjustment.	





Agency Harris County Flood Control District

Location 440: D100\_440 Brays Bayou @ Rice Avenue

Last 7 Days

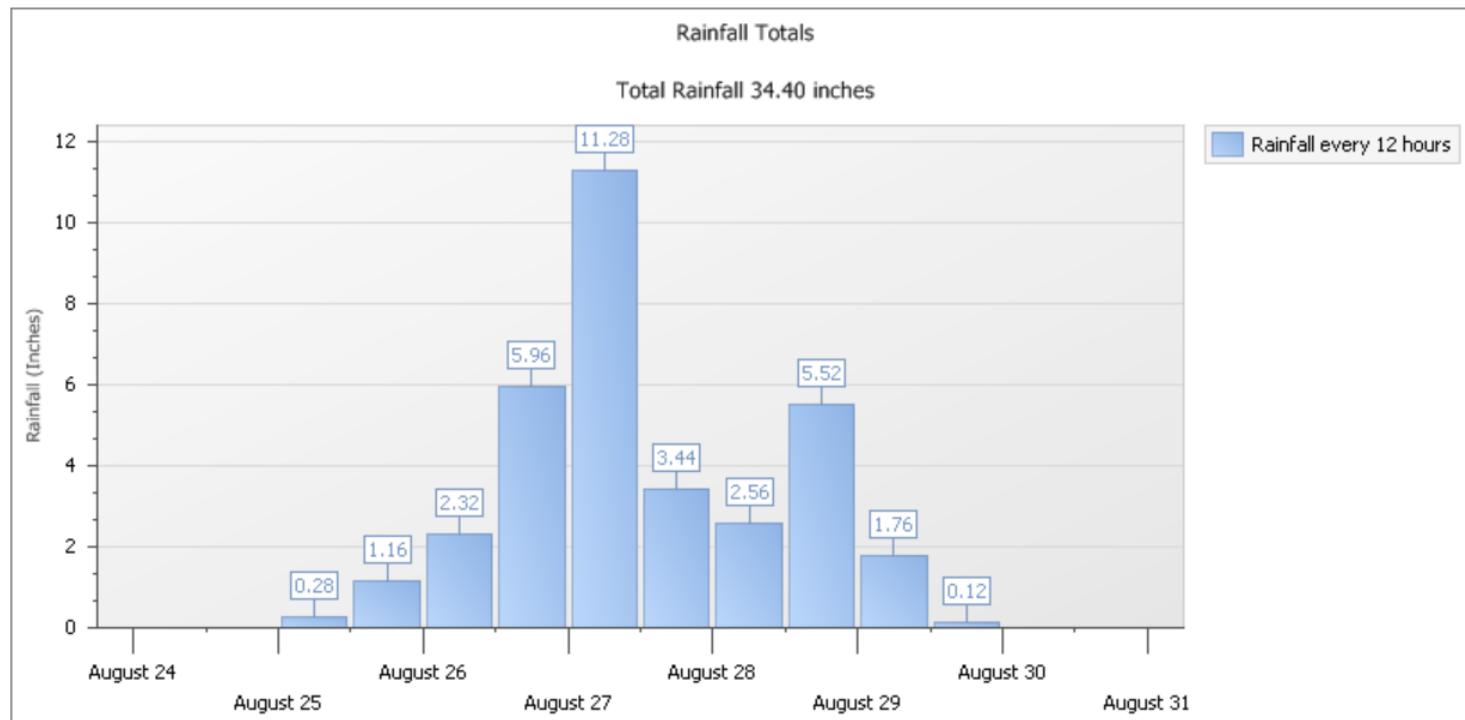
Reported from 8/30/2017 9:46 AM

Show Current Conditions

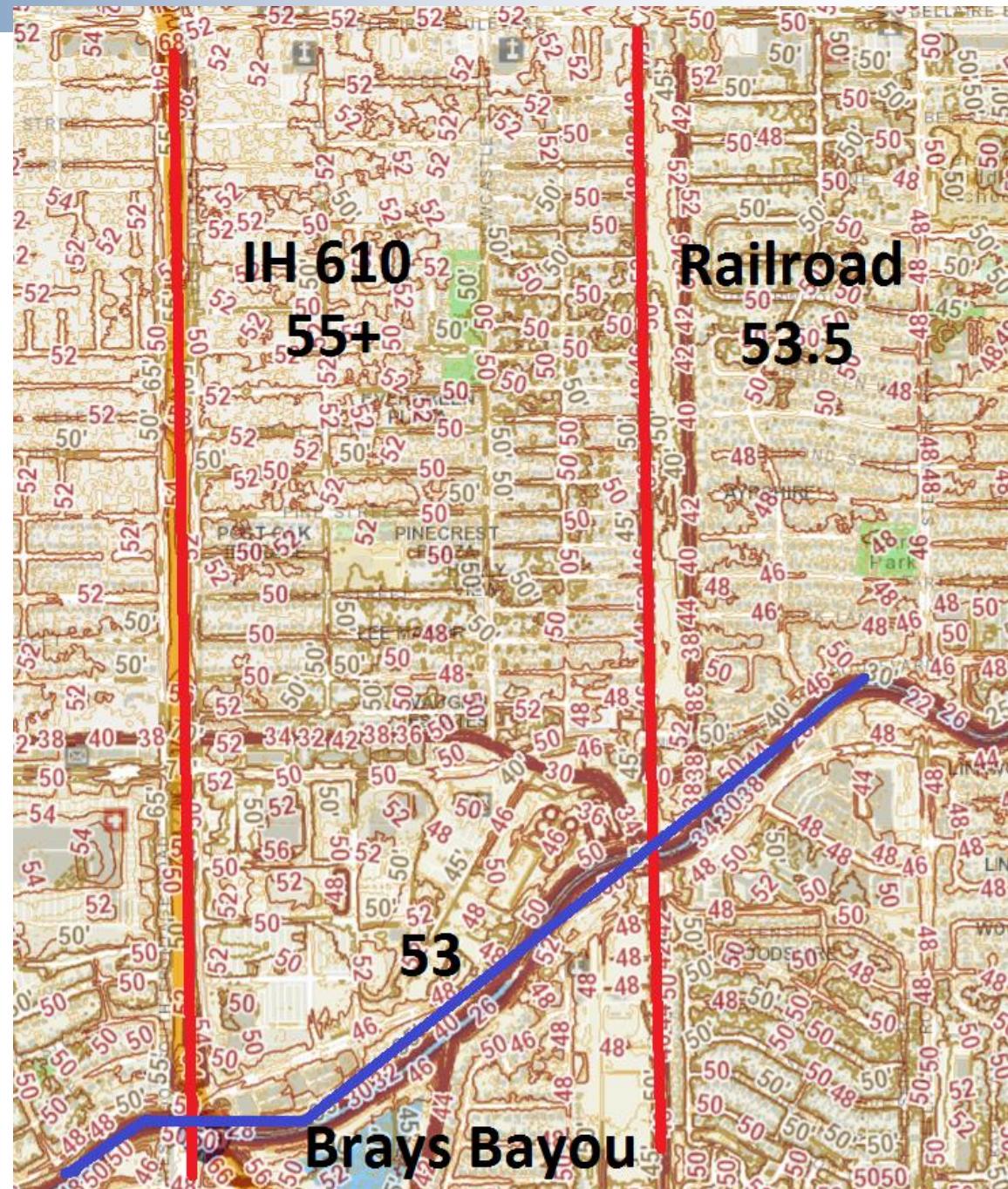
Stream Elevation

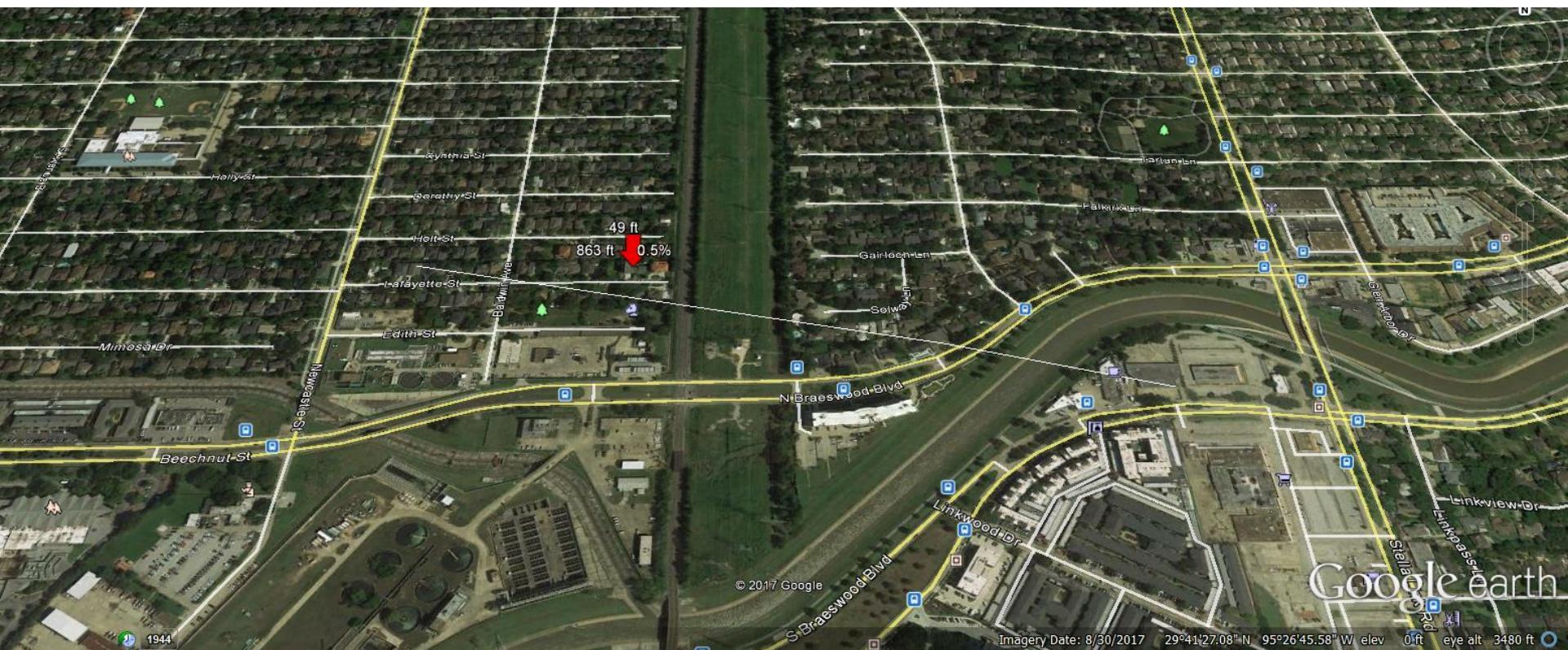
Rainfall

Showing rainfall totals from 8/24/2017 12:00 AM to 8/31/2017 12:00 AM CDT



# Potential Overland Flow Obstacles





Graph: Min, Avg, Max Elevation: 22, 47, 54 ft

Range Totals: Distance: 0.53 mi | Elev Gain/Loss: 76.2 ft, -78.3 ft

Max Slope: 40.7%, -45.9% | Avg Slope: 5.5%, -4.9%

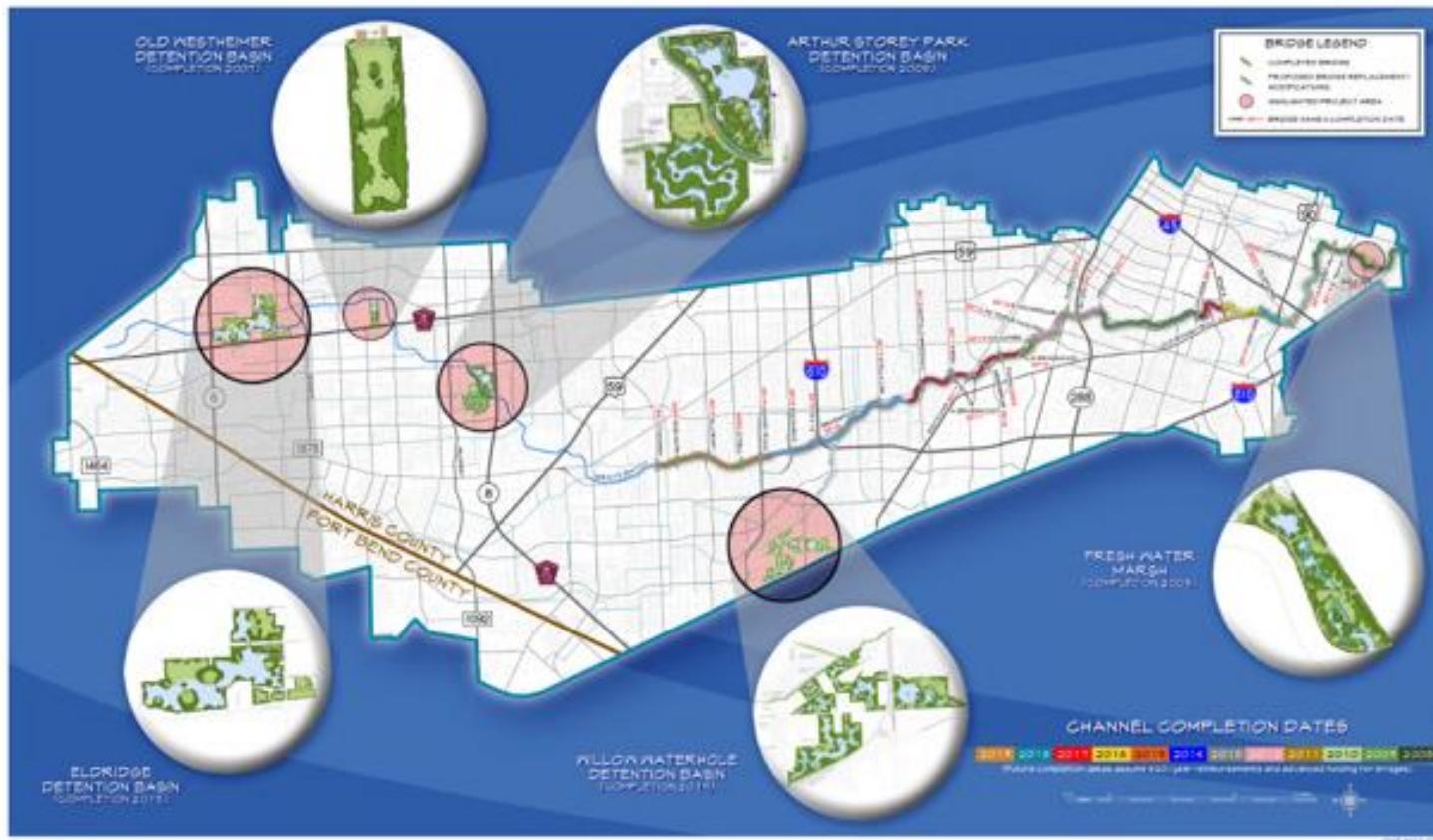
Imagery Date: 8/30/2017 | 29°41'27.08" N, 95°26'45.58" W | elev 0 ft | eye alt 3480 ft



Tour Guide

**ARKK** ENGINEERS

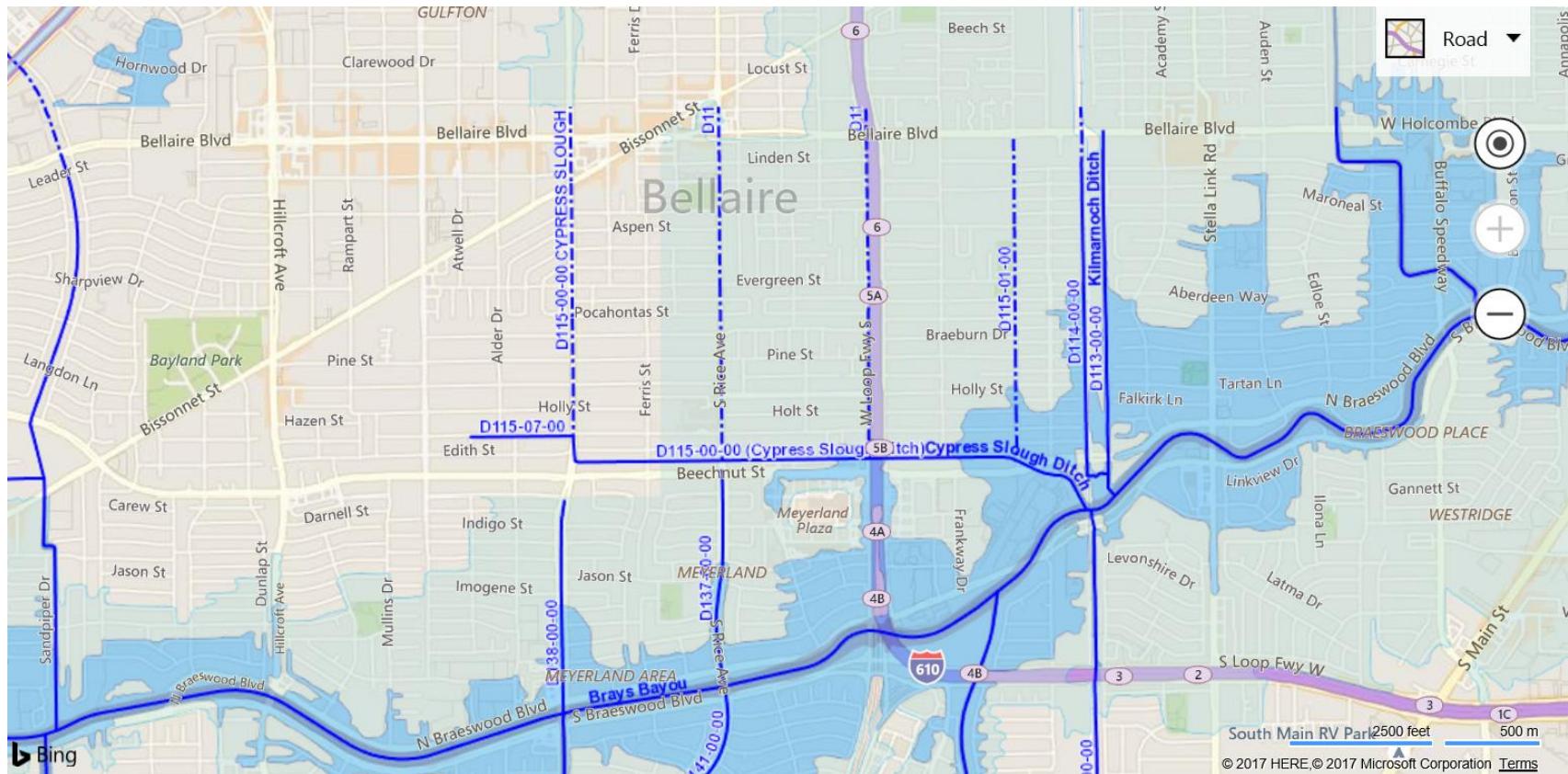
## Brays Bayou Project Locations



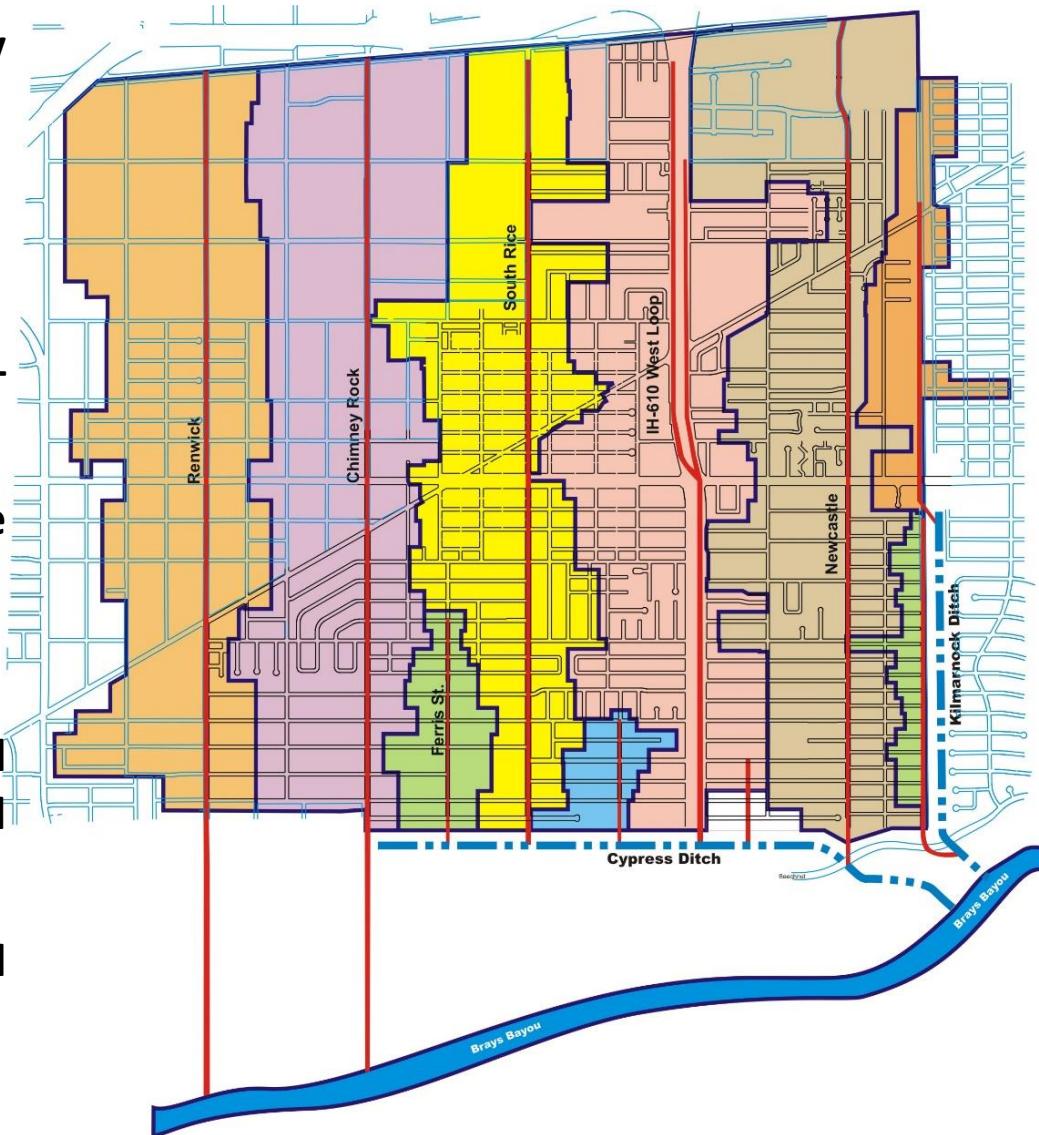
FEDERAL BRIEFING  
April 2013 | Washington, D.C.

# Project Brays

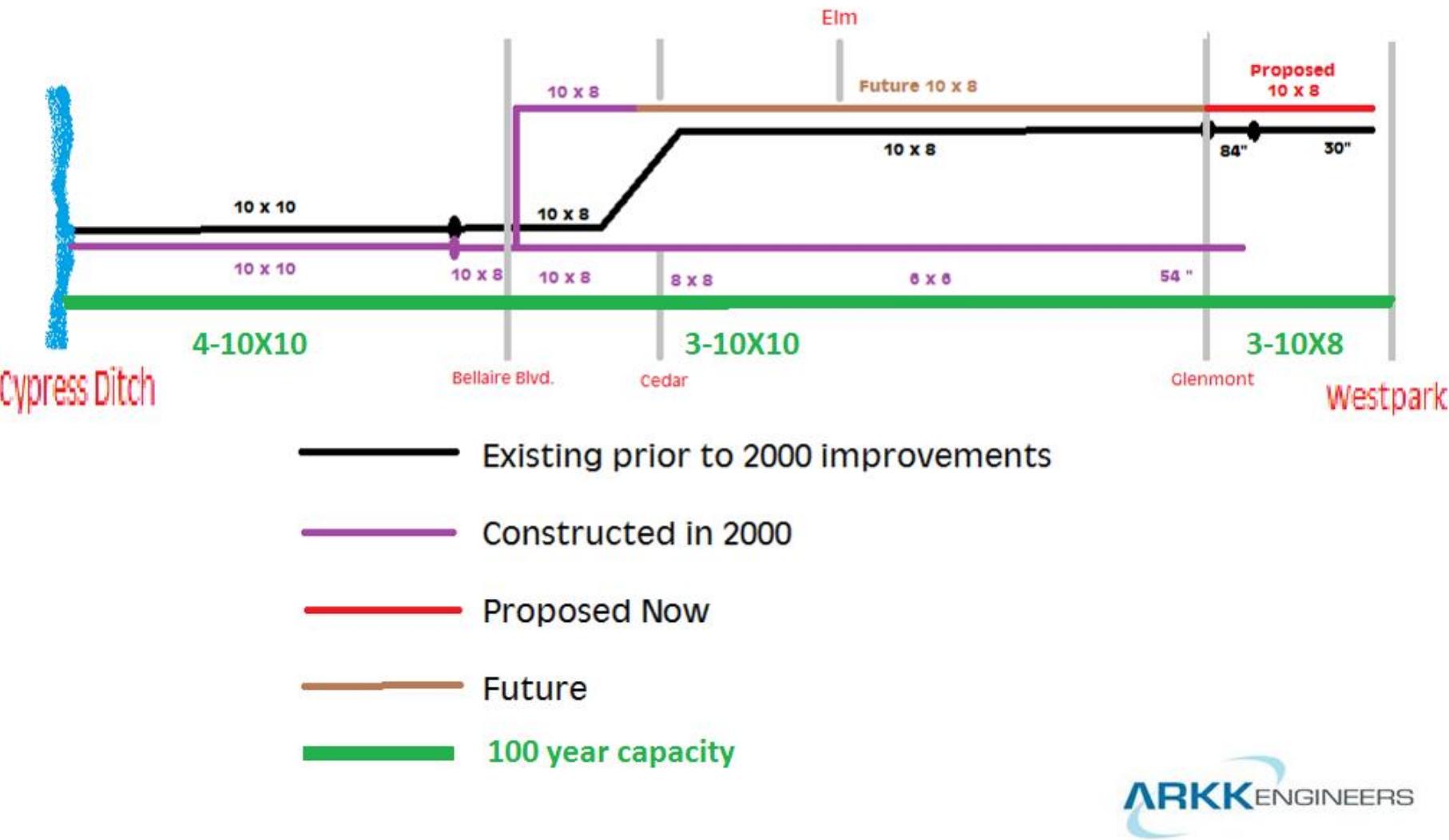
# Conditional Letter Of Map Revision (CLOMR)



- Brays Bayou – HCFCD & US Army Corps
- Cypress Ditch – HCFCD & Houston
- Renwick Drainage System – Houston
- Alder, Chimney Rock, S. Rice – Houston and City of Bellaire
- Ferris, Englewood, Ave. B, Newcastle and Baldwin – City of Bellaire
- IH 610 – TxDOT
- 96-inch Monolithic Pipe in railroad right-of-way – City of Houston and City of West University
- Railroad Ditch – City of Houston and Harris County



# IH 610 Drainage Systems



# Cypress Ditch





# **SP Railroad Ditch**

## **East of Bellaire**

## Appendix 15

### 15. Meeting with City of Houston Meeting Minutes (2/21/2018)

**Meeting w/ City of Bellaire**  
**02/21/2018 11:00 AM**  
**611 Walker**

Project Name: Richmond Plaza North Drainage and Paving Improvements  
WBS No.: M-410023-0001-3

**1. Introductions**

- a. COH Team Lead – Sherry Yu Cang, P.E.
- b. COH Supervising Engineer – Craig Hutson, P.E.
- c. COH Project Manager – Roger Duong
- d. Halff Associates – Emily Anderson, P.E.
- e. City of Bellaire Public Works Director – Michael Leech
- f. City of Bellaire Engineer - James Andrews, P.E.

**2. Brief Project History**

- a. Project Boundaries
- b. Drainage and Paving Improvements
- c. Design Issues
- d. Halff 2D Modeling and Report Findings

**3. Any Current Projects in Design or Planning from the City of Bellaire**

- a. There are no current identified projects in planning, design, or construction for the Chimney Rock drainage system.

**4. Drainage System for Chimney Rock**

- a. FY 2016 Drainage Study – Dated September 7, 2016 by ARKK Engineers
  - i. “The Chimney Rock storm sewer system is undersized for the large urban watershed area currently serviced by the major trunk line that outfalls into Brays Bayou. It is estimated that the current system is not capable of carrying the two-year roadway standard design storm and furthermore, should be sized to handle the 100-year event for such a major storm sewer system. At a minimum the system should handle a 10- year event given the large drainage area it serves.”
- b. DRAFT – WO47 Richmond Plaza Paving and Drainage Improvements Dated December 20, 2017 by Halff Associates
  - i. “The existing Chimney Rock system consists of 10-foot by 10-foot RCB and dual 10-foot by 7-foot RCB located within the City of Bellaire. This system does not have the capacity for the 2-year storm event which causes ponding within the neighborhood. The lack of 2-year capacity was also confirmed in the September 2016 drainage study conducted by the City of Bellaire.”

## **5. Discussion of Solutions**

- a. It was agreed upon that the City of Bellaire and City of Houston should collaboratively implement a drainage system study to determine the proposed LOS for the Chimney Rock drainage system as a first step to work together in improving this area. An interlocal agreement will be needed to execute a drainage study along the Chimney Rock drainage system.
- b. There will be additional discussion on scoping the study, designating a design firm, and establishing shared financial responsibility.
- c. Drainage areas and benefit were suggested as possible means to quantify the percentage of responsibility for each City.
- d. The City of Bellaire could provide a portion of funds for the study through their bond program. There were discussions of other possible funding mechanisms such as FEMA flood mitigation programs. Also, we discussed the possibilities of working with additional agencies such as HCFCD and the state.

## **6. Action Items**

- a. City of Houston
  - i. Sherry (City of Houston) will consult with additional management for feedback and approval to continue the possibility of working with the City of Bellaire. Once the discussion has taken place and a conclusion has been reached, City of Bellaire will be contacted immediately to continue the discussion and schedule a follow-up meeting.
  - ii. Craig and Roger (City of Houston) will provide mark-ups for exhibits to clarify the drainage areas to be included in this scope.
  - iii. Emily (Halff Associates) will create a general scope for this drainage analysis so City of Houston team members can discuss internally the feasibility of continuing this approach.
  - iv. The point of contact between the City of Bellaire and City of Houston will remain as Roger Duong.
- b. City of Bellaire
  - i. City of Bellaire will also send the City of Houston a letter confirming their interest in collaborating to implement a drainage study for the Chimney Rock drainage system and potential improvements.
  - ii. The City of Bellaire will forward any relevant existing drainage studies to the City of Houston for future reference and likewise for the City of Houston.

## SIGN - IN SHEET

## MEETING W/ CITY OF BELLAIRE

## RICHMOND PLAZA NORTH DRAINAGE AND PAVING IMPROVEMENTS

M-410023-0001-3

02/21/2018 @ 11:00 AM, 611 WALKER

NAME (PRINT)	AFFILIATION	PHONE NUMBER	MOBILE NUMBER	E-MAIL	SIGNATURE
Craig Nutson	COH	832-395-2394		craig.nutson@houstontx.gov	Craig Nutson
Emily Anderson	Half	832-908-2735		Anderson@half.com	Emily Anderson
Michael Leed	City of Bellaire	713 201 3379	713 201 3379	MLEED@BellaireTx.gov	Michael Leed
Sherry Gang	COH / <del>COH</del> INT	832-395-3068		YUSHERY.GANG@HOUSTONTX.GOV	Sherry Gang
Roger Duong	COH / COH INT	832-395-2715		MR. ROGER DUONG@HOUSTONTX.GOV	Roger Duong
James Schellhas	City of Bellaire	713 824 4309		James.Schellhas@BellaireTx.gov	James Schellhas

## Appendix 16

### 16. Draft Notice to Surrounding Communities

March 5, 2018

<<Contact\_Name>>  
<<Company>>  
<<Address>>  
<<City\_>>, <<State>> <<ZIP>>

Re: City of Bellaire, Texas  
Floodplain Management and Hazard Mitigation Plan

Dear <<salutations>>:

The City of Bellaire is in the process of preparing a Floodplain Management Plan according to the standards of the National Flood Insurance Program's Community Rating System. This Plan will identify flood hazards and mitigation activities to reduce flood losses and educate the public about flooding issues.

Since flooding is a regional issue, the City would like to coordinate the surrounding agencies and organizations about their projects or planning that may affect the City's floodplain management planning. The City would also like to develop partnerships to address this regional problem.

In order to accomplish this goal, the City is soliciting comments and information that you may have concerning flooding issues. In general, the types of information being sought are on-going projects, studies or other planning information that might influence the City's planning process. A response by March 16, 2018 would be appreciated.

Please contact me at 713-662-8243 if you need additional information or if you would like to schedule a meeting.

Sincerely,


ChaVonne Sampson  
Director of Development Services

## Appendix 17

### 17. Overview of Repetitive Loss Reserved (7-26-2021)

## Appendix 18

18. Map of 1% (100-year) Flood Plain in Bellaire



## **Appendix 19**

### **19. City Engineer Drainage Study**



September 7, 2016

Mr. Brant Gary  
Director of Public Works  
City of Bellaire  
7008 S. Rice Avenue  
Bellaire, Texas 77401

Re: City of Bellaire, Texas  
FY 2016 Drainage Study

Dear Mr. Gary:

ARKK Engineers, LLC (ARKK) is pleased to submit an electronic copy of the City of Bellaire, Texas Drainage Study Report. Please note that we are finalizing the Flooded Structures Area Map and Geographic Information System (GIS) location of detention systems that will be included as Appendix C and Appendix D, respectively. We are also working on the presentation material for the September 19, 2016 Council meeting that will highlight expectations and future implementation strategies.

This report addresses drainage problems local to Bellaire and those regional to the Bellaire area. The recommended improvements include providing strategically located underground detention systems to replace the typical 2 – year design storm sewers on a select group of streets in areas to reduce the depth of flooding.

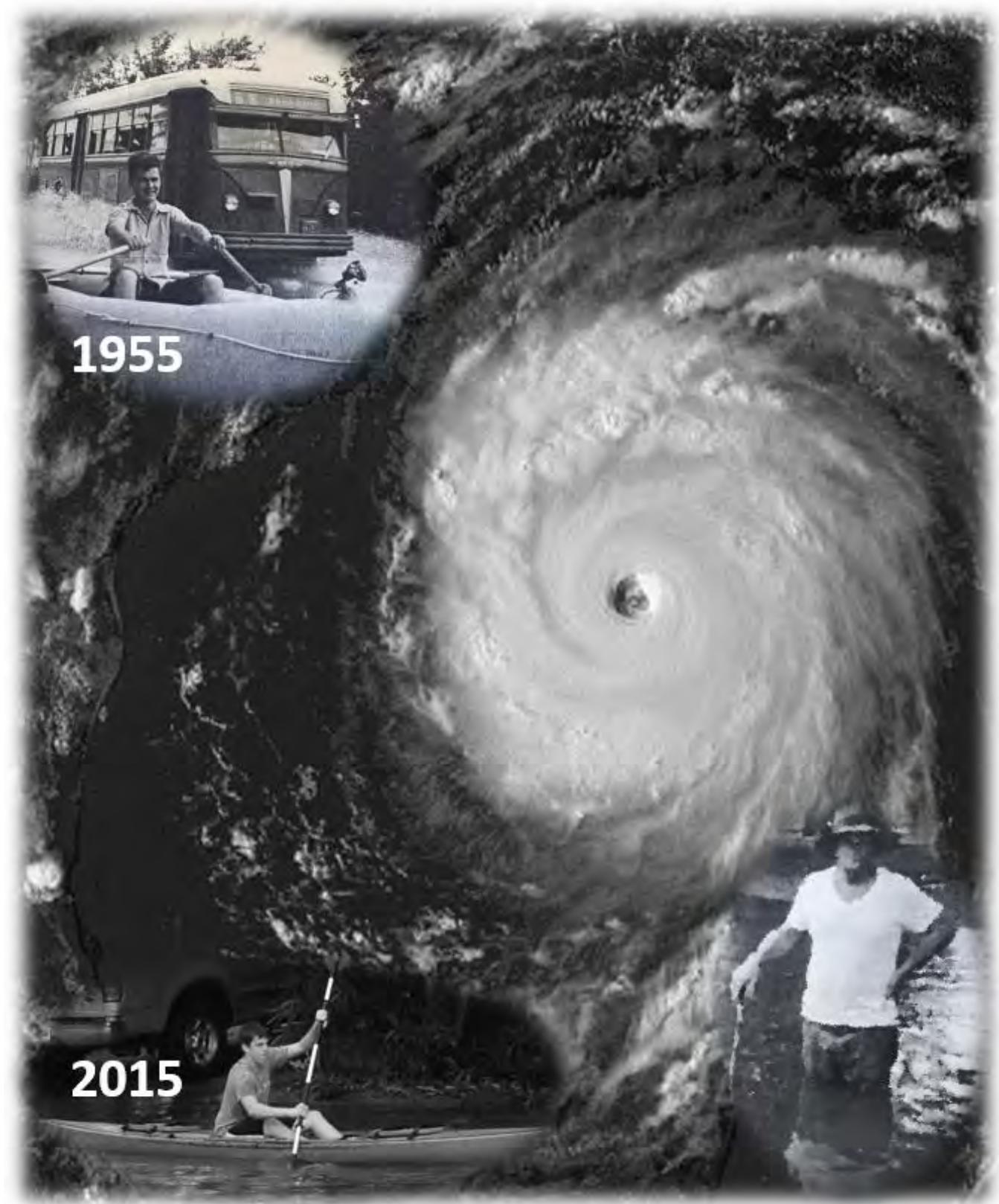
We want to thank you and Fire Chief, Mr. Darryl Anderson and your departments for your assistance with this report and in particular helping to identify properties and areas of the City that flooded during recent severe storms.

ARKK Engineers, LLC appreciates the opportunity to work on this important project for the City of Bellaire. We are available at your convenience to discuss the Drainage Study.

Sincerely,  
ARKK Engineers, LLC

A handwritten signature in blue ink, appearing to read "James B. Andrews".

James B. Andrews, P.E.  
City Engineer



**City of Bellaire, Texas  
Drainage Study  
September 2016**



# City of Bellaire Drainage Study

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Exhibit 15 –	Results of Flooding from 2-D Model for 4-in/hr. Rainfall- Low Areas with Water – Estimated Street Flooding approximate to 1% Flood
Exhibit 16 –	Proposed City Wide Storm Sewer Improvements

## **Appendix**

Appendix A – 2-D run Videos

Appendix B –City of Bellaire Overall Drainage Area Map, Flows and Sample Calculation for the Underground Culvert Sizing

Appendix C – Flooded Structures Area Maps – May 25-26 Storm, April 18 2016 Storm

Appendix D – GIS Location of Detention Systems

# City of Bellaire Drainage Study

## Executive Summary

The City of Bellaire, Texas retained ARKK Engineers, LLC to conduct a Drainage Study to investigate possible alternatives to reduce the occurrence of structures flooding within the city. This study discusses the types of floods that are prevalent in the Bellaire area and practical improvements the City of Bellaire may implement on its own and suggestions for regional projects that Bellaire could partner with other entities for mutual flood control benefits. It is anticipated that the recommendations for drainage improvements in this study will help prioritize future street and drainage capital improvements.

The Drainage Study also addresses plans for removing certain areas of the City from the floodplain by Letter of Map Revision (LOMR). The goal of the LOMR is to remove as many homes from the Flood Insurance Rate Map designated floodplain as possible and significantly lower flood insurance cost for those residents. Currently, there are 4,780 flood insurance policies in Bellaire costing residents almost \$5.6 million every year. It is important to note that this exercise is not intended to suggest that flood insurance is not needed in any area of Bellaire, but to simply reduce the cost of flood insurance to Bellaire residents. The LOMR process is currently underway and should be ready to submit to the Harris County Flood Control District (HCFCD) for their review and approval this year. If the LOMR is approved, the cost saving to the citizens of Bellaire is anticipated to be approximately \$3 million every year.

ARKK teamed with SIRRUS Engineers, Inc. to develop a storm water overland flow model to understand flow patterns in and around Bellaire and to help determine areas of the City most in need of drainage improvements. The model showed areas more likely to pond to elevations that could flood structures before flowing overland during various rainfall intensities. Once the flooding areas were identified, potential storm drainage improvements were identified to lower flood elevations anticipated during a localized 100 – year storm event.

The Drainage Study included a background review of storm intensity history, including the major rainfall event during May 25-26, 2015 and more recently the April 18, 2016 or Tax Day event. Rainfall data, stream data and the general location of structures flooded during Tropical Storm Allison were also reviewed and compared to the model results.

## General

The City of Bellaire is located in southeast Texas and has a population of approximately 17,000 residents. Bellaire is a small developed city with an area of 3.6 square miles that is surrounded by the City of Houston and is located just west of the cities of West University Place and Southside Place and very near downtown Houston, the Galleria and the Texas Medical Center.

Bellaire is part of the 137 square mile Brays Bayou watershed and the entire City is within Brays Bayou watershed.

### **Factors Contributing to Flooding in Bellaire**

Bellaire has flooded from various severe storms over the last century. Various degrees of flooding have plagued the City of Bellaire and for that matter Southeast Texas for decades. Recently, heavy rainfall amounts and a large number of severe storms have produced more occasions for flooding than normal. While the City of Bellaire is dedicated to minimizing adverse impacts associated with flood events, there are many factors not within the city's control that contribute to flooding in Bellaire. Some of these are:

- very high average annual rainfall of about 50 inches
- very flat topography
- clay soils that do not absorb water very well
- close proximity to an undersized Brays Bayou
- large amounts of storm water from the City of Houston flow into Bellaire from the north
- localized storm water runoff from Bellaire drains into undersized drainage systems owned by the City of Houston
- Below base flood finished floor elevations of homes constructed prior to the National Flood Insurance Rate Standards.

The City of Bellaire does control the drainage improvements constructed within the City limits and the finished floor elevation requirements for new residential and commercial development. Residential lot drainage and fill requirements and requires storm water detention on commercial development are also controlled by City of Bellaire.

### **Recent Flood Events**

Over a recent 13-month period, Harris County experienced six (6) significant flood events occurring on the following dates:

May 12-13, 2015

May 25-26 2015

Oct. 24-25, 2015

Oct. 31 2015

April 18 2016

May 25-27, 2016

Each one of these events resulted in rainfall totals over eight (8) inches in portions of Harris County. Never, in modern records, has Harris County experienced such frequent back to back flooding events. The only year that comes close is 1998 when three major floods affected the county in September (Frances), October, and November.

Two of these recent significant events caused major flooding in Bellaire. The May 25-26<sup>th</sup> 2015 flood event within the City of Bellaire resulted in approximately 220 homes being flooded. Fire Department records indicate approximately 175 of those homes flooded were located east of IH 610. A handful of homes flooded during the April Tax Day storm of 2016.

It is important to note that all storm events are different. A review of the Tropical Storm Allison flood event documentation of 2001 shows approximately 1,432 homes were flooded in Bellaire with 1,015 of those homes located east of IH 610.

