HAZARD MITIGATION PLAN
(including Flood Mitigation Plan)

For The

CITY OF BENBROOK

August 2010
Revised September 20, 2011

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Executive Summary

The Hazard Mitigation Plan for the City of Benbrook has been prepared in accordance with the requirements of the Disaster Mitigation Act of 2000 and will be adopted by the Benbrook City Council upon approval by the State Hazard Mitigation Officer and the Federal Emergency Management Agency. The Plan reviews the risks and vulnerability for a range of 23 potential natural hazards and has identified the following as the most important in Benbrook (ranked High or Serious Risk), in decreasing order of priority:

Wildland Fire
Flooding
Tornadoes
Dam failures
Landslides
Lightning
Stream bank erosion
Severe thunderstorms and high winds
Expansive soils
Extreme heat
Severe winter and ice storms
Droughts
Hail

Each hazard was profiled and assessed for risk based on the State of Texas Emergency Operations and FEMA criteria.

At least two mitigation projects were identified for each hazard, and were prioritized based on vulnerability and cost effectiveness. The Plan will be adopted by the Benbrook City Council, following public hearings before the Planning and Zoning Commission and City Council.

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I. Introduction

This Hazard Mitigation Plan (HMP) has been developed for the City of Benbrook to comply with the requirements of the Code of Federal Regulations, Title 44, Section 201.6 – Local Mitigation Plans, of the Federal Emergency Management Agency (FEMA). These regulations were promulgated to comply with the requirements of the Disaster Mitigation Act of 2000. The HMP describes the goals and activities of the City of Benbrook to reduce the effects of natural hazards. It is also a pre-condition to future disaster funding from the Federal Government.

While presented as a stand-alone document, the City will incorporate a Response and Preparedness of the Benbrook Comprehensive Plan. *Section 12.4* previously discussed the most significant natural hazard risks and vulnerability (flooding, tornadoes, and winter storms) and man-made hazards (fire and conflagration, and hazardous chemical spills), as well as a summary of the response plan included in the City's Emergency Management Plan (EMP). This HMP also serves as a supplement to *Annex P* of the City of Benbrook's Emergency Management Plan and is intended to comply with the requirements of the Texas Division of Emergency Management (GDEM).

A. Previous Mitigation Planning Efforts

The City of Benbrook performed a limited risk and vulnerability assessment as part of its Comprehensive Plan in 1995. This analysis included an assessment of the risks and vulnerability from flooding, tornadoes, winter storms, fires and conflagration, and hazardous chemical spills. That plan was developed by City staff, recommended by the Benbrook Planning and Zoning Commission and adopted by the Benbrook City Council following two public hearings (one before P&Z and one before City Council.)

The City of Benbrook prepared a draft Hazard Mitigation Plan (HMP) in 2004 to comply with the November 2004 deadline established by the Disaster Mitigation Act of 2000. The Plan was prepared by a Hazard Mitigation Plan Committee comprised of the following City staff: Assistant City Manager, Emergency Management Coordinator (EMC), City Planner, City Building Official, and Geographic Information System Technician. The Plan was adopted by the Benbrook Planning and Zoning Commission in 2004 and City Council in 2005 following three public hearings (one before P&Z and two before City Council.) A number of the action steps included in that Plan have been implemented by the City since its adoption. Although submitted by the City for approval, the 2004 HMP was never approved by the Governor's Department of Emergency Management (GDEM) or the Federal Emergency Management Agency (FEMA).

In addition to the specific mitigation plans prepared and adopted by the City of Benbrook, the City has undertaken other planning efforts related to hazard mitigation. Since flooding is the most common potential natural hazard present in the City, the City has undertaken a number of steps over the years to mitigate the severity and vulnerability of the City's residents to flooding events. The City joined the National Flood Insurance Program (NFIP) in 1977 and has aggressively enforced its floodplain management ordinance ever since. The City's Ordinance includes many provisions for higher regulatory standards as part of that ordinance, and the City has participated in the Community Rating System since 1990, with a current CRS rating of "6". The City has adopted several city-wide drainage plans over the years, including a citywide comprehensive drainage plan in the early 1990s, a more specific drainage plan for the City's four most vulnerable streams in 2004, and Storm Water Management Plans in 2003 and 2008 to comply with State and Federal Phase 2 storm water permitting requirements. The City adopted the regional integrated Storm Water Management (iSWM) design standards in 2005 (and adopted the revised standards in 2010), and established a storm water utility in 2007 to fund small drainage projects. The City's voters most recently passed a bond issue in 2004 to fund construction of five drainage projects to remove residents from the 100-year floodplain, with all five projects being completed as of 2010.