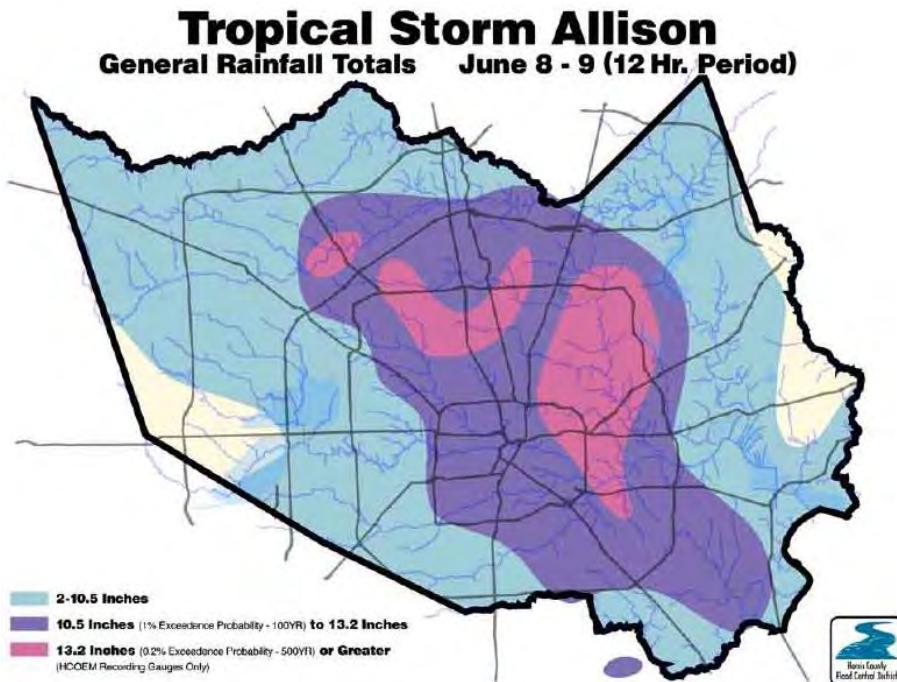


Figure 1- HCFCD Tropical Storm Allison Rainfall Totals (Source HCFCD)

This HCFCD graphic shows considerably higher rainfall totals occurred inside the Loop within Bellaire than outside the Loop.

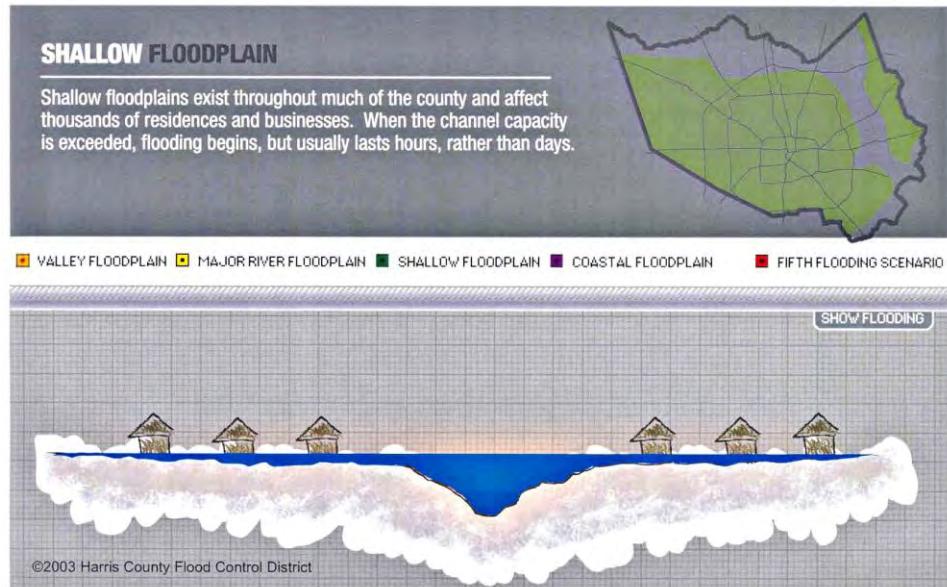
## **TYPES OF FLOODS**

Flooding occurs in the Bellaire area because of shallow floodplain flooding or ponding/overland flow problems or some combination of both.

### **Shallow Floodplain Flooding**

Shallow floodplains exist throughout much of Harris County. Bellaire is located very near Brays Bayou and is in the shallow floodplain of Brays Bayou.

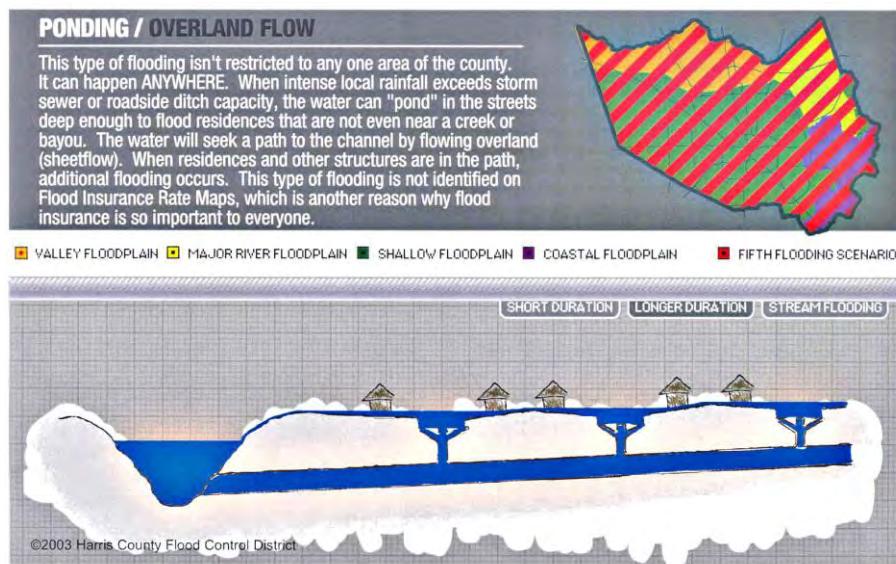
When the Bayou capacity is exceeded and flood waters overtop the bayou banks, flooding occurs in the land areas near the bayou that are located at lower elevations. Land areas can remain flooded for hours until water surface elevations drop in the bayou.



**Figure 2- HCFCD Shallow Floodplain (Source HCFCD)**

### Ponding/Overland Flow Flooding

Ponding or overland flow flooding occurs when intense local rainfall exceeds storm sewer or roadside ditch capacity, the water can “pond” in the streets deep enough to flood residences that are away from the bayou.



**Figure 3- HCFCD Ponding/Overland Flow (Source HCFCD)**

This type of flood is not restricted to any one area. It can happen anywhere. The storm water ponds until it eventually seeks a path to the outfall by flowing overland. When residences and other structures are below the surrounding land elevation or in the path of the overland flow, flooding may occur. The probability of this type of flooding is not shown as a floodplain on the Flood Insurance Rate Maps.

### **Floodplain in Bellaire**

The ARKK/SIRRUS team performed a preliminary review of the existing FEMA flood insurance rate maps for the City of Bellaire. The current FEMA Flood Insurance Rate Maps were prepared based on FEMA Hydrological and Hydraulic models. The review of the models revealed inconsistencies that have been discussed with the Harris County Flood Control District. The preliminary review of the mapping and the models indicates the floodplain water surface elevation changes by approximately 2.75 feet from the IH610 Bridge upstream to the west city limits. This is a significant increase in only about a mile upstream when there is no dramatic increase in flows through this reach. It appears that the HEC-RAS model used in mapping the floodplain incorrectly shows an obstruction that results in an increase in the water surface elevation within the City of Bellaire west of IH610. This higher base flood elevation may erroneously place more Bellaire properties within the designated floodplain.

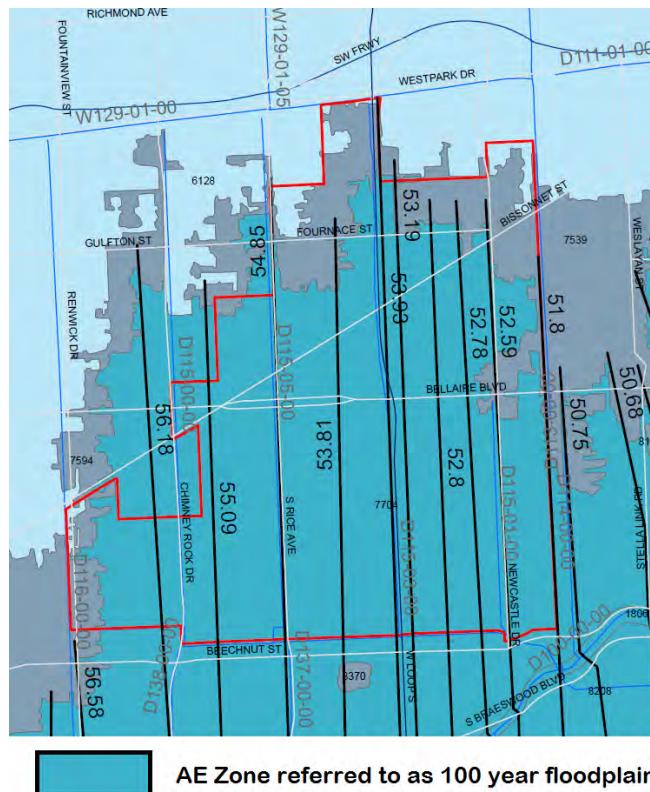


Figure 4- 100-year or 1% Floodplain in Bellaire

The HCFCD has indicated they will consider this new information during their planned remapping effort of the floodplain to reflect improvements completed to date because of Project Brays. Project Brays is an over \$400 million major flood control project being undertaken with the Corps of Engineers with major improvements already completed and providing benefits to the Brays Bayou watershed. The HCFCD plans to begin a new floodplain mapping project in 2017 to show the reduction in floodplain realized due to the ongoing construction of Project Brays. This remapping effort by the HCFCD could take a minimum of five years to complete, because it must be approved by FEMA.

### **Letter of Map Revision**

On a more immediate basis and as recommended by this study, the City of Bellaire is currently developing a Letter of Map Revision report that will be submitted to the HCFCD to potentially remove certain areas within the City of Bellaire from the floodplain as shown on the existing FEMA maps. The current floodplain maps do not reflect the spatial ground realities like the presence of buildings, fences and other obstructions that can prevent flood waters from flowing back into the City of Bellaire when flood water elevations exceed the capacity of Brays Bayou. This remapping effort will attempt to remove properties from the flood plain showing the backwater flow to be through the street system versus through the obstructions. If this remapping effort is successful and approved by the HCFCD and FEMA, many Bellaire properties will be removed from the mapped 100-year floodplain, thus providing significantly lower flood insurance premiums for those citizens of Bellaire.

This immediate effort to remap the FIRM will be submitted directly to the HCFCD as the local FEMA designated partner. Possibly as soon as four (4) months after the letter of map revisions are submitted to the HCFCD, the revised maps may be used to determine lower insurance premiums for those citizens located in the affected area.

### **Drainage Improvement Alternatives**

The Drainage Study team looked at several alternatives for drainage improvements. Some improvement options, while theoretically could protect the City of Bellaire from both the Shallow Floodplain Flood and the Ponding/Overland Flood, are very cost prohibitive. The recommended alternative identified, provided increased flood protection during the very intense local storms and suggests the need to partner with other entities to reduce the probability of flooding from Brays Bayou overtopping its banks.

To prevent the City of Bellaire from flooding from a 100-year localized flood event, where large amounts of rainwater fall directly within the city and from flooding occurring from the backwater effects of Brays Bayou water overtopping the banks is possible. In other words, the City of Bellaire requirements of protection during the 100-year flood event requires improvements outside Bellaire and thus are not solely under Bellaire's control.

### 100-Year Level of Protection for All Drainage Systems Alternative

Improve Brays Bayou to completely contain the 100-year storm, improve Cypress Ditch to contain the 100-year event, improve all North/South major drainage arterials to transport the 100-year storm water flows through the City of Bellaire and to Cypress Ditch or Brays Bayou and improve all local storm sewers and local street systems to convey 100-year flows to their respective outfalls. The improvements to Brays Bayou alone would cost much more than current Project Brays which is anticipated to provide a 10-year level of flood protection. The current Project Brays has an estimated price tag of over \$400 million and does not provide protection from the 100-year event. Cypress Ditch drains approximately 2,400 acres of the City of Houston and the City of Bellaire. There is insufficient right-of-way to construct an open channel section capable of carrying the 100-year event and it is estimated that a closed conduit section to accommodate the 100-year event would cost over \$80.1 million. To reconstruct all of the interior pipe systems to the 100-year level of service is estimated to cost another \$236 million. The total upgrade to the entire drainage system serving the City of Bellaire is not an economically feasible option considering the number of homes flooded during the historical major storm events previously discussed.

### Neighborhood Detention Pond Alternative

This alternative considers building detention ponds capable of storing flood waters generated from localized extreme storm events within each individual neighborhood. A 10 acre-ft. pond could be constructed for each 40 or so homes. The storm drainage systems would need to be improved to the 100-year capacity to transport storm water to ponds and improvements to Brays Bayou to contain the 100-year event so flood waters from the bayou would not back up into the city would be required as previously described. This option would displace homes to build detention ponds and significantly displace neighborhoods and therefore was not considered a viable option.

### Levee System Alternative

This option would consider constructing a levee system around the City of Bellaire similar to the levees in Fort Bend County for subdivisions located within the floodplain. The levee would prevent storm water that overtops the banks of Brays Bayou from entering or back flowing into the City from the south and block overland flow from City of Houston to the north from entering Bellaire. The City of Bellaire's internal storm sewers would operate at a 100-year level of protection with large storm water pump stations and storage areas required to prevent the localized storms from flooding the City. The storage would be required to offset the loss of floodplain storage the City of Bellaire is providing to the Brays Bayou watershed. This option would require large amounts of land within City of Bellaire, several pump stations, blocking the City of Houston off-site sheet flows into Bellaire, and changes to the road elevations exiting the City of Bellaire to drive over the perimeter levee. The levee alternative perhaps would be viable if the City of Bellaire was being developed from scratch but would not be practical to try and retrofit a levee system in a fully developed urban area.

### Strategic Underground Detention Storage Recommended Alternative

Using new technologies available, a more practical and cost effective alternative was developed to provide reasonable flood protection to the City of Bellaire. This option involved identifying potential ponding areas within the City utilizing a SOBEK 2-D model supplemented with observed flooding locations within the City of Bellaire. The 2-D complex urban drainage model analyzed different rainfall intensities to predict flooding areas.

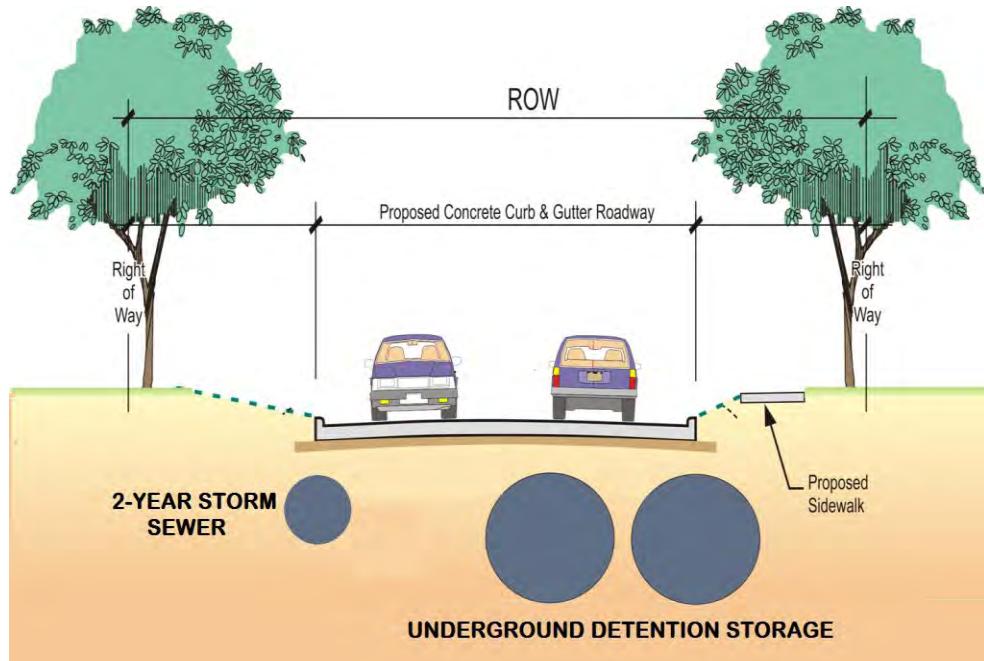


Figure 5- Underground Detention

This option would include strategically locating underground storage pipes within the existing street right-of-way within the ponding or flooding areas identified and constructed as part of new street and drainage reconstruction projects were undertaken. The typical two-year underground storm sewer pipe system constructed during the total reconstruction of a roadway improvement project would be upsized to store a 100-year localized rainfall event. The goal would be to lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist.

This underground storm sewer drainage and detention systems would limit the flow at the respective outlet to the existing conditions and not require the entire underground system downstream of these detention systems to be improved. Costly mitigation efforts for potentially increasing flows to downstream areas would also be avoided.

Based on the ponding maps from the 2-D model video, individual storm sewer detention locations for the 100-year flood event were identified and a preliminary cost estimate was provided. The final location and size configuration of these storage systems should be

determined during the Preliminary Engineering Phase of each street reconstruction project. The available outfall depth is critical to determine the vertical dimension of the storage system. Also during this PER stage, the detention system material type will be determined. Reinforced Concrete Boxes, Reinforced Concrete Pipe and High Density Polyethylene Pipe would be considered suitable for the detention storage systems.

These detention systems would replace the two-year design storm sewer systems normally used during street reconstruction on a particular block at a cost of about five to six times that of a typical two-year design storm sewer system. These localized detention storage systems constructed by the City of Bellaire would not increase flows downstream because the outfall would be restricted to the 2-year storm flows or existing flows.

The approximate location of the individual localized underground detention systems are shown on Exhibit 13 of this report. The approximate cost of the 100-year capacity storm sewer detention systems associated with major drainage areas is as follows:

- Chimney Rock Rd. system \$1.3 million
- South Rice system \$2.9 million
- IH 610 West Loop system \$41.1 million
- Newcastle system \$36.7 million
- Rail Road system area north of Bellaire Blvd. \$2.9 million
- Southdale system \$0.9 million

The estimated total cost of the storm water storage systems is \$85.8 million versus approximately \$30 million for the two year systems or an increase of approximately \$56 million to the overall Street and Drainage reconstruction program. The underground detention storage systems would allow for storing the 100-year storm water underground with the exception of the allowable six inches to one foot of water ponding in the street. Storm water ponding in the street is typical to storm water management in Harris County.

This underground detention storage option would be focused on reducing the localized flooding events and would not prevent flood waters from Brays Bayou from flowing back into the City as water surface elevations in the bayou exceeded the top of banks.

It is suggested that the City consider the viability of building backflow systems such as flap gates within the major underground North/South drainage arterials to help prevent back water flows from the bayou from taking up the capacity of Bellaire's local systems when waters start to rise in Brays Bayou. These local detention systems and back flow devices would provide less and less protection from flooding as more and more storm water overflowed the banks of Brays Bayou.

It is also recommended that Bellaire continue to require the finished floors of new structures to be built above the base flood elevation. The vast majority of homes flooded during the recent storms were older original Bellaire homes constructed at a low elevation compared to the

surrounding land. There were a few homes flooded that were rebuilt prior to the current ordinance requiring finished floors to be above the 100-year base flood elevation.

Cost sharing regional projects with TxDOT, the City of Houston, the Texas Water Development Board, FEMA and the HCFCD are also recommended to be considered when others entities in addition to City of Bellaire would benefit from drainage system improvements. The most benefit to all being additional improvements to Brays Bayou to completely contain the 100-year or 1% storm events.

In summary, this Drainage Study recommends the City of Bellaire consider the following:

1. Construct local underground storage systems by increasing the normal two-year design storm sewer system to store the 100-year storm volumes at selected strategic locations.
2. Construct backflow prevention systems at several of the major drainage system outfalls like the Newcastle and IH 610 system outfalls to Cypress Ditch to prevent back water flow from Brays Bayou backing up into these systems during high water flood stages.
3. Prepare and submit a LOMR to the HCFCD for approval to remove certain areas of the City of Bellaire from the floodplain.
4. Request TxDOT to improve the IH 610 drainage system to properly receive the existing drainage area storm water runoff and convey to Brays Bayou. The system should be increased to meet their current design criteria for a system receiving this amount of runoff from such a large drainage area.
5. Request interim improvements to the system directly adjacent to the proposed improvements associated with the US69/IH610 interchange improvements to receive the storm water runoff from the existing drainage area and meter the outfall until such time as downstream improvements are constructed as mentioned above.
6. Request the City of Houston/Texas Water Development Board/FEMA to participate in conveyance and storage capability improvements within the Chimney Rock and S. Rice Ave. drainage systems because they serve such large areas of the City of Houston as well.
7. Develop inter-local agreements with the City of Houston for future improvements and maintenance for drainage facilities that serve both entities. These agreements should consider development and detention requirement standards for any new development.
8. Request the City of Houston and/or the City of West University Place to consider installing back flow prevention systems in Cypress Ditch, Kilmarnock Ditch and the Railroad Ditch to prevent back water from Brays Bayou backing up into these systems during high water flood stages.

9. Remove existing identified utility conflicts within the major N/S drainage systems, where possible.

The City of Bellaire would concentrate funding for local improvements to reduce localized flooding within Bellaire and request regional partners to help with the larger projects like improving Brays Bayou, Cypress Ditch and the major North/South drainage arterials that also benefit other entities.

The priority for proposed localized detention storage improvements should consider the severity of flooding by area as it relates to structures flooding and the potential for lowering the water surface from a localized 100-year storm event. This improvement need would be weighted with other needs like the level of roadway condition, gutter ponding and pedestrian and traffic volumes to determine the priority order of street and drainage reconstruction projects.

The City Engineer and the Director of Public works are currently formulating the implementation strategy for the prioritizing the storm water improvements as part of the next street and drainage reconstruction program.

## **1.0 Introduction**

### **1.1 Project Location and Background**

City of Bellaire is located in southeast Texas and has a population of over 17,000 residents. Bellaire was founded in 1908 as a residential neighborhood and agricultural trading center. Bellaire is located southwest of downtown Houston and the Houston Galleria. Major universities and the Texas Medical Center are very close to Bellaire. The approximately 6500 homes in the city are a mix of 1940 - 1960's ranch homes and newly constructed large two-plus story homes and commercial properties located in several sectors of the city. Bellaire is a zoned community, and known as the City of Homes. The City of Bellaire is part of the 137 square mile Brays Bayou watershed. The Brays Bayou watershed is fully urbanized, although several large urban parks and regions of open space are located within the watershed. See Exhibit 1 for the City Limits and Location Map.

Bellaire, like most of southeast Texas near the Gulf of Mexico, is subject to flooding because of high amounts of rainfall typical of area, very flat topography, clay soils that do not absorb water very well and the inability of the main flood control facility (Brays Bayou for the Bellaire area) to contain extreme event storms. As pointed out on the HCFCD website, the flooding problems in most of Harris County are severe. Several hundred thousand homes and businesses are in the identified floodplain (not all flooding areas are mapped), and projects to reduce the risk of flooding are estimated in the billions of dollars.

Harris County Flood Control District (HCFCD) is the agency in charge of flood control for Harris County. HCFCD is a special purpose district that was created by the State Legislature in 1937 in response to devastating floods occurring in 1929 and 1935. The HCFCD boundaries are coincident with Harris County and is responsible for devising flood damage reduction plans, and maintaining the primary drainage infrastructure.

Communities like the City of Houston and the City of Bellaire are floodplain administrators for their own community and participate in the National Flood Insurance Program (NFIP). Everyone living in a participating community of the NFIP can buy flood insurance. Just because your home is not mapped within the 100-year floodplain does not mean that you are free from the potential to flood. The mapped floodplain is only an estimate of where flooding is predicted to occur from a bayou or creek, given a set of parameters including a hypothetical rainfall occurring over a watershed for an assumed amount of time. FEMA Flood Insurance Rate Maps (FIRMs) show areas subject to flooding from a primary flooding source, typically major rivers, bayous and their tributaries, and are meant to help determine the risk of flooding for a property. However, flooding from sources that are not identified on the FIRMs is possible and occurs often in Harris County and sometimes in Bellaire. Many homes flood because excess storm water cannot drain into a storm drainage system fast enough to prevent localized ponding from reaching the inside of a home. On a national basis, one-third of the flood loss claims are from property located outside of the mapped 1% (100-year) floodplain. This does

not mean the FIRMs are wrong. It simply means that not all flooding sources are mapped and that more severe floods can occur than the ones mapped. It is costlier for homes located within the floodplain to purchase flood insurance because the risk of flooding is considered greater at these locations than those properties located outside the mapped floodplains.

It is important to realize that preventing all flooding in Harris County "is virtually impossible" as stated on the HCFCD website, however larger storm sewers, more street storage and detention systems help each community cope with flooding by reducing the risk and more particularly, the frequency of flood damage.

Most of Harris County is in the San Jacinto River watershed. Within that larger area, most Harris County watersheds drain into one of nearly two dozen major creeks and bayous. The City of Bellaire is in the Brays Bayou watershed, the rain that falls in the City of Bellaire will eventually end up in Brays Bayou. The Brays Bayou watershed is located in southwest Harris County and portions of Ft. Bend County and drains parts of the cities of Houston, Missouri City, Stafford, Bellaire, West University Place, Southside Place and Meadows Place. The bayou flows eastward from Fort Bend County to its confluence with the Houston Ship Channel.

Currently, the HCFCD is partnering with the U.S. Army Corps of Engineers (the Corps) on a major flood damage reduction project called "Project Brays." Project Brays (or the Brays Bayou Flood Damage Reduction Project), is a multi-year, \$413 million project to reduce the risks associated with flooding. For local drainage projects, the City of Bellaire generally follows the City of Houston's design criteria for the design of storm sewers, street drainage and also stormwater detention systems.

Stormwater detention basins are a place to store damaging flood waters temporarily until the channels or storm sewers can safely carry the water away. As flat as Harris County is, most of our stormwater storage has to be excavated. The HCFCD detention basins are typically large regional facilities that may be several hundred acres in size. New developments often use stormwater detention to offset or mitigate the negative effect development may have on flooding (due to covering up soil with buildings and concrete, and speeding up the rate water runs off an area).

The City of Bellaire was built prior to our current understanding of flooding potential and prior to current regulations that restrict certain uses of flood-prone land. Streets and storm sewers are typically designed for normal rainfall events and, when heavy rains fall, the systems are overloaded. Water will begin to pond in the streets and then try to flow overland to Cypress Ditch or Brays Bayou, sometimes flooding houses along the way.

Flooding occurs in the Bellaire area because of shallow floodplain flooding or ponding/overland flow problems or some combination of both. Shallow floodplains exist throughout much of Harris County. The City of Bellaire is located very near Brays Bayou and when the Bayou capacity is exceeded and flood waters overtop the bayou banks, flooding occurs. Land areas can remain flooded for hours until water surface elevations recede.

Ponding or overland flow flooding is not restricted to any one area. It can happen anywhere. When intense local rainfall exceeds storm sewer or roadside ditch capacity, the water can “pond” in the streets deep enough to flood residences that are away from the bayou. The storm water ponds until it eventually seeks a path to the outfall by flowing overland. When residences and other structures are below the surrounding land elevation or are in the path of the overland flow, flooding may occur. The probability of this type of flooding is not shown as a floodplain on the Flood Insurance Rate Maps.

In most areas, the streets are considered to be a part of the drainage system. During a typical rainfall event, water will flow through storm sewers located underneath the street or in roadside ditches to a drainage channel such as a ditch or bayou. When the capacity of the storm sewers or roadside ditches is exceeded, the street itself will hold the water until the storm sewer or roadside ditch has additional room to drain the water. Just because your home is not mapped within the 100-year floodplain does not mean that you are free from the potential to flood. Restricted development is permitted in the 1% (100-year) floodplain. The floodplain administrators at each municipality within Harris County are responsible for enforcing floodplain management rules and regulations that govern construction in the floodplain. The City of Bellaire requires the finished floor of new structures to be a minimum of one foot above the base flood elevation. Bellaire also restricts the amount of fill allowed on residential lots.

## **1.2 Definitions for this Drainage Study**

The definition of some of the terms used in this drainage study and defined by HCFCD with changes to reflect the City of Bellaire are listed below:

### **1% (100-year) Floodplain**

The area of land that has a 1% chance of being inundated by flood waters from a bayou, stream or creek in a given year. It is commonly referred to as the 100-year floodplain. This is a regulatory standard used to administer floodplain management programs, the National Flood Insurance Program (NFIP) and to set building requirements for new construction. Statistically, the 1% (100-year) flood has a 26% chance of occurring during a 30-year period of time – the length of many mortgages. The 1% (100-year) floodplain is the Base Flood or Special Flood Hazard Area. It is referred to as Zones AE, AO, A, or VE for insurance purposes on Flood Insurance Rate Maps (FIRMs). Properties located in these mapped zones are required to have flood insurance if the owner has a federally backed mortgage on the property.

### **1% (100-year) Rainfall**

An amount of rain having a 1% chance of being equaled or exceeded in any given year. For City of Bellaire this amount of rainfall is just over 13 inches in 24 hours or just under 11 inches in 12 hours.

### **Base Flood**

A flood having a 1 % chance of being equaled or exceeded in any given year. This flood is sometimes called the 1% or 100-year flood.

### **Base Flood Elevation**

This is the elevation above the average sea level that waters from a 1% (100-year) flood will reach at a given point along a creek or bayou. These elevations are determined using hydrology and hydraulic computer models. The elevations are then mapped on the topographic data for the county to produce the 1% (100-year) floodplain.

### **FEMA (Federal Emergency Management Agency)**

The federal agency responsible for providing leadership and support to reduce loss of life and property and to protect our institutions from all types of hazards. This is accomplished through a comprehensive, risk based, all hazards emergency management program consisting of mitigation, preparedness, response, and recovery. In relation to flooding hazards, FEMA is the federal agency responsible for administering the National Flood Insurance Program (NFIP).

### **FIRM Panel FIRM stands for Flood Insurance Rate Map**

In order to print the FEMA Flood Insurance Rate Maps at a scale of 1-inch = 1,000-feet, the maps are broken out into over 150 FIRM panels that cover the entire Harris County area. The City of Bellaire is located on one (1) FIRM panel.

### **Flood Insurance Rate Maps**

Prepared by FEMA, Flood Insurance Rate Maps, or FIRMs, show areas that have the highest probability of flooding and illustrate the extent of flood hazards in a flood-prone community. These maps are used to determine flood insurance rates for communities participating in the National Flood Insurance Program (NFIP). Properties located in mapped zones AE, AO, A, or VE are required to have flood insurance if the owner has a federally backed mortgage on the property.

### **Floodplain**

From time to time, bayous and creeks naturally come out of their banks due to heavy rainfall and inundate the adjacent land. This area that is inundated is referred to as a floodplain. Residences and businesses within the floodplain are considered to be at risk of being damaged by flooding. The floodplain is typically expressed by stating its frequency of occurrence. For example, the 1% (100-year) floodplain represents an area of inundation having a 1% chance of being equaled or exceeded in any given year, whereas the 2% (50-year) flood plain has a 2% chance of being equaled or exceeded in any given year. FEMA Flood Insurance Rate Maps (FIRMs) show the 1% (100-year) and 0.2% (500-year) floodplains.

### **Infrastructure**

For the Harris County Flood Control District, infrastructure typically refers to the primary drainage system, including channels and detention basins. The City of Bellaire's streets, storm

sewers, detention systems, storm inlets and roadside ditches are considered storm water management infrastructure.

### **Insufficient Capacity**

Exists when the desired capacity of an infrastructure exceeds the existing capacity; that is, when the infrastructure cannot carry or hold all of the stormwater that could flow to it.

### **Lidar**

LiDAR for Light Detection and Ranging. A highly detailed ground elevation data through cutting-edge technology that utilizes the projection of millions of laser signals to the ground from a specially equipped aircraft. Using powerful software, the data from these LiDAR reflections is collected by measuring the time it takes for the aircraft to receive each of the millions of laser reflections. The resulting data is then combined and converted into an image that looks exactly like the terrain below, including buildings, trees, roadways, creeks and bayous.

### **Levee**

A physical barrier constructed to protect areas from rising floodwaters.

### **LOMR**

(Letter of Map Revision) - FEMA's modification to an effective Flood Insurance Rate Map (FIRM), or Flood Boundary and Floodway Map (FBFM), or both. LOMRs are generally based on the implementation of physical measures that affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway, the effective Base Flood Elevations (BFEs), or the Special Flood Hazard Area (SFHA). The LOMR officially revises the Flood Insurance Rate Map (FIRM) or Flood Boundary and Floodway Map (FBFM), and sometimes the Flood Insurance Study (FIS) report, and when appropriate, includes a description of the modifications. The LOMR is generally accompanied by an annotated copy of the affected portions of the FIRM, FBFM, or FIS report. An Appeal/Protest period exists only when there is a change in the BFE.

### **NFIP**

(National Flood Insurance Program) - Created by Congress in 1968 to provide low cost flood insurance for property owners in flood-prone communities. In exchange for flood insurance eligibility, communities agree to implement and enforce floodplain management measures to reduce the possibilities of future damage. FEMA arranges for periodic community assistance visits with local officials to provide technical assistance regarding complying with NFIP floodplain management requirements. FEMA works with local officials to evaluate the FIRMs and associated Flood Insurance Study and conducts updates as needs and priorities dictate. Harris County and the incorporated cities within the county are participants in the NFIP, so flood insurance is available to all residents.

### **Rainfall Event**

(Rain Events for the modeling) – A 4-inch/hr rainfall is defined as the rainfall amount when measured for an hour equals a total rainfall of 4-inches. Similarly, 2-in/hr, 3-in/hr and 6-in/hr represents the amount of rainfall measured in an hour.

### **Repetitive Loss**

Repetitive Loss property is any insurable building for which two or more claims of more than \$1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. A Repetitive Loss property may or may not be currently insured by the NFIP.

### **Sheet Flow**

(Overland Flow Flooding) - Flooding that occurs when intense local rainfall flows overland to reach a channel. Frequently, this conditions exists when runoff exceeds storm sewer or roadside ditch capacity, and the water can "pond" in the streets deep enough to flood residences that are not even near a creek or bayou. The water will seek a path to the channel by flowing overland (Sheet Flow). When residences and other structures are in that path, flooding occurs and this type of flooding is not identified on the Flood Insurance Rate Maps.

### **1.3 History of Drainage in Bellaire**

Bellaire has been subjected to flooding from various severe storms and hurricanes over the last century. The City of Bellaire has remained dedicated to minimizing the loss of life and property that is associated with flood events as evidenced by historical improvements



Figure 6- A History of Flooding

Bellaire's drainage systems have evolved from natural flow from the northwest to the southeast to ditch systems to underground systems. Prior to development of the Bellaire area, storm water followed the natural topography of the land, which sloped from the northwest to the southeast. Storm water traveled overland through gulleys and creeks to the Bay. Natural flow was first disrupted by the Galveston/Harrisburg and San Antonio railroad built to the east and the San Antonio and Aransas Pass railroad built to the north.

The first drainage system improvements consisted of small open ditches discharging into deep open drainage ditches located parallel to North-South streets and the Railroad. These North-South ditches were located within and on the west side of the rights-of-way of the Railroad, Avenue A (Newcastle), Avenue C (IH 610), Rice Avenue, Avenue D (Chimney Rock) and smaller North-South ditches on Sixth (Ferris) and Ninth (Alder) Streets. These North-South ditches, except the Railroad ditch, converged into Cypress Ditch at the south city limits. Cypress Ditch discharged into Brays just upstream from the Railroad crossing over the Bayou. The North-South ditch in the Railroad right-of-way flowed from Old Richmond Road (Bissonnet) under the tracks and into Brays Bayou.

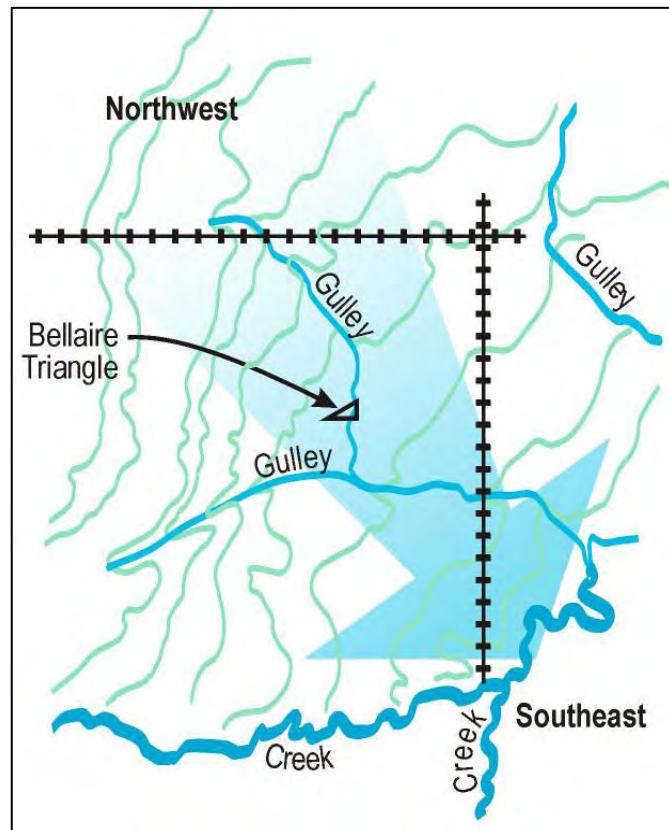


Figure 7- Natural Flow

This first drainage system was designed and constructed with the idea of a ditch and levee from the railroad to Cypress Ditch at approximately one-half mile intervals and parallel to North-South streets. The levee was placed on the east side of the ditch to confine all of the drainage from the west in this ditch. Records indicate that properties near the ditch sometimes flooded, but a large portion of the area was dry a few minutes after rain stopped. As the area developed, small laterals were constructed into the ditch from the east and most of the levee was removed. As a result, the storm water no longer was confined to the ditch into which it was supposed to flow, but overflowed to the next ditch which was not designed to handle this additional stormwater, and so on to the east side of town where the most serious flooding occurred.

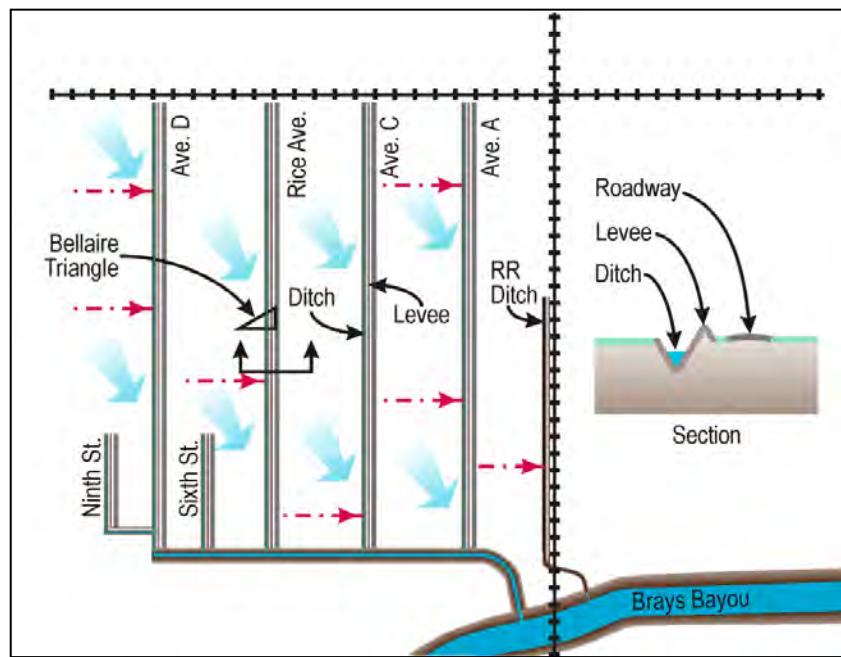


Figure 8- Early Drainage Improvements

During the early development of Bellaire, these existing surface ditches probably were sufficient to carry the floodwaters away within a few hours. However, as areas within the City of Bellaire developed from a prairie to homes and businesses with paved streets, driveways and terraced lawns, the rate of storm water runoff increased and these main drainage ditches became inadequate. The City of Bellaire and the Harris County Flood Control District attempted to improve the capacity of these main drainage ditches. However, very little was accomplished within the limited right-of-way and flat topography.

### 1.3.1 1950 Improvements

The drainage ditch overflow problem combined with the increasing development of the area prompted the City to engage a consultant to study and recommend improvements to the

drainage system. Their 1953 Drainage Master Plan recommended replacing these N/S ditches with underground trunk sewers in lieu of widening because of limited right-of-way and disruption to private property.

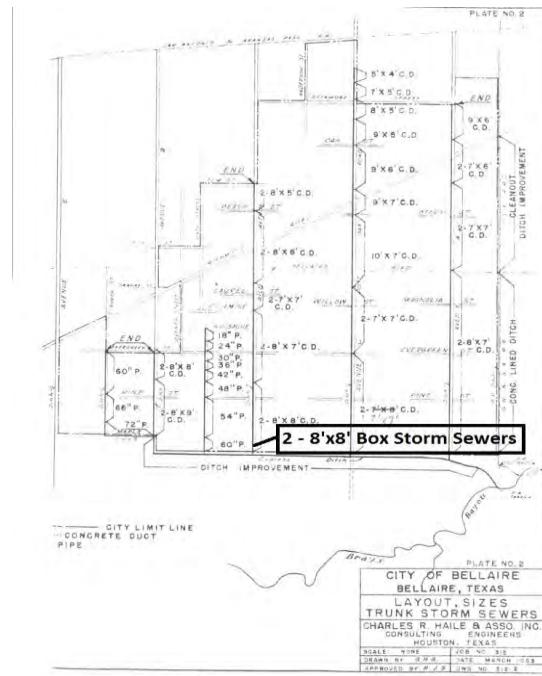


Figure 9- 1950 Drainage Improvements within City of Bellaire

The consultant recommended the following:

1. Improve Cypress Ditch from Brays Bayou to Ave. D (Chimney Rock).
2. Improve the Railroad Ditch from south city limits to Richmond Road.
3. Enclose Avenue A (Newcastle) Ditch from Cypress Ditch to Sycamore Street (Glenmont).
4. Enclose Avenue C (Post Oak Road) Ditch from Cypress Ditch to the north city limits.
5. Enclose Rice Avenue Ditch from Cypress Ditch to Elm Street.
6. Enclose Sixth Street (Ferris) Ditch from Cypress Ditch to Huisache Street.
7. Enclose Avenue D (Chimney Rock) Ditch from Maple Street to Evergreen Street.
8. And, enclose Ninth Street (Alder) Ditch from Maple to Evergreen Street.

Some of these improvements were made over the years and others were changed.

### 1.3.2 Today's System

The City's major North/South storm sewer systems that exist today include:

- 2 – 10'x12' Box Culverts on Renwick owned by the City of Houston
- A 42" Storm Sewer on Alder outfall to Maple currently being replaced with an outfall to Valerie then to S Rice.
- Double 7'x10'Boxes on Chimney Rock
- Storm Sewer on Ferris
- Double 8'x8' Boxes on S. Rice Ave.
- Double 8'x7' Boxes on Newcastle
- The Railroad Ditch
- A 96-inch monolithic storm sewer and open ditch system along the east side of Bellaire discharging to Kilmarnock Ditch east of the railroad tracks, and
- The Loop 610 system

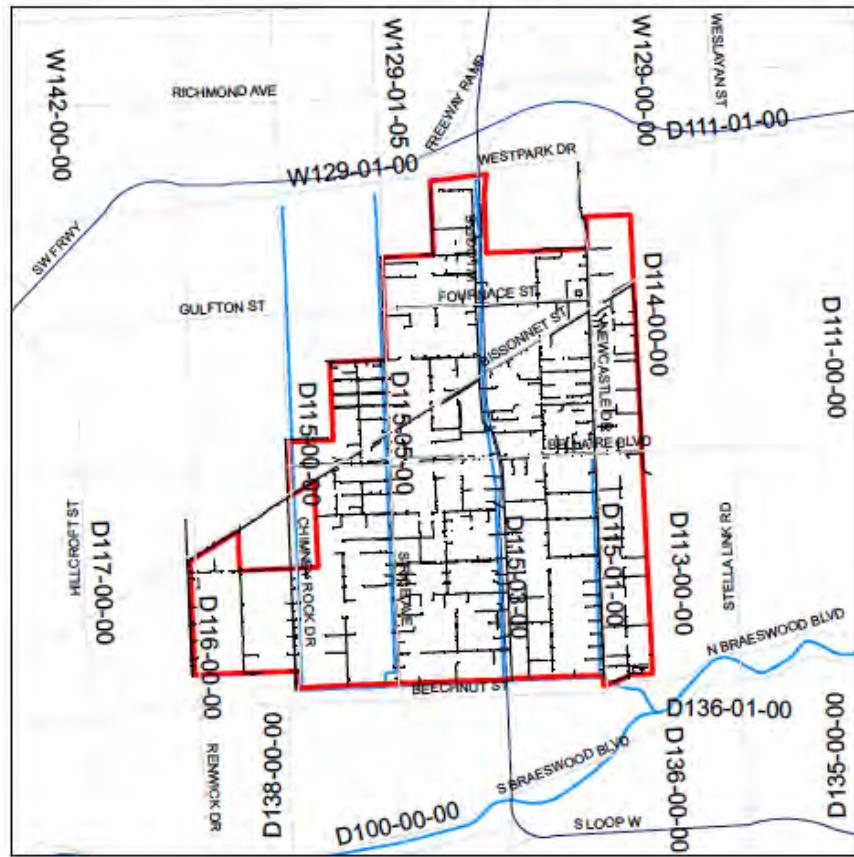


Figure 10- Today's Drainage Systems

### **1.3.3 IH 610 Drainage Improvements**

In 1965, the State of Texas replaced Post Oak Road with a freeway. The drainage system was modified to accommodate the new freeway geometrics. The overall system remained about the same size as the 1953 drainage plan had suggested. In the late 90's, the Texas Department of Transportation (TxDOT) began designing upgrades to IH 610 through the City of Bellaire. TxDOT's original plan did not include any drainage improvements. The City of Bellaire requested that the very undersized drainage system for the Loop be improved because it was inadequate for the large drainage area it served and for the simple fact that the original construction of the Loop did not consider the increased impervious cover created when the freeway replaced a much smaller road.

An agreement was reached for the City of Bellaire to partner with TxDOT to increase the capacity of the IH 610-drainage system in 2000 by adding a 10' x 10' box culvert underground system from south of Bellaire Blvd. to Cypress Ditch. The new box was constructed on the east side of the IH 610 right-of-way with 7- 48-inch reinforced concrete pipes tunneled under the freeway to provide outfall points for drainage west of IH 610.

This additional drainage structure provided improvements to the IH 610 drainage system, but not enough for the amount of storm water runoff it receives.

This system serves over 750 acres of fully developed urban drainage area. To convey and fully mitigate the 100-year storm event within the TxDOT right-of-way for this very large drainage area could require as many as 13- 10' x 10' box culverts versus the 2-10" x 10' boxes that exist today.

### **1.4 Drainage System Responsibilities**

There are many components to the drainage systems that serve Bellaire. And, there are many entities besides Bellaire that are responsible for the maintenance and improvements to these systems. These various components and system responsibilities are listed below:

- Brays Bayou – HCFCD and the US Army Corps of Engineers
- Cypress Ditch – HCFCD and the City of Houston
- Renwick Drainage System – City of Houston
- Alder, Chimney Rock, S. Rice – City of Houston and City of Bellaire
- Ferris, Englewood, Ave. B, Newcastle and Baldwin – City of Bellaire
- IH 610 – TxDOT
- 96-inch Monolithic Pipe in railroad right-of-way – City of Houston and City of West

## University

- Railroad Ditch – City of Houston and Harris County

There are many different entities responsible for the reliability and sufficiency of the drainage systems that serve the City of Bellaire requiring coordinated efforts for stormwater management.

The City of Bellaire has identified several areas of the city that frequently pond water in the street. Before major reconstruction of the old street and drainage system is planned on some streets, it is recommended that the city televise the existing storm sewer system to identify failure of the pipes and if any blockages can be addressed in ongoing maintenance projects. In some instances, the inlet capacity is found to be insufficient and can be improved at a relatively low cost.

Past inspections of drainage recommendations included removing all unnecessary pipe conflicts that run through the large North South drainage arterials and correct the two-foot off-set in the flowline of the S. Rice boxes near Bellaire High School to improve flow.

Cypress Ditch, the Railroad Ditch and the storm sewer outside the City limits require periodic maintenance or the systems become inefficient. The City of Bellaire should coordinate and ensure that these are maintained to the intended storm design capacities for conveyance.

## 1.5 Flood Insurance and Recent Flooding

The City of Bellaire participates in the National Flood Insurance Program and in the Community Rating System (CRS), a voluntary federal program that rewards communities that implement higher standards by providing discounts on flood insurance policies. Currently, there are approximately 4,780 Bellaire flood insurance policy holders and Bellaire holds a CRS classification of Class 7, which saves policy holders 15 % on their flood insurance premiums each year. Bellaire is designated as a Repetitive Loss Community and the current Floodplain map shows most of the Bellaire to be within the 1% or 100-year flood frequency limits.

Over the last 13 months, Harris County experienced six (6) significant flood events:

May 12-13, 2015  
May 25-26 2015  
Oct. 24-25, 2015  
Oct. 31 2015  
April 18 2016  
May 25-27, 2016

Each one of these events resulted in rainfall totals over eight (8) inches in portions of Harris County. Never, in modern records, has Harris County experienced such frequent back to back

flooding events. The only year that comes close is 1998 when three major floods affected the county in September (Frances), October, and November.

Two of these recent significant events caused major flooding in Bellaire. The 2015 May 25-26<sup>th</sup> flood event within the City of Bellaire resulted in approximately 220 homes being flooded. Approximately 175 homes flooded were located east of the IH 610.

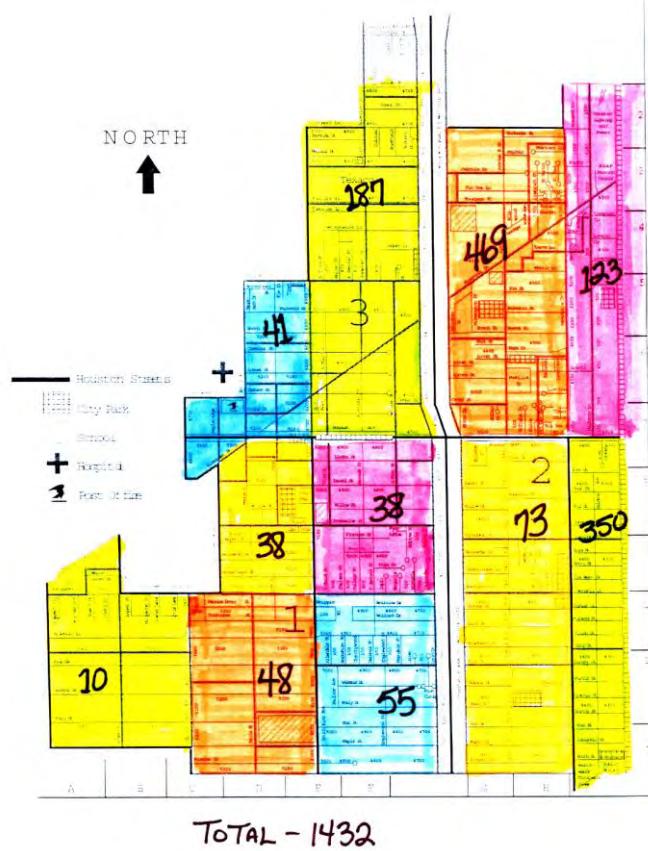


Figure 11- Structures Flooded due to Tropical Storm Allison within City of Bellaire

A review of the Tropical Storm Allison flood event documentation of the 2001 shows 1432 homes being flooded with 1015 homes flooded east of IH 610 and approximately 417 homes were flooded west of IH610. Exhibit 17 shows the historical information of some of the events where there were flooded homes. There are approximately 57 homes in City of Bellaire that can be considered as repetitive loss properties. FEMA, State and HCFCD funds may be available to purchase those properties that flood repeatedly.

## 1.6 Coordination and Discussions with Other Agencies

HCFCD is in charge of the Project Brays and anything outside the City of Bellaire involves coordination with City of Houston and subsequent studies to demonstrate that there are no downstream or upstream impacts on the receiving channels.

The following tasks are outlined for the coordination and discussions with other agencies:

1. Prepare and submit a LOMR to the HCFCD for approval to remove certain areas of the City of Bellaire from the floodplain.
2. Request TxDOT to improve the IH 610 drainage system to properly receive the existing drainage area storm water runoff and convey to Brays Bayou. The system should be increased to meet their current design criteria for a system receiving this amount of runoff from such a large drainage area.
3. Request interim improvements to the system directly adjacent to the proposed improvements associated with the US69/IH610 interchange improvements to receive the storm water runoff from the existing drainage area and meter the outfall until such time as downstream improvements are constructed as mentioned above.
4. Request the City of Houston/Texas Water Development Board/FEMA to participate in conveyance and storage capability improvements within the Chimney Rock and S. Rice Ave. drainage systems because they serve such large areas of the City of Houston as well.
5. Develop inter-local agreements with the City of Houston for future improvements and maintenance for drainage facilities that serve both entities. These agreements should consider development and detention requirement standards for any new development.
6. Request the City of Houston to consider installing back flow prevention systems like a flap gate in Cypress Ditch and the Railroad Ditch to prevent back water from Brays Bayou backing up into these systems during high water flood stages.

## **2.0 Drainage Problems and Possible Solutions**

Certain areas of the City of Bellaire are more susceptible to flooding than others because the internal underground drainage infrastructure, overland sheet flow capabilities through the street system and the receiving outfall systems are not adequate to drain intense rainfall events. In general, the overall drainage problems can be attributed to the following:

- very high average annual rainfall of about 50 inches
- very flat topography
- clay soils that do not absorb water very well
- close proximity to an undersized Brays Bayou
- large amounts of storm water from the City of Houston flow into Bellaire from the north
- localized storm water runoff from Bellaire drains into undersized drainage systems owned by the City of Houston
- Below base flood finished floor elevations of homes constructed prior to the National Flood Insurance Rate Standards.

The underground drainage infrastructure within the City of Bellaire is generally designed to carry the industry standard 2-year design storm on newer streets and much less rain events on the older streets are not capable of adequately handling the 2-year storm event. In fact, some neighborhood streets have little or no underground storm sewers.

The street system grades from one end of the City to the other are very flat and in some cases pond water during heavy rainfalls. On occasion, the ponding elevations in certain locations around the City of Bellaire reach a height that will flood structures that are built at a low elevation until the storm sewer system eventually drains the area.

The major outfalls for Bellaire are also inadequate to handle the 100-year storm event. Ideally, the major North/South systems such as IH 610, Newcastle, S. Rice and Chimney Rock should be capable of handling the 100-year event storm event. These systems currently cannot adequately handle a 2-year storm event. The Cypress Ditch drainage area is over 2,400 acres of urban runoff and should be designed to carry the 100-year event and the Project Brays does not address this limitation. Currently, the largest section of Cypress Ditch cannot adequately handle the 10-year storm event. These system inadequacies all contribute to flooding in the City of Bellaire.

The street system was originally constructed prior to current sheet flow cascading guidelines and because of the very flat topography across Bellaire is not practical to completely correct. Ideally, the street network system would be graded to an overall slope of about a 0.2% from the northwest city limit to the southeast city limit or to the top of the bank of Brays Bayou. That would be about a 30-ft. fall across Bellaire.

Brays Bayou has received significant improvements during the HCFCD and Army Corps of Engineers' Project Brays, however much more improvements are necessary to improve the bayou system to the 100-year flow capability. Bellaire should maintain pressure on HCFCD and the federal government to continue improvements to the Brays Bayou system.

The City of Bellaire does have control over their internal underground drainage systems to some degree. While Bellaire can control the size of the internal drainage systems, it is important to note that increases in the size and efficiencies of the City owned drainage systems should not cause adverse impacts to downstream property owners. With this in mind, it is recommended that the City of Bellaire selectively locate areas that pond or flood during heavy rainfall events and increase the size of underground storm sewer to store the 100-year flow volume. This would lower the height of floodwaters in a particular area by storing the water underground and releasing it slowing into existing downstream systems. The various options for this drainage study are considered are described below:

## **2.1 100-Year Level of Protection for All Drainage Systems Alternative**

Improve Brays Bayou to completely contain the 100-year storm, improve Cypress Ditch to contain the 100-year event, improve all North/South major drainage arterials to transport the 100-year storm water flows through the City of Bellaire and to Cypress Ditch or Brays Bayou and improve all local storm sewers and local street systems to convey 100-year flows to their respective outfalls. The improvements to Brays Bayou alone would cost much more than current Project Brays which is anticipated to provide a 10-year level of flood protection. The current Project Brays has an estimated price tag of over \$400 million and does not provide protection from the 100-year event. Cypress Ditch drains approximately 2,400 acres of the City of Houston and the City of Bellaire. There is insufficient right-of-way to construct an open channel section capable of carrying the 100-year event and it is estimated that a closed conduit section to accommodate the 100-year event would cost over \$80.1 million. To reconstruct all of the interior pipe systems to the 100-year level of service is estimated to cost another \$236 million. The total upgrade to the entire drainage system serving the City of Bellaire is not an economically feasible option considering the number of homes flooded during the historical major storm events previously discussed.

## **2.2 Neighborhood Detention Pond Alternative**

This alternative considers building detention ponds capable of storing flood waters generated from localized extreme storm events within each individual neighborhood. A 10-acre-ft. pond could be constructed for each 40 or so homes. The storm drainage systems would need to be improved to the 100-year capacity to transport storm water to ponds and improvements to Brays Bayou to contain the 100-year event so flood waters from the bayou would not back up into the city would be required as previously described. This option would displace homes to build detention ponds and significantly displace neighborhoods and therefore was not considered a viable option.

## **2.3 Levee System Alternative**

This option would consider constructing a levee system around the City of Bellaire similar to the levees in Fort Bend County for subdivisions located within the floodplain. The levee would prevent storm water that overtops the banks of Brays Bayou from entering or back flowing into the City from the south and block overland flow from City of Houston to the north from entering Bellaire. The City of Bellaire's internal storm sewers would operate at a 100-year level of protection with large storm water pump stations and storage areas required to prevent the localized storms from flooding the City. The storage would be required to offset the loss of floodplain storage the City of Bellaire is providing to the Brays Bayou watershed. This option would require large amounts of land within City of Bellaire, several pump stations, blocking the City of Houston off-site sheet flows into Bellaire, and changes to the road elevations exiting the City of Bellaire to drive over the perimeter levee. The levee alternative perhaps would be viable if the City of Bellaire was being developed from scratch but would not be practical to try and retrofit a levee system in a fully developed urban area.

Levee systems must meet and continue to meet minimum design, operation, and maintenance requirements to receive recognition by FEMA under the National Flood Insurance Program (NFIP) as providing protection from the 100-year flood on the Flood Insurance Rate Maps (FIRM's).

The Feasibility of an Urban Levee District which encompasses City of Bellaire was considered as an alternative to prevent the backing up of the Brays Bayou into City of Bellaire. The legislature of the State of Texas has manifested an intention to protect the public interest by establishing a centralized and coordinated method for planning and review of drainage and reclamation activity. The Levee district formation to protect the public from flooding is established under Texas Water Code Chapters 5, 16, and 57, that pertains to implement this policy by the promulgation of these sections. The TCEQ Chapter 301-Levee Improvement Districts, District Plans of Reclamation, and Levees and Other Improvements should be considered as a funding mechanism to create and implement an overall plan of improvements to reduce flooding within City of Bellaire.

The levee system around the City of Bellaire would be to prevent any areas of the City of Houston upstream of Bellaire from draining excessively into the City of Bellaire infrastructure. This levee would also prevent storm water overflowing from Brays Bayou from backing up into the city. The levee system drainage systems would be designed to convey the 100-year local rainfall event out of the levee area. Flap gates would be installed to prevent Brays Bayou overflow water from coming back into the City. Another levee option would be to include all of the areas outside the City of Bellaire that shall drain through the City of Bellaire and include as an overall Urban Levee district. This would require City of Houston cooperation and approval.

TCEQ requires the creation of a Levee District shall obtain the approval of the Harris County Commissioners Court. This Levee district if formed can levees an ad valorem tax each year on all taxable property to pay for the bonds that are used to finance the design and construction of the levee systems and other related flood control works.

## **2.4 Strategic Underground Detention Storage Recommended Alternative**

Using new technologies available, a more practical and cost effective alternative was developed to provide reasonable flood protection to the City of Bellaire. This option involved identifying potential ponding areas within the City utilizing a SOBEK 2-D model supplemented with observed flooding locations within the City of Bellaire. The 2-D complex urban drainage model analyzed different rainfall intensities to predict flooding areas.

This option would include strategically locating underground storage pipes within the existing street right-of-way within the ponding or flooding areas identified and constructed as part of new street and drainage reconstruction projects were undertaken. The typical two-year underground storm sewer pipe system constructed during the total reconstruction of a roadway improvement project would be upsized to store a 100-year localized rainfall event.

The goal would be to lower the height of the floodwaters during a localized 100-year storm event in areas where overland flow problems exist.

This underground storm sewer drainage and detention systems would limit the flow at the respective outlet to the existing conditions and not require the entire underground system downstream of these detention systems to be improved. Costly mitigation efforts for potentially increasing flows to downstream areas would also be avoided. Further discussions and description is provided in the below sections. These detention systems would replace the two-year design storm sewer systems normally used during street reconstruction on a particular block at a cost of about four (4) times that of a typical two-year design storm sewer system. These localized detention storage systems constructed by the City of Bellaire would not increase flows downstream because the outfall would be restricted to the 2-year storm flows or existing flows.

## **2.5 Backflow prevention from the storm sewer outfalls**

The City of Bellaire should consider the construction of backflow prevention systems at several of the major drainage system outfalls and any proposed improvements within the City of Bellaire where localized detention storm sewers are constructed. Back flow prevention systems prohibit back water flow from Brays Bayou backing up into these systems during high water flood stages. The feasibility of the back flow devices would be determined during the PER stage of each street and drainage reconstruction project.

## **3.0 2-D Model and Findings**

SOBEK is a program used to develop a 2-D model and offers one software environment for the simulation of all management problems in the areas of rivers and drainage systems. This allows for combinations of flow in closed conduits, open channels, rivers overland flows, as well as a variety of hydraulic, hydrological and environmental processes. An Integrated approach which combines the 1-D and 2-D modeling methods. SOBEK is a fully dynamic 2-D hydraulic model, which can be used for floodplain modeling. The SOBEK model is grid based and the solution scheme utilizes the finite difference method.

An overland flow model of SOBEK with the ground topography represented by the HCFCD LiDAR was converted to a 150-ft grid so as to encompass a wider area in determining appropriate boundary conditions and the flow patterns. A free outlet condition at the end of the LiDAR boundary represents the outfall to the boundary conditions. The 2-D model was developed to understand the potential ponding and flow patterns within the City of Bellaire.

Several rainfall intensities were studied along with the topography and anticipated flow paths to identify ponding/flooding problem areas. The 2-D model uses LiDAR land terrain and a hydraulic model component to determine potential flooding locations. This was considered as the first step in locating the drainage improvement needs.

Once the flow patterns were established and the areas of ponding or flooding identified, underground systems capable of detaining the localized 100-year storm event were determined. The size of the underground system was determined based on 100-year storm flows and a sample calculation along with the drainage area exhibit is shown in Appendix B. A description of the required detention recommended for each major drainage system is presented in the sections that follow.

The various SOBEK model videos are provided in Appendix A for various storm events which are based on the 2-inch/hr., 3-inch/hr., 4-inch/hr. and 6-inch/hr. and includes a 3-hour and 6-hour event. For example, the rainfall event of 3-inch/hr. assumes that the entire City of Bellaire experiences a rainfall of 3-inches per hour for a SOBEK model run for 12-hour duration. Similarly, a 3-inches for 3-hours translates to 3- inches of rainfall for a duration of 3 hours. Based on the runs, it is evident that there is ponding within the City of Bellaire given flow patterns.

Individual storm sewer detention locations for the 100-year flood event were identified and a preliminary cost estimate was provided based on the 2-D model video. The final location and size configuration of these storage systems should be determined during the Preliminary Engineering Phase of each street reconstruction project. The available outfall depth is critical to determine the vertical dimension of the storage system. Also during this PER stage, the detention system material type will be determined. Reinforced Concrete Boxes, Reinforced Concrete Pipe and High Density Polyethylene Pipe would be considered suitable for the detention storage systems.

The various flood event models provided in Exhibits 5 - 12 show the extent of ponding within the City of Bellaire for the various runs. These 2-D models were used in evaluating a best possible option in determining the storm sewer options which are described in Section 4.0.

Based on the above assumption and by limiting the outflow from the proposed storm sewer improvements to the existing conditions, no additional detention is required as the current release rate is maintained. The storm sewer sizes and the estimated cost are presented in the Tables section of the report. The individual storm sewer systems are shown in Exhibit 14 which shows the city wide storm sewer improvements and the basis for these improvements is an approximate 4-in/hr. rain which simulates a 100-year flood frequency event. See Exhibit 15 for the extents of ponding.

It is important to point out that model shows IH 610 acts as a barrier to the flow path and the underground system along IH 610 is not able to adequately drain the runoff, consequently, the feeder streets flood during heavy rains.

#### **4.0 Recommended Drainage System Improvements by Drainage area**

A Capital Improvement Program (CIP) to correct the ponding or flooding occurrence based on increasing the current industry standard 2-year storm sewer system to a 100-year or 1% flood

event in selected areas of the city and based on various rainfall amounts and durations was estimated on a conceptual level with associated costs. Those costs associated with each major drainage area are described in the following sections. It is important to note that partnerships with various entities should be investigated to share in the cost of those improvements that would also benefit from them.

#### **4.1 Renwick System**

The Renwick underground drainage system is owned and operated by the City of Houston with the exception of the storm sewers located in the 5400 blocks of Bellaire that drain into the Renwick system. Approximately 50 acres of Bellaire drains into the Renwick storm sewer system of various sizes (see Appendix B for the overall storm sewer map.) This area of the City of Bellaire appears to drain well even during severe storms and the SOBEK model does not indicate significant amount of ponding issues. Accordingly, no storm sewer detention improvements are proposed for this area.

#### **4.2 Alder System**

The Alder drainage system consists of an underground system that drains to the City of Houston's Maple system which then outfalls into the Chimney Rock storm sewer system. For the storm sewer sizes see Appendix B for the overall storm sewer map. Based on the Sobek model, this area of the City of Bellaire does not show significant ponding during extreme events and no storm sewer detention improvements at this time are recommended.

Currently, the Alder Drainage System is being improved during Rebuild Bellaire. The outfall is changing to Valerie St. and a direct restrictor will be added to prevent increase in downstream storm sewer flows.

#### **4.3 Chimney Rock System**

The Chimney Rock drainage system drains a significant area of the City of Houston north of Bellaire and approximately 164 acres of the City of Bellaire. The drainage area from the City of Bellaire outfalls into the Chimney Rock storm sewer system via existing storm sewer infrastructure of various sizes. See Appendix B for the overall storm sewer map. The total drainage outfall area at the Bellaire city limits near Maple St. is approximately 790 acres and outfalls from the City of Bellaire with two 7' x 10' Reinforced Concrete Box culverts to a City of Houston open ditch system and eventually flowing into Brays Bayou.

The Chimney Rock storm sewer system is undersized for the large urban watershed area currently serviced by the major trunk line that outfalls into Brays Bayou. It is estimated that the current system is not capable of carrying the two-year roadway standard design storm and furthermore, should be sized to handle the 100-year event for such a major storm sewer system. At a minimum the system should handle a 10- year event given the large drainage area

it serves. A 10-year storm system would cost approximately \$51.5 million and a 100-year storm system would cost approximately \$80.1 million. (See Tables section of the report.)

The preliminary sizes of the culverts for the trunk line are provided in the table section of the report and it is anticipated that a restrictor prior to the discharge into the receiving channel will limit the flows to the existing conditions flow rate so as not to impact the Chimney Rock ditch. The sizes and the number of the culverts would present a challenge and may be impractical because of limited road ROW. This storm outfall system would also require improvements within the lateral streets to convey the 100-year event to the Chimney Rock system.

Each contributing drainage area from the Chimney Rock storm sewer system within the City of Bellaire has been identified and is shown in Appendix B. Based on the Sobek runs that identifies ponding areas, localized storm sewer improvements are proposed and shown on the City wide storm sewer exhibit. Within this drainage area, a storm sewer designed to either a 10-year or a 100-year flood frequency capacity with appropriate inlets and other appurtenances so that the flow from this is captured within the storm sewer and released at the existing release rate is recommended. Based on the assumption, the storm sewer sizes and the estimated cost are presented in the Tables section of the report. The approximate cost is \$1.0 million for 10-year and \$1.3 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. These storm sewer improvements create underground storage systems and the flows are locally captured prior to the release into Chimney Rock storm sewer system. This should improve the local drainage issues; however, backwater effects may still flood the improved areas with these enlarged storm sewers because they are sized for the local drainage area and not overflow from outside areas. The proposed recommended storm sewer improvements solve the localized flood by storing the storm waters in the underground storage system. Regardless, the Chimney Rock storm sewer system is undersized and should be enlarged for the benefit of City of Bellaire and City of Houston.

#### **4.4 Ferris System**

The Ferris Street storm sewer system was reconstructed in 2007 during the Bellaire Millennium Renewal project. The underground system sizes are provided in Appendix B on the overall storm sewer map. The new outfall was approved by the City of Houston. The overall storm sewer system is in good shape with a few intersecting streets experiencing some ponding.

#### **4.5 S. Rice System**

This drainage area from the City of Bellaire outfalls into the South Rice storm sewer system via existing storm infrastructure of various sizes. See Appendix B for the overall storm sewer map. The S. Rice drainage system within the City of Bellaire serves approximately 507 acres of the City of Houston and 116 acres of the City of Bellaire and outfalls to Cypress Ditch with 2-8'x8' Reinforced Concrete Boxes (RCB). There is also an overflow pipe to the S. Rice ditch south of Beechnut.

The South Rice storm sewer system is undersized for the large urban watershed area currently serviced by the major trunk line that outfalls into Brays Bayou. It is estimated that the current system is not capable of carrying the roadway standard design storm and furthermore, should be sized to handle the 100-year event for such a major storm sewer system and at the minimum, a 10- year event given the large drainage area it serves. A 10-year storm system would cost approximately \$88.6 million and a 100-year storm system would cost approximately \$129.7 million. (See Tables section of the report.)

The preliminary sizes of the culverts for the trunk line are provided in the table section of the report and it is anticipated that a restrictor prior to the discharge into the receiving channel would be constructed to limit the flows to the existing conditions flow rate. The sizes and the number of the culverts would present a challenge and because of limited road ROW. A combination of conveyance pipe and mitigation storage or receiving stream improvements may be more practical. Even if this overall system was improved to receive the extreme event storm, improvements within the lateral streets would still be required for conveyance to this system.

Each contributing drainage area from the South Rice storm sewer system within the City of Bellaire has been identified and is shown in Appendix B. Based on the Sobek runs that identify ponding areas, localized storm sewer improvements are proposed and shown on the City wide storm sewer exhibit. Within this drainage area, a storm sewer designed to either a 10-year or a 100-year flood frequency capacity with appropriate inlets and other appurtenances so that the flow from this is captured within the storm sewer and released at the existing release rate is recommended. Based on the assumption, the storm sewer sizes and the estimated cost are presented in the Tables section of the report. The approximate cost is \$2.5 million for 10-year and \$2.9 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. These storm sewer improvements create underground storage systems and the flows are locally captured prior to the release into South Rice storm sewer system. This should help solve the local flooding issues; however, backwater effects may still flood the improved areas with storm sewers. The proposed recommended storm sewer improvements solve the localized flood by storing the storm waters in this underground storage system. Regardless, the South Rice storm sewer system is undersized and should be enlarged for the benefit of City of Bellaire and City of Houston.

#### **4.6 Englewood System**

The City of Bellaire's Englewood storm sewer system serves approximately 58.9 acres and with a 36-inch storm sewer outfalls into the Cypress Ditch. See Appendix B for the overall storm sewer map. Overall this system is in good shape with a few intersecting streets experiencing some ponding during severe storms.

#### **4.7 IH 610 West Loop System**

The West Loop drainage area from the City of Bellaire outfalls into the IH610 storm sewer system from the existing storm infrastructure of various sizes see Appendix B for the overall

storm sewer map. The total drainage area at the City of Bellaire limits is approximately 758.5 acres and outfalls into Cypress Ditch with 2-10' x 10' RCB.

The IH 610 freeway intercepts the off site sheet flow west of IH610 and ponding occurs at several intersections. Historically, the sheet flow was to the east of IH610 but the freeway dams the water and the cascading effect to the downstream outfall is not present. It appears that this was not considered at the time of the original design or during the 2000 design. Current TxDOT and HCFCD requirements require that the design of the storm sewer should account for the offsite areas draining into the roadway in its current development condition.

The IH610 storm sewer system should be designed to account for this offsite sheet flow. The City should request TxDOT to size this outfall for a minimum 10-year or preferably a 100-year storm sewer design to serve as a main outfall and the expected cost is \$77.8 million for 10-year and \$158.2 million for the 100-year flood frequency (see Tables section of the report.) The sizes of the culverts are preliminary and it is anticipated that a restrictor prior to discharge into Cypress ditch would limit the flows to the existing conditions flow rate.

In addition to the needed TxDOT IH 610 storm sewer improvements, the offsite sheet flows from the West Loop drainage areas should be designed based on the ponding conditions. Each contributing drainage area from IH610 within the City of Bellaire has been identified. Within this drainage area a storm sewer designed to either a 10-year or a 100-year flood frequency capacity with appropriate inlets and other appurtenances so that the flow from this designated area cascades and is captured in the storm sewer and released at the existing release rate. Based on the above assumption, the storm sewer sizes and the estimated cost are presented in the Tables section of the report the expected cost is \$29.2 million for 10-year and \$41.1 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. The cost of this storm sewer is significantly different than the overall IH610 system cost as the flows are locally captured prior to the release into the IH610 system. During the preliminary engineering, a design to limit the flows accessing this storage should be considered and includes, the weir within the storm sewer systems, roadway speed bumps to prevent the cascading water from entering the street with increased underground storage.

Recent storm events have flooded areas adjacent to IH 610 and the feeder street are impassible and inaccessible to the emergency vehicles. The City of Bellaire should partner with TxDOT to improve the IH 610 drainage system to reduce this frequent nuisance flooding.

#### **4.8 Newcastle System**

The drainage area from the City of Bellaire outfalls into the Newcastle storm sewer system via existing storm infrastructure of various sizes. See Appendix B for the overall storm sewer map. The Newcastle storm sewer system drainage area within the City of Bellaire serves approximately 572.2 acres. The total drainage outfall area at the City of Bellaire city limits is approximately 761.9 acres and outfalls to Cypress Ditch through 2-8' x 7' RCB.

The Newcastle storm sewer system is undersized for the large urban watershed area currently serviced by this major trunk line. It is estimated that the current system is not capable of carrying the roadway standard design storm and furthermore, should be sized to handle the 100-year event for such a major storm sewer system and at a minimum, a 10- year event given the large drainage area it serves. A 10-year storm system would cost approximately \$61.5 million and a 100-year storm system would cost approximately \$126 million. (See Tables section of the report.)

The preliminary sizes of the culverts for the trunk line are provided in the table section of the report and it is anticipated that a restrictor prior to the discharge into the receiving channel will limit the flows to the existing conditions flow rate. The sizes and number of the culverts would present a challenge due to limited road ROW because the lateral streets would still require storm sewer improvements to convey the extreme event flows to the underground system along Newcastle

Each contributing drainage area from the Newcastle storm sewer system within the City of Bellaire has been identified and is shown in Appendix B. Based on the Sobek runs that identify ponding areas, localized storm sewer improvements are proposed and shown on the City wide storm sewer exhibit. Within this drainage area, a storm sewer designed to either a 10-year or a 100-year flood frequency capacity with appropriate inlets and other appurtenances so that the flow from this is captured within the storm sewer and released at the existing release rate is recommended. Based on the assumption, the storm sewer sizes and the estimated cost are presented in the Tables section of the report. The approximate cost is \$27.1 million for 10-year and \$36.7 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. These storm sewer improvements create underground storage systems and the flows are locally captured prior to the release into South Rice storm sewer system. This should help solve the local flooding issues; however, backwater effects may still flood the improved areas with storm sewers. The proposed recommended storm sewer improvements solve the localized flood by storing the storm waters in this underground storage system.

#### **4.9 Railroad 96-inch Storm Sewer System**

The drainage area east of the Newcastle system and north of Bellaire Blvd. outfalls as individual storm sewer systems into a 60-inch to 96-inch monolithic storm sewer system within the Southern Pacific Railroad ROW and is designated as HCFCD Unit No. D113-00-00. This system of monolithic pipes begins south of Bissonnet and runs south along the west side of the railroad tracks. Approximately 500 feet south of Bellaire Blvd., this storm sewer turns southeast under the tracks and outfalls to Kilmarnock Ditch owned by West University Place. This pipe and ditch system should be studied in a joint venture with West University Place for potential improvements benefiting both cities.

For the existing storm sewer of various sizes see Appendix B for the overall storm sewer map.

Based on the Sobek runs this area has substantial ponding and as such storm sewer improvements are needed. The storm sewers are proposed on Mulberry and other lateral streets as shown on the City wide storm sewer improvements exhibit.

Each contributing drainage area to the Southern Pacific Railroad storm sewer system within the City of Bellaire has a designation identified in the preliminary cost calculations tables. Within this drainage area, a storm sewer designed to either a 10-year or a 100-year flood frequency capacity with appropriate inlets and other appurtenances so that the flow from this designated area cascades and gets captured in the storm sewer and released at the existing release rate. Based on the above assumption, the storm sewer sizes and the estimated cost are presented in the Tables section of the report the expected cost is \$2.1 million for 10-year and \$2.9 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. These storm sewer improvements create underground storage systems and the flows are locally captured prior to the release into the outfall pipe. This should help solve the local flooding issues but the backwater effects of Brays Bayou could at times flood this area. During the preliminary engineering report stage of the reconstruction projects, a design to limit the flows accessing this additional storm sewer storage should be considered and includes, the weir within the storm sewer systems, roadway speed bumps to prevent the cascading entering the street with increased underground storage.

#### **4.10 Southdale Drainage Systems**

The drainage area east of the Newcastle system and south of Bellaire outfall as individual systems into the Southern Pacific Railroad ditch which is HCFCD Unit No. D113-00-00. This is a concrete lined open channel beginning at lone St. and drains south towards North Braeswood Blvd. This ditch outfalls into two 6' culverts and merges with Kilmarnock Ditch before emptying into Brays Bayou. The ditch, when kept free from debris, actually has an approximately 10- year capacity, but is greatly influenced by the water surface elevation in Brays Bayou. It is important that Bellaire develop an arrangement with Harris County to periodically clean this ditch and explore the possibility of placing back flow prevention devices on the outfall structures to prevent backwater from flowing into Southdale. For the existing storm sewer of various sizes see Appendix B for the overall storm sewer map.

The Baldwin Ave. extreme event storm sewer will be the primary drainage system for Southdale after all the intersecting streets have been reconstructed. It should be noted that additional inlets at the intersecting streets may be required to convey the extreme event storm water into the new system under Baldwin. Citizens on Mildred have suggested that their street floods more now, after the Baldwin system was constructed. A preliminary analysis indicates that there is a low area on Baldwin at the Mildred/Verone St. area that may collect overland flow storm water from areas to the north before overtopping a high point on Baldwin to the south. This may be corrected by adding additional inlets at the intersecting streets to allow runoff to enter the large underground pipe system.

There are some storm sewer improvements which the City has undertaken and as such the Sobek runs identify isolated ponding areas and these ponding areas need some storm sewer improvements.

The model identified the need to place several detention system pipes under various streets within Southdale to lower the water ponding height during severe storms. The storm sewer sizes and the estimated cost are presented in the Tables section of the report the expected cost is \$0.7 million for 10-year and \$0.9 million for the 100-year flood frequencies. Exhibit 13 shows the proposed location of these storm sewer improvements. These storm sewer improvements create underground storage systems and the flows are locally captured prior to the release into Southern Pacific Railroad ditch or Baldwin storm sewer system. This should help solve the local drainage issues but the ditch may overtop from the banks and flood the streets given the backwater of the Brays Bayou. During the preliminary engineering report stage of the reconstruction projects, a design to limit the flows accessing this additional storm sewer storage should be considered and includes, the weir within the storm sewer systems, roadway speed bumps to prevent the cascading entering the street with increased under ground storage.

#### **4.11 Cypress Ditch**

Cypress Ditch is the primary channel that carries storm water runoff from the City of Bellaire to Brays Bayou. Cypress Ditch flows eastward from its upstream end located about 50-feet east of Chimney Rock and outfalls into Brays Bayou about one-half mile west of Stella Link. The ditch is located outside the City of Bellaire and in the City of Houston. The ditch is concrete lined from its outfall at Brays Bayou to a point about 50-feet west of South Rice Avenue. Under the S. Rice Ave. Bridge, directly opposite the storm sewer outfall to Cypress Ditch, is an 84-inch diameter diversion pipe which outfalls to the S. Rice Ave. open ditch beginning south of Beechnut. Records indicate the Ditch is located within a street right-of-way dedicated for the passage of pedestrians and vehicles only. It is owned and operated by the City of Houston.

The HCFCD has stated they are not responsible for Cypress Ditch. Cypress Ditch computed flows from FEMA models show that a flow of approximately 1.5 cfs per acre was used which is not consistent with the highly urbanized developed flows into the Cypress Ditch. A cursory review of the existing HEC-HMS model indicates the drainage area for the Cypress Ditch is 2,387.2 acres and the computed flow for the 100-year flow is 2379.9 cfs and the 10-year flow is 1368.6 cfs. This translates into 1cfs/ac for this highly urbanized system. This HEC-HMS flow computed is not consistent with the developed flows. The above information is presented to aid future HCFCD mapping updates so that appropriate modeling method is used to depict the flows from this area to properly document the flooding risks.

Cypress Ditch does not have adequate ROW to convey the expected flows. For example, an earthen channel receiving this much runoff would require approximately 300 feet of ROW. Alternatively, a closed RCB for the 10-year and the 100-year sizes were estimated and cost is presented in the Tables section of the report the expected cost is \$51.5 million for 10-year and

\$80.1 million for the 100-year flood frequencies. To consider any of these improvements, regional participation for funding and implementation must be discussed.

#### **4.12 Summary of Recommendations**

The recommended storm sewer systems that outfall into the Chimney Rock Rd. system the preliminary estimated cost is \$1.3 million, similarly the South Rice system the preliminary estimated cost is \$2.9 million, West Loop system the preliminary estimated cost is \$41.1 million, Newcastle system the preliminary estimated cost is \$36.7 million, Rail Road system area north of Bellaire Blvd. \$2.9 million and Southdale system \$0.9 million. The anticipated benefits from the storm sewer detention improvements is shown in Exhibit 16 and the reduced depth from flooding during the 100-year localized rainfall is approximated to be between half a foot to 1 ½ reduction depending on the drainage area. Some consideration for preventing sheet flow from outside the drainage areas is recommended during the Preliminary Engineering Report phase.

This preferred option would be focused on reducing the localized flooding events and would not prevent flood waters from Brays Bayou from flowing back into the City as water surface elevations in the bayou reached flood stages or exceeded the top of banks. It is suggested that the City consider the viability of building backflow systems such as flap gates within the large North/South drainage arterials to help prevent back water flows from the bayou from taking up the capacity of Bellaire's local systems.

It is also recommended that Bellaire continue to require the finished floors of new structures to be built above the base flood elevation. The vast majority of homes flooded during the recent storms were older homes constructed at a low elevation compared to the surrounding land.

### **5.0 Floodplain Re-Mapping**

The existing current FEMA flood Insurance Map is attached as Exhibit 3. A description of the floodplain and re-mapping is described in below sections.

#### **5.1 Current FEMA Models**

The existing current FEMA flood Insurance Map was prepared by the current available Hydrological and Hydraulic models. A cursory review of the mapping and the models indicates that seven (7) FEMA designated HEC-RAS cross sections define the floodplain west of IH610. The elevation change is approximately 2.75-feet from IH610 Bridge upstream to the city limits which is approximately a mile upstream. Within the City of Bellaire, the FEMA elevation change is approximately 4.4-feet that translating into 2.75-ft on the west side of IH 610 and 1.35-ft east side of IH 610. Based on the documented damages for the various events, the majority of the flooding damage within the Bellaire occurs east of IH610. This documented difference when compared with the FEMA models and mapping reveal that the Hydraulic models have encroachments stations modeled which may artificially increase the water surface elevations

west of IH610. The floodplain mapping through the urban developed areas should reflect the spatial ground realities like presence of the buildings and other obstructions that prevent the the flood waters travelling backwards through these obstructions which is not currently accounted for in the existing floodplain mapping.

## **5.2 HCFCD Project Brays Re-Mapping**

HCFCD has indicated they will consider this new information during their planned remapping effort of the floodplain to reflect improvements completed to date because of Project Brays. Project Brays is an over \$400 million major flood control project being undertaken with the Corps of Engineers with major improvements already completed and providing benefits to the Brays Bayou watershed. The HCFCD plans to begin a new floodplain mapping project in 2017 to show the reduction in floodplain realized due to the ongoing construction of Project Brays. This remapping effort by the HCFCD could take a minimum of five years to complete, because it must be approved by FEMA.