B. Current Planning Process

On February 18, 2010, the City began the process of developing a new Hazard Mitigation Plan (HMP), with the intent of adopting the new plan by July 1, 2011. On March 10, 2010 the City staff formed an *ad hoc* committee to draft a new Hazard Mitigation Plan, with the following members:

<u>Hazard Mitigation Planning Committee</u>

David R. Gattis, FAICP, CFM, ... Deputy City Manager and Committee Chair
Mark O'Connor . Assistant Fire Chief and Emergency Management Coordinator
Ed Gallagher.....City Planner
Wayne Carlisle..... Building Official
Walter Shumac, P.E..... Director of Public Services
Chris Bobbitt, Katheryn Cromwell ..... City Management Interns
Amy Roach, Jonathan White.....Geographic Information Systems Technicians

Each committee member lent their respective expertise during the planning process, as well as reviewing and editing the draft. The City did not employ any external contributors or contractors during the planning process.

The committee met on four separate occasions throughout the planning process:

Committee Meeting Dates and Agendas

March 17, 2010 – First Committee Meeting
- Identified hazards that affected the City
- Reviewed the sources contained in this plan
- Determined which hazards were most significant to Benbrook

May 26, 2010 – Second Committee Meeting
- Reviewed risk assessment results
- Refined the City's overall risk assessment
- Discussed potential mitigation measures

August 4, 2010 – Third Committee Meeting
- Discussed hazard mitigation efforts

June 23, 2011 – Final Committee Meeting
- Reviewed the re-draft of the Hazard Mitigation Action Plan
- Reviewed the new mitigation action items

On August 18, 2010 the draft HMP was sent to the State's Department of Public Safety's Division of Emergency Management for review and approval. On January 26, 2011, the State responded that the plan was not approved and the City began the process of revising the Plan to respond to the review comments. The current revision of the plan is based on feedback from the public (especially pertaining to dam failure risks), in addition to the reviewer's comments from the State.

C. Method and Schedule for Monitoring the Plan

The City's Deputy City Manager (or his designee) is responsible for preparing annual reports regarding the status of the Benbrook Hazard Mitigation Action Plan to the Hazard Mitigation Planning Committee in September of each year. These reports will contain:

- A current Hazard Mitigation Committee roster
- Status of any hazard mitigation projects in process
- Status of any funding
- Potential funding opportunities
- Any new or changed risks or vulnerabilities
- Any revisions to the Benbrook Hazard Mitigation Action Plan

A summary of the Hazard Mitigation Plan, including Plan Maintenance, will be incorporated into Chapter 12 – Public Safety of the

Comprehensive Plan for the City of Benbrook by the end of 2011. The Capital Improvement Plan (CIP) is also included as *Chapter 17* of the Comprehensive Plan. Many of the projects included in the various components of the Plan, including this Hazard Mitigation Plan, are incorporated for future funding within the CIP.

D. Method and Schedule for Evaluating the Plan

The Deputy City Manager is responsible for providing that the Hazard Mitigation Action Plan is reviewed and updated annually by September of each year. The City's Hazard Mitigation Planning Committee, neighboring communities, the public and external agencies will be invited to participate in Hazard Mitigation Plan evaluations.

Criteria for evaluating the Benbrook Hazard Mitigation Action Plan will include:

- Successful implementation of mitigation projects,
- Success in increasing public involvement in hazard mitigation,
- Success in increasing external agency involvement in hazard mitigation,
- Compliance with FEMA Hazard Mitigation Program regulations and guidance,
- Compliance with Texas Governor's Division of Emergency Management Standards,
- Compliance with applicable City & County codes and ordinances,
- Changes in National Flood Insurance Plan policy status (number and location of policies in effect, any increase or decrease in policies), and
- Status of repetitive loss properties (number of claims, new claims, property purchased).

E. Method and Schedule for Updating the Plan on a Five-Year Cycle

Benbrook's Hazard Mitigation Action Plan will be reviewed for potential updates every five years, or more often as necessary. The FEMA/DEM Plan Review Crosswalk for Review of Local Mitigation Action Plans and DEM Planning Standards will be the criteria for review and updates. Updates to this plan will be coordinated by Deputy City Manager, the Benbrook Hazard Mitigation Action Plan Committee, other City departments, the public and other external agencies.

Notice of significant updates will be posted on the City of Benbrook website and communicated to the public and affected/interested parties by the Deputy City Manager (or his designee). Future updates will include additional information on risks that may become available, the reduction of risks as projects are implemented, the removal of

potential projects as they are implemented, and the addition of new projects where new risks or vulnerabilities are identified.

F. Review and Incorporation of Existing Plans, Studies, Reports and Technical Information

A number of existing documents have been incorporated in the City of Benbrook Hazard Mitigation Action Plan. These documents include:

- NCTCOG's Multi-Hazard Risk Assessment
- City of Benbrook Comprehensive Plan
- State of Texas Mitigation Plan
- FEMA Digital Flood Insurance Rate Maps
- Tarrant County Hazard Mitigation Action Plan

The NCTCOG Multi-Hazard Risk Assessment provides an excellent assessment of hazards in our area. Information from the assessment on each hazard was reviewed to determine potential applicability to Benbrook.

The City of Benbrook's Comprehensive Plan is the city's official guide for making decisions about growth and development. The plan provides a wealth of information about recommended policies, strategies, programs, and projects that the City plans to pursue. Population and economic trends in the Comprehensive plan provided a valuable perspective for identifying potential mitigation projects. The Plan is updated regularly, but no less frequently than once every five years.