## **5.3 City of Bellaire Letter of Map Revision**

On a more immediate basis and as recommended by this study, the City of Bellaire is currently developing a Letter of Map Revision report that will be submitted to the HCFCD to potentially remove certain areas within the City of Bellaire from the floodplain as shown on the existing FEMA maps. The current floodplain maps do not reflect the spatial ground realities like the presence of buildings, fences and other obstructions that can prevent flood waters from flowing back into the City of Bellaire when flood water elevations exceed the capacity of Brays Bayou. This remapping effort will attempt to remove properties from the flood plain showing the backwater flow to be through the street system versus through the obstructions. If this remapping effort is successful and approved by the HCFCD and FEMA, many Bellaire properties will be removed from the mapped 100-year floodplain, thus providing significantly lower flood insurance premiums for those citizens of Bellaire.

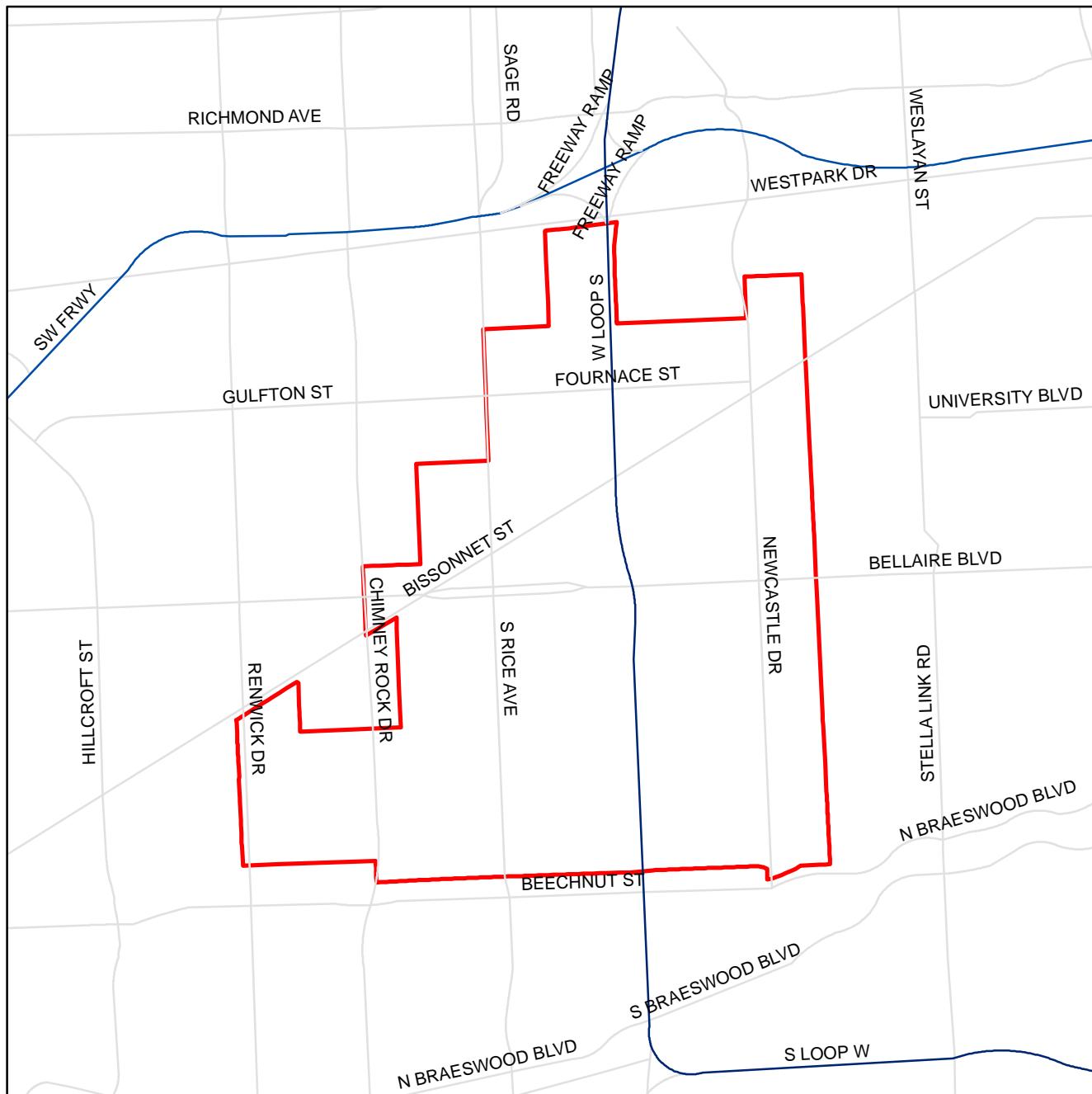
This immediate effort to remap the FIRM will be submitted directly to the HCFCD as the local FEMA designated partner. Possibly as soon as four (4) months after the letter of map revisions are submitted to the HCFCD, the revised maps may be used to determine lower insurance premiums for those citizens located in the affective area.

## **6.0 Recommendations**

Based on the drainage study investigations, it is recommended that the City of Bellaire consider the following:

1. Construct local underground storage systems by increasing the normal two-year design storm sewer system to store the 100-year storm volumes at selected strategic locations.

2. Construct backflow prevention systems at several of the major drainage system outfalls like the Newcastle and IH 610 system outfalls to Cypress Ditch to prevent back water flow from Brays Bayou backing up into these systems during high water flood stages.
3. Prepare and submit a LOMR to the HCFCD for approval to remove certain areas of the City of Bellaire from the floodplain.
4. Request TxDOT to improve the IH 610 drainage system to properly receive the existing drainage area storm water runoff and convey to Brays Bayou. The system should be increased to meet their current design criteria for a system receiving this amount of runoff from such a large drainage area.
5. Request interim improvements to the system directly adjacent to the proposed improvements associated with the US69/IH610 interchange improvements to receive the storm water runoff from the existing drainage area and meter the outfall until such time as downstream improvements are constructed as mentioned above.
6. Request the City of Houston/Texas Water Development Board/FEMA to participate in conveyance and storage capability improvements within the Chimney Rock and S. Rice Ave. drainage systems because they serve such large areas of the City of Houston as well.
7. Develop inter-local agreements with the City of Houston for future improvements and maintenance for drainage facilities that serve both entities. These agreements should consider development and detention requirement standards for any new development.
8. Request the City of Houston and/or City of West University Place to consider installing back flow prevention systems in Cypress Ditch and Kilmarnock Ditch to prevent back water from Brays Bayou backing up into these systems during high water flood stages.
9. Remove existing identified utility conflicts where possible.



**Legend**

City of Bellaire

**mjroad\_n83**

St.

**HWY\_NO**

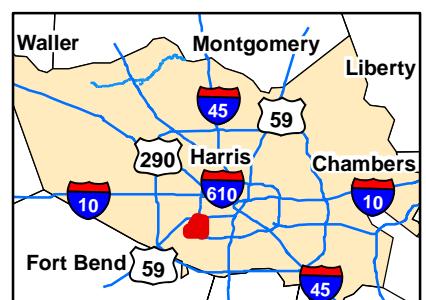
59

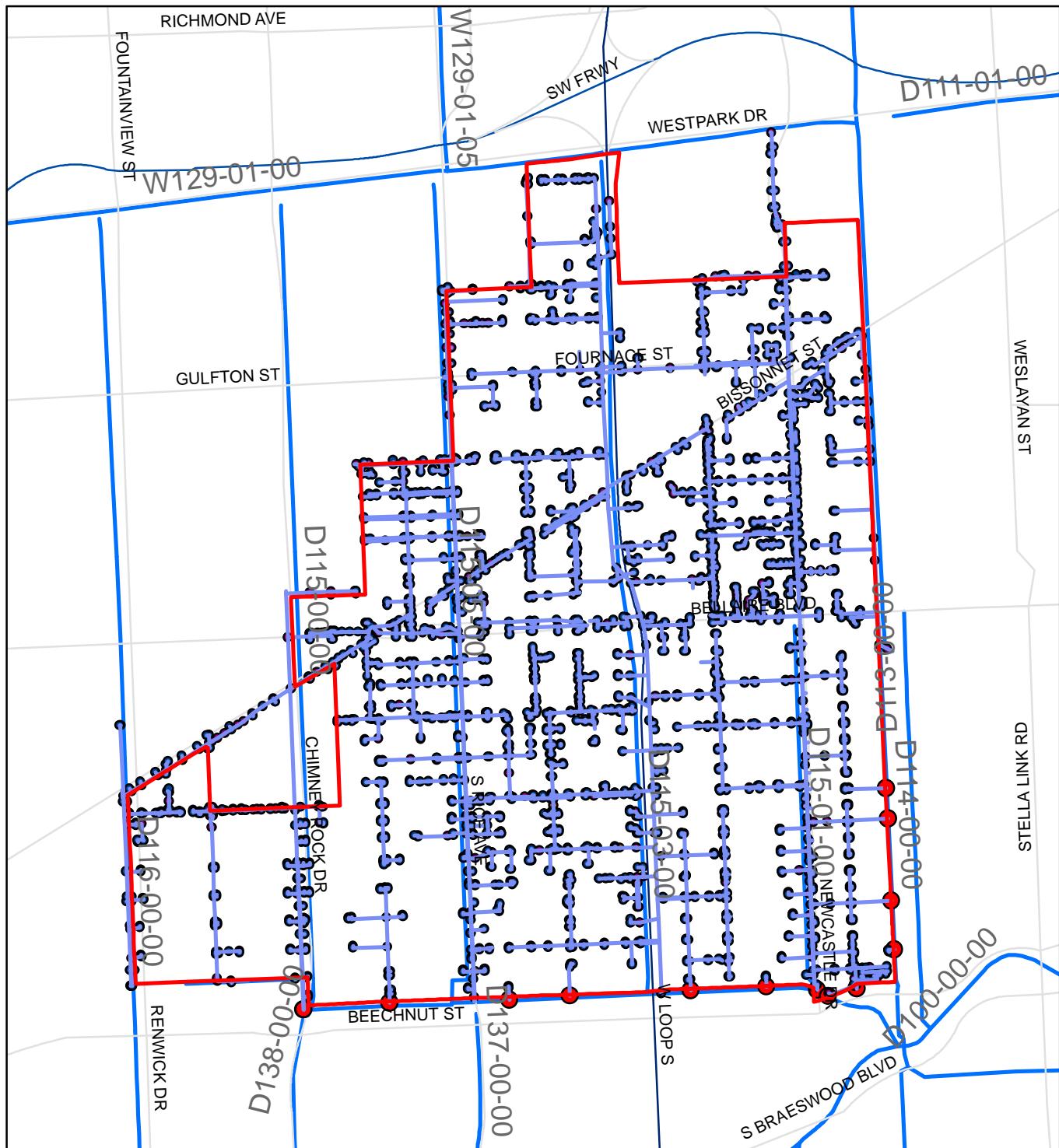
610

## City of Bellaire Drainage Study

### City Limits and Location Map

# EXHIBIT 1



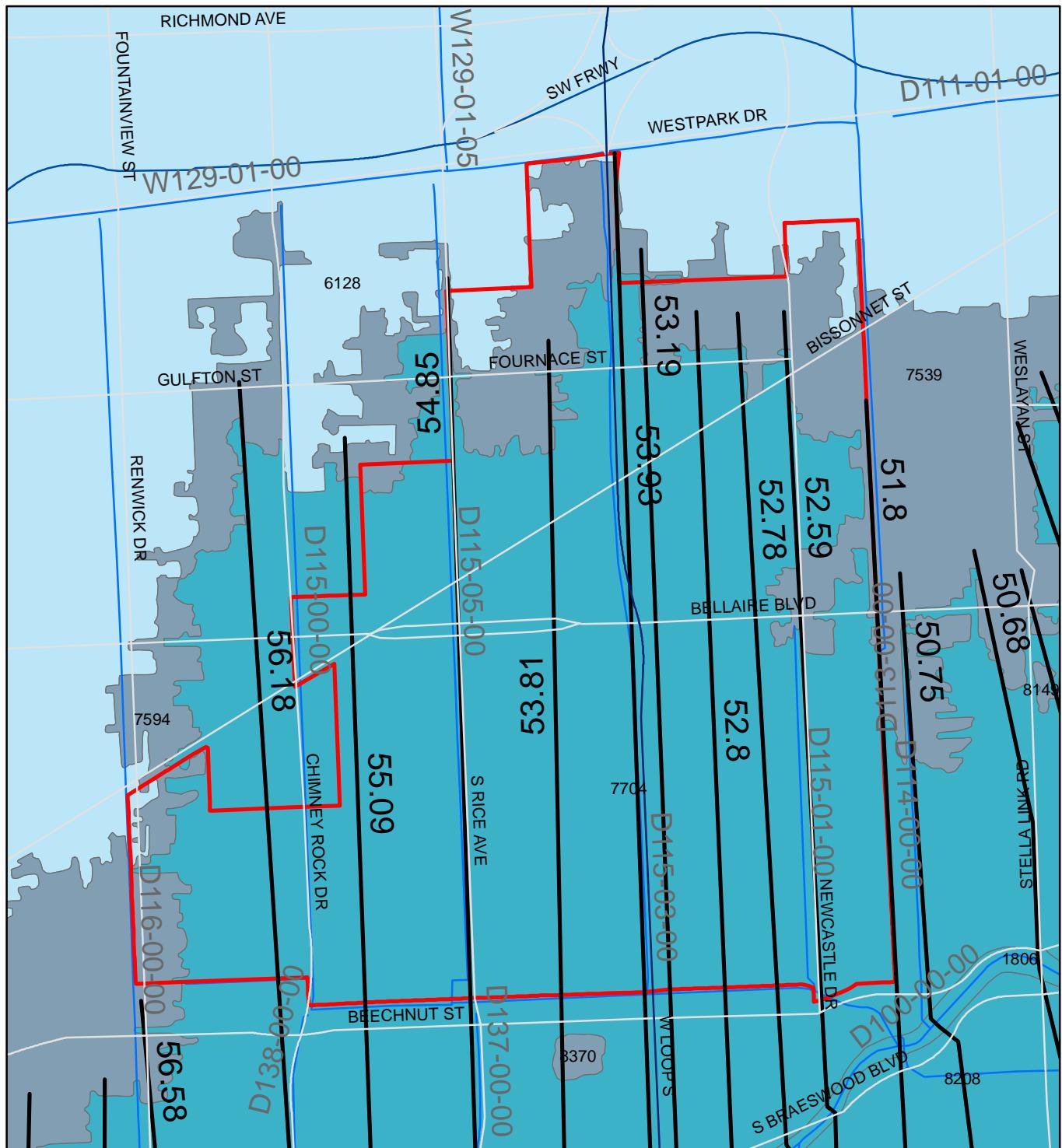


**Legend**

- City of Bellaire
- Outfall
- Manholes\_Storm
- JunctionBoxes
- Inlets
- STMains
- cap2000\_n83

**City of Bellaire Drainage Study**  
**City of Bellaire Drainage Systems**

**EXHIBIT 2**



#### Legend

— FEMA Base Flood Elev.

■ City of Bellaire

— cap2000\_n83

#### FLD\_ZONE

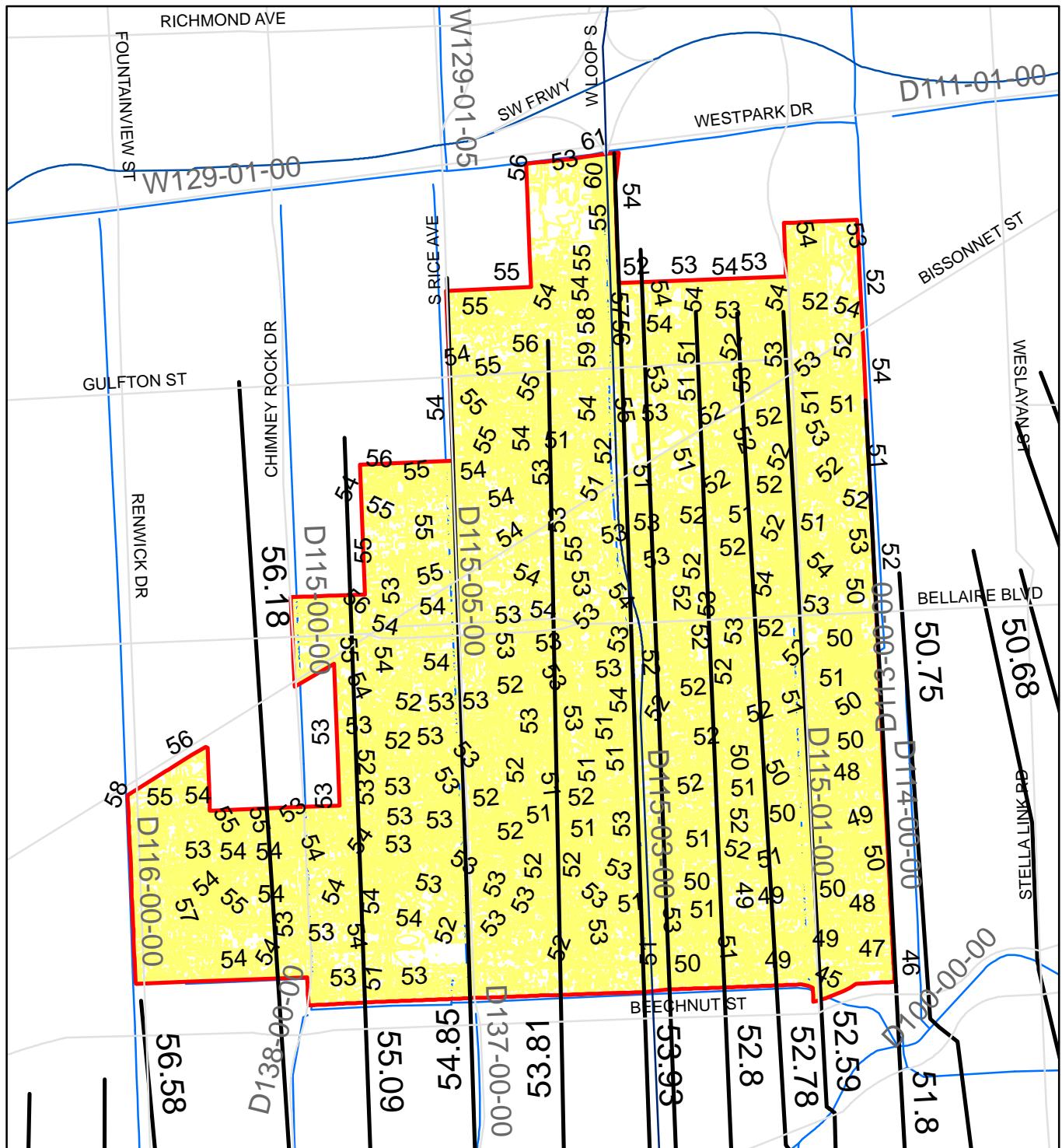
■ 0.2 PCT ANNUAL CHANCE FLOOD HAZARD

■ AE

■ X

## City of Bellaire Drainage Study FEMA FIRM MAP

### EXHIBIT 3



# **City of Bellaire Drainage Study**

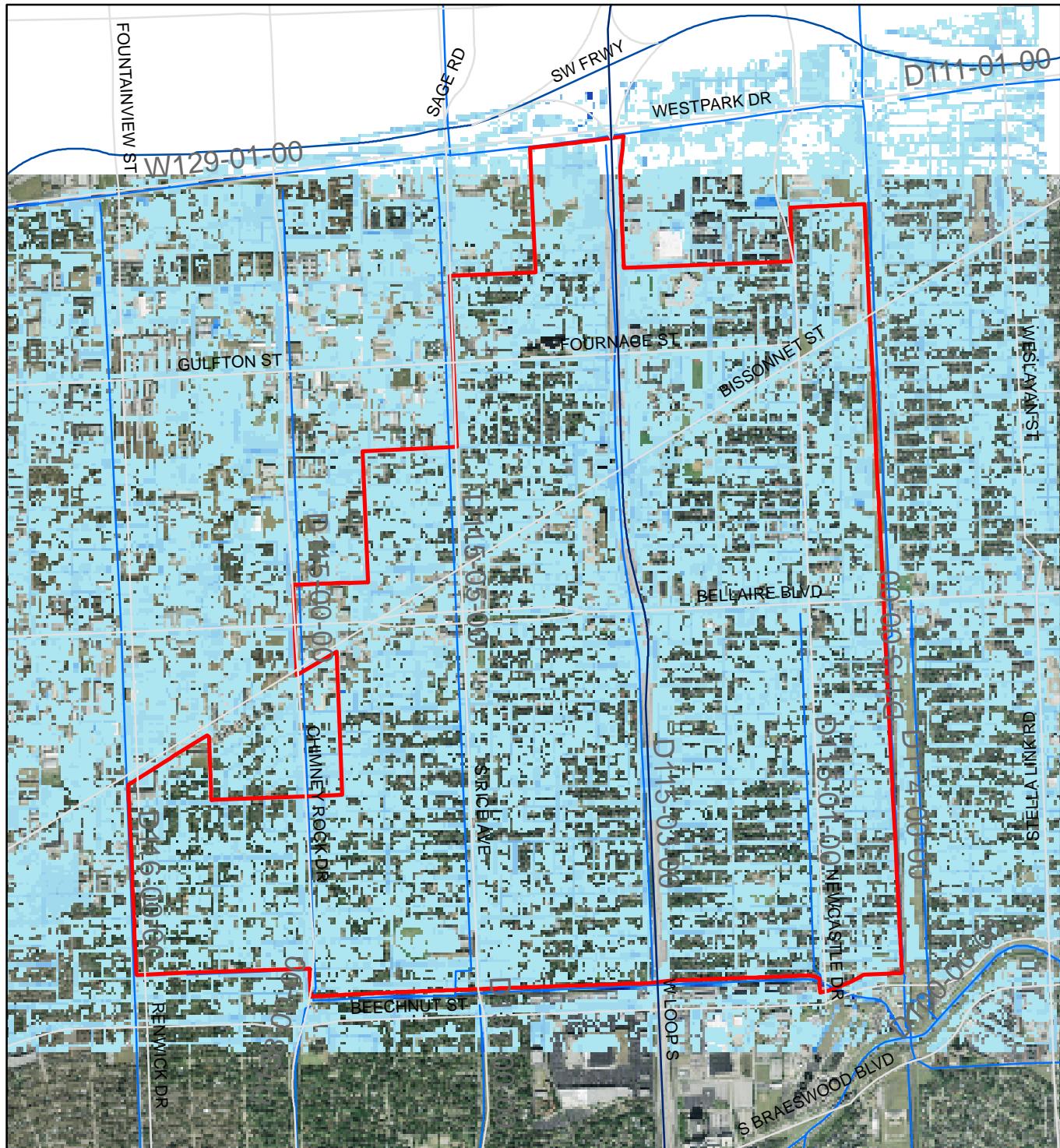
## **Contour Map and Base Flood Elevations**

## Legend

— FEMA Base Flood Elev.  
□ City of Bellaire  
— cap2000\_n83  
— B\_CONTOUR\_Clip

# EXHIBIT 4



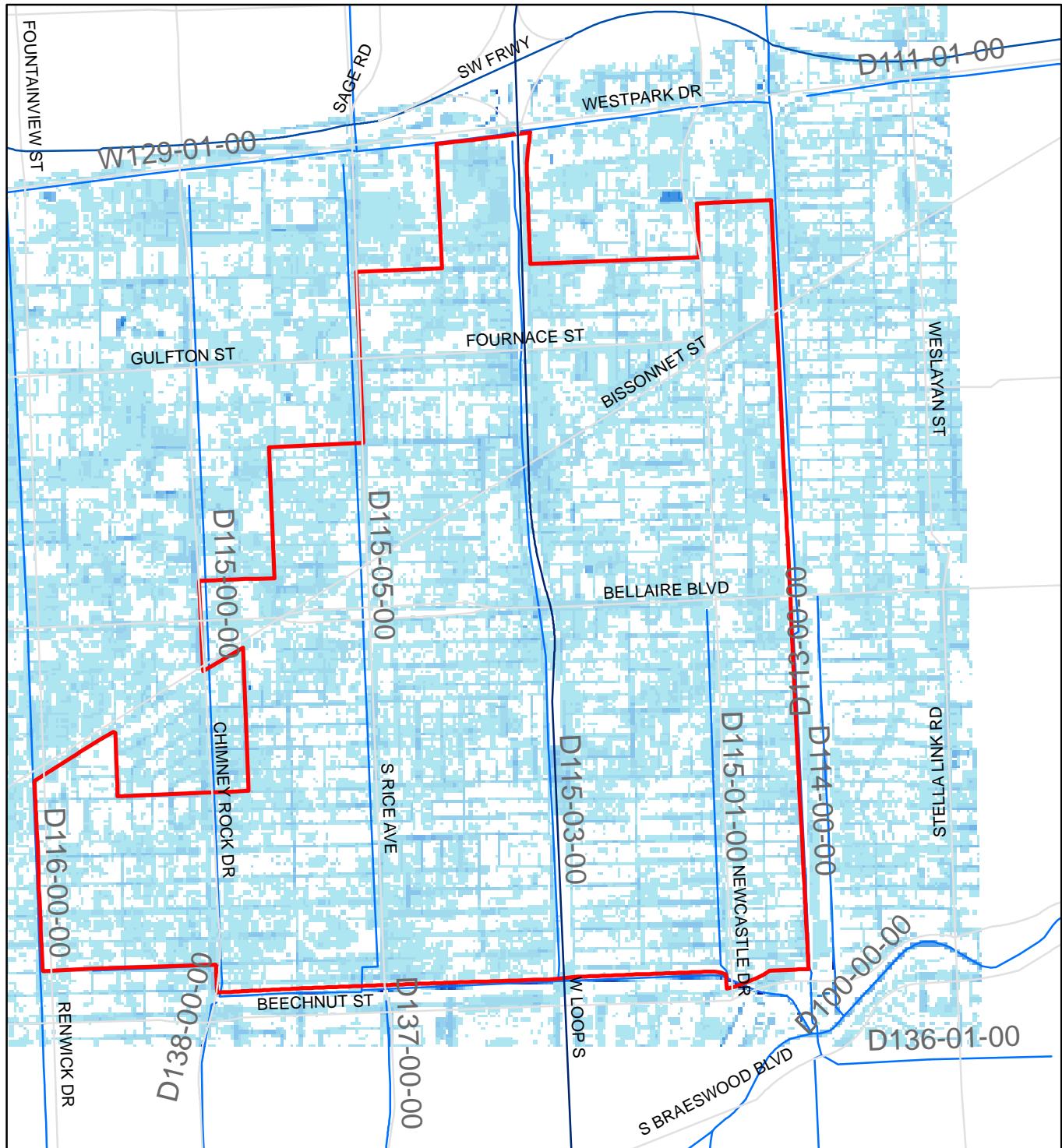


**City of Bellaire Drainage Study**  
**Results of flooding above 0.5-foot from 2-D Model**  
**for 6-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 5**

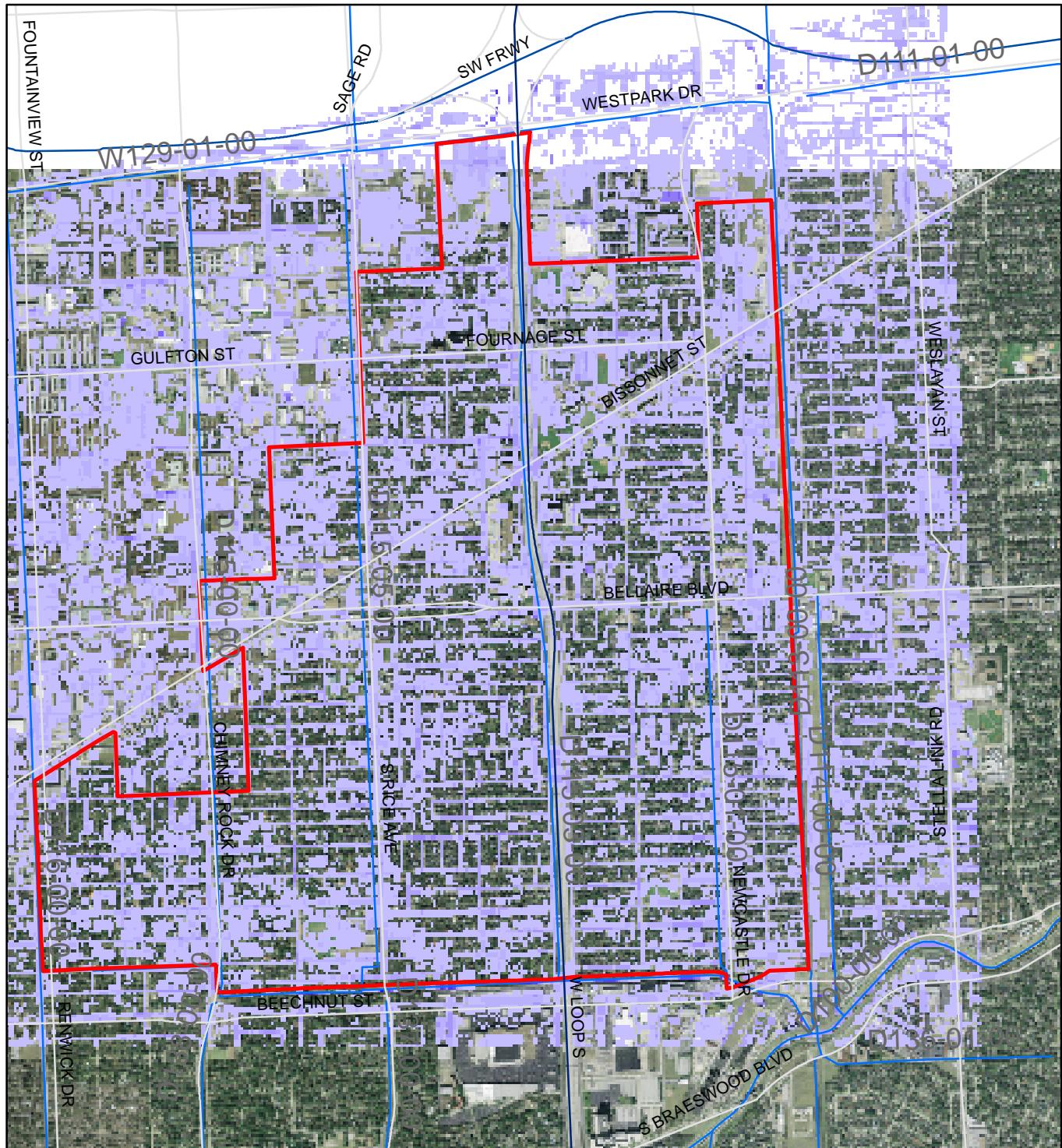


**City of Bellaire Drainage Study**  
**Results of flooding from 2-D Model**  
**for 6-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 6**

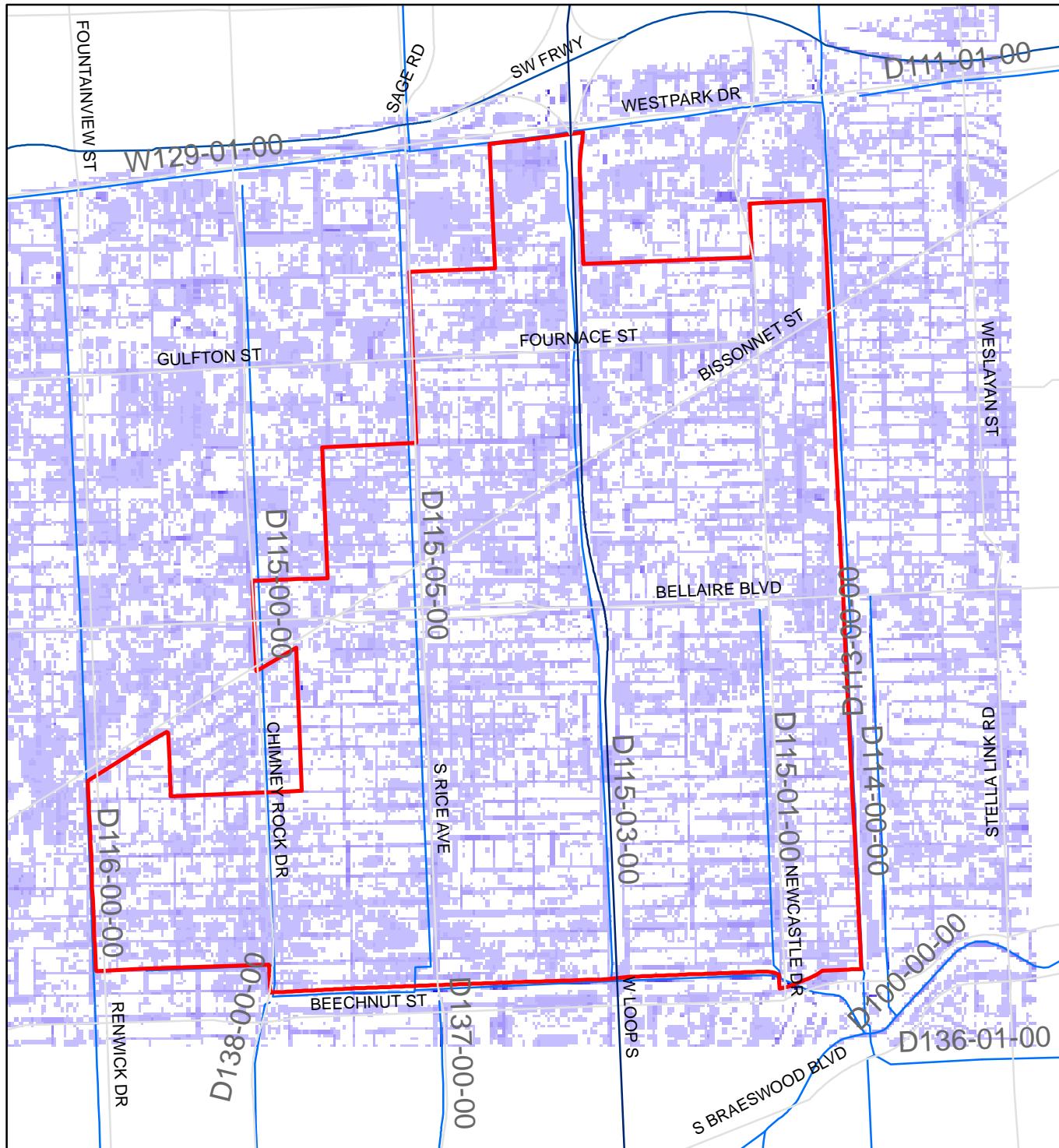


**City of Bellaire Drainage Study**  
**Results of flooding above 0.5-foot from 2-D Model**  
**for 4-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 7**

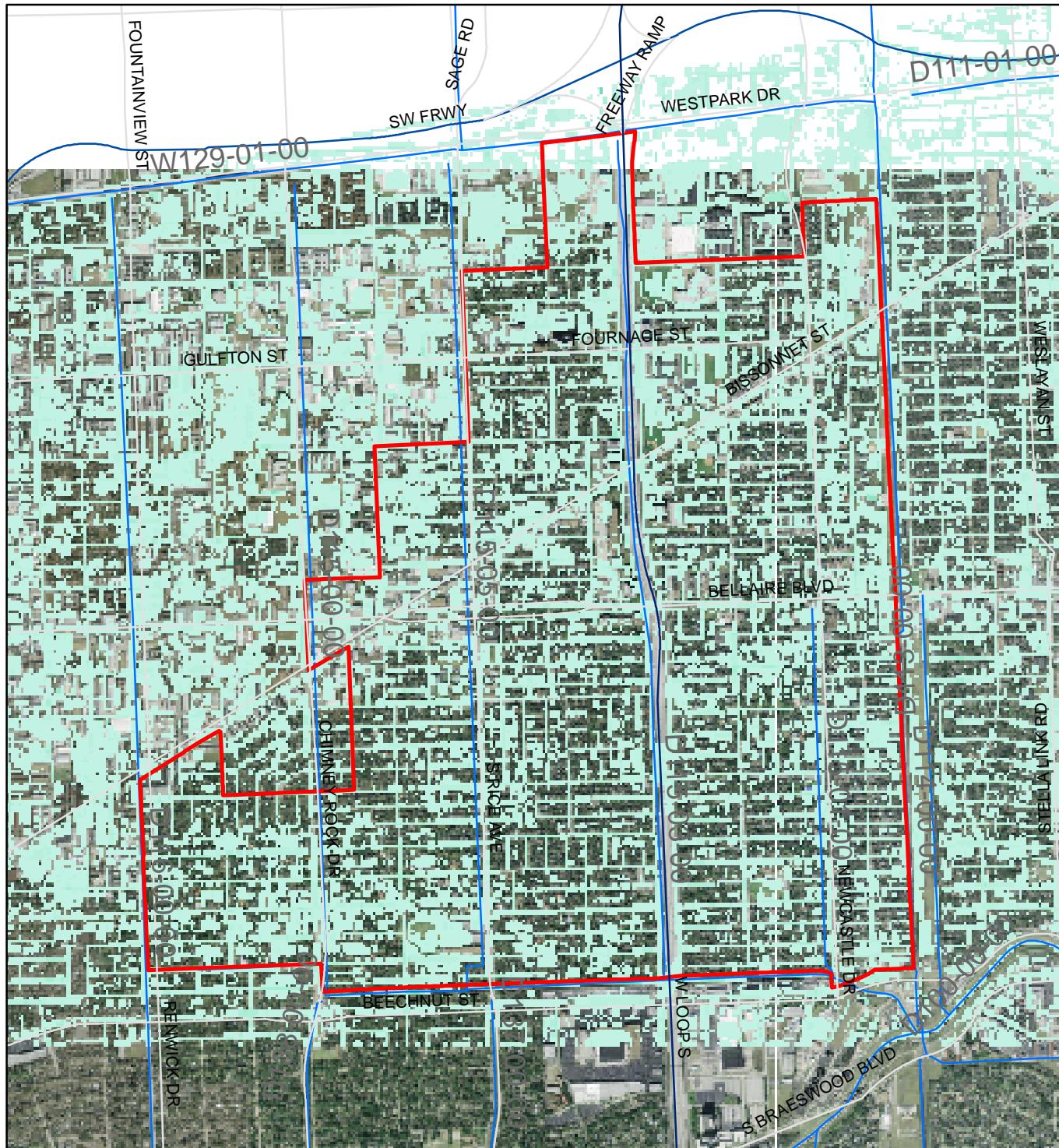


**City of Bellaire Drainage Study**  
**Results of flooding from 2-D Model**  
**for 4-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 8**

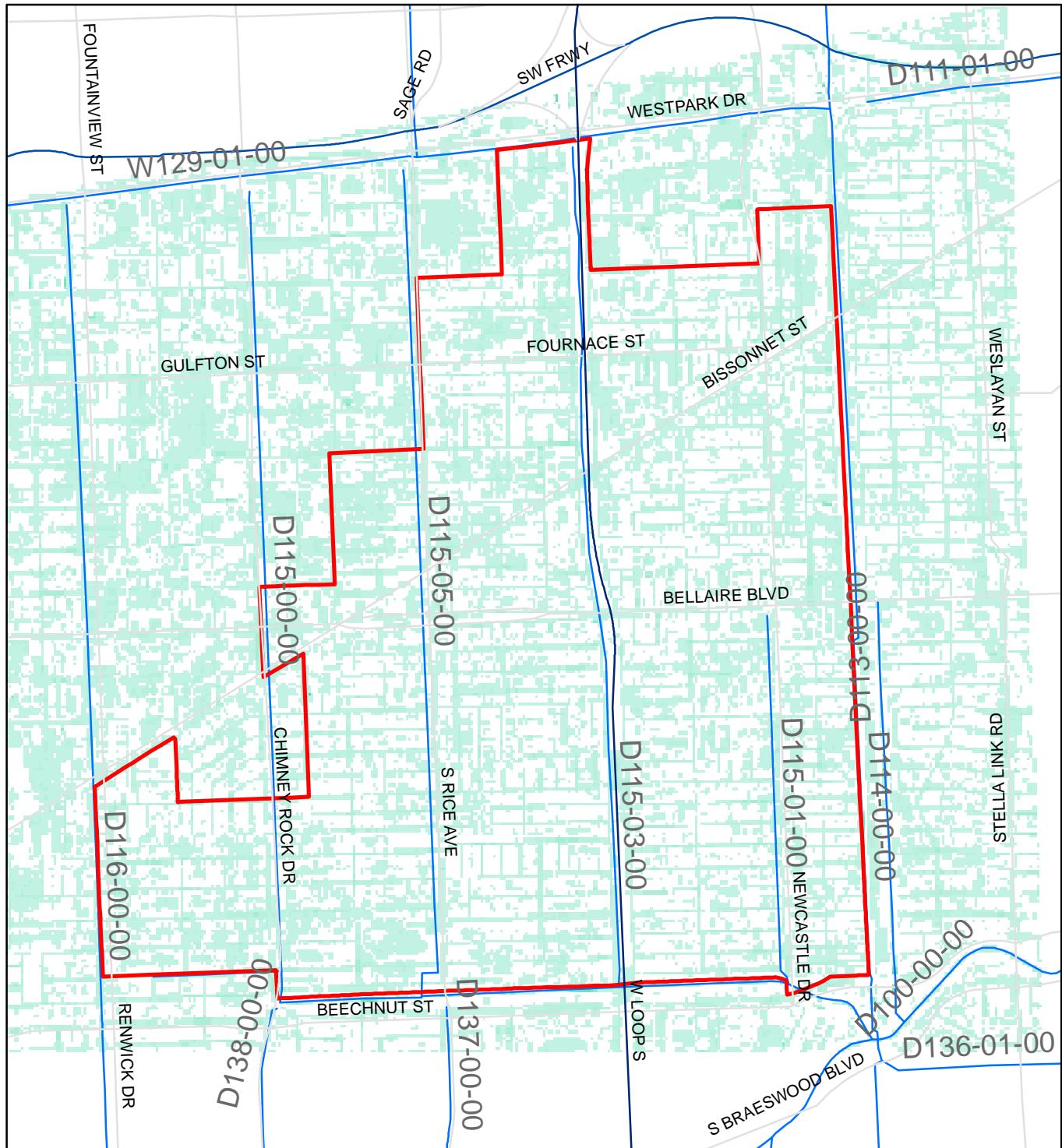


**City of Bellaire Drainage Study**  
**Results of flooding above 0.5-foot from 2-D Model**  
**for 3-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 9**

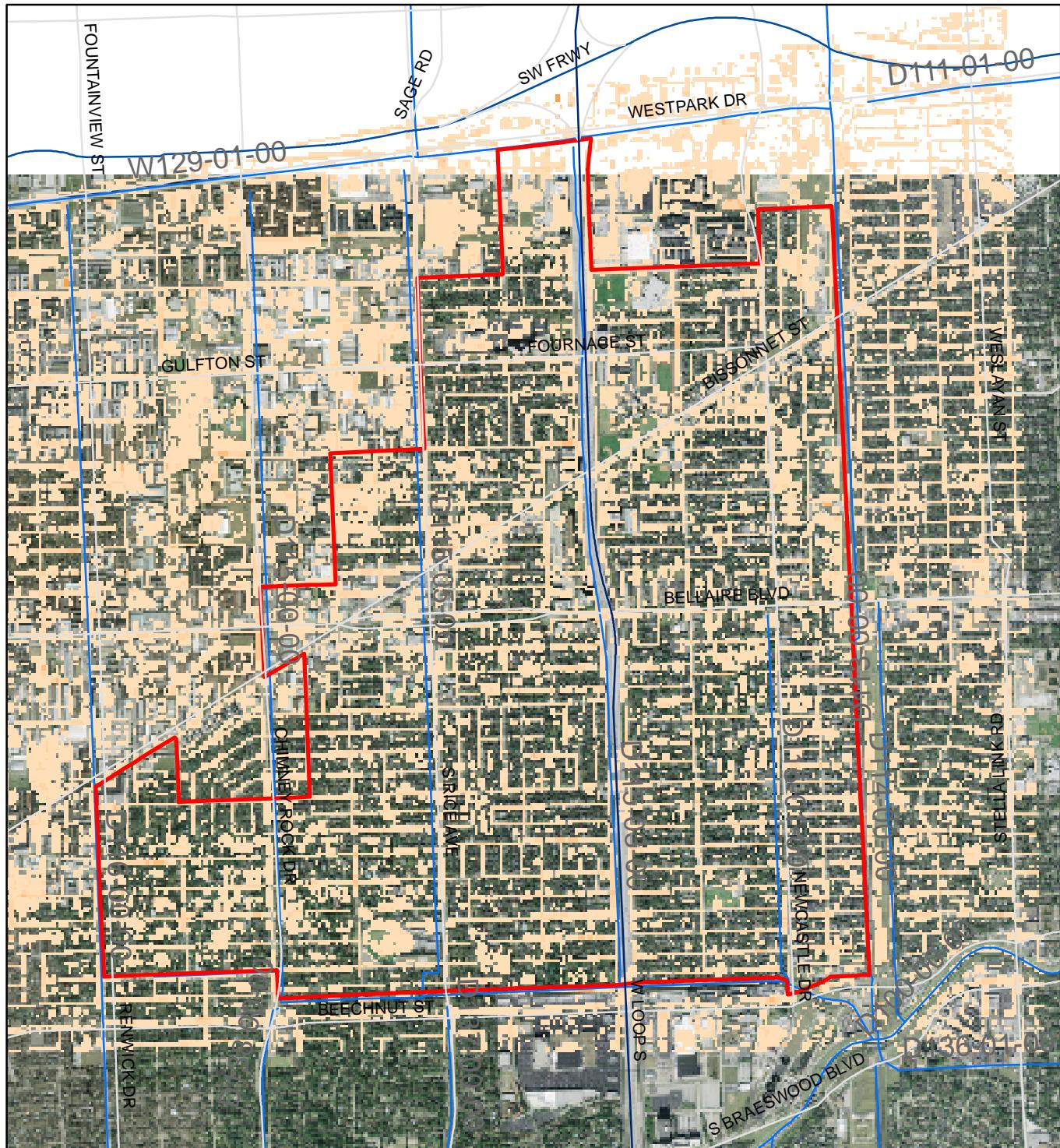


**City of Bellaire Drainage Study**  
**Results of flooding from 2-D Model**  
**for 3-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 10**

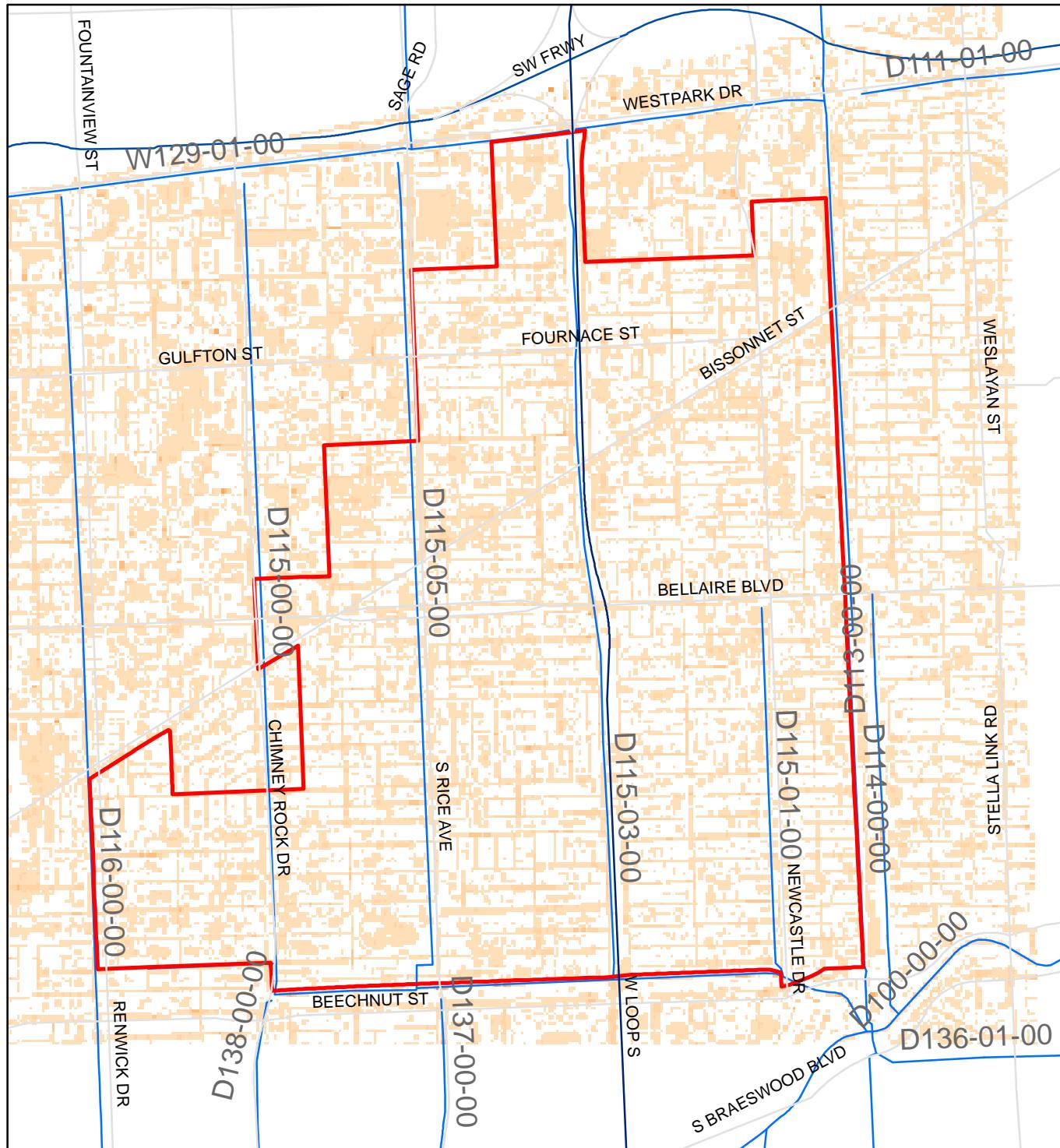


**City of Bellaire Drainage Study**  
**Results of flooding above 0.5-foot from 2-D Model**  
**for 2-in/hr Rainfall-Low areas with water**

**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 11**



**City of Bellaire Drainage Study**  
**Results of flooding from 2-D Model**  
**for 2-in/hr Rainfall-Low areas with water**

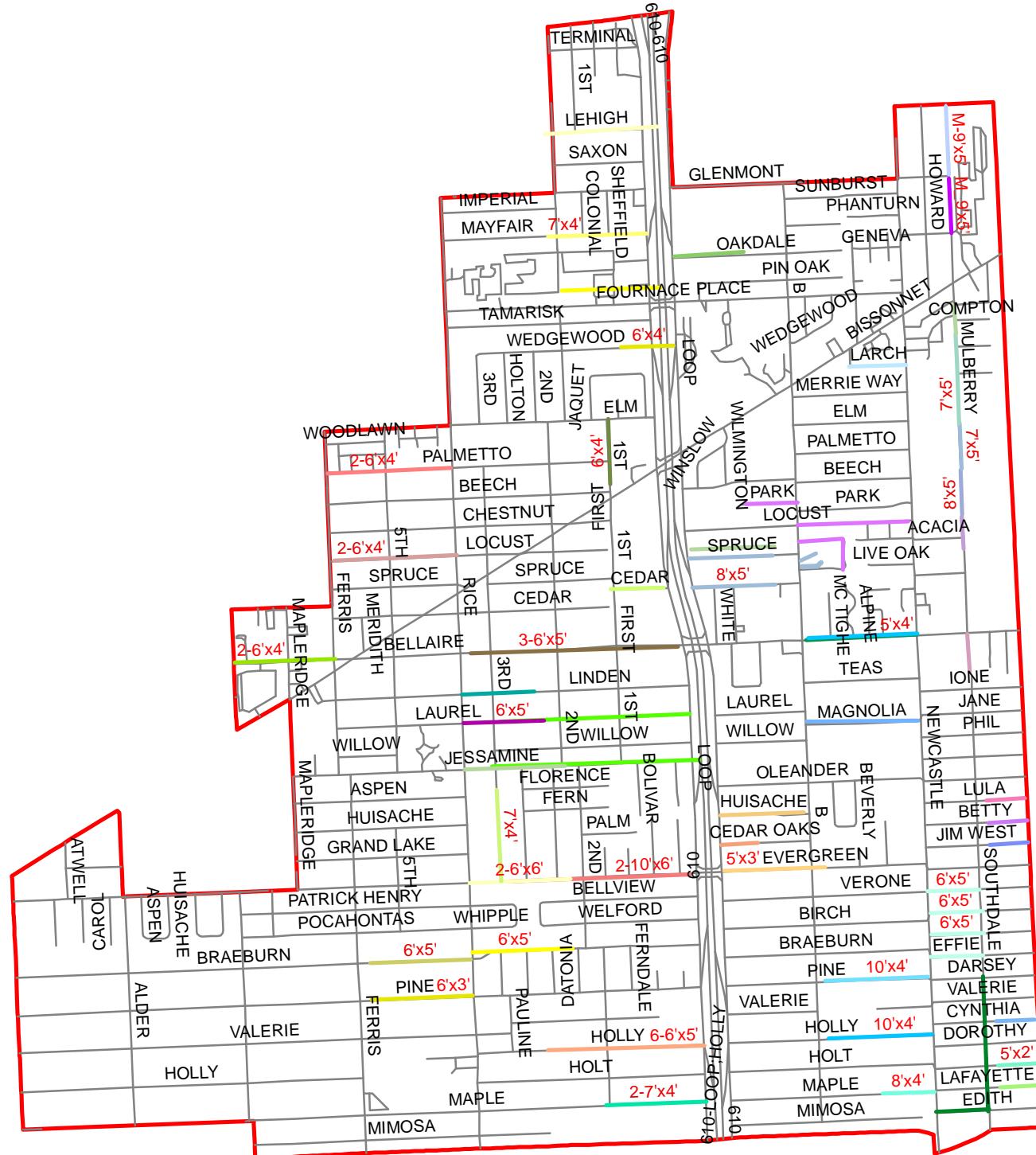
**Legend**

- City of Bellaire
- cap2000\_n83

**EXHIBIT 12**

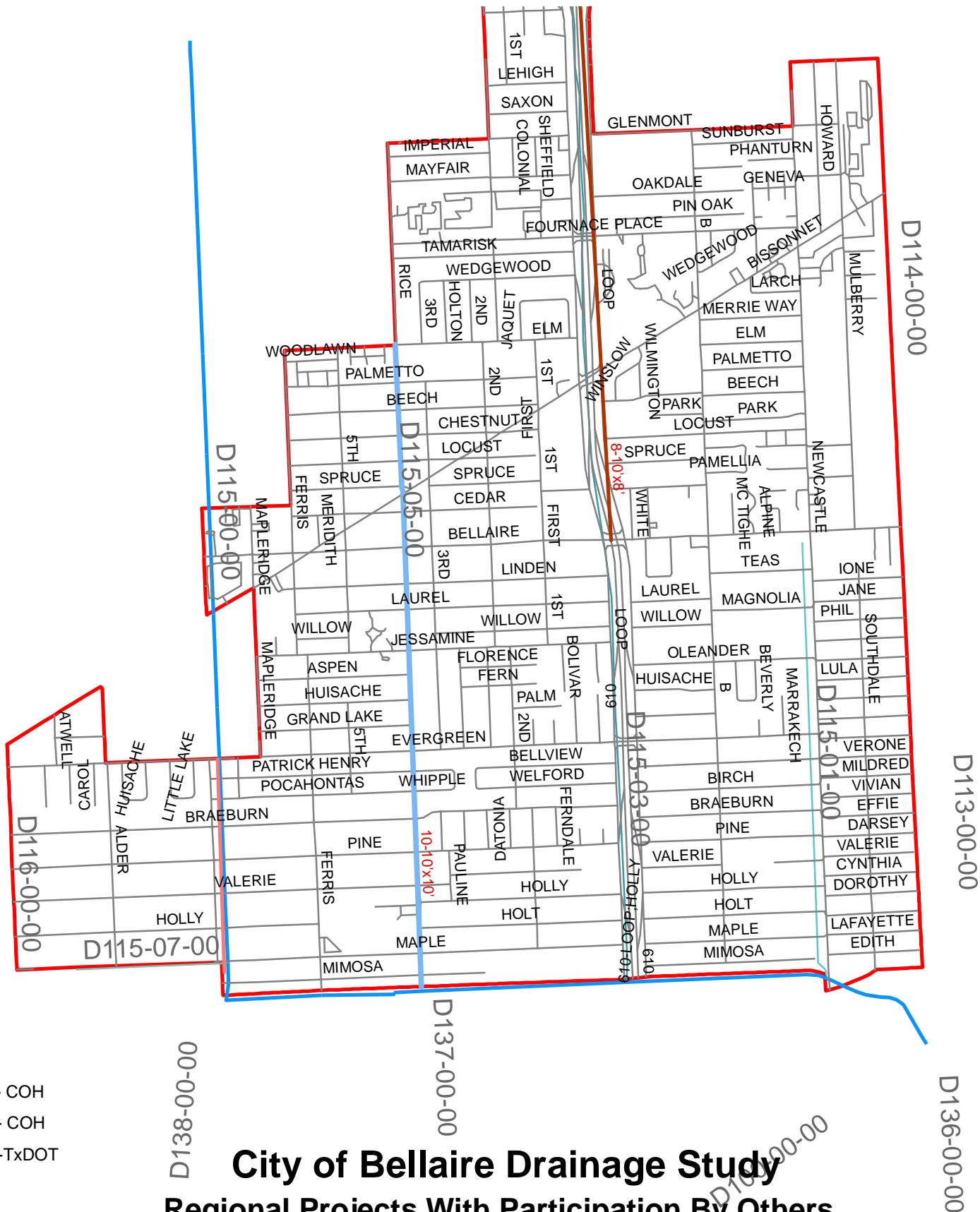
### Legend

- SD1
- SD3
- SD7
- SD23
- SD25
- SD27
- RR19
- RR17
- RR13
- RR11
- RR09
- RR07
- RR03
- SR24
- SR22
- SR33
- SR39
- SR20
- SR18
- SR16
- SR12
- SR9
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- NC13
- NC09
- NC08
- NC05
- NC04
- COB\_ROADS



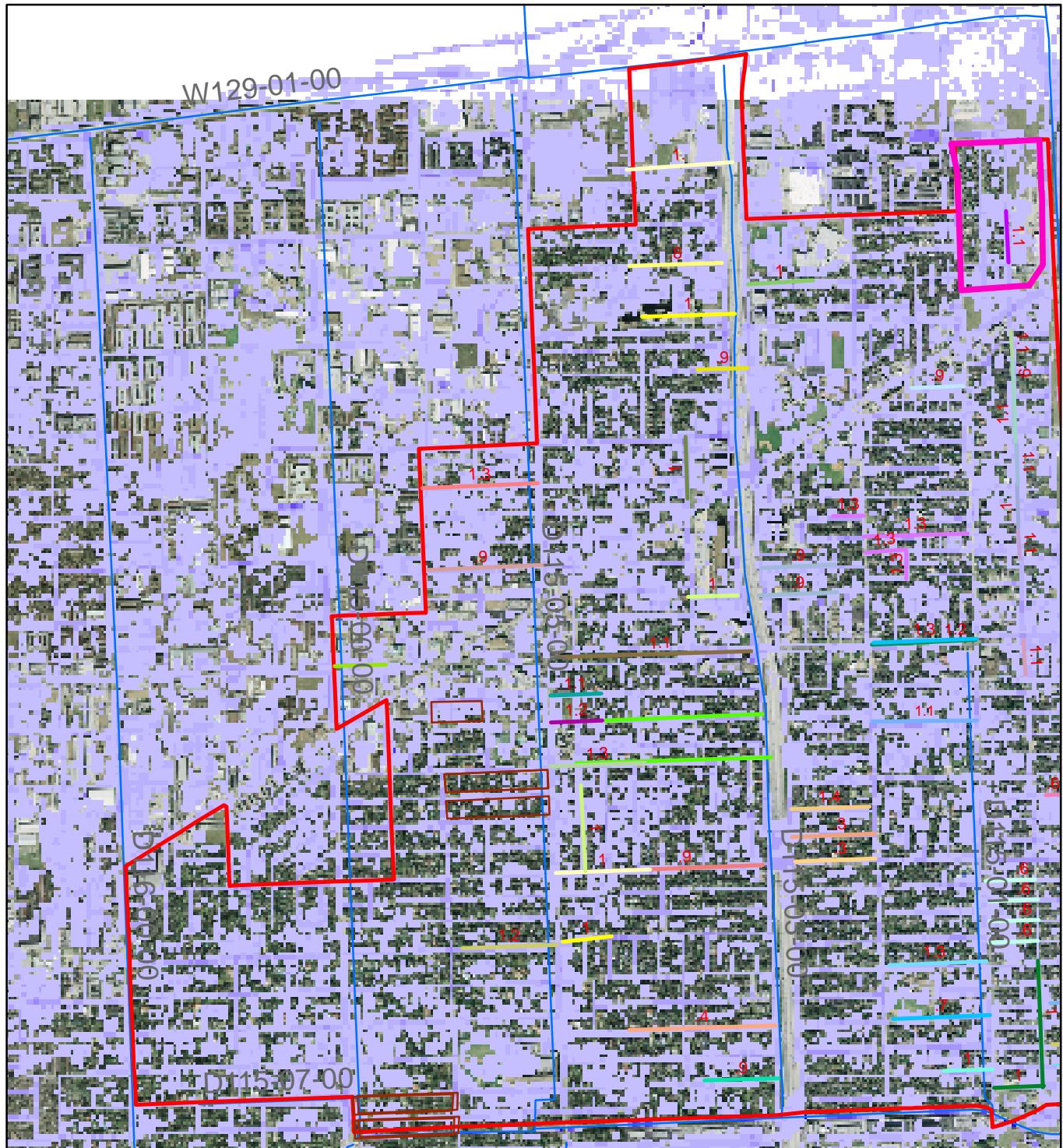
## EXHIBIT 13

### City of Bellaire Drainage Study Proposed City Wide Storm Sewer Improvements



## City of Bellaire Drainage Study Regional Projects With Participation By Others

### EXHIBIT 14



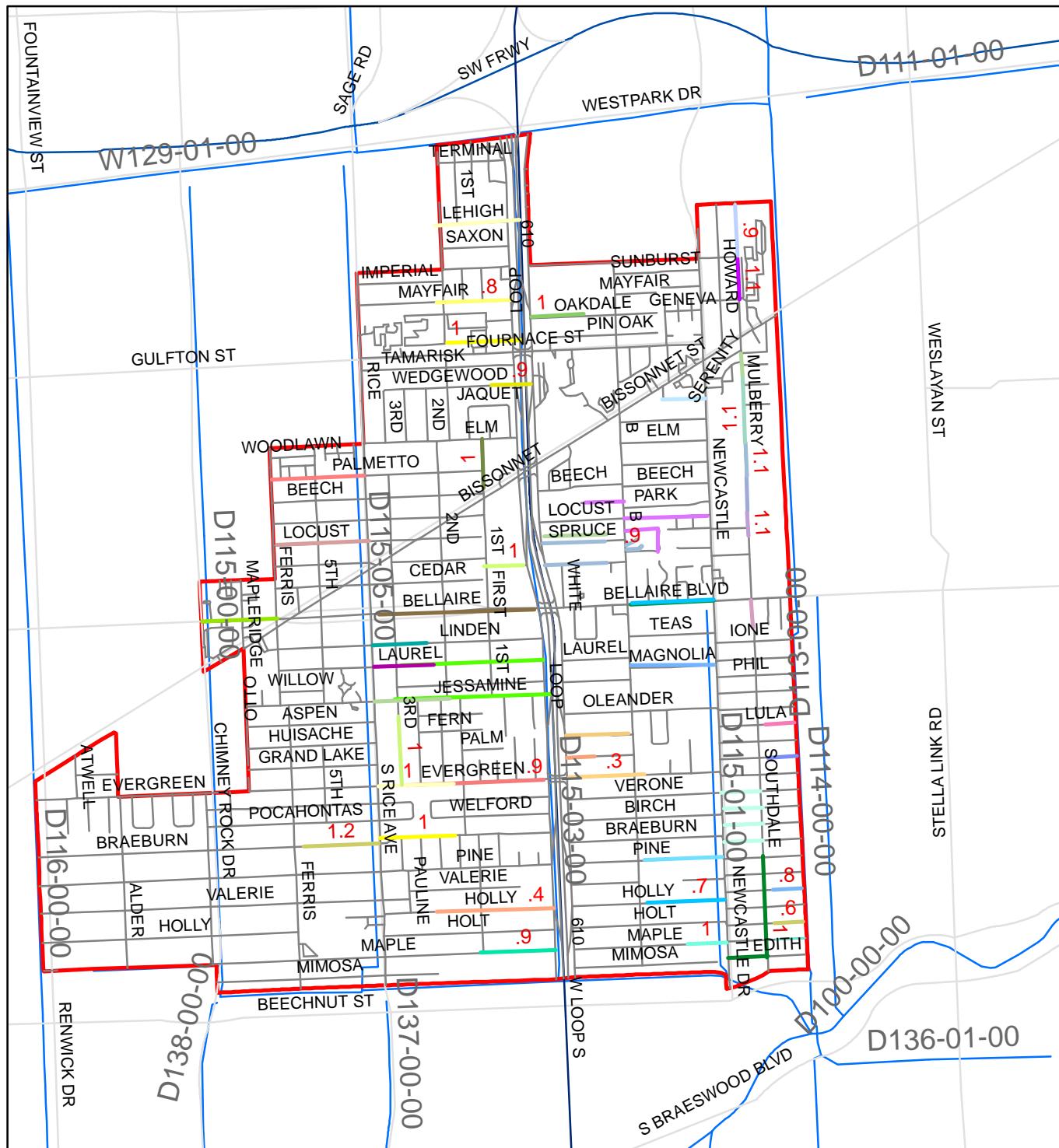
# **City of Bellaire Drainage Study**

## **Estimated Benefits With Storm Sewer Improvements**

**Assumptions in Benefits see Text**

# EXHIBIT 15





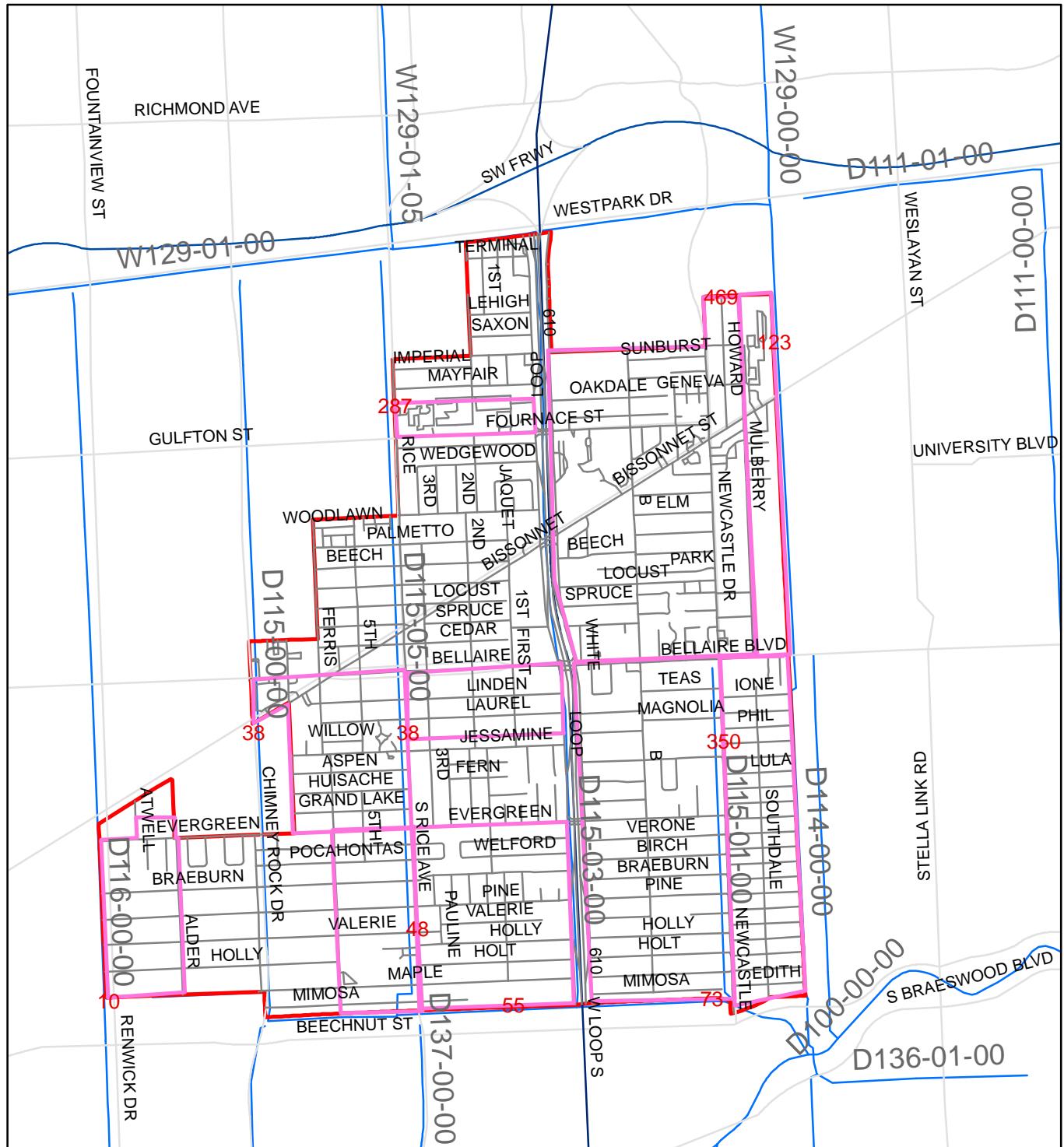
# **City of Bellaire Drainage Study**

## **Benefits of Localized Storm Sewer Improvements**

### **Estimated Reduction in Water Surface Elevations**

# EXHIBIT 16





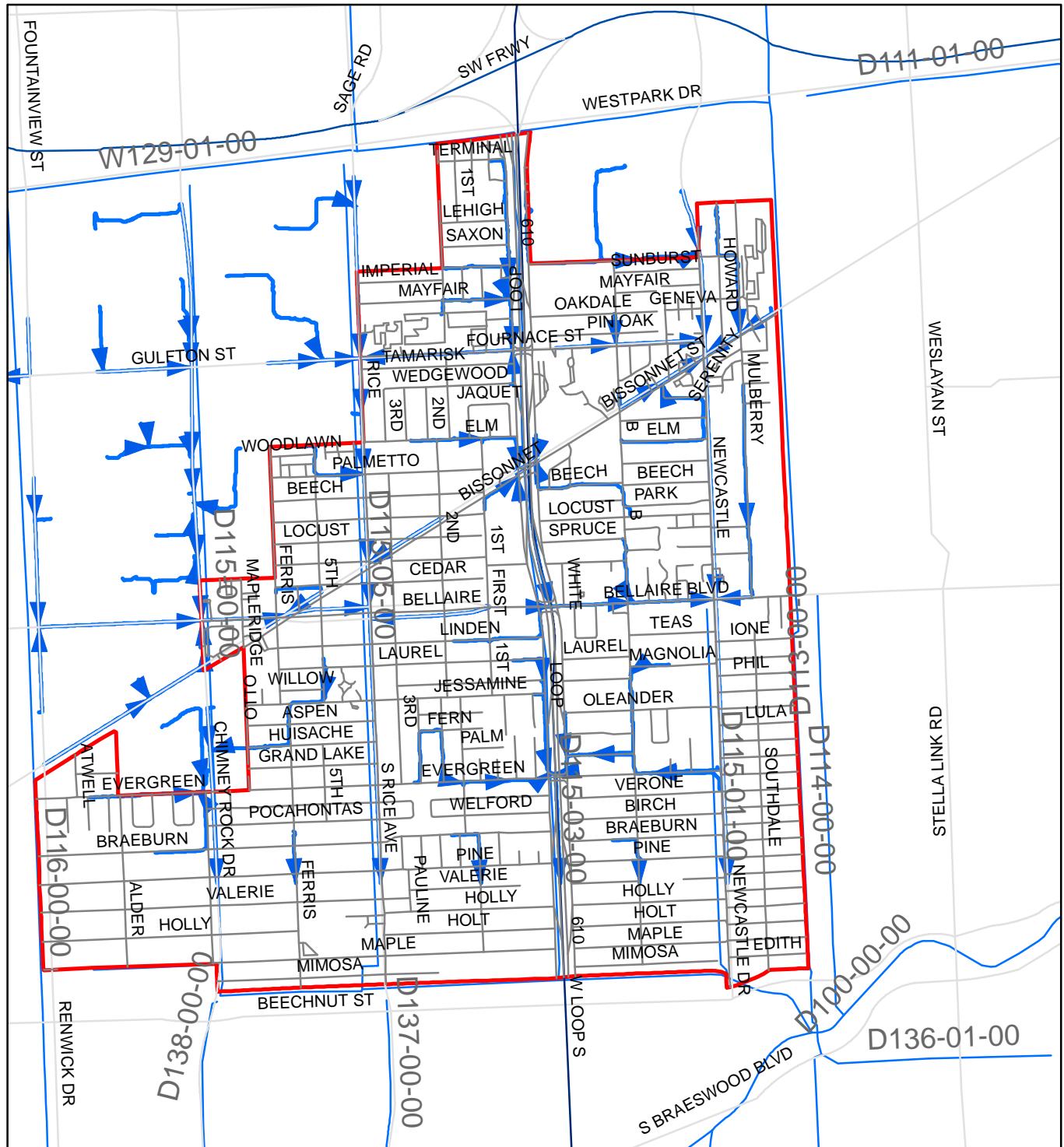
## City of Bellaire Drainage Study

### Historical Flooding Information (TSARP)

#### Legend

- Historical\_Flooding\_Str
- City of Bellaire

**EXHIBIT 17**



## City of Bellaire Drainage Study

## Flow Paths

# EXHIBIT 18



EXIST. R.O.W.

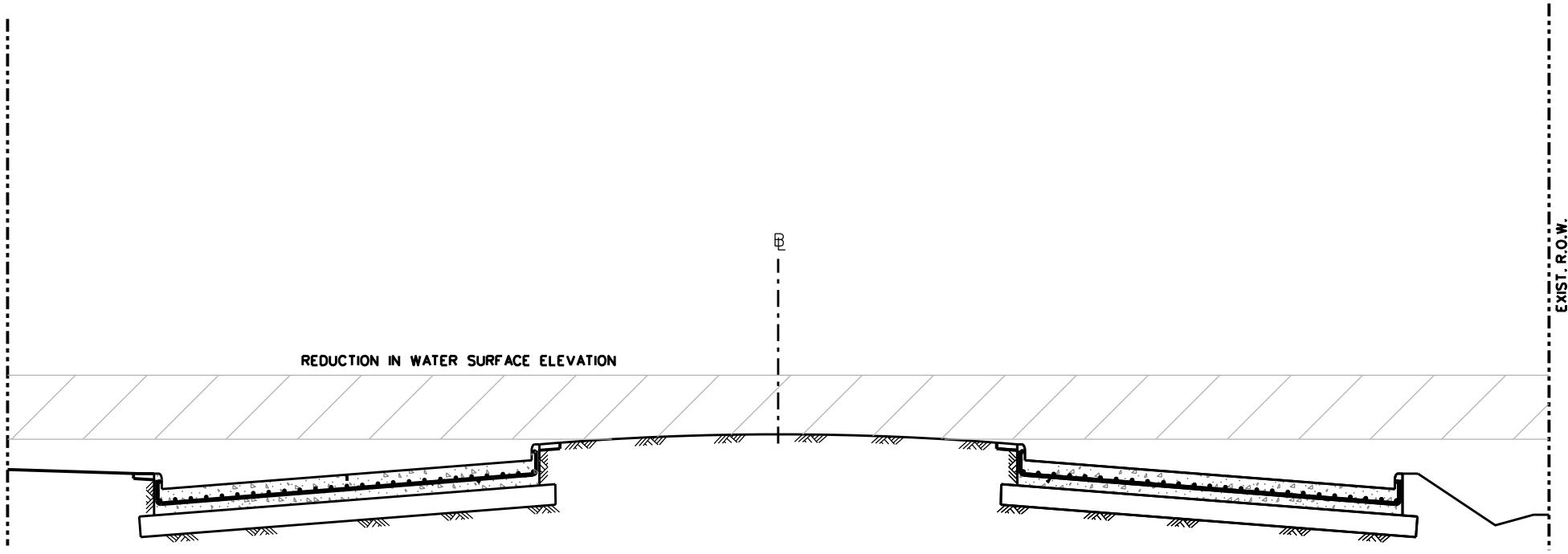
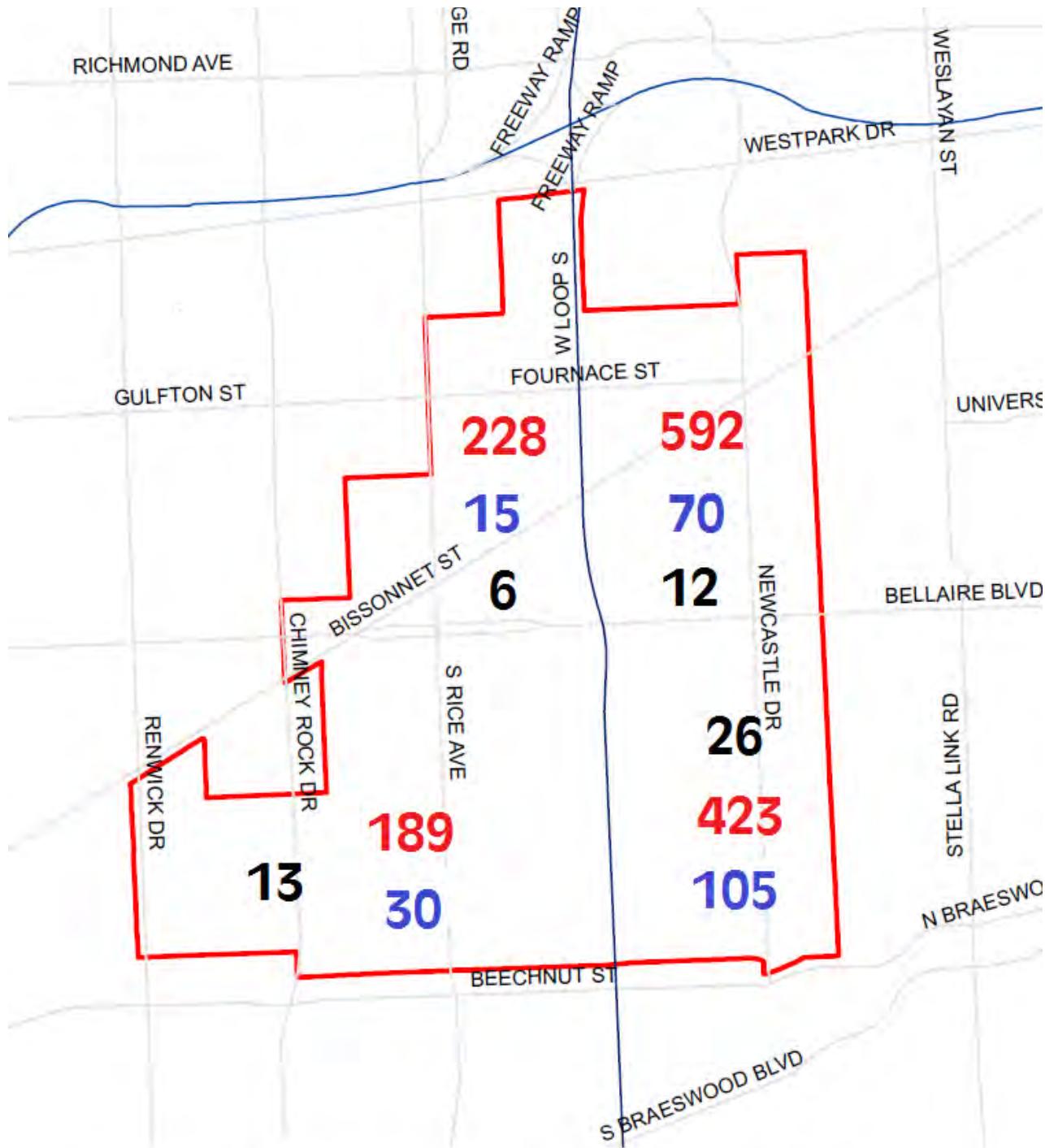


EXHIBIT 17

EXIST. R.O.W.



**Reported Structures Flooded**  
**Allison 1432      May 2015 220**  
**Repetitive Loss 57**

## **Appendix 20**

### **20. City Engineer Hurricane Harvey Report**



# MEMORANDUM

**TO** : **Paul Hofmann, Bellaire City Manager**

**FROM** : **James Andrews, P.E. Bellaire City Engineer**

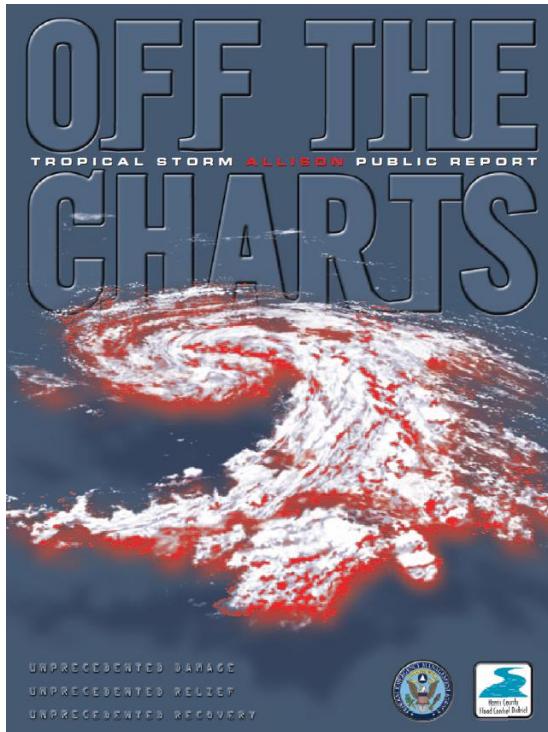
**DATE** : **September 27, 2017**

**SUBJECT** : **Hurricane Harvey Storm Event**

Homes in the City of Bellaire have flooded on numerous occasions over many decades. There are many factors that contribute to structures flooding in the area. Some of those include:

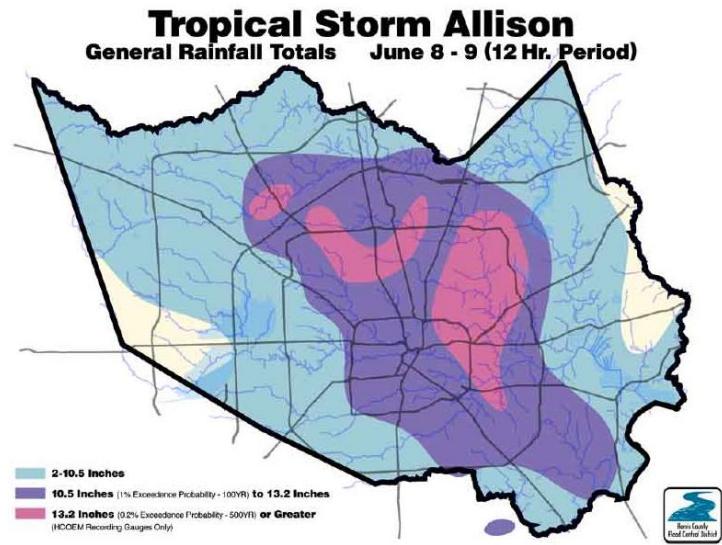
- very high annual rainfall of about 50 inches
- very flat topography with poor sheet flow characteristics
- clay soils that do not absorb water very well
- close proximity to an undersized Brays Bayou
- Low finished floor elevations of older homes
- Extreme storm events

Before Hurricane Harvey, the most devastating storm to flood Bellaire in recent times was Tropical Storm Allison in June of 2001. The Harris County Flood Control District (HCFCD) described Tropical Storm Allison as “Off the Charts” in terms of unprecedented rainfall amounts.



When the local rains finally eased, Allison had left Harris County, with 22 fatalities, 95,000 damaged automobiles and trucks, 73,000 damaged residences, 30,000 residents in shelters, and more than \$5 billion in property damage in its wake.

At the time, the rainfall amounts were truly off the charts.



That is until Harvey...if TSA was off the chart, then Harvey broke the chart.

HCFCD provided a good description of the path Harvey followed that is worth repeating. The tropical wave that would eventually develop into Hurricane Harvey moved off the west coast of Africa on August 11th and tracked westward across the tropical Atlantic becoming a tropical storm on August 17th and then moved into the Caribbean Sea where Harvey became disorganized and was downgraded to a tropical wave. The tropical wave entered the Gulf of Mexico on the afternoon of the 22nd and was upgraded again to tropical depression Harvey on the morning of the 23rd. Over the



next 48 hours Harvey would undergo a period of rapid intensification from a tropical depression to a category 4 hurricane and make landfall along the Texas coast near Port Aransas around 10:00 p.m. on August 25th. The upper air steering patterns that moved Harvey toward the Texas coast weakened and Harvey's forward motion slowed to near 5mph after landfall and then to a meander just north of Victoria, TX on the 26th. Rain bands on the eastern side of the circulation of Harvey moved into southeast Texas and Harris County on the morning of the 25th and continued through much of the night and into the 26th. A strong rain band developed over Fort Bend and Brazoria Counties during the evening hours of the 26th and spread into Harris County and slowed while training from south to north. Flash flooding developed rapidly between 10:00 p.m. and 1:00 a.m. as tremendous rainfall rates occurred across much of Harris County. Additional rain bands continued to develop into the morning hours of the 27th producing additional excessive rainfall amounts.

As the center of Harvey slowly moved east-southeast and back offshore heavy rainfall continued to spread across Harris County through much of the 29th and the 30th exacerbating the ongoing widespread and devastating flooding. Harvey maintained tropical storm intensity the entire time while inland over the Texas coastal bend and southeast Texas. After moving offshore, Harvey made a third landfall just west of Cameron, Louisiana on the morning of the 30th.

Total rainfall amounts ranged from 25 to 47 inches across the county for the 4 days. The 2 day amount ranged from 20 to 35 inches.

Rainfall was less than a 4% (25-yr) event for the 15-min to 6-hr time periods for most areas except southeast Harris County and Brays Bayou where 2% (50-yr) to 0.2% (500-yr) and greater rainfall occurred. Rainfall for the 12-hr to 4-day time periods ranged from 2% (50-yr) to 0.2% (500-yr) and greater for all watersheds.

Time	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr	2-day	4-day
<b>Peak</b>	6.8	11.9	14.8	18.9	20.9	25.6	34.5	47.4
<b>Rainfall</b>								
(inches)								

The Harris County Flood Control District (HCFCD) approximated the magnitude of the Hurricane Harvey storm event as follows:

Duration	Rainfall Amount	Return Interval – years (exceedance probability)
<b>1-Hour</b>		
Maximum	6.8"	1,500 (0.0667%)
Weighted Range	4-5"	50-500 (2.0% - 0.2%)
<b>24-Hour</b>		
Maximum	28.6"	8,000 (0.0125%)
Weighted Range	16-20"	200-1,000 (0.5%-0.1%)
<b>2-Day</b>		
Maximum	35.2"	9,000 (0.011%)
Weighted Range	27-33"	2,500-6,000 (0.04%-0.0167%)
<b>4-Day</b>		
Maximum	47.4"	40,000 (0.0025%)
Weighted Range	35-43"	500-20,000 (0.2%-0.005%)

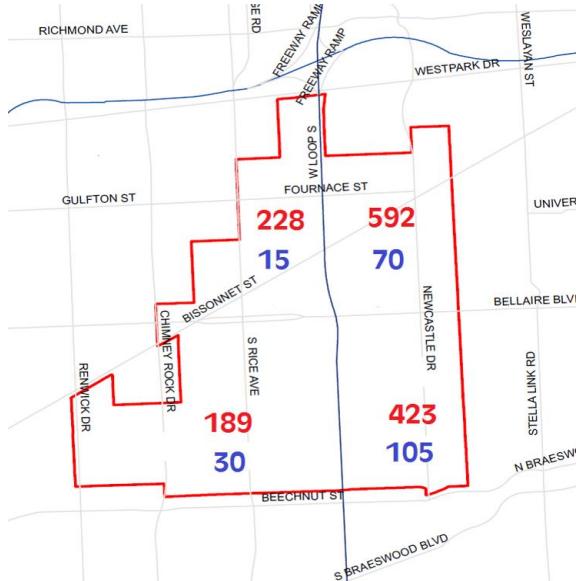
The next table compares the extraordinary rainfall associated with Harvey against Tropical Storm Allison in June 2001 and the Tax Day Flood of April 2016 for various time periods. It is interesting that Tropical Storm Allison exceeds Harvey's rainfall in the 12 and 24-hr periods. In the 2 day period Harvey dropped 6.0 inches more than Allison and 8.9 inches more over 4 days.

<b>Duration</b>	<b>Harvey</b>	<b>Allison</b>	<b>"Tax Day"</b>
		<b>June 2001</b>	<b>2016</b>
1-hr	6.8	5.7	4.7
2-hr	11.9	9.9	7.3
3-hr	14.8	13.5	8.3
6-hr	18.9	21.2	13.9
12-hr	20.9	28.3	16.7
1 day	25.6	28.4	17.4
2 days	34.5	28.5	17.5
4 days	47.4	38.5	N/A

A total of 1 trillion gallons of water fell across Harris County over the 4 day period which would fill the Houston Astrodome 3200 times and cover Harris County's 1800 square miles with an average of 33 inches of water. This volume of water would also run Niagara Falls for 15 days.

Disastrous flooding occurred on nearly every watershed in Harris County with many creeks and bayous rising to record or near record levels. Historical records held by the October 1994 flood and Tropical Storm Allison were exceeded by Harvey at many locations. Field work continues to collect high water marks and document the flooding extents and depth.

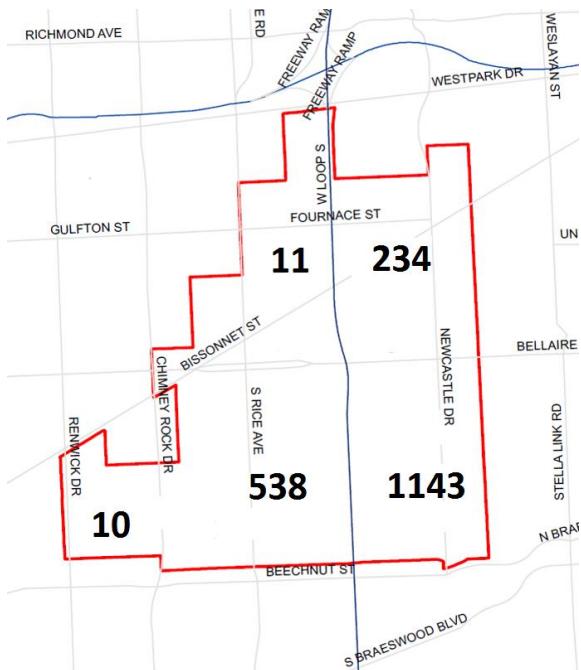
A review of the Tropical Storm Allison flood event documentation for the City of Bellaire showed approximately 1,432 homes were flooded in Bellaire with 1,015 of those homes located east of 610. The largest number of homes flooded were located in the northeast quadrant of the City away from the bayou.



Reported Structures Flooded  
**Allison 1432**      **May 2015 220**

JUNE 9, 2001

ARKK ENGINEERS



**Homes Flooded  
 not including garages**

Hurricane Harvey flooded approximately 2318 structures including garages. We estimated approximately 1936 homes had water damage to the main house structure. The areas with the most structures flooded were located in the southeast quadrant of the city followed by the south central area. Both of these areas close to Brays Bayou.

Two independent sets of structural flooding data were collected, one by the fire department and the other by ARKK Engineers. The number of flooded structures is our best guess at the time of inspection determined by identifying water surface elevation debris lines immediately after the storm and debris piles in the front yards a few days after the flood.

### **Types of Floods in Bellaire**

As we have discussed in the past, flooding occurs in the Bellaire area because of shallow floodplain flooding and ponding/overland flow problems or some combination of both. Harvey was an extreme combination of both types of flooding events.

#### Shallow Floodplain Flooding

Shallow floodplains exist throughout much of Harris County. Bellaire is located very near Brays Bayou and is in the shallow floodplain of Brays Bayou.

When the Bayou capacity is exceeded and flood waters overtop the bayou banks, flooding occurs in the land areas near the bayou that are located at lower elevations. Land areas can remain flooded for hours until water surface elevations drop in the bayou.

As Brays Bayou comes out of its banks, the City drainage is adversely and directly affected.

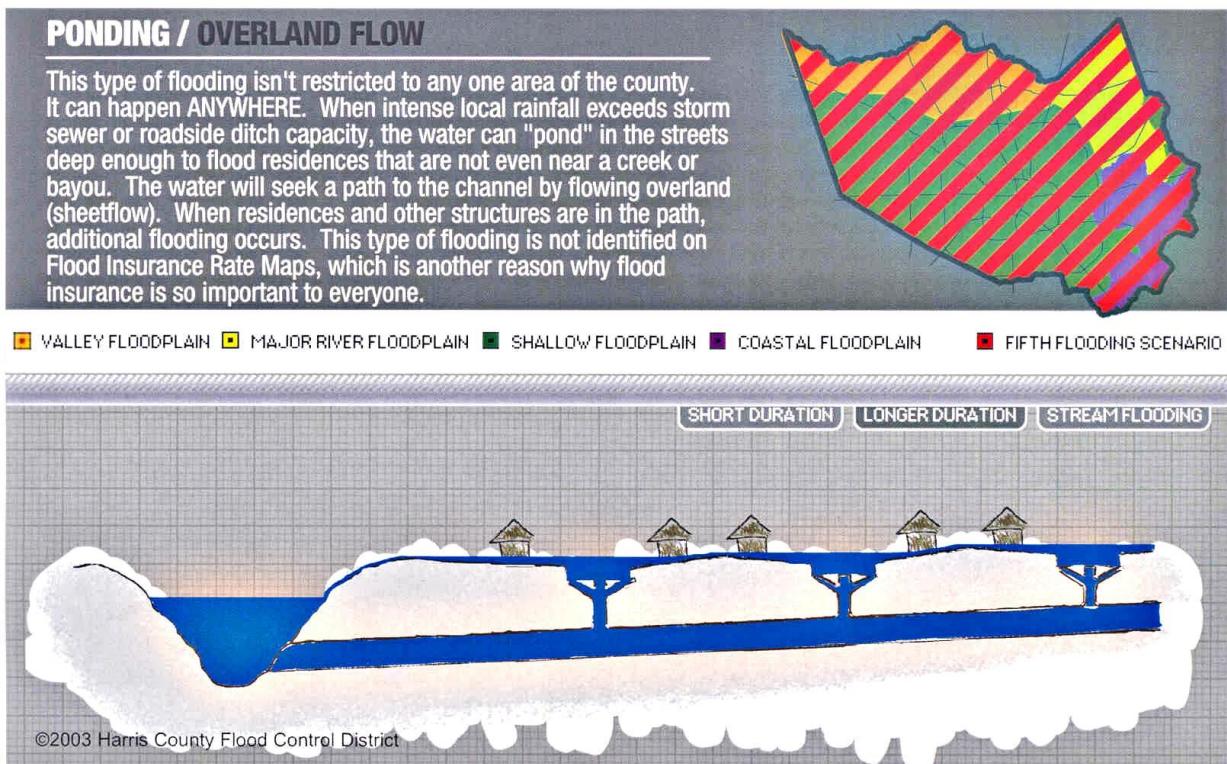
#### Ponding/Overland Flow Flooding

Ponding or overland flow flooding occurs when intense local rainfall exceeds the storm sewer capacity, the water can “pond” in the streets deep enough to flood residences that are away from the bayou.

This type of flood is not restricted to any one area. It can happen anywhere. The storm water ponds until it eventually seeks a path to the outfall by flowing

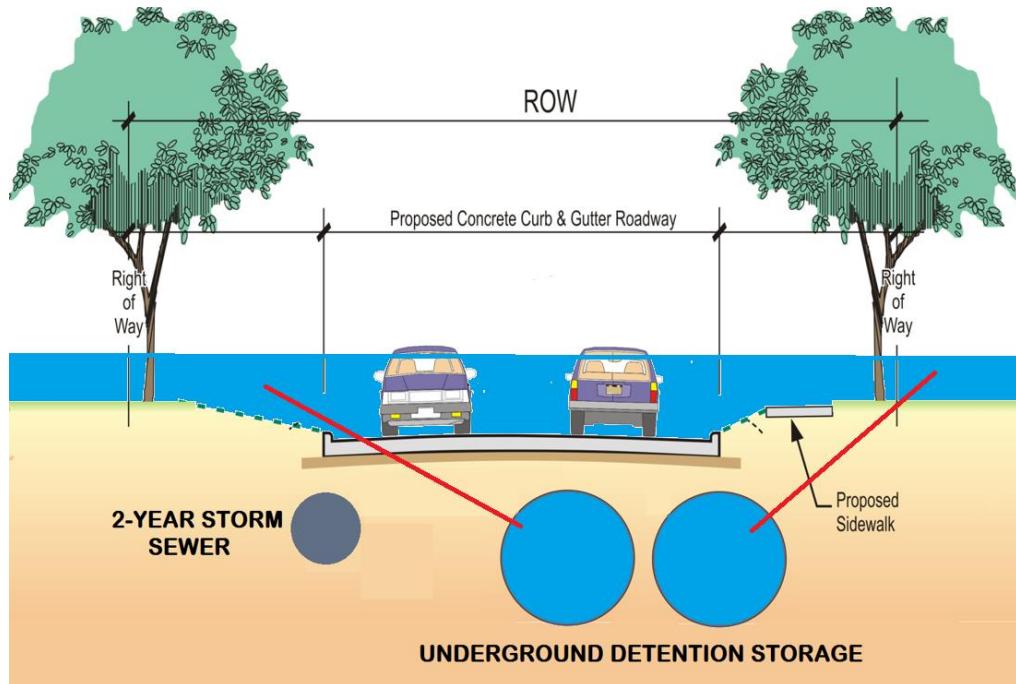
overland. When residences and other structures are below the surrounding land elevation or in the path of the overland flow, flooding may occur. The probability of this type of flooding is not shown as a floodplain on the Flood Insurance Rate Maps. This type of flooding condition is something that Bellaire is addressing during the current Bonds for a Better Bellaire 2016 program.

As you know, our current Bonds for a Better Bellaire Street reconstruction program focuses on the street condition and drainage needs based on local heavy rainfall problem areas. In other words, trying to lower ponding heights when the

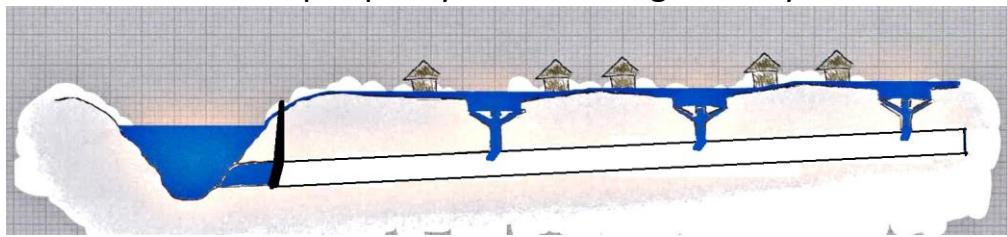


City of Bellaire is hit with a localized 100 year event and water ponds to a height that begins to flood structures before it can flow away from the area overland.

The Bonds for a Better Bellaire 2016 program does two things to improve the drainage during this type of rain event. First, the underground system for these streets with major localized drainage problems will be upsized above the typical two year to the 100-year capacity. The idea being to improve the underground storage capacity under the pavement, thus decreasing the height of ponding during a major local rainfall.



We are also in the preliminary design stage of developing backflow devices in certain locations to prevent storm water from the bayou during high water surface conditions from coming back into the City's underground system. This backflow can take up capacity in the underground system even when there is no



local rainfall, so the idea is to restrict stormwater from Brays

Bayou from back flowing into the City's underground system, thus allowing local storm water to use the City's underground system capacity

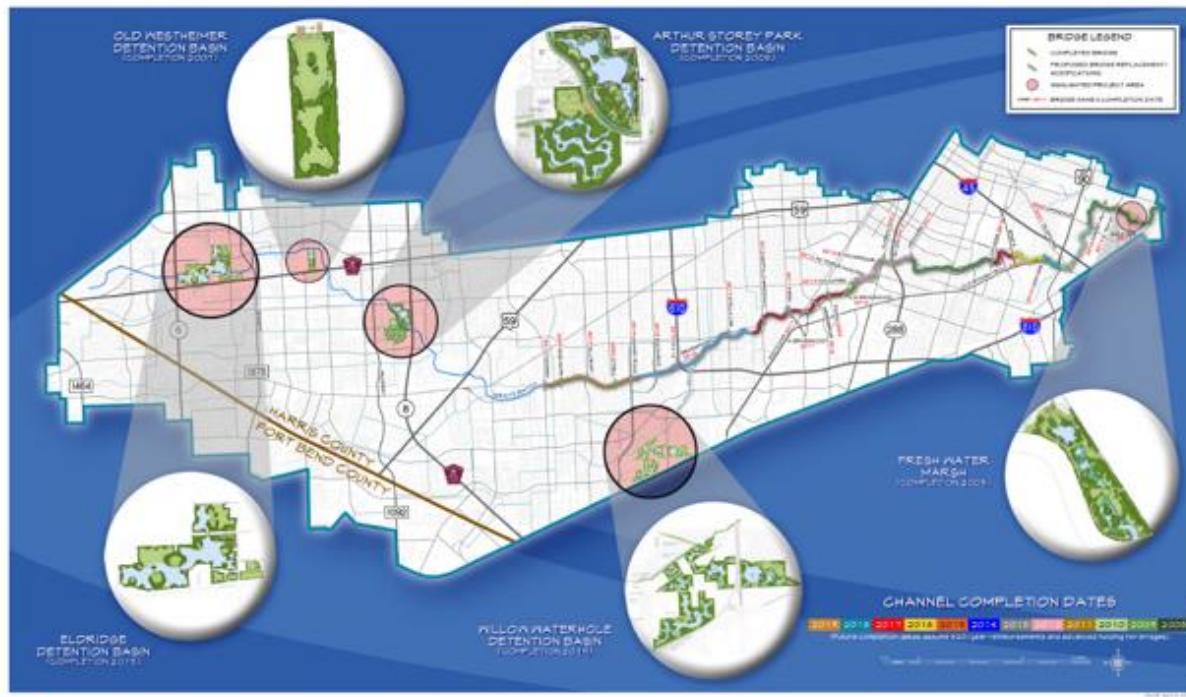
The majority of the first phases of the Bonds for a Better Bellaire program has focused on these local drainage improvements that the City of Bellaire can improve without outside agency approval.

In some cases, the backflow devices require approval from other entities like TxDOT and the City of Houston because they affect their drainage systems as well. The City of Bellaire continues to explore ways to leverage bond dollars to construct projects with other entities that will benefit the citizens of Bellaire. For example, the City took advantage of the current plans TxDOT has for reconstructing the I69/IH610 interchange by contributing a third of the cost for upsizing storm sewers in the vicinity of the new construction.

### Project Brays

The single most significant flood control improvement project for our area has been under construction for many years and is outside the control of the City of Bellaire and under control of the HCFCD and Army Corps of Engineers. That is Project Brays.

### Brays Bayou Project Locations



The Brays Bayou Federal Flood Damage Reduction Project, known as Project Brays, is the largest flood damage reduction program undertaken by the Harris County Flood Control District to date.

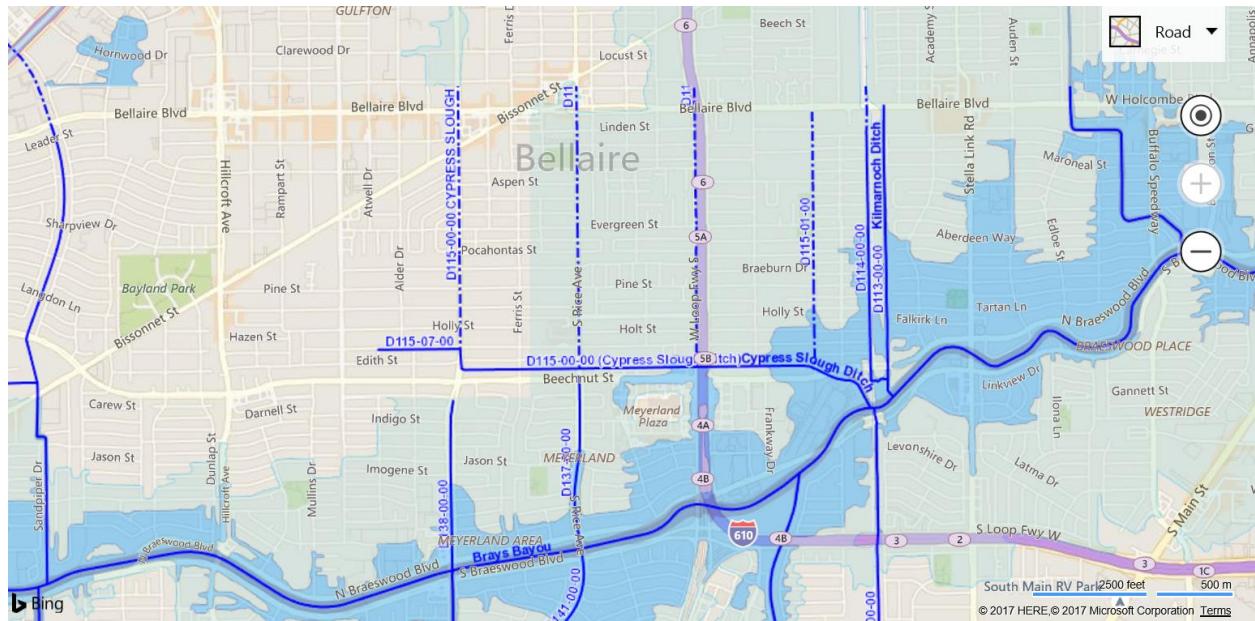
A cooperative effort between the Flood Control District and the U.S. Army Corps of Engineers (Corps), Project Brays is an active multi-year, \$480 million project that substantially reduces flooding risks in the Brays Bayou watershed. It is the largest partnership project the Flood Control District and Corps have conducted to date.

Encompassing more than 75 individual project components, Project Brays will help to reduce flooding risks by widening 21 miles of Brays Bayou from the Houston Ship Channel to Fondren Road and from West Houston Center Boulevard to State Highway 6, replacing or modifying 32 bridges (including two pedestrian bridges) to accommodate channel modifications and excavating four storm water detention basins that will hold a collective 3.5 billion gallons of storm water.

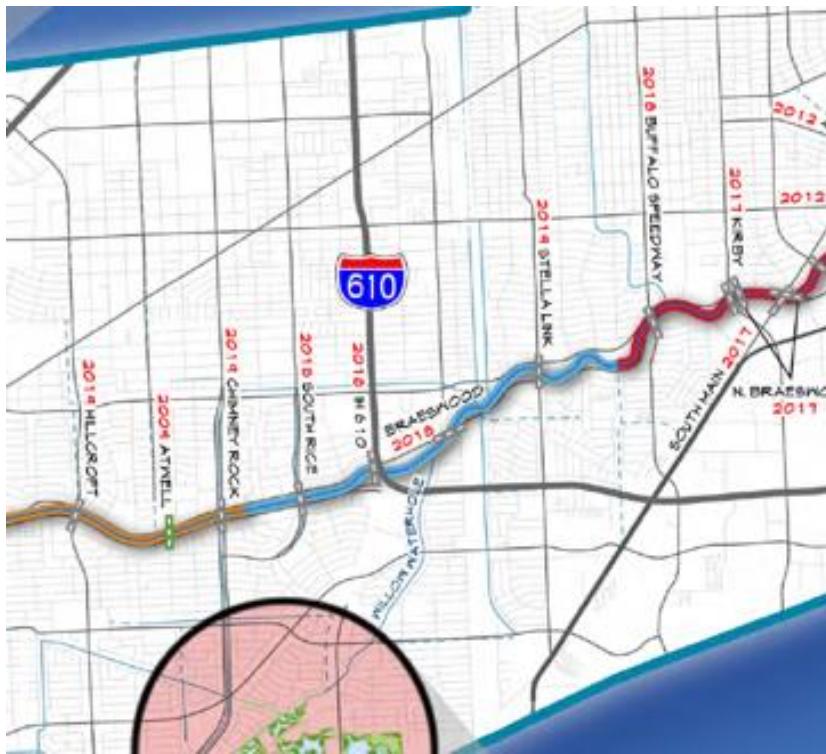
The map below shows the Conditional Letter of Map Revision (CLOMR) that was approved by FEMA for Project Brays. It represents an *estimate* of the revised 1% floodplain as a result of the proposed project and is *not to be used as an official map* for floodplain determinations or for setting insurance rates. The map is subject to change based on complete construction of the proposed Project Brays elements. The purpose of this map is to provide information to Brays Bayou residents about the potential flood risk reduction benefits of Project Brays.

Upon completion, Project Brays will provide a 1 percent (100-year) level of protection along the main stem of Brays Bayou upstream of Beltway 8. After the construction of all elements of Project Brays, the area downstream of Beltway 8 will see the removal of the 1 percent (100-year) floodplain from approximately 15,000 homes/businesses in the watershed according to the HCFCD.

The CLOMR map shows much of 100-year floodplain removed from the majority of Bellaire. It is important to keep in mind that it does not show flooding that may occur from extreme local rainfall events.



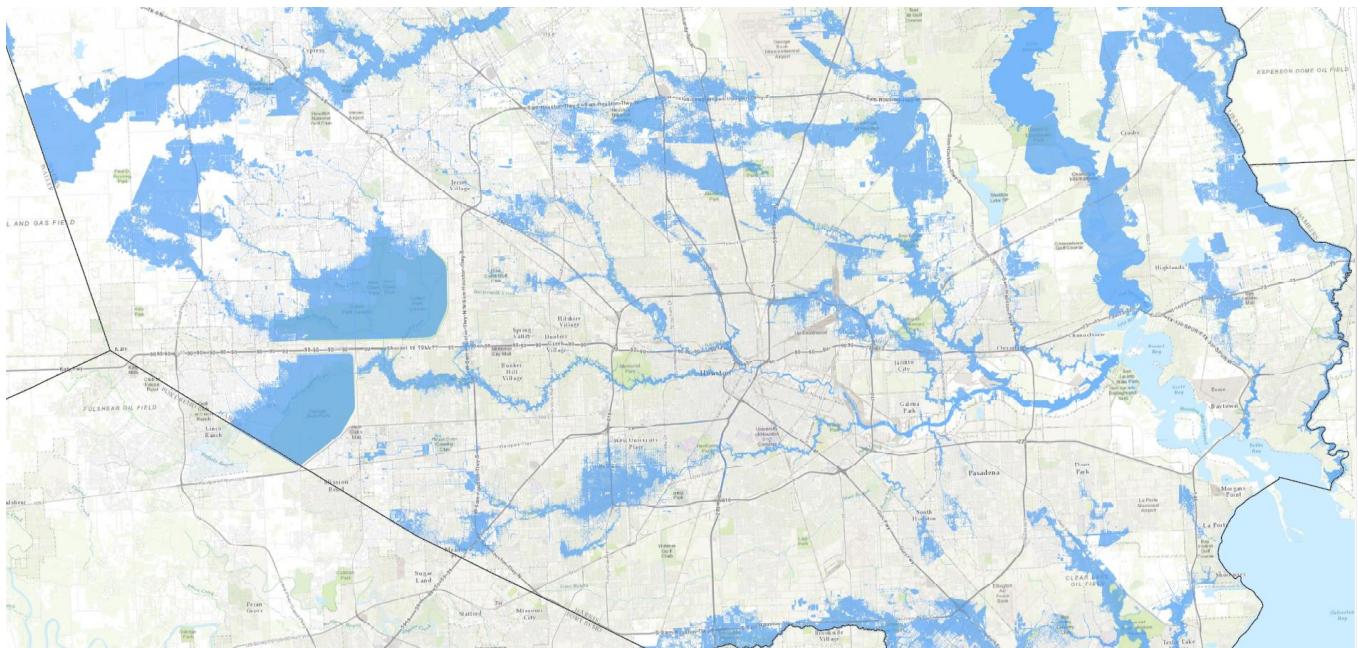
The portion of Project Brays that should benefit the City of Bellaire the most is channel widening and increasing capacity scheduled to be completed in 2021.



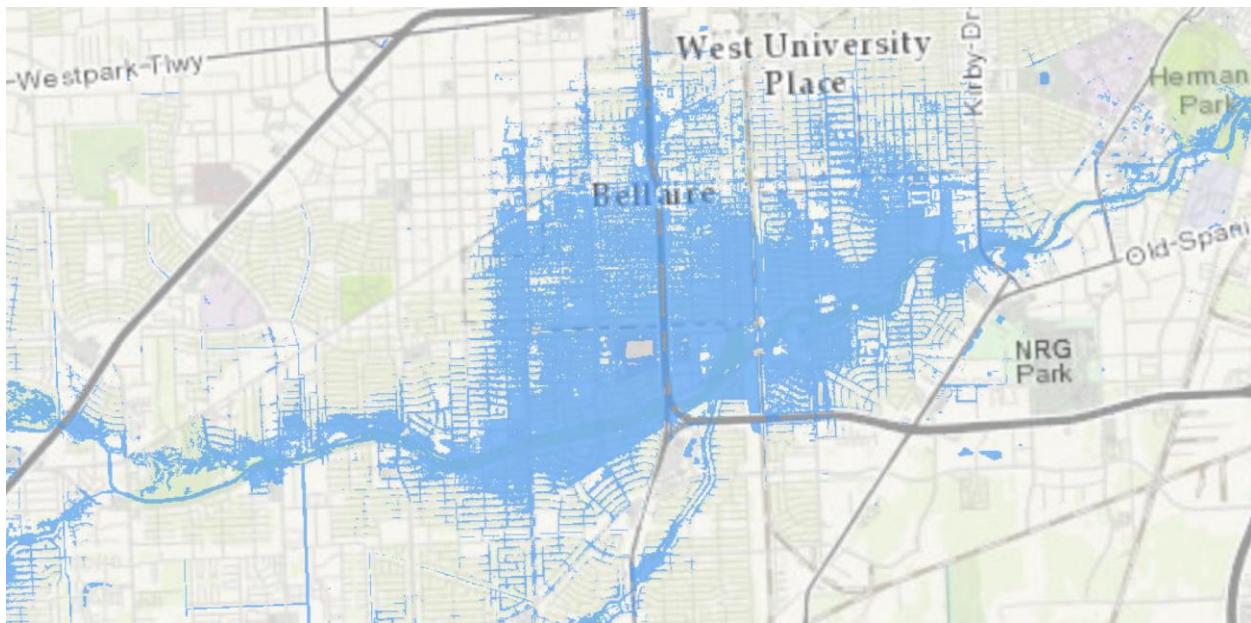
Because high water surface elevations within the banks of the bayou may still cause backflow into the city's storm sewers even after Project Brays is completed, the back flow prevention methods recommended in the City's Drainage Study and started under Bonds for a Better Bellaire 2016 should remain a priority.

Project Brays and the Bonds for a Better Bellaire 2016 program together still do not solve the catastrophic flooding problems caused by a storm like Hurricane Harvey.

As previously mentioned, Harvey broke the Charts for a severe storm. There appear to be several factors that caused the severe flooding in Bellaire during Harvey. This DRAFT inundation map prepared by the HCFCD shows the City of Bellaire as one of the, if not the, worst hit areas along the entire reach of the 128 square mile Brays Bayou watershed.



The large inundation area highlighted below is mostly Bellaire and Meyerland.



This shows the importance of expediting the improvements to Brays near the City of Bellaire.

During an event like Harvey, there appears to be other factors that contributed to flooding. The elevated railroad track to the east of the City and the elevated IH 610 roadway in the center of Bellaire combined with the inadequate capacity of Brays Bayou may have blocked the overland flow from the area creating excessive flood depths.

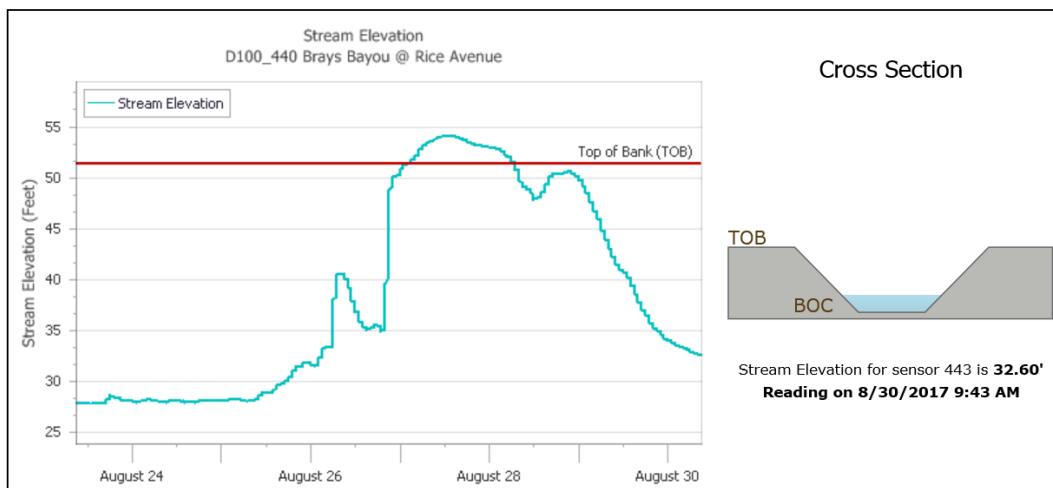
I reviewed the HCFCD Flood Warning System information that shows both historical storm events and real time rainfall and flood stages in the Harris County bayou and stream system. A detailed look at rainfall amounts and flood stage elevations in Brays Bayou on August 27th through the 29<sup>th</sup> provides valuable insight as to why the southeast and south central portion of Bellaire flooded to such a depth.

Both the HCFCD rain gages on Brays Bayou near the City of Bellaire show the bayou out of or at the top of its banks for 2 days, August 27<sup>th</sup> and 28<sup>th</sup>.

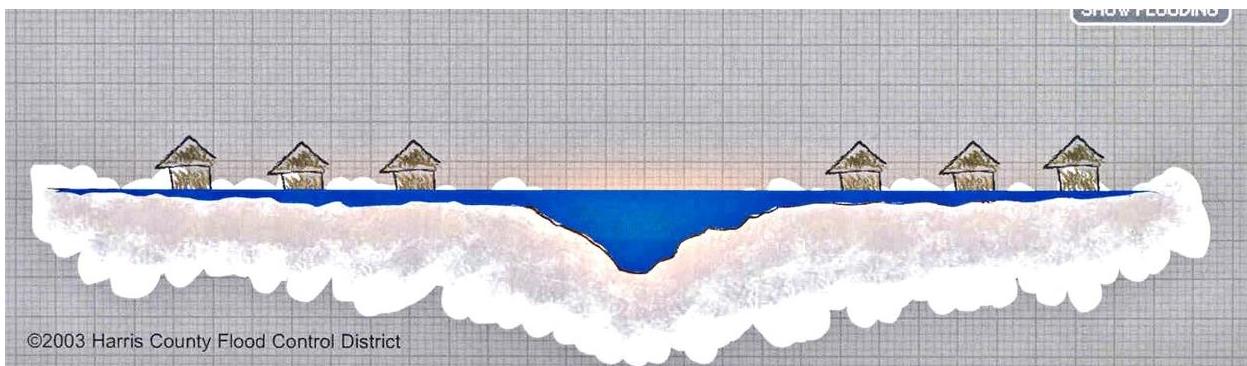
Stream Elevation Sensor 443

D100\_440 Brays Bayou @ Rice Avenue

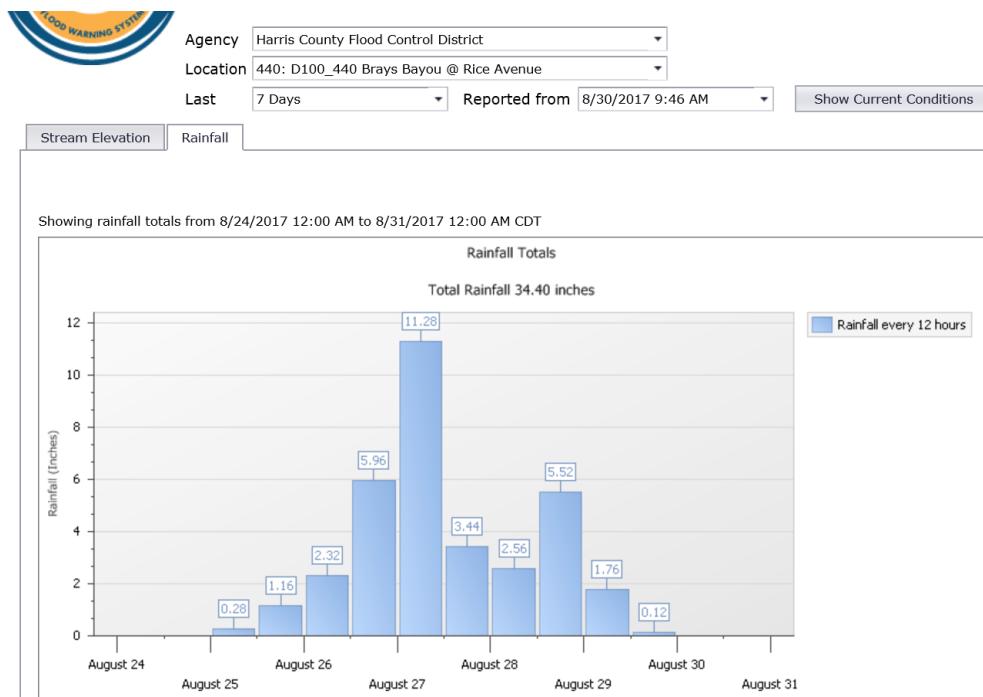
Key Map 531U	443
Sensor ID	443
Sensor Type	Bubbler
Installed	8/10/1984
Top of Bank (TOB)	51.30'
Bottom of Stream	25.97'
Tip of Orifice	27.45'
Measuring Plate	54.84'
Benchmark	53.81'
RM 040160 stamped D100 BM 20 located on the downstream sidewalk of northbound bridge at stream centerline, 1988 NAVD, 2001 adjustment. 78 to 01 Adjustment -1.99	
As of July 1, 2007, the elevation datum was changed from 1929 NGVD, 1978 adjustment to the 1988 NAVD, 2001 adjustment.	



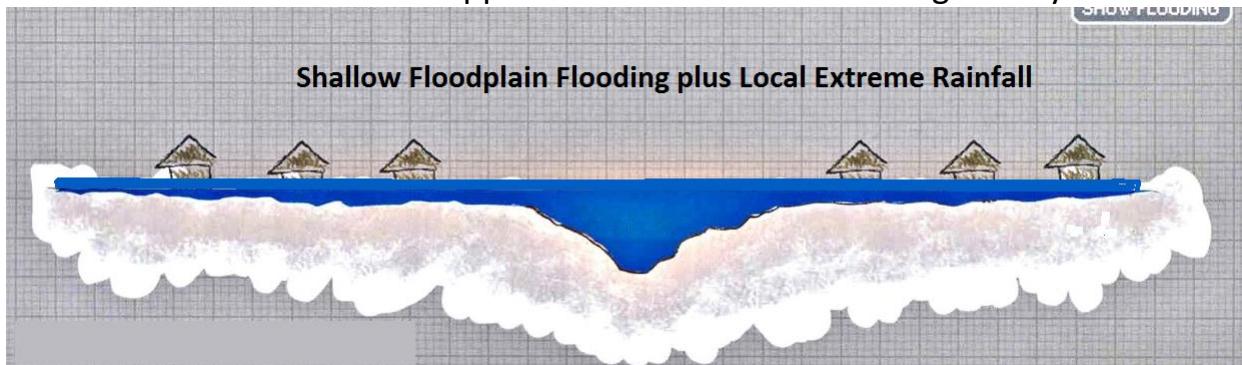
This illustration shows the bayou at flood stage during that 2 day period. This condition alone would flood the lower elevations of Bellaire.



At the same time this shallow floodplain flooding was occurring, the City of Bellaire received over 2 ½ feet of rainfall that simply put, added to the depth of the flooding.



These two flood conditions happened at the same time during Harvey.

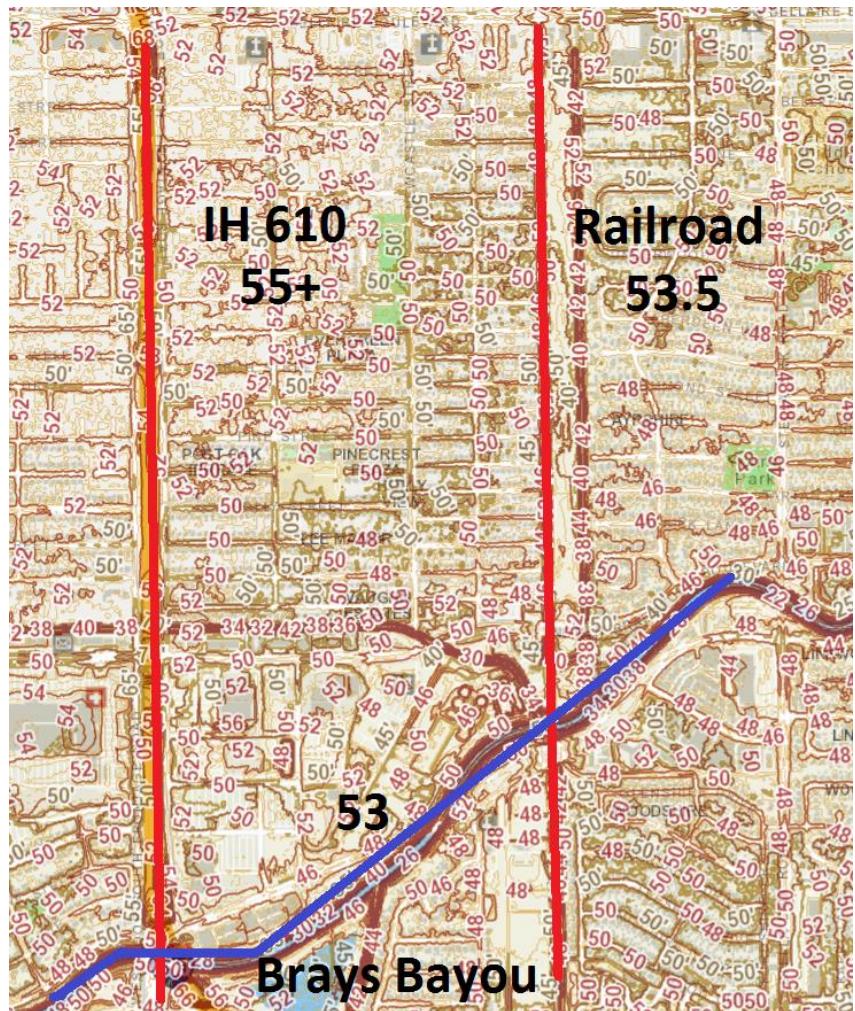


The bayou was at are over the banks creating a wall of water in which the local extreme event rainfall had nowhere to drain.

The elevated section of IH 610 and the railroad prevented the natural flow of the storm water from flowing to the southeast when the bayou was at flood stage.

The magnitude of rainfall that hit the Bellaire area at the same time the water surfaces in the bayou were at or above the 100 year levels was unprecedented. The HCFCD has estimated the 2.5 to 3 feet of rainfall over this two day period to be within the 2500 to 6000 year reoccurrence or return interval. Absolutely devastating amounts of rain.

What would have helped?  
More capacity in Brays Bayou as Project Brays will provide and perhaps flood relief structures through the elevated railroad and IH 610 structures.



We are still collecting data on homes that flooded in Bellaire, but preliminary indications are the current standard for building homes above the base flood elevation was a success. We found that the homes constructed under the newest National Flood Insurance and City of Bellaire standards performed well.

<u>SUMMARY</u>							
Description	Existing Homes	May 2015 Flood		August 2017 Flood		Flooded in Both Storms	
		Structural Flooding	% Flooded Homes	Structural Flooding	% Homes w/Structural Flooding		
Tier I	Pre 1980	2313	122	5%	1039	45%	80
Tier II	1980-1993	1087	32	3%	291	27%	12
Tier III	1994-2007	2348	56	2%	554	24%	30
Tier IV	2008-Present	739	16	2%	47	6%	5
	Year Build Unknown	201	2	1%	5	2%	0
<b>TOTAL</b>		<b>6688</b>	<b>228</b>	<b>3%</b>	<b>1936</b>	<b>29%</b>	<b>127</b>

Our preliminary review of flood data and elevation certificate data, indicates that 47 homes or 6 % of the homes that flooded were constructed to today's finished floor height regulations. Consequently, building 1 foot above the current base flood elevation provided greater protection even during this catastrophic event.

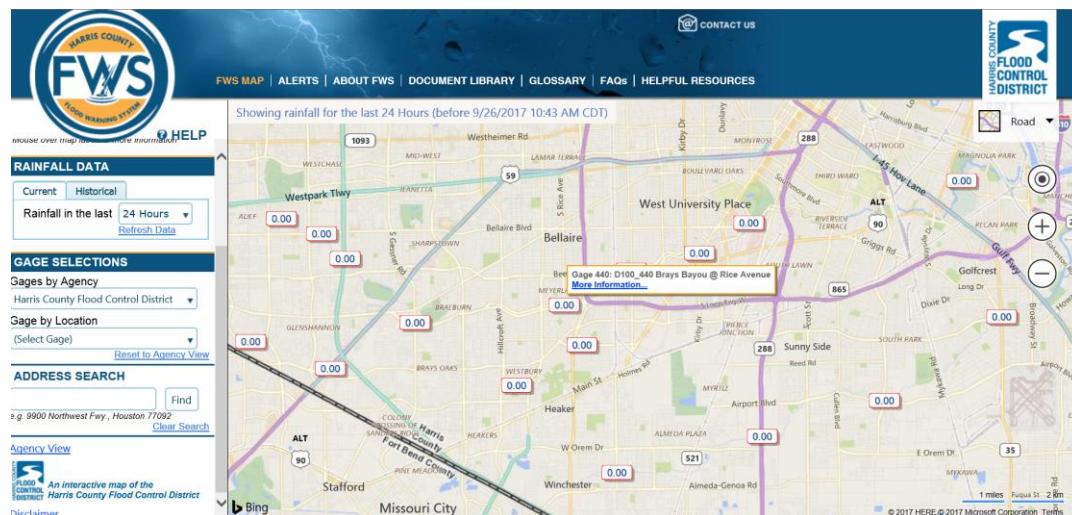


In summary, Hurricane Harvey was an unprecedent catastrophic storm that in my opinion cannot realistically be completely controlled. Furthermore, there is nothing the City of Bellaire can build on its own to remove flooding conditions during an event of this magnitude. Some have suggested buying perimeter properties around the city to construct levees and pump stations to protect the City of Bellaire. Not only would this be extremely costly, it would require approvals from surrounding agencies like the Harris County Flood Control District and the City of Houston for proof there would be no adverse impact to others outside Bellaire.

Hurricane Harvey did show us the need to work together with our state and federal government to expedite improvements to Brays Bayou to add capacity and lower the flood stage water surface elevations and to perhaps explore the benefits of removing the overland flow obstacles that the railroad and IH 610 may create.

Finally, there have been some citizens that have asked for information to help warn them about flooding during these extreme storms. The HCFCD's Flood Warning System previously mentioned is a very useful site that anyone can use. It can be found at: <https://www.harriscountyfws.org/>

Again, you can review historical flood conditions and real time water surface elevations in the Bayou and real time



rainfall amounts occurring at selected rain gages.

## **Appendix 21**

### **21. Draft Action Plan/Matrix Organization**

## **DRAFT ACTION/MATRIX ORGANIZATION**

### **Preventative Activities**

1. **Activity – Matrix Line Item 4 (Public Communication)**  
Develop an educational program/campaign warning residents of dangers of blocked storm sewers, and how they can help mitigate this problem.
2. **Activity – Matrix Line Item 19 (Infrastructure (COB & Others))**  
Develop plan to inform residents of the importance of not filling in the floodplain.
3. **Activity – Matrix Line Item 21 (Infrastructure (COB & Others))**  
Establish a comprehensive asset management plan allowing for better short and long-term planning of maintenance and capital improvement costs and needs.
4. **Activity – Matrix Line Item 32 (Storms > 100 yr)**  
Establish a desired level of protection versus the cost to implement (cost benefit analysis).

### **Floodplain Management Regulatory Activities (Current and Future)**

1. **Activity – Matrix Line Item 28 (Economic Impact)**  
Ensure adequate City resources are in place to assist residents when applying for buy-out and elevation grants.
2. **Activity – Matrix Line Item 28 (Economic Impact)**  
Develop Bellaire specific commercial drainage requirements.
3. **Activity – Matrix Line Item 28 (Economic Impact)**  
At all stages of infrastructure project development in the floodplain, gather community input strategies to be examined; allowing the public to see the results, costs, and benefits for alternatives studied.
4. **Activity – Matrix Line Item 28 (Economic Impact)**  
Evaluate a buy-out program for properties that have flooded repeatedly.
5. **Activity – Matrix Line Item 29 (Economic Impact)**  
Update City Ordinances to clearly define development guidelines for structures in the designated flood areas, as defined by current Special Hazard Flood Area Maps. Review and update City Codes based on the recommended changes to the Special Flood Hazard Area Maps.
6. **Activity – Matrix Line Item 30 (Economic Impact)**  
Research and evaluate regional approach to the 50% rule, for the development of City of Bellaire guidelines.

### **Property Protection Activities**

1. Activity – Matrix Line Item 29 (Economic Impact)

Evaluate updates to the Building Code which would allow residents to take proactive mitigation efforts on their property.

**Emergency Service Activities**

1. Activity – Matrix Line Item 9 (Mobility)

Develop a plan to identify, utilize, and position non-conventional access vehicles for use when weather events dictate.

2. Activity – Matrix Line Item 10 (Mobility)

Properly budget for rescue oriented persons to make logical purchases for rescue equipment. Develop a program to identify, train, and utilize Citizen Rescuers and create MOU (cover liability of the asses use donation). Evaluate reinstating Citizen Emergency Response Team (CERT).

3. Activity – Matrix Line Item 11 (Mobility)

Research, develop scope and policies and procedures, and place into effect a mass notification system.

4. Activity – Matrix Line Item 12 (Mobility)

Develop a rescue plan which utilizes field-confirmed data to generate on-the-fly response maps for rescuer pathways.

5. Activity – Matrix Line Item 8 (Mobility)

Formalize a mechanism within the scope of EOC operations whereby a team would be responsible for field reconnaissance as well as publication of information for use by the public via the website, social media, local news media, etc.

6. Activity – Matrix Line Item 24 (Preparedness)

Develop a plan to address rescues from one-story homes and older two-story homes. Develop a plan to evacuate disabled/physically impaired/elderly individuals from homes in advance of anticipated high rainfall events.

**Structural Projects**

1. Activity – Matrix Line Item 24 (Infrastructure (COB & Others))

Coordinate with Harris County Flood Control District (HCFCD) and the U.S. Army Corps of Engineers to determine how additional widening of Brays Bayou will reduce flooding for the City of Bellaire.

2. Activity – Matrix Line Items 14 & 16 (Infrastructure (COB & Others))

Evaluate increasing the size of existing storm water drainage culverts in Bellaire while continuing to utilize drainage impact when selecting roads to be reconstructed. Lower street level when streets are under construction. Strategically locate undergoing storage pipes within the existing street right-of-way to store 100-year localized rainfall events.

3. Activity – Matrix Line Item 17 (Infrastructure (COB & Others))

Determine partners, study alternatives, and develop cost estimates for improvements to increase capacity of the north/south drainage systems and Cypress Ditch.

4. Activity – Matrix Line Item 13 (Infrastructure (COB & Others))

Include design and installation of backflow prevention systems in the upcoming Bonds for Better Bellaire 2016 Projects. Coordinate with neighboring agencies (i.e. TxDOT, City of Houston, and HCFCD) to prevent backflow storm water from entering the City's underground drainage systems.

5. Activity – Matrix Line Item 33 (Representation)

Identify any and all regional partnership opportunities (elected & appointed). Determine appropriate representatives from the City for regional agencies.

6. Activity - Matrix Line Item 19 (Infrastructure (COB & Others))

Identify barriers restricting sheet flow and determine what project could relieve this problem.

7. Activity – Matrix Line Item 18 (Infrastructure (COB & Others))

Create a proactive approach to repair and maintain drainage systems in desirable development areas and neighborhoods with storm drainage systems. Develop a schedule to perform routine maintenance, inspections, and repairs to storm water infrastructure. Expedite a plan to repair and replace the highly critical local drainage systems in the current Cond for Better Bellaire 2016. Re-evaluate the priorities annually and aggressively pursue future bond programs.

8. Activity – Matrix Line Item 20 (Infrastructure (COB & Others))

Coordinate with HCFCD to determine steps necessary to increase the size of the outfall of Kilmarnock Ditch. Construct extreme event outfalls at Bellaire Blvd and within the Southdale Subdivision to Kilmarnock Ditch.

9. Activity – Matrix Line Item 22 (Infrastructure (COB & Others))

Contact surrounding municipalities and the agencies that own the storm sewers to consider upgrading their storm sewer and providing more detention. Investigate City of Houston developments north of Bellaire for total runoff.

10. Activity – Matrix Line Items 15 & 16 (Infrastructure (COB & Others))

Evaluate the conversion of Bellaire's Wastewater Treatment Plant and the dog park and soccer fields along Edith into detentions areas. Evaluate the conversion of the trash transfer station at Beltway 8 to a reservoir for Brays Bayou.

11. Activity – Matrix Line Item 15 (Infrastructure (COB & Others))

Evaluate the feasibility of adding flood stage gauges at strategic locations in the City to provide flood water readings for public safety.

**12. Activity – Matrix Line Item 25 (Facilities and Equipment)**

Evaluate the transfer of Wastewater Treatment for the City of Bellaire to the City of Houston Facility, including hazard mitigation funding opportunities.

**Public Information Activities**

**1. Activity – Matrix Line Item 1 (Public Communication)**

Develop a marketing plan which identifies the City outlets and how to increase participation in them. The plan should list events, stakeholders, etc. Develop and update a list of frequently utilized non-City outlets which the City should use to distribute its messages. This list should include media contacts, etc.

**2. Activity – Matrix Line Item 2 (Public Communication)**

Pre-populate communication outlets which needed information, allowing contacts to “opt-out”, instead of having to “opt-in”. Develop a communication matrix to outline what messages should be sent through which outlets. Evaluate the implementation of a “local street warden” program to deliver City produced storm related communication to their assigned area.

**3. Activity – Matrix Line Item 2 (Public Communication)**

Evaluate the implementation of a “local street warden” program to deliver City produced storm related communication to their assigned area.

**4. Activity – Matrix Line Item 3 (Public Communication)**

Develop public messages to be used prior to and during an event to outline when residents should use 911. The public messages should also include other communication outlets residents can utilize in non-emergency situations.

**5. Activity – Matrix Line Item 4 (Public Communication)**

Develop an educational program/campaign to inform residents and stakeholders of regularly utilized communication outlets.

**6. Activity – Matrix Line Item 5, 6 & 7 (Public Communication)**

Develop a communication template to be utilized prior to, during and after a flooding event which includes updates on information the City has deemed important based on lessons learned from previous events.

**7. Activity – Matrix Line Item 24 (Preparedness)**

Utilize Town Hall meetings to discuss all hazard preparedness. Create a preparedness milestone for families.

**8. Activity – Matrix Line Items 18 & 32 (Infrastructure (COB & Others)& Storm > 100yr)**

Develop an education program/campaign to inform residents on the level of protection provided by the City's infrastructure. Educate the public that street flooding is preferable to structural flooding.

9. **Activity – Matrix Line Item 26 (Health & Safety)**

Periodically distribute messages to residents warning of dangers of walking or playing in floodwaters. Everyone should refrain from walking or riding bicycles in floodwaters. Develop a plan with local schools to educate children to avoid walking, playing, or riding bicycles in floodwaters.

## **Appendix 22**

### **22. Bonds for Better Bellaire 2016**

# GROUP B PHASE I STREETS, DRAINAGE AND SIDEWALKS

## Bonds for Better Bellaire 2016 Program

**Background** The roadways identified in this project were designed with the prior 2005 Rebuild Bellaire bond program. They were then eliminated from construction due to funding constraints. The Bonds for Better Bellaire 2016 program approved \$20 million for street, drainage and sidewalk construction. The program will continue the City's practice to design and construct streets and drainage concurrently in one project with sidewalks to be installed on at least one side of the street. This project is the first of three that was approved with the funding.

**Resources** Project Background: [February 20, 2017 City Manager Presentation](#)  
Maps are in the presentation above. Reference Group B Phase I project and Group A Phases 1-3 Map for waterline location.  
2016 Bonds for Better Bellaire 2016 Program: [City of Bellaire Webpage](#)

**Scope:** Remove and replace the existing roadway, and upgrade the existing storm sewer for the following blocks:

- 4900 - 5000 Imperial Street (Including Water)
- 4700 Linden Street
- 4900 - 5000 Mayfair Street
- 4700 Willow Street

Add sidewalks to one side of the street for the following blocks:

- 4900 - 5000 Imperial Street
- 4900 - 5000 Mayfair Street

Replace several locations of existing sidewalks on both sides of the street for the following blocks:

- 4700 Willow Street
- 4700 Linden Street

**Schedule:** Design: Summer 2017 to Fall 2017  
Neighborhood Meeting: November 14, 2017 from 6:00pm – 8:00pm,  
CenterPoint Room, 7001 5<sup>th</sup> St, Bellaire, Texas 77401  
(Above the Bellaire Family Aquatic Center)  
Construction: Winter 2017 – Winter 2018

Project Budget: \$4,800,000 Bond Funds

Type of Contracts	Firm	Cost	City Council Approval
Design and Construction	HDR	\$46,030	<a href="#">March 20, 2017</a>
Administration			
Third Party Review	ARKK Engineers	\$9,000	<a href="#">March 20, 2017</a>
Construction Management	TBD		
Construction Contractor	TBD		

# GROUP C PHASE II STREETS, DRAINAGE AND SIDEWALK PROJECT

## Bonds for Better Bellaire 2016 Program

**Background** The roadways identified in this project were designed with the prior 2005 Rebuild Bellaire bond program. They were then eliminated from construction due to funding constraints. The Bonds for Better Bellaire 2016 program approved \$20 million for street, drainage and sidewalk construction. The program will continue the City's practice to design and construct streets and drainage concurrently in one project with sidewalks to be installed on at least one side of the street. This project is the second of three that was approved with the funding.

This project also has a drainage focus. Four flap gate locations along the southern perimeter of the City will be analyzed to determine if they will prevent flooding from Brays Bayou. If they do, they will be constructed with this project. Coordination from several agencies including Harris County Flood Control District, the Texas Department of Transportation, and the City of Houston is required for implementation.

**Resources** Project Background: [February 20, 2017 City Manager Presentation](#)  
Maps are in the presentation above. Reference Group C Phase II project and Group A Phases 1-3 Map for waterline location.  
2016 Bonds for Better Bellaire 2016 Program: [City of Bellaire Webpage](#)  
Report from City Engineer on Hurricane Harvey Flooding: [October 2, 2017 Report](#)

**Scope:** Remove and replace the existing roadways, sidewalks and upgrade the existing storm sewer of the following streets:

- 500 Block of Bolivar
- 4500 Block of Maple
- 5100 - 5200 Blocks of Spruce
- 700 Block of N Fifth Street

Improve waterline at the following blocks:

- 700 Block of N Fifth Street

Install Flap gates at the following locations:

- Cypress Creek Ditch at Newcastle
- S Rice Outfall
- 610 Ditch
- Union Pacific Railroad Ditch

**Schedule:** Pre-Design: Preliminary Engineering Report Completed  
Design: Fall 2017 – Spring 2018  
Neighborhood Meeting: TBD  
Construction: Fall 2017 – Fall 2018

Project Budget: \$7,600,000 Bond Funds

Type of Contracts	Firm	Cost	City Council Approval
Design and Construction Administration	Costello	\$500,000	<a href="#">March 20, 2017</a>
Third Party Review	ARKK Engineers	\$43,000	<a href="#">March 20, 2017</a>
Construction Management	TBD		
Construction Contractor	TBD		

## Appendix 23

### 23. Flap Gates Memo



# City of Bellaire

## Public Works Department

### MEMORANDUM

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TO: Paul A. Hofmann, City Manager  
FROM: Michael Leech, Public Work Director  
DATE: November 3, 2017  
SUBJECT: Flap Gate Project Update

At the March 20, 2017 City Council Meeting, Costello Engineering was awarded a contract to provide design services for the reconstruction of several street segments. The project also included the design of drainage system flap gates. The purpose of the proposed flap gates is to keep Brays Bayou storm water from entering the City's storm sewer system during high water surface elevation events along Brays. This memorandum will provide an update on the schedule of this work.

The street segments currently in design for reconstruction are listed below:

- 500 Block of Bolivar
- 4500 Block of Maple
- 5100 - 5200 Blocks of Spruce
- 700 Block of N Fifth Street

The flap gates, also currently in design, will be located at the following outfall locations:

- South Rice
- IH 610
- New Castle

Soon after the design of this project began, staff asked the Costello to explore the possibility of splitting the flap gate portion of the work from the roadway reconstruction portion. The logic behind the request was as follows:

- It may be possible to accelerate the schedule of the flap gate portion of the work.
- There may be savings in awarding two construction contracts rather than one as flap gate construction is relatively specialized when compared to roadway reconstruction.



# City of Bellaire

## Public Works Department

### MEMORANDUM

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Attached please find a letter from Costello supporting the installation of flap gates and explaining the results of their analysis relative to the flap gates. The letter generally states that the proposed flap gates would provide protection to the City during most high surface water events on Brays Bayou. It also states that there is no risk of a negative impact from the flap gates. However, during a record breaking event like Harvey, the flap gates would provide little benefit.

Also attached to this memorandum are revised project schedules for both the flap gate and roadway projects. By splitting the two projects the revised construction start date for the flap gates portion of the work is January 2019. This is approximately seven months sooner than the original schedule which combined both projects. The roadway portion of the project is scheduled to begin in August of 2019.



October 26, 2017

Ms. Cristin Emshoff  
City of Bellaire  
4440 Edith Street  
Bellaire, Texas 77401

**Re: Storm Sewer Outfall Flap Gate Hydraulic Analysis**  
City of Bellaire  
CI Job No. 2017114-000-00-011

Dear Ms. Emshoff:

This purpose of this letter is to present the results of a preliminary analysis to install flap gates at three major storm sewer outfall locations within the City of Bellaire: South Rice Avenue, IH-610, and Newcastle Street. These three systems discharge into the Cypress Ditch that runs along the south boundary of the city, generally parallel to Beechnut Street, and ultimately discharges into Brays Bayou. The purpose of the flap gates would be to prevent floodwaters from Brays Bayou from backing-up the Cypress Ditch into the storm sewer systems, thus reducing the capacity of the storm sewers. This analysis quantifies the amount of the storm sewer systems affected by the Brays backwater for a range of storm events and identifies under which conditions the flap gates provide a hydraulic benefit.

The main trunks flowlines and top of pipe elevations along each storm sewer system were compared to the Brays Bayou effective FEMA HEC-RAS model water surface elevations for the 10, 50, and 100-year event. The geometric data for each storm sewer was taken from the report tables provided by the city. The vertical elevation information provided was stated to be on the NGVD 1929, 73 adjustment. The FEMA model is on NAVD 1988, 2001 adjustment. A datum adjustment was computed of -3.24 feet (29, 73 – 3.24 feet = 88,2001) from HCFCD monument B 1211.

The attached **Exhibit 1** shows a profile of the South Rice Avenue storm sewer which compares the storm sewer system to the FEMA water surface elevations from Brays Bayou at the outfall location. The Brays 50 and 100-year backwater elevation in the ditch completely fill up the storm sewer pipes. The Brays 10-year backwater elevation leaves very little storage available. Installing a flap gate at the storm sewer outfall would prevent the ditch floodwater from backing up into the Bellaire storm sewers. However, when the river floodwater overtops the banks of the ditch, flap gates will provide no benefit. This elevation is between the 10-year and 50-year elevation, as indicated on the profiles. Additionally, if a local intense rainfall event occurs over Bellaire simultaneously, the local rain will fill up the system and balance itself hydraulically, regardless of the flap gate. In these situations, the flap gate does not provide a negative impact, but also does not provide any hydraulic value to the system.

To better define the range of hydrologic conditions in which a flap gate would provide benefit to the storm sewer system, an XP-STORM 2-dimensional analysis (2D) was created that simulates the main trunk of the underground storm sewer with the overlaying topographic ground. This 2D analysis allows

for simulation of a range of dynamic tailwater conditions with varying levels of rainfall to determine what conditions a flap gate would be beneficial to the hydraulics of the system.

The storm sewer pipes and manholes have been modeled as 1D elements connected to a 2D grid of the city created using the HGAC 2008 LiDAR dataset. A variable tailwater curve was created that approximates a Brays Bayou flooding event that fills up the Cypress Ditch in three separate tailwater conditions: bank ½ fill, bank full, and overtopping. Runoff hydrographs for a range of local rainfall events were computed which include the 2, 5, 10, 25, 50, and 100-year events. Each condition was then simulated with and without a flap gate. The benefits of the flap gate were determined by comparing the resultant water surface elevations with and without the flap gate. **Exhibit 2** shows a table of each storm event versus tailwater conditions.

The models indicate that the flap gate provides the greatest benefit when the local rainfall event occurs after the peak of Brays Bayou begins to recede. Additionally, as underground detention is planned to be constructed to aid in reducing internal peak ponding levels within the city, the benefit of the flap gate would increase due to the additional volume that would be at risk of being lost due to backwater from Brays Bayou.

Based on the above analysis, the addition of a flap gate would provide a benefit only during a certain range of hydrologic conditions, but these hydrologic conditions are experienced on a more frequent basis. No condition was determined that would create an adverse impact due to the flap gate being in place. With the planned underground detention improvements, the utilization of a flap gate would provide a reduced risk of flooding within the City of Bellaire. If you have any questions or comments, please feel free to contact me at 713-783-7788 or by email at [swilcox@costelloinc.com](mailto:swilcox@costelloinc.com).

Sincerely,  
Costello, Inc.



J. Stephen Wilcox, P.E., CFM  
Project Manager – Hydrology & Hydraulics

Attachments

**Exhibit 1** – Storm Sewer Profile

**Exhibit 2** – Benefit Summary Table

V:\Bellaire\300\_Drainage Analysis\302 (Flap Gate Analysis)\Memo - Flapgate 2D Analysis.docx

Schedule  
City of Bellaire  
Group C, Phase 2 Flap Gates

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names	4th Quarter			1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
							Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1																																	
2	60% Design	155 days	Mon 11/6/17	Fri 6/8/18																													
3	Utility Coord	120 days	Wed 11/8/17	Tue 4/24/18																													
4	Agency Coord	120 days	Wed 11/8/17	Tue 4/24/18																													
5	Surveying	44 days	Wed 11/8/17	Mon 1/8/18																													
6	Geotechnical	44 days	Wed 11/8/17	Mon 1/8/18																													
7	Structural Design	115 days	Wed 11/15/17	Tue 4/24/18																													
8	Details	103 days	Fri 12/1/17	Tue 4/24/18																													
9	Traffic Control	81 days	Tue 1/2/18	Tue 4/24/18																													
10	SW3P	72 days	Mon 1/15/18	Tue 4/24/18																													
11	Project Manual	72 days	Mon 1/15/18	Tue 4/24/18																													
12	Cost Estimate	72 days	Mon 1/15/18	Tue 4/24/18																													
13	60% Submittal	1 day	Mon 5/7/18	Mon 5/7/18																													
14	60% Reviews	24 days	Tue 5/8/18	Fri 6/8/18																													
15																																	
16	90% Design	91 days	Mon 6/11/18	Mon 10/15/18																													
17	90% Submittals	1 day	Tue 9/11/18	Tue 9/11/18																													
18	Approvals	24 days	Wed 9/12/18	Mon 10/15/18																													
19																																	
20	100% Design	13 days	Tue 10/16/18	Thu 11/1/18																													
21	100% Submittal	1 day	Thu 11/1/18	Thu 11/1/18																													
22																																	
23	Bid Process	23 days	Mon 11/5/18	Wed 12/5/18																													
24																																	
25	Contracts Process	23 days	Thu 12/6/18	Mon 1/7/19																													
26																																	
27	Construction	196 days	Tue 1/8/19	Tue 10/8/19																													

Project: Flap Gate schedule 110 Date: Thu 11/2/17	Task		Project Summary		Manual Task		Start-only		Deadline	
	Split		Inactive Task		Duration-only		Finish-only		Progress	
	Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
	Summary		Inactive Summary		Manual Summary		External Milestone			

**Preliminary Schedule  
Bonds for Bellaire, Group C  
Ph 2 Streets & Drainage\***

Project: Group C Phase 2 Street  
Date: 11/2/17



\* - Flap Gate work in Separate Construction Contract

## Appendix 24

### 24. Task Force Meeting Minutes

**City of Bellaire**  
**Flood Hazard Mitigation Task Force**  
**Meeting Notes**  
**October 30, 2017**

City Manager, Paul Hofmann called the meeting to order at 6:00 PM. He explained that where this meeting will deal more with introduction and orientation, future meetings will be much more involved. Mr. Hofmann added that all meetings will be open to the public and will continue to solicit public comment. He mentioned that they most likely will take place in the CenterPoint Energy room, which is located above the swimming pool. Mr. Hofmann recognized that many members of the Task Force were impacted by the recent flood event and voiced his appreciation for their service during a time when their lives have been significantly impacted. He then explained that this is a process that the City is actually behind on, and is required as part of the City's involvement in the Community Rating System (CRS). He added that one of the decisions that will be made in the upcoming months is whether or not the City will continue to be part of the CRS. Mr. Hofmann then asked the members of the Task Force to introduce themselves and to answer the question of **“What are we trying to accomplish?”**

**Jonathan Reichek**- Mr. Reichek stated that he has resided in Bellaire since 2017 on Lula Street. He added that their home did flood, and that he would like to help Bellaire to mitigate and prevent any future flooding.

**Win Frazier**- Mr. Frazier stated that he has been a resident of Bellaire since 1981, and has dedicated his service to the City in several different ways, including being a member and Chairman of the Planning and Zoning Commission. He added that he wants to be a part of the changes that need to be made.

**David Roylance**-Mr. Roylance stated that he has been a resident of Bellaire since 1995. He added that he was interested in serving on the Task Force for his own education as well as to insure that there is a robust and clear conversation about what we can do as a city to improve flood mitigation and access what funds may be available.

**Robyn Rosenblatt**- Ms. Rosenblatt stated that she moved to Bellaire 5 years ago. She added that she worked in public finance for 15 years, and is hoping to bring her Wall Street and government experience to the Task Force. Ms. Rosenblatt explained that she went through Hurricanes Ike and Katrina as an analyst. She stated that Bellaire needs to be somewhere that her and her family can stay.

**Brian Sanford**-Mr. Sanford stated that he moved to Bellaire in May 31, 2017, and this is his first home to ever own. He added that he has a very vested interest in the future of Bellaire, and what the Task Force does will help to pay dividends for the City Moving forward. He wants to ensure that the Task Force do the best they can.

**Yana Kristal**- Ms. Kristal stated that she has been a resident since January of 2017. She added that she had shoulder deep water and had to be evacuated by boat. Ms. Kristal said that it was very scary, especially with a toddler and that she never wants to go through an event like that again. She explained that her background in engineering and finance will help to contribute to the Task Force.

**Millie Hast**-Ms. Hast also stated that her home had flooded and that she had to be evacuated by the fire department. She added that she never wants to have to go through that again. Ms. Hast explained that she has been in Bellaire since 1979, and was a member of City Council from 1996-1999. She stated that she has also been on several other boards and commissions, and currently serves on the Patrons for Bellaire Parks. Ms. Hast stated that she is very dedicated to Bellaire and wants to ensure that Bellaire never has flooding again.

**Michael Ling**- Mr. Ling explained that he has lived in Bellaire since 2003, and was impacted by Hurricane Harvey. He added that this event was very near and dear to his heart. Mr. Ling stated that he is an engineer for oil and gas company and hopes he can contribute as much as possible. He mentioned that he appreciates the opportunity to serve on the Task Force and does not want to suffer again like the City did during Harvey.

Mr. Hofmann then explained that **Chris Canonico** and **Menny Rosenbaum** were also members of the Task Force, but were not in attendance. He stated that Mr. Canonico is an engineer specializing in the public utility area. He added that he lives in the Southdale area of the City and was flooded as well. He stated that Mr. Rosenbaum is a local builder and has been in the Bellaire area for several years. Mr. Hofmann mentioned that he has been very active in helping the residents of Bellaire to recover after Harvey.

Mr. Hofmann then reviewed the formal purpose of why the Task Force was formed and what the City is hoping to accomplish. He stated that based on the City Council's Resolution that was amended and passed in early October of this year, there are three primary purposes:

1. Identify flood hazards
2. Limit the impact of flood related losses to commercial and residential properties
3. Remain in good standing in the CRS of the National Flood Insurance Program (NFIP).

Mr. Hofmann explained that questions have recently been asked about what the City has done and what the City will continue to do to mitigate/prevent/control flood events in Bellaire. He mentioned that staff has been organizing their thinking around the "three realms," a regulatory realm, a local realm, and a regional realm. He then reviewed what each of those realms entails and explained what the Task Force's role would be in each. To view the entire presentation by the City Manager, please click [HERE](#).

Mr. Hofmann then asked the Task Force to answer the question of "**Why does flooding happen in Bellaire?**" The following responses were given:

**Jonathan Reichek**- Brays Bayou is undersized. The improvement of the railroad ditch going from concrete to unimproved could slow the water down. The tracks drain perpendicular to the bayou, making it harder for water to flow in.

**Millie Hast**- The current design standard for the storm sewer system in Bellaire is undersized. The impact of commercial development, is the City doing an adequate job in preventing downstream impacts.

**Win Frazier**- The flat topography of the area.

**Michael Ling**-The lack of control that the City has over the flow of upstream to downstream.

**Yana Kristal**-The Baldwin Street improvements need to be looked at in greater detail, is the water now higher after project, did it make things worse?

The following responses to “Why does flooding happen in Bellaire” were given by the public:

- The railroad track serves as a damn.
- The development on South Rice & the 59 feeder (Wal-Mart, Sams) was completed very rapidly. Was adequate detention designed by the City of Houston?
- The Cypress Ditch (controlled by City of Houston) is also undersized, and more development within the City of Houston pushes more water into the Cypress Ditch.
- The zoning code leads to more lot coverage and gutters drain directly into the street, filling them up faster.
- New sources of water are being routed into Brays Bayou.
- Water is coming out of Brays Bayou and going into the railroad ditch, which is acting as a tributary to the bayou. The City needs a backflow preventer.
- The increase of development upstream, west of Bellaire, and the possibility of more detention.
- Lack of information on the relationship between the reservoirs (Addick's, Barker, etc.) and Brays Bayou.
- The City's lack of success with mitigation grants, FEMA grants. Overstating Project Brays as a solution when the benefit of the completed project will only be minimal to the City of Bellaire.
- Drainage across from Westpark, was it developed sufficiently?

A member of the public then asked if there is a map of the flooded areas?

Mr. Hofmann explained that there are maps of where the flooding was most intense, and the report will be brought forward in the future.

Mr. Hofmann then introduced the members of the Council Liaison Team, Staff Advisory Team, and Consultant Advisory Teams and reviewed the roles and responsibilities that each of the groups, including the Task Force, are specifically charged with. He mentioned that one of the most important parts of the Mitigation Plan is public involvement and engagement.

A member of the public that used to be a floodplain manager for Harris County asked if the City will use different design criteria for storm water systems moving forward. Will more than the 100 year flood be taken into consideration?

Mr. Hofmann explained that this will ultimately be up to the City Council and the Task Force's recommendation. He added that for the most part the City's design criteria has been built around the 2 year storm event. Mr. Hofmann mentioned that the 2016 report, which was completed by the City Engineer, suggested a more aggressive design approach that would include underground detention in certain areas of the City, designed for the 100 year event.

Mr. Hofmann then reviewed the schedule of upcoming meetings, stating that the next meeting is tentatively being held on November 14<sup>th</sup>, with the heart of the agenda being a report from the City on the first draft of the risk assessment and mitigation strategy. He added that the City is currently envisioning a public hearing on Monday, January 29<sup>th</sup>, with the final action plan going before Council on

Monday, March 19<sup>th</sup>. Mr. Hofmann added that the start time of the meetings have not been nailed down yet. He mentioned that a separate site will be added to the City's webpage devoted to the work of the Task Force and reviewed what types of information will be made available on that site.

**Public Comments:**

**Sonya Regee:** Ms. Regee stated that she is very familiar with the benefits of participating in the CRS & NFIP, and wanted to know why the City's participation is under review.

Mr. Hofmann explained that the City's participation in the CRS is under review in order to determine if the benefits are worth the regulatory overreach of the City. He added that the people who were recently handed a Substantial Damage Declaration for their home are not going to be satisfied with the explanation that the City must do this in order to participate in the system and have lower insurance rates. He stated that he is not suggesting that the City no longer participate, just that it is something that needs to be evaluated.

**Jana Badian:** She asked if planning for the City's responders would be in the Task Force's purview. She also asked how funding would be allocated if and when a report is completed.

Mr. Hofmann explained that funding would be part of the risk assessment/ action plan. He added that the City's responders should be taken into consideration as part of the emergency response efforts and included in the plan.

**Lynn McBee:** Ms. McBee stated that she would like for the City to provide a list to the Task Force of all damages to the City buildings and equipment. She also suggested that the City buy a boat. Ms. McBee mentioned that a past Task Force said that the City would create its own drainage criteria and never has. She stated that it is about time that Bellaire took on that load. Ms. McBee also mentioned that the City has not seriously considered a location of land for Bellaire detention facilities, and that she would like to see the Task Force address that. She also stated that the media needs to be specifically invited to the meetings and given background material in advance. Ms. McBee also urged the City to invest in microphones for the CenterPoint room if future meetings are to be held there.

**Sean Hansen:** He encouraged the City to collect data from Harvey on how deep the water got at various locations.

**Robert Riquelmy:** Mr. Riquelmy asked how much subsidence there has been in the City since 2001? He added that this plan will require a significant amount of money and the police need the money more than drainage.

**Lynn McBee:** Ms. McBee mentioned that the City has participated in the CRS since 2004, and it was the first time that a pre-thought scheme was presented to justify a public policy decision. She added that it was very organized because the rules were preset. Ms. McBee felt that if the City does nothing other than to make a community policy decision, that process is the best the City could possibly have.



**City of Bellaire**  
**Flood Hazard Mitigation Task Force**  
**Meeting Notes**  
**November 14, 2017**

City Manager, Paul Hofmann began the meeting by reviewing the agenda. He stated that Ms. Sampson, Interim Director of Development Services, will spend a few minutes reviewing the City of Bellaire's approach to following the requirements of the Community Rating System (CRS). Mr. Hofmann added that a blank chart or template of what the Task Force's final report will look like will be shown during her presentation, and will include different elements that the Task Force will be charged with taking a look at. He stated that the purpose of this meeting is really to present information to the Task Force to aid in the preparation of the final report. Mr. Hofmann explained that once Ms. Sampson is done, Shawn Cox will be reviewing previous responses of the Task Force that have been compiled. He mentioned that the bulk of the meeting will be dedicated to a presentation from the City's Engineer, James Andrews.

Ms. Sampson then began her presentation on the City's involvement in the CRS. To view the entire presentation, please click [HERE](#).

The questions that were asked during the presentation include:

**Millie Hast-Won't the premiums be going up due to Hurricane Harvey? Will the City still continue to get a discount of 15%?**

-Ms. Sampson explained that she does not know what the future holds with regard to premiums. She added that those are decided on by the National Flood Insurance Program and would not be impacted by the actions of the City. She added that the 15% discount that the City currently benefits from will remain for as long as the City has a CRS rating of 7.

**David Roylance-Was information given to the City explaining how it could get a lower classification, and/or where the gaps were?**

-Ms. Sampson stated that at this time the City does not have that information, but more will be found out during the City's re-verification process.

Mr. Roylance added that it would also be beneficial to know what the neighboring cities' ratings were and how much of that can actually be controlled by the City versus how much is simply due to demographics.

**Robyn Rosenblatt-How much of the 15% discount is reflecting the risks of the City's topography and geography versus the process and the activities that the City takes part in?**

-Ms. Sampson explained that there are some areas of the rating system that are based upon things that the City cannot change, such as how much open land is present. However, there are other aspects, such as mapping, that the City's activities do impact.

**Chris Canonico**-Is there a cost matrix for the different CRS levels?

-Mr. Hofmann stated that the City should get a better sense of that as it moves forward and begins to assess the different aspects.

**Win Frazier-How will the 2017 regulations differ from the previous regulations? Are there any significant changes that would make a difference?**

Ms. Sampson stated that the point system is being split up differently than it was before. She added that there may be some areas that will require more work in order to get the credit.

**Brian Sanford-Is there a breakdown of the points that the City has received?**

-Ms. Sampson explained that she doesn't currently have that information, but will work on getting it.

**Millie Hast-What it would take for the City to become a Class 6?**

-Mr. Hofmann stated that these are questions that staff will do their best to get the answers to. He added that he isn't sure that the goal is to go from a 7 to a 6 or a 7 to a 5, but more to determine what steps can be taken in order to make the City a safer place.

Ms. Hast mentioned that it would be beneficial to know if there are actions that can be taken that would accomplish both of those things.

Mr. Cox then presented a compilation of the responses that were received from members of the Task Force after the last meeting. The three questions and responses are below.

**What are we trying to accomplish...**

**With the City of Bellaire drainage improvements?**

- Lower the frequency of both structural flooding and road inundation
- Protect the safety, health, & general welfare of residents
- Ensure development are compliant, which will result in proper storm water drainage & sediment control
- Minimize & mitigate the impact of flooding events
- Prevent future flooding from a Memorial Day type of event
- Systematically modernize drainage to address/replace aging infrastructure
- Reflect the changing residential improvements and commercial development objectives of the City
- Mitigate the adverse impact to residents, businesses and City property from flooding
- Any and all flood prevention measures, within our control, must be considered for implementation to mitigate our ongoing risk

### **From a regulatory perspective?**

- Review and define minimum level of service for drainage with Bellaire and what regulatory constraints would be borne by private property development as part of this level of service
- Identify FEMA and Hazard Mitigation Grant Program (HMGP) opportunities to bring federal dollars to Bellaire for hardening
- Clarify, either through law or regulation, how to implement flood mitigation
- Need to determine maximum impervious coverage allowed
- New & Redevelopment should have onsite detention
- Discourage or prohibit development in flood prone areas
- Assess current building code requirements with potential upcoming changes of the floodplain
- Reassess participation by the City of Bellaire in the national flood insurance program
- Develop and institutionalize a guideline for the City regarding infrastructure design, code, and investment criteria regarding flood control, e.g. City infrastructure, codes and involvement with regional solutions will be based on ensuring adequate response of XXX year events
- Assess building code requirements relevant to flood mitigation for adequacy
- Review NFIP CRS regulations and make any and all changes needed so that Bellaire's approach is consistent with surrounding jurisdictions

### **With other jurisdictions in the region?**

- Identify partnership opportunities to improve drainage retention/detention and proposed cost share
- FEMA and HMGP opportunities to bring federal dollars to Bellaire for hardening
- Evaluate pros, cons, and funding streams of Innovative regional solutions with joint benefits, such as wastewater consolidation and hardening with cost effective development of a localized detention pond/amenity park.
- Evaluate Project Brays impact and determine relative regional versus local drainage requirements to improve level of service
- Coordination to would include consistency in flood plain studies and flood mitigation plans in the region
- Improved drainage to Cypress Ditch, Railroad & IH610
- Work together to prevent future flooding
- Develop guidelines as criteria for investments of time and capital in supporting regional solutions that yield favorable progress toward City's outcomes on flood response and mitigation
- Work with jurisdictions to ensure actions do not adversely impact the City of Bellaire

Additional responses included:

**Millie Hast**-We can prevent flooding; we just need a commitment to do so. Currently, Bellaire streets are considered as part of the drainage, and she's not sure that this is a good idea. Ms. Hast mentioned that maybe a different solution is needed. She also felt that the terminology of "100 year" and "500 year" flood event should not be used anymore, that it is not relevant today. Ms. Hast stated that the City needs to modernize its approach to flooding. She referred to a study that she had read stating that storms are expected to increase in frequency.

**Michael Ling**-Half of the homes that were flooded were on the south side of the City, what can the City do to mitigate the "wall of water" from the bayou? He added that Project Brays only protects from a 100 year event. Does the City need to install detention ponds?

**Chris Canonico**-Felt that the Task Force should take into consideration the level of service that residents are expecting the City to provide.

**Win Frazier**-Mr. Frazier mentioned the same study that Ms. Hast had referred to, stating that bigger storms should be expected in the future. He added that this reinforces the need for the Task Force.

City Engineer, James Andrews, then made a presentation on the recently completed drainage report and Hurricane Harvey study. His presentation begins on page 15 of the document available [HERE](#).

Comments and questions that came out of Mr. Andrews' presentation included:

**Jonathan Reichek**-Do we know what areas of the City are more susceptible to flooding?  
-Mr. Andrews stated that a two dimensional model was prepared to reflect which areas were impacted the most.

**Yana Kristal**-Is Project Brays trying to mitigate for the 100 year flood?

-Mr. Andrews confirmed that it is.

**Millie Hast**-Does the City of Houston water from the Westpark area flow into the City of Bellaire's drainage system?  
-Mr. Andrews confirmed that City of Houston water does flow into the City of Bellaire drainage pipes and vice versa. He added that all of the systems are interconnected.

**Yana Kristal**-Would a backflow prevention system have helped during Harvey?

-Mr. Andrews explained that due to the amount of water that the drainage systems were inundated with, the backflow prevention system would not have helped.

**Millie Hast**-Is there anything that would prevent the City of Bellaire from pumping the water out of our system?

-Mr. Andrews stated that during an event such as Harvey, there would be nowhere to pump the water to, as all of the systems were full.

**Chris Canonico**-How many homes would have flooded if Project Brays had been complete during Harvey?

-Mr. Andrews stated that there would have been a significant decrease in the amount of homes flooded.

**Robyn Rosenblatt**-Should be cautious about getting a false sense of security from a project that is focusing on the 100 year event.

**Millie Hast**-Hopes that the improvements to Brays Bayou help as much as they are proposing they will, but agreed that Bellaire should not be counting on this project to solved all of the problems.

**Council Member Trisha Pollard**-Will the proposed backflow preventers have any negative downstream impact?

-Mr. Andrews stated that they will not negatively impact anyone downstream.

**Jonathan Reichek**-If Bellaire had control over Cypress or Kilmarnock Ditch, is there anything that the City would do differently?

-Mr. Andrews stated that he would like for more water to be put into Kilmarnock Ditch and possibly even expand it into the CenterPoint Energy tract.

**Robyn Rosenblatt**-Can or has the City entered into any interlocal agreements with the surrounding jurisdictions to ensure that all of the drainage systems are well maintained?

-Mr. Andrews stated that the City would certainly be open to entering into agreements of that kind.

**Michael Ling**- What is the City of Bellaire's approach for flood mitigation? 100 year event, 200 year event?

-Mr. Andrews explained that typically the City builds roadways with underground drainage systems to accommodate a two year storm, and rain intensities above the two year will begin to store in the street. He added that the problem is that there are pockets of neighborhoods that were built with a lower elevation and therefore the City is selecting larger detention storage, underground systems to install in those areas to help lower the flood heights. Mr. Andrews stated that the larger detention storage is for a 100 year flood event.

**Chris Canonico**-What constitutes a 100 year flood event?

-Mr. Andrews stated that the rainfall intensity varies for what is considered a 100 year flood event. He added that he would get that information for the Task Force.

**Council Member Montague**-Mentioned that the 100 year detention design was just recently started. How long will it take to install throughout the City, assuming that future bond programs are passed to fund the project?

-Mr. Andrews stated that the City is probably looking at the 20 year bond program before this initiative will be complete. He added that there are 70 miles of streets and 30% of them have been reconstructed with drainage improvements.

Council Member Montague felt that a responsibility of the Task Force should be to decide the magnitude and the length of the project.

**Mayor Friedberg** pointed out that nothing in the Bonds for Better Bellaire 2016 funding is intended to achieve the 100 year underground detention in given spots, but rather represents the turning point in our approach to design for that standard.

**Robyn Rosenblatt**-Is part of the charge of the Task Force to determine if the City's bond capacity is adequate to address the drainage problems in Bellaire at the speed at which they should be addressed.

-Mr. Hofmann stated that ultimately the City Council will be faced with some difficult decisions with regard to funding. He admitted that he is not sure if it would be part of the Task Force's responsibility to prepare a cost benefit analysis, and suggested that the decision be made once they see where the conversations lead. Mr. Hofmann added that it is the goal of the Task Force to present a recommendation to City Council by the spring of 2018, but acknowledged that this report may not answer every question or fully evaluate every scenario. He mentioned that the Task Force should not be too constrained by affordability when trying to come up with creative ways to address the City's drainage issues.

Mr. Hofmann informed the Task Force that there were additional reports prepared, but due to time constraints would not be addressed during the meeting. He added that staff would be providing them to the Task Force for review. Mr. Hofmann then stated that what staff had hoped to accomplish during the meeting was to show the Task Force what the Risk Assessment and Mitigation Strategy will ultimately include. He added that the biggest job of the Task Force is to ensure that the thinking is complete and includes all of the information that has been shared. Mr. Hofmann stated that staff will take a shot at filling out the template for the November 28<sup>th</sup> meeting, based on the comments and concerns that have been voiced by the Task Force. He also mentioned that the blank template will be sent out to all of the members so that they can add their thoughts and get it back to staff. Mr. Hofmann stated that the goal is to hold a public hearing on Jan 29<sup>th</sup>. He reminded the Task Force to keep thinking about the three realms, local, regulatory, and regional, and to focus on what information they think is missing thus far. Mr. Hofmann asked that the Task Force get everything back to staff by Monday, November 27<sup>th</sup> to include in the meeting on the 28<sup>th</sup>.

Public Comments included:

- Jim Borrough – He stated that good planning brings good results, and that the City needs to quantify the risks and go with what make the most impact. Mr. Borrough added that the biggest risk is in the southeast quadrant of the City, which is where the task force needs to put the most emphasis on.
- David Blake – This is a county problem, and the county does not believe in rules. He added that the City needs to stand up to the county.
- Robert Riquelmy – Mr. Riquelmy felt that the money needs to go to other departments, not drainage. He added that no lives were lost due to Harvey, and that Project Brays and new homes being build will eventually solve the problem.
- Tim Reed – Mr. Reed questioned whether run-off from Westpark comes into the City of Bellaire, and whether there are backflow preventers in the City now. He also asked if the City addresses the water from the North (overland flow). Mr. Reed stated that “we want to avoid becoming a detention pond.” He also asked if Wal-Mart has detention, and if so, if it is designed to handle the 100yr. storm.
- Lynn McBee – Ms. McBee mentioned the lot coverage requirements throughout the City and stated that the Planning and Zoning Commission needs to be involved in this process. She also mentioned that her discount is at 5%, not 15%, and that Project Brays is using data from 2001.
- Kara Hersh – Ms. Hersh suggested the use of the Recycling Center in the drainage plan. She also asked if bonds can be issued in 2018 for further improvements, and/or more mitigation.
- Ronald Burns – Mr. Burns asked if the 50% rule is required to be cumulative by the CRS?
- Another individual stated that the City needs to look at the broad picture of flooding patterns, and that everyone needs to work together.

City of Bellaire  
Flood Hazard Mitigation Task Force  
Meeting Notes  
December 5, 2017

Mr. Hofmann thanked all of the Task Force members for allowing staff the extra week to prepare for the meeting, as well as for taking the opportunity to contribute their ideas to the working draft of the matrix that was described at the last meeting. He then reviewed the agenda and stated that there would be a lot of opportunity for input during the meeting. Mr. Hofmann explained that comments that are listed on the matrix in red are comments that came from the Task Force, and comments in green reflect comments that came from staff and at least one member of the Task Force. He urged the Task Force to concentrate on the middle two columns of the matrix, and gave them three key words to guide them:

1. Clarity
2. Common understanding
3. Consistency

**Millie Hast**-Do we have an overarching goal for the City regarding flooding?

-Mr. Hofmann stated that at the first meeting of the Task Force, a presentation was given on City Council's charge and what the City is trying to accomplish. He referred the members back to that information and stated that if staff is still missing something, he is happy to hear a suggestion.

**David Roylance**-He would like to gain a better understanding of the expectations of the Task Force. He doesn't think that no flooding is a realistic outcome. What should we, as citizens of Bellaire, expect and what actions can be taken between now and then to accomplish those goals?

-Mr. Hofmann stated that he anticipates that as the Task Force goes through the process and carefully listens to each other, the end result will be some consensus on thematic messages to send forward to City Council. He added that this will include necessary discussions on what is predictable and what is not predictable, and what's feasible and what is not feasible. Mr. Hofmann felt that the final report in March will identify and recommend some ongoing efforts that the City Council will then need to decide to allocate money towards.

**Millie Hast**-What is an acceptable amount of flooding in Bellaire? 2,000 homes? 100 homes?

-Mr. Hofmann stated that he doesn't anticipate that any of the recommendations will be worded in such a manner. He asked the Task Force to trust in the process, and added that the overall/general goal of the Task Force is to mitigate flooding in the City of Bellaire.

**Council Member Pollard**-Is it to mitigate flooding, or to mitigate the damage caused due to flooding?

Mr. Hofmann felt that the Task Force is running the risk of getting too precise.

**Mayor Freidberg**-Reminded the Task Force that it was initially formed prior to Harvey in an effort to complete the requirements of the CRS program. He added that there is a timeline associated with the completion of those requirements. Mayor Freidberg also mentioned that in getting deeper into the CRS process, answers will come on how to mitigate flooding within the City.

Shawn Cox then went through the Public Communications section of the draft of the Hazard/Risk Assessment Matrix.

Comments and questions from this section of the matrix were:

**Council Member Montague**-Agreed with everything that was said, but feels that it is too complex. He stated that reverse 911 would cover all of the bases.

Mr. Hofmann stated that the residents have to be open to receiving the information and therefore there is no system that is fool proof.

**Millie Hast**-There is nothing that talks about what to do if there are power and cell phone failures. She added that normally electricity is one of the first things to go in an event like Harvey, and that residents will not be on the computer during a natural disaster.

**Win Frazier**-You are never going to be able to reach every resident within the City, but the Task Force should attempt to address these issues within the action implementation goals.

**David Roylance**-The Task Force should have realistic expectations about who will be reached depending on the avenues of communication used.

Mr. Hofmann stated that consistency is the key with regard to communication, and ensuring that the same message is being sent out across the board, whether it be via email, Facebook, Next Door Bellaire, etc.

**Brian Sanford**-Suggested that the City utilize an “opt out” system, where resident emails would automatically be entered into the notification system through the Utility Billing Department and they would have to unsubscribe in order to stop receiving the messages.

Fire Chief Darryl Anderson then reviewed the Mobility section within the matrix.

Comments and questions from this section of the matrix were:

**Chris Canonico**-A mitigation option that should be added to the matrix is improving the drainage capabilities within the City, which will then improve the mobility issues.

**Yana Kristal**-Was the City able to effectively segregate and rank the issues in terms of emergency, and/or identify priority houses?

Mr. Hofmann stated that he feels as though the City did an excellent job with that on the fly, but that the point is that there should have been a plan put into place beforehand.

**Millie Hast**-It is important to have adequate equipment in the vehicles, life jackets, waterproof bags, etc. Why can't Bellaire have a shelter?

Mr. Hofmann asked how a shelter located in Bellaire would be beneficial.

Ms. Hast explained that it would allow people to stay closer to their homes.

Mr. Hofmann pointed out that the shelter would not be limited to just residents of Bellaire.

Ms. Hast asked that it at least be looked into as a possibility.

Mr. Hofmann stated that ultimately the decisions regarding the opening of shelters are made by individuals other than City staff.

**Mayor Friedberg** stated that he felt as though the City could improve on taking a proactive approach with regard to communication, and anticipate some of the issues prior to the event taking place.

**David Roylance**-Asked if the City is comfortable with the call system during an event of this nature, in terms of capacity.

Mr. Hofmann explained that the 911 system operated fine through Harvey, however, the regular phone lines went dead for approximately one hour during the event. He added that Mr. Roylance had identified a risk.

**Council Member Montague**-Doesn't feel that residents, especially new ones, understand what happens and/or how to prepare during a flood event in the City of Bellaire. He suggested that the City find a better way to educate the citizens on this topic.

**Chris Canonico**-Made an observation that not all risks are created equal.

City Engineer, James Andrews then reviewed the Infrastructure section of the matrix.

Comments and questions from this section of the matrix were:

**Chris Canonico**-Mentioned that Harvey changed the standards of the 100 year flood event. A risk that should be assessed for the City of Bellaire is how those changes will impact the life safety issues and structural flooding issues throughout the City. Do residents need to be made aware that they are at more risk of flooding in the future?

**Millie Hast**-If we prepare for a 100 year flood event, the City will be inadequately prepared.

Mr. Andrews stated that the 2015 Memorial Day flood was a 75 year event, whereas Harvey was obviously much worse. He added that with the increased rainfall intensities, he isn't sure that it will be physically possible to mitigate against a flood event of that size.

**Chris Canonico**-Goal is to minimize the potential for structural flooding under any event.

**Council Member Montague**-The City is putting a lot of faith in the fact that Project Brays will be completed in 2021. Is there anything that the City of Bellaire can do to ensure that it is completed on schedule?

Mr. Hofmann agreed that the completion time of Project Brays should be listed as a risk.

**Win Frazier**-There is only so much that the City of Bellaire itself can do to mitigate; regional partners also need to be involved to obtain the desired outcome.

**David Roylance**-Felt that it is important to address the fact that a lack of cooperation from the surrounding cities is a hazard for the City of Bellaire.

**Michael Ling**-City of Houston developments are negatively impacting downstream areas, such as Bellaire.

It was determined that the risks are a lack of influence and a lack of cooperation from regional partners.

**Chris Canonico**-Are the engineers for the City of Houston running a series of tests to determine if drainage is adequate?

Mr. Hofmann stated that the City of Houston will not diligently review that model/analysis, even if the City of Bellaire were to go to the City of Houston and prove that the analysis that was completed was flawed.

**Yana Kristal**-Are areas where the City has worked to improve the drainage, such as Baldwin, doing their job?

Mr. Andrews stated that very recently the City has begun replacing those backbones of the system. He added that there is still much more that needs to be done, but major improvements in flooding have been witnessed in areas that have improved drainage.

**Win Frazier**-Is subsidence within the City an issue?

Mr. Andrews explained that originally it was an issue, but it has stabilized since.

**Mayor Friedberg**-Pointed out that the City is only about 30% done with drainage improvements throughout the City. He added that the full benefit will not be realized until the branches that

feed into that system are completely developed. How many more decades out is that? The risk is whether or not the City will ever actually get there.

Mr. Hofmann agreed that continuing to build the laterals into the Baldwin spine is a way to get certain areas of the City out of the flood risk area.

Mr. Andrews stated that the completion of Project Brays is an integral part of the puzzle, and the City then has to get the water to the Bayou.

Mr. Cox then explained that another risk is that residents will not be adequately prepared for natural and manmade disasters, and that the goal is to utilize community outreach to increase preparedness/awareness.

**Chris Canonico**-Mentioned that the risk isn't necessarily that the resident is not prepared, but more so that they are then taxing the City's system with calls. He added that he feels as though the hazard is that residents are not prepared and they in turn create the risks.

Public Works Director, Michael Leech then reviewed the facilities and equipment part of the matrix.

Brian Sanford-Asked Mr. Leech to quantify how close the public works facility came to being overtaken during Harvey.

Mr. Leech stated that it was very close. He added that the reason that operations were able to be continued had a lot to do with equipment that was not designed to be underwater but actually continued to work once it was, as well as members of staff staying on site to help alleviate the issues. He mentioned that once the computer system goes down then it becomes a manual operation, and as equipment would go out, employees would go to the site to try to triage the equipment to get it back up and running.

**David Roylance**-Are there financial incentives or other avenues that the City is not aware of with regard to relocating, upgrading, or even terminating service at that facility?

Mr. Leech stated that the City of Bellaire is plugged into many organizations and programs that could potentially offer a variety of options.

**Win Frazier**-At what point will the Task Force be in the position to prioritize the goals?

Mr. Hofmann explained that he doesn't feel as though the Task Force is missing any deadlines in terms of identifying projects. He added that right now the focus is on identifying projects and creating lists; in terms of prioritizing, that will all come through in the Task Force's final report.

**Millie Hast**-A risk that is not listed is the possibility of pollution in the event that the public works facility fails.

Mr. Hofmann explained that during and after the event, the City is in contact with TCEQ regarding that possibility. During those types of events, the City will not be held accountable.

Mr. Hofmann then stated that although the Task Force did not get through the entire matrix, they were pushing the two hour mark and he would like to open the floor up to the public. He added that the next version of the matrix, based on the discussion that was held during the meeting, will be brought back to the December 19<sup>th</sup> meeting. Mr. Hofmann mentioned that they may be able to start a conversation about the actionable items at that meeting as well. He asked that some of the members of the Task Force take a few minutes to list a few of the overarching theme or goal statements and email them to Shawn Cox by December 14<sup>th</sup>. Mr. Hofmann stated that eventually a narrative will need to be prepared that covers the matrix and pulls all of the information together.

Public Comments included:

**James Burrough**-Wanted to emphasize that time and time again the Task Force has referred to the needs and benefits of good advanced planning. He asked that this idea be included as part of the plan. He also mentioned that improved under the street mitigation is a great idea to help alleviate flooding and asked that it be included in the final report as well.

**Roxanna Ward**-She urged the Task Force members to attend the Brays Bayou Association meetings that are held on the third Monday of every month.

**Charles Platt**-Would be helpful for members of the public if documents were available on the website. Need to consider different scenarios than just the 100 year flood event.

**Millie Hast**-Could models be prepared to help the Task Force get a better idea of which actions would be beneficial and which wouldn't, such as turning the sewer plant into a detention pond?

**Chris Canonico**-Stated that answering all of those questions could potentially take a significant amount of time. He suggested that the Task Force focus more on setting the direction of the level of service that they would like implemented.

**Mayor Friedberg**-Nothing prevents the Task Force from, in its report, making specific recommendations for Council to look into, with the disclaimer that they do not know whether it would ultimately be an effective solution.

Mr. Hofmann thanked everyone for coming and reminded the Task Force that the next meeting will be held on December 19<sup>th</sup>, at 6:30 pm.

**City of Bellaire**  
**Flood Hazard Mitigation Task Force**  
**Meeting Notes**  
**December 19, 2017**

Mr. Hofmann welcomed everyone to the meeting. He stated that at the last meeting, the members of the Task Force were asked to send staff an idea of what they felt were the overarching goals of the committee. Mr. Hofmann stated that staff has attempted to take all of those comments and summarize, categorize, and use consistent goal oriented language for each of them. He mentioned that part of the agenda will be to review those goals and asked that the members please let staff know if there is anything that was missed. Mr. Hofmann then mentioned that for this meeting they were going to take a step back and take some time to review the term “100 year flood,” which is used very regularly, and try to help the members understand how the phrase is used from a technical standpoint, how it is applied, and where it comes from. He introduced Marcus McRae from ARKK Engineering.

Mr. McRae then gave an overview of the terminology used when discussing base flood elevations and the 100 year floodplain. To view the entire presentation, please click [HERE](#).

Questions and comments that came from the presentation included:

**Mayor Friedberg**-Mentioned that the term “BFE,” or base flood elevation, specifically refers to a 100 year flood event. He then asked if, in theory, a standard “BFE” could be adopted for a 200 year or 500 year event.

Mr. McRae confirmed that it could.

**Millie Hast**-Harvey caused a huge flood, but according to the numbers, the amount of flooding from Brays Bayou at South Rice Avenue and Stella Link didn’t reach the 100 year standard?

Mr. McRae & James Andrews, the City’s Engineer, stated that at South Rice Avenue it did not reach the 100 year standard, but it did at Stella Link.

Mr. Hofmann clarified that the point of the presentation is more about allowing for a common understanding of the different ways that the term “100 year event” is used so that everyone is on the same page. He added that it isn’t so much about an analysis of why certain areas flooded. Mr. Hofmann added that once Brays Bayou has been improved to better contain an extreme event, Bellaire’s local storm sewer improvements then have a better chance to do their job.

**Michael Ling**-Even if Bellaire didn’t have any localized rain, the City could still potentially flood due to the water coming out of the banks of Brays Bayou?

Mr. Andrews confirmed this, and stated that the combination of the localized rain and the overflow of Brays Bayou is what caused Harvey to be so significant.

**Millie Hast**-What year event corresponds to the point at which Brays Bayou's bank overflows in the areas near Bellaire?

Mr. Andrews stated that they could get this information for the Task Force.

Ms. Hast stated that it would be beneficial to have that information in order to plan for the future because if the BFE requirements within Bellaire change periodically, then homes that were built based upon a previous regulation are no longer protected from flooding.

Mr. Hofmann stated that the truth is that the City of Bellaire doesn't establish what the BFE is and is not in charge of the data that determines what the 100 year event is. He added that less than 2% of the homes that flooded during Harvey were built to the current BFE requirements. Mr. Hofmann mentioned that it all depends on how big of a role the government plays in the matter. He stated that Ms. Hast's concerns are very legitimate, but any changes made to the current regulations will be a policy decision. He also pointed out that there is value in having a standard that the rest of the country follows.

**Chris Canonico**-Stated that no one is ever fully protected from flood events, regardless of whether their structure is above or below BFE. He added that duration and/or the intensity of storm events will never be perfect.

**Council Member Montague**-Pointed out that the local geography plays a role as well. He stated that more homes on the north side of Bellaire flooded during Allison, whereas the south side was hit harder during Harvey. Council Member Montague also mentioned that he was surprised by the number of bungalow style homes that were impacted by Harvey, but had never flooded in any other event.

**Mayor Friedberg**-Mentioned that the government's role is to set the minimum standard for the health, safety, and welfare of both the current and future residents of each home, but there is nothing stopping the resident from going above and beyond those requirements to further protect themselves from potential flooding events.

**Robyn Rosenblatt**-Mentioned that establishing the correct height that a home should be built above BFE is important, but the most important topic, in her opinion, is what to do to help those residents that are already living in existing structures.

Mr. Hofmann then moved on to the topic of the Task Force's overarching goals. He stated that many of the members did email City staff with their ideas of what those might be, and that they were included in the document that he was about to review. Mr. Hofmann asked that the authors of those goals speak up if staff did not correctly capture the idea.

To view the goal statements, please click [HERE](#).

Questions and comments that came from the presentation were:

**Millie Hast-** Asked what the City's definition of "unreasonably" is within the first goal statement.

Mr. Hofmann asked for ideas from the Task Force on what would be considered "unreasonable."

**Brian Sanford-** "Unreasonable" would be for Bellaire residents to assume that the City of Bellaire can control the circumstances that take place outside of its boundaries.

**Win Frazier-** Felt that the goals need to be specific and time-bound. He questioned whether the term "unreasonable" could be either of those.

**Chris Canonico-** Adding some language at the end of the statement, such as, "during an event similar in intensity and magnitude of Harvey" gives a value to the term "unreasonable." A level of service needs to be set.

Mr. Hofmann explained that where he thought that the conversation was going during the last meeting was the broad, big picture, long-term overarching goals of what the Task Force is trying to accomplish. He felt that some consensus should be created around the broad concepts prior to whittling those down to include more precise and measurable language. Mr. Hofmann pointed out that he doesn't feel as though a level of service has been established yet. He then asked the members how they felt about that goal statement without the deletion of the word "unreasonable," which would read "Bellaire residents and property owners should not need to worry about flooding."

**Millie Hast-** Stated that she likes the statement without the use of the word "unreasonable." She added that no Bellaire homeowner should have to worry about their home or their business flooding. Ms. Hast mentioned that the word "unreasonably" opens the door to the idea that it is alright for some of the houses in Bellaire to flood, and that she would like to say that it is not alright for houses in Bellaire to flood.

**Chris Canonico, Council Member Pollard-** Mentioned that an unplanned disaster of this nature is unable to be 100% protected against. They compared it to a fire or someone getting hit by a drunk driver.

Ms. Hast stated that she didn't feel as though flooding is unplanned because of the fact that the City of Bellaire has had several major flood events and knows to plan for future ones, whereas no one knows if/when a fire is going to take place.

Mr. Hofmann stated that he didn't believe that anyone was arguing with the principal or the ideals, however, if the City does decide to do whatever it takes to prevent all future flooding in Bellaire, it will take a significant amount of time, money, and other resources to accomplish that.

Ms. Hast felt that the terms “worry” and “unreasonable” should be taken out of the statement, and that it should read something along the lines of “prevent flooding of structures in Bellaire.”

**Jonathan Reichek**-Would love it if no one in Bellaire ever had to worry about flooding again, but felt that it is a very unrealistic goal given what has happened in the past and the fact that the City of Bellaire is relying on outside entities to help in that effort.

**Brian Sanford**-Pointed out that there are multiple variables that play into flooding, such as, individuals who are buying houses at multiple elevations and in certain locations, and storms that are always changing. He added that there is no right answer, the Task Force just needs to come up with a reasonable plan to try to mitigate as much as possible for future events.

**Mayor Friedberg**-Agreed with Mr. Hofmann that no one is arguing about the broader objective, but in trying to navigate the individual consideration versus the broader policy objective, it is very difficult, in a compassionate way, to sit down with an affected resident and say “there is a reason that the rule is what it is, and we are sorry that you were negatively impacted by that.” He questioned whether referring to a level of severity would be more beneficial than a level of service.

**Millie Hast**- stated that if the Task Force is going to develop a level of service that falls short of protecting every home, then something needs to be done about the older houses that are not built above the BFE. She added that the City cannot just assume that they are going to be sold as tear downs.

**Council Member Pollard**-There needs to be a distinction in the statement between primary residences and garages. Based on the way that it currently reads, one could assume that it means that they will have no flooding to their property at all.

**Council Member Montague**-He was under the opinion that what the City is attempting to do is design against the 100 year flood. He suggested that language be added to the statement to read “Bellaire residents and property owners should not need to worry about flooding in the event of a 100 year storm.” He agreed with Ms. Hast that the City needs to find some way to address the houses that are more susceptible to flooding within Bellaire.

Mr. Hofmann stated that it is true that the City’s current approach revolves around the 100 year event, but that he would be careful about what that means to residents. He questioned if there was a descriptor or standard around which the City can contain what’s appropriately worrisome.

**Robyn Rosenblatt**-She doesn’t know if there is a better descriptor to use, but mentioned that it needs to be clear that they are not just talking about street flooding, but also about the fact that the water has nowhere to go.

**Win Frazier**-Agreed with Mr. Hofmann and stated that this would be a good umbrella for the other goals to fall under.

Mr. Hofmann stated that the elephant in the room is in dealing with the 60 year old homes that just flooded. Does the City build projects sufficient enough to keep that home from ever flooding again when that project is going to cost the taxpayers more than what that house is worth? What is reasonable?

**Millie Hast** -Stated that she doesn't feel as though you can talk about what is "reasonable" for those 60 year old homes without talking about a buyout.

Mr. Hofmann stated that this was a fair statement. He added however that there are other factors that play into this option. Mr. Hofmann stated that FEMA will supply some funding, but that it will not be 100%, and that there is also the opportunity loss of what could happen on that parcel. He added that those properties can never be developed on, and that not every parcel is well-positioned to be a detention facility or park.

Ms. Hast stated that property owners aren't even able to sell for lot value right now. She added that the City of Dickinson has some sort of grant program that they are taking part in and asked if there are other options such as that, that the City can look into.

Mr. Hofmann agreed that it is a very difficult situation. He confirmed that there are other options to look into.

**Chris Canonico**-Stated that the goal needs to be applied to a level of service and that the Task Force needs to determine what that level of service is going to be. He added that if the goal is to protect against the 100 year flood then the regulations, elevations, and capital improvement projects that the Task Force recommends will correspond to that level of service.

Mr. Hofmann then moved on to the other goals and asked that the Task Force speak up if they had suggestions on revisions to the wording.

Council Member Montague suggested that "trained" be added to the second bullet point. He stated that a lot of people still do not know to move their cars to higher ground, not to drive down a flooded street, and not to put their trash out when a flood is occurring.

Council Member Pollard asked for examples of what "prepared and equipped to deal with flooding" would include.

Mr. Hofmann stated that being plugged into the City's messaging efforts prior to the event would be the key.

**Millie Hast**-Felt that the wording of the statement would lead one to think that it is all on the property owners to be prepared and equipped. She stated that it should be revised to explain that the City will take the necessary steps to ensure that everyone is prepared and equipped with the necessary information prior to the flood event.

Mr. Hofmann reiterated that it is meant, at this point, to be a broad goal statement. He added that the City clearly has a role in that. Mr. Hofmann then moved on to the Planning and Implementation goals.

Mr. Frazier mentioned goal #3 on that page and asked that the regional projects be articulated.

Mr. Hofmann stated that obviously the number one project on that list would be the improvement of Brays Bayou. He added that there are some other things that could potentially impact the City's drainage, such as, changes made to the wastewater plant, which would not be a possibility without regional participation, as well as the City of Bellaire's involvement with the City of West University Place regarding the Kilmarnock Ditch.

Council Member Montague stated that the first and fourth bullet points need to say who is in charge of establishing those standards.

**Robyn Rosenblatt**-What does it take to fully protect the City from the 100 year flood event, and what does that translate to in tax effort?

Mr. Hofmann stated that it will take roughly 50 years and \$350 million. He added that City has and does attempt to quantify those things and will educate the public on that prior to the creation of a bond program. Mr. Hofmann then asked the Task Force if cost benefit is relevant. He questioned whether the cost of the projects compared to the value of the structures that are being protected is relevant.

The Task Force stated that it is relevant.

Mr. Hofmann asked how the level of protection is determined without a more complete analysis. How can that be done by March? What is the Task Force's message to City Council today about the level of protection?

**Chris Canonico**-Stated that it would be to protect against a certain size storm.

Mr. Hofmann asked what size storm that would be. He questioned what would be a reasonable size to protect against, and how that would be determined without some cost benefit analysis.

**Millie Hast**-Mentioned that the benefit is more than just financial, it's impacting lives.

Mr. Hofmann explained that it is completely incongruous for the City to hold new construction to a certain standard and ignore what is happening with the existing developments. He asked the Task Force to really think about whether or not cost benefit is relevant and what the level of protection should be. Mr. Hofmann also mentioned that if any members have any more thoughts about the goal statements or the Risk Assessment Matrix to let Shawn Cox know prior to the next meeting.

## **Public Comments**

A member of the public mentioned that there is nothing in writing explaining where the City takes those who have been impacted by the flood. He added that he feels as though that needs to be specified and the appropriate provisions need to be available at that location.

Mr. Hofmann mentioned that some of those logistics are not determined until during the event, and there is also some strategy involved when deciding whether or not to disclose the location of the shelters.

**Ronnie Burns**-Stated that he lives in Southdale. He felt that due to constant development that is happening, there will always be flooding within the City, especially in Southdale, regardless of the improvements made to Brays Bayou. Mr. Burns pointed out that the reality is that if you live in that area of the City, you should live there with the reality that your property will flood.

**Roxanna Ward**-Stated that the building code is very important to those property owners who were impacted by Harvey and are now trying to rebuild and/or elevate their homes. She added that there is a limit on the number of feet that a home can be elevated within the City of Bellaire, whereas in other cities there is not. Ms. Ward mentioned that she has some friends that live in Braes Heights, across the railroad tracks from Southdale that are elevating their homes 9 ½ feet so that they can put their garages on the first story. She added that not only does this help alleviate flooding to the primary structure, but it also creates more green space for the water to be absorbed. Ms. Ward added that she felt as though both the local and federal government could do a better job of helping flood victims find resources to help with the rebuilding process.

Mr. Hofmann and Mr. Cox stated that the next meeting will be on January 9<sup>th</sup>. He added that at the end of that meeting, the Task Force will need to determine whether they will be ready to hold a public meeting on January 29<sup>th</sup>.

**Chris Canonico**-Asked that a calendar invite be sent to the Task Force's City email addresses to remind them of the meeting dates.

**Mayor Friedberg**-Gave kudos to the group for the productive discussion during the meeting.

**City of Bellaire**  
**Flood Hazard Mitigation Task Force**  
**Meeting Notes**  
**January 9, 2018**

Mr. Hofmann welcomed everyone to the meeting. He then thanked everyone for their input at the last meeting and stated that he felt as though a lot was accomplished. Mr. Hofmann mentioned that he hopes the members of the Task Force got a chance to look through the new draft of the matrix which Mr. Cox sent out a few days before. He added that staff is doing their best to try and reflect all of the concepts/ideas that have been discussed in a consistent way. Mr. Hofmann stated that he would like to take some time to review how the regulatory process and the 50% rule works, which will be presented by ChaVonne Sampson. He also mentioned that there needs to be a discussion regarding the public hearing that is on the schedule for January 29<sup>th</sup>. He stated that he felt as though the Task Force is ready to hold the hearing on the scheduled day.

ChaVonne Sampson, Director of Development Services & City's Floodplain Manager-Mrs. Sampson reviewed the regulatory process with the Task Force. She explained how the 50% Rule comes into play as well as the suggested approach that staff would like to enforce during the next flood event. To view the entire presentation, please click [HERE](#).

Questions/Comments that came from the presentation were:

**Brian Sanford**-So the amount spent on permits for residential remodels is not a factor that is taken into consideration after the first flood of a home? What about the second time that the home floods?

Mrs. Sampson confirmed that those numbers are not looked at after the first flood, but will be taken into consideration after the structure has flooded for a second time.

**Chris Canonico**-What is the current approach that is being taken with regard to deciding whether or not a permit will be issued?

Mrs. Sampson stated that currently, all residential remodel permits and all flood permits were looked at throughout the event when deciding what permits to issue.

**Millie Hast**-Mentioned that she thought that the City had stopped doing that.

Mrs. Sampson explained that during Harvey was when staff starting making changes, but prior to Harvey everything was looked at cumulatively. She added that actually having regulations in writing will help during future events.

Mr. Hofmann agreed that at this point all the City can say is what the prior practice has been, but having something in the books that explains the cumulative approach would be very beneficial. He stated that members of the task force have brought up a valid issue about how

the City of Bellaire's approach differs from other entities in the region, and that there are consequences associated with that which the City needs to think about. Mr. Hofmann added the purpose of this is to define a policy direction that can be codified, ultimately by the City Council. He stated that Ms. Hast is correct that the City did change their approach half-way through the process during Harvey, and that moving forward this process needs to be established.

**Millie Hast**-Is the 50% Rule a requirement of the Community Rating System (CRS)?

Mr. Hofmann explained that how the cumulative issue is dealt with is decided on a local level. He added that the 50% Rule is not negotiable, but the "cumulative" approach is.

**Mayor Friedberg**-He asked for clarification that the difference in the current approach and the suggested approach is that the resident gets a "second bite at the apple." He added that due to the magnitude of Harvey, it didn't seem right to count a small remodel permit against the homeowner's ability to get a flood repair permit.

**Council Member Montague**-Mentioned that past flood events and future remodel permits will count against the resident after two flood events.

**Robyn Rosenblatt**- Clarified that the third box is triggered by a third flood or a remodel after a second flood.

**Millie Hast**-Will the previous permits be pulled from as far back as when the house was built or when the current owners purchased it?

Mrs. Sampson explained that based on conversations with Mr. Hofmann, the new standard would be from 2015 (Memorial Day Flood) on.

Mr. Hofmann explained that prior to two flood events no single permit is allowed to be more than 50% of the value of the structure, however cumulative does not come into play. After the second instance of flood damage, prior flood permits as well as remodel permits (from 2015 on) will count towards the 50% Rule.

**Chris Canonico**-Why are remodel permits included in the cumulative review of the structures?

Mr. Hofmann stated that the goal of the City is to enforce and create compliance. He questioned whether it makes sense for the City of Bellaire to continue allowing residents to invest money into structures that are subject to repetitive flooding.

**Menny Rosenbaum**-Aren't we then creating an environment where residents will begin to do work without a permit?

Mrs. Sampson mentioned that in those instances, the property owners are taking a huge risk on a home that is subject to multiple instances of flood damage.

Mr. Hofmann asked Mr. Rosenbaum what his suggestion is on how the City should approach the 50% Rule and the accumulation of costs towards that rule, moving forward.

Mr. Rosenbaum felt that each incident should be considered independently. He stated that only 47 structures that are compliant received flood damage, and that new processes and major investments shouldn't be made for such a small amount of homes within the City. He felt that the current system works. Mr. Rosenbaum mentioned that nature will find a way to clear the path for new construction to build better homes.

Mr. Hofmann explained that the 50% Rule only applies to those homes that are not compliant (built one foot above the Base Flood Elevation).

**Millie Hast**-Feels that it is wrong to force people to tear down their home. She added that many residents may not be able to afford to demolish and rebuild and therefore should be able to improve/remodel it as they wish.

**Mayor Friedberg**-Pointed out that the 50% Rule is the same with the City's zoning code as it is with flooding. He explained that the zoning regulations state that any property built prior to the code going into effect is grandfathered in. However, if an incident takes place that requires the remodeling or rebuilding of 50% of the structure then it must comply with the new zoning requirements. Mayor Friedberg stated that it is the same with a home that was not built under the current regulations of one foot above BFE. The home is grandfathered in until such time that it is deemed substantially damaged and 50% or more of the value of the home must be invested in order to make repairs.

**Millie Hast**-The City needs to help people elevate if this is going to be the standard. She added that although property owners are able to apply for loans and grants through FEMA, those funds are not guaranteed.

**David Roylance**- Asked Ms. Hast how she would view the City's handling of the valuation of that land for future tax purchases, if the City were to contribute funds to help with the elevation.

Ms. Hast stated that obviously more thought would need to be put into the idea; she just feels that if the goal is compliance, people should be helped rather than punished.

Mr. Hofmann reiterated that the question once again becomes, what is the appropriate role of government? Where should the City be putting its very limited resources?

**Brian Sanford**-Mentioned that no one that he has spoken to outside of the City of Bellaire had ever heard of the cumulative approach. He felt that the City needs to be cognizant of the fact that because the surrounding entities are not taking the cumulative approach, homes in Bellaire will become less valuable. He added that this will lead to a decrease in demand for homes within Bellaire when compared to homes in other areas of Houston. Mr. Sanford then stated that, hypothetically, the regulations to be built one foot above BFE could be increased, which then means that the majority of homes within the City will no longer be compliant. He also

mentioned that the \$30,000 of Increased Cost of Compliance (ICC) funding that is provided by FEMA to residents who have flood insurance and are deemed substantially damaged, does not take the cumulative approach. He suggested that the City of Bellaire adopt a process that aligns with the process that other jurisdictions have in place.

**Robyn Rosenblatt**-How is the City calculating the value of the structure? Is it strictly based off of the HCAD appraisal?

Mr. Hofmann explained that the City has established an alternate formula to determine the value of the structure, which includes the HCAD appraisal, along with several other factors.

Ms. Rosenblatt asked if the value of the lot is also part of that calculation.

Mr. Hofmann stated that it is just the value of the structure (improvement).

**Chris Canonico**-Feels that the City should use only the HCAD appraisal in determining the value of the home, and encourage people to get flood insurance. He added that he feels as though the City's current regulations are penalizing the residents who own a home that was built between 1990 and 2007.

**Robyn Rosenblatt**- She mentioned Ms. Hast's comment regarding the City helping to fund the elevation of homes. She questioned what the assessed value would be on the home, and how many years the City would have to tax that home in order to get a return on its investment. Ms. Rosenblatt stated that the homeowner gains the benefit while the cost is borne by the whole community.

**Council Member Montague**-If in fact Project Brays is completed, and the floodplain recedes, then the number of houses that are non-compliant within the City of Bellaire are going to be significantly reduced. He stated that he would like for the Task Force to fast forward and assume that Brays is going to happen; what is the community going to look like in 2022 with a "clean slate, and what regulations need to be put into place for when that time comes?

**Menny Rosenbaum**-FEMA is providing funding for homeowners of 1950s homes to repair and elevate the structure that is of no value in today's market.

**Mayor Friedberg**-Mentioned Ms. Hast's comment about the City "forcing" people to tear down their home and pointed out that the idea that someone would want to continue living in a home after 4 floods is irrational. He added that there is a lot of value associated with the property which can be used to rebuild and/or go elsewhere.

**Win Frazier**-Agreed with Council Member Montague's comment regarding Project Brays. He disagreed with the idea that Bellaire should just adopt the same regulations as other jurisdictions. He stated that Bellaire has made it a point to be different than the surrounding cities, and should make decisions with that in mind. Mr. Frazier then asked how the Task

Force's recommendation was going to be codified prior to going to Council. Are there any Boards or Commissions that it will need to go to prior to Council seeing it?

Mr. Hofmann stated that if any amendments were recommended to Chapter 9, then the Building and Standards Commission will need to be included in that review.

**David Roylance**-Mentioned that the City's formula essentially creates more leeway for a homeowner to come in below the 50% and agreed with Mr. Rosenbaum's comment that it makes no sense to invest a significant amount of money to repair a home with a HCAD value of \$1,000. He also agreed that including the amount spent in remodel permits in the cumulative approach will create an environment of residents doing work on their home without a permit and asked how that will be controlled.

**Robyn Rosenblatt**-Is anyone currently monitoring the situation of what houses have not remediated or are working without a permit?

Mr. Hofmann stated that City staff is actively monitoring that, but unfortunately is unable to know what is going on with each and every house within the City. He mentioned that currently only 50 homes have been deemed substantially damaged under the formula that the City is implementing. He added that if only the HCAD valuation was taken into consideration that number would be significantly increased. Mr. Hofmann then asked Mr. Canonico to better explain his reasoning for wanting to only use the HCAD value of the structure.

**Chris Canonico**-Stated that in only using the HCAD value, the City can achieve a higher level of safety, and it will help to get more homes within the City into compliance with the floodplain regulations.

Mr. Hofmann stated that he understands the logic, but reiterated that there would be hundreds more people without options in Bellaire today if that was the only number taken into consideration.

Mr. Canonico agreed that at the beginning there would be a lot of people that would be negatively impacted, but moving forward the City should require that everyone has flood insurance.

Mr. Hofmann asked if having flood insurance would really solve the problem.

**Robyn Rosenblatt**-Stated that even with flood insurance and funding from FEMA, the application is going to be looked at with a cumulative approach and they may or may not be able to get a permit.

**Chris Canonico**-Mentioned that the property owners who have flood insurance receive funding to help pay for the elevation of the home.

Mr. Hofmann pointed out that only \$30,000 is contributed to that effort.

**Council Member Montague**-He asked how the City of Houston calculates the value of the structure.

Mrs. Sampson explained that they use a formula similar to what Bellaire is using.

**Mayor Friedberg**-Didn't feel that simply using the HCAD value as opposed to a cost estimator, after the fact, is going to persuade individuals to get flood insurance.

**David Roylance**-Felt that if the City wants to continue using the cost estimator then taking the cumulative approach makes sense. However, if only the HCAD value is used then it does not need to be cumulative.

Mr. Hofmann then showed the Task Force the updated matrix, and stated that according to the schedule, the next meeting would be on January 29<sup>th</sup> in the form of a public hearing. He asked if they felt as though the draft version of the Task Force's work is sufficient to receive public comment on in 20 days.

**Jonathan Reichek**-Stated that he didn't feel as though it was ready for public comment. He suggested that the Task Force meet with James Andrews, the City Engineer, to see if the ideas are feasible options.

**Win Frazier**-Felt that the Task Force should move forward with the public hearing. He added that it gives the public the opportunity to give their opinion on what is being proposed and then time for the Task Force to take those comments into consideration.

Mr. Hofmann mentioned that Mr. Reichek's concerns don't necessarily need to be vetted prior to getting public input.

**Chris Canonico**-Suggested that the City require homeowners to have flood insurance prior to being issued a flood repair permit.

The consensus from the Task Force is that a public hearing should take place on January 29<sup>th</sup>.

Mr. Hofmann stated that City staff would start to push out some public messages about the hearing. He added that the public hearing will be in the Council Chambers, at 6:30 PM on the 29<sup>th</sup>. Mr. Hofmann stated that the Task Force will meet again on February 6<sup>th</sup>, which will concentrate on what was heard at the public hearing, and then again on February 20<sup>th</sup>. He asked the members to please continue to read the materials and let staff know about any suggestions that they may have. Mr. Hofmann also explained that Mrs. Sampson is communicating with a Community Rating System (CRS) representative and will be getting their opinion on the work that has been done with the Task Force.

**David Roylance**-Felt that the Task Force may need to add an additional meeting to the schedule.

Mr. Hofmann stated that staff will make note of holding an additional meeting that might include a discussion with Mr. Andrews about the recommendations.

**Public Comments:**

**Roxanna Ward**-Does the City of Bellaire's CRS have a severe repetitive loss revision?

Mrs. Sampson stated that it does not.

Mrs. Ward stated that from what she understands, the standard that is being proposed for the City of Bellaire is potentially more relaxed than what the City of Houston has in place. The City of Houston's CRS does have a severe repetitive loss revision which states that if a structure floods twice in two years and each time the cost to repair is more than 25% of the value of the house, then the house must either be elevated or demolished.

**Doug Newport, 4820 Spruce**- Mentioned that there is a recommendation in the draft that deals with increasing the capacity of Cypress Ditch. He stated that it is probably not a bad idea and that if the ditch was a box shape it would almost double the capacity. Mr. Newport pointed out that just that one improvement could make a big impact on the future of flooding in Bellaire. He suggested that the draft include something that is more visual to present to City Council.