The State of Texas Mitigation Plan and the Tarrant County Hazard Mitigation Action Plan were reviewed to provide guidance for identifying and prioritizing mitigation projects.

Digital FEMA Flood Insurance Rate Maps for Tarrant County and Incorporated Areas were published in September 2010 and were used to identify flood hazard areas and potential mitigation projects.

G. Public Involvement

On August 17, 2010, a draft copy of the HMP was placed on the City's web site (www.cityofbenbrook.com) for public review and comment. The City sent an official e-mail alerting citizens on the City's email list that the mitigation plan was available for review and feedback. The following is a copy of the e-mail that was sent to the businesses, non-profits, citizens of Benbrook and other groups who subscribe to the City of Benbrook's News Update List:

> "To: "City of Benbrook News Update List"
> Date: Wednesday, June 29, 2011, 1:56 PM
>
> We apologize for the broken link sent in the email yesterday. The link in this email is corrected.
>
> The City of Benbrook has posted a news story relating to the new draft of the Hazard Mitigation Plan. Please visit City Seeks Comments on Re-Drafted Hazard Mitigation Plan on the City Website."

The City of Benbrook's e-mail subscription list includes non-profit organizations such as the Fort Worth YMCA, The Better Business Bureau, Benbrook Water and Sewer Authority and local churches and religious institutions. Other subscribers to Benbrook's News Update List include local developers, engineering firms and local news media outlets. The City of Benbrook sent the following e-mail to the Fort Worth Independent School District Emergency Management Coordinator on September 17, 2011, asking for questions, comments or suggestions for improvement:

> "The City of Benbrook is in the process of drafting our Hazard Mitigation Plan. Please let us know if you have any questions, comments or suggestions for improvement regarding our plan (attached)."

Since the plan was available to the public online, all concerned businesses, nonprofit agencies, neighboring communities and other interested parties had an opportunity to review and comment on the plan. The following paragraph was placed on the City of Benbrook website, followed by a link to a full draft of the HMP at the time.

> "9/10/2010 – City Seeks Comments on Draft Hazard Mitigation Plan
>
> Benbrook is preparing a new Hazard Mitigation Plan, which describes the natural hazards that are present and the projects that the City could implement to protect existing and future development. The plan evaluates risks associated with 24 different natural hazards, and proposes specific mitigation plans for two of them: flooding and stream bank erosion. If you have any comments or suggestions on the draft plan, send them to Dave Gattis at dgattis@cityofbenbrook.com."

The City received two comments as part of this process, one concurring with the Plan and one comment requesting additional information regarding dam failure.

The draft of the HMP also was sent to the U.S. Army Corp of Engineers, the North Central Texas Council of Governments and the Fort Worth-Tarrant County Emergency Management Office for review. At the time the draft plan was sent, the Fort Worth-Tarrant County Emergency Management Office was a joint office between the City of Fort Worth and Tarrant County. Tarrant County now operates its own Emergency Management Office. No comments on the content of the plan were received from any of these agencies.

On August 18, 2010 the HMP was sent to the Texas Department of Public Safety's Division of Emergency Management office for review and approval. On January 26, 2011, the State responded that the plan was not approved and the City began the process of revising to the plan. The current revision of the plan is based on feedback from the public (especially pertaining to dam failure risks), in addition to the reviewer's comments from the State. Once the plan has been tentatively-approved by the State, public hearings will be held before the City's Planning and Zoning Commission and City Council prior to formal adoption. Public hearings are advertised in the City's local newspaper (The Benbrook News) and on the City's web site. The Plan will also be submitted to FEMA for their approval, once approved by the State.

H. Community Profile

According to the U.S. Bureau of the Census, Benbrook had a population of 21,234 people in 2010 (U.S. Census, 2010). Benbrook has a total land area of 12 square miles and is located in southwest Tarrant County. The City is a suburb of Fort Worth and is entirely surrounded by the corporate limits of Fort Worth. A more detailed analysis of demographics in Benbrook can be found in *Chapter 3* of the Benbrook Comprehensive Plan, which can be found at http://www.cityofbenbrook.com/content/56/117/160/default.aspx.

The 2009 American Community Survey indicates that 15.5 percent of the population was over the age of 65 years. No information on the number of residents with disabilities in Benbrook was included in the 2009 American Community Survey, but in the 2000 Census, 15 percent of the population over five years of age had some type of disability. A total of 9.8 percent of the population spoke a language other than English at home (2009 American Community Survey.) There are no significant concentrations of ethnic minorities or low income residents within the community. Benbrook does not meet the criteria of a "special community" as defined in 44 CFR 201.2.

The City of Benbrook has identified a number of special facilities that may be vulnerable to natural hazards, including two nursing homes, one retirement home, three public schools, four child care facilities and the Benbrook Water Authority's (BWA's) water treatment plant. None of these facilities are located within the 100-year floodplain. The City of Benbrook has also identified land uses that may cause additional man-made hazards during a disaster (e.g. gas stations and chemical storage facilities). None of these facilities are located within a 100-year floodplain, but several are located on expansive soils.

I. Building Codes, Building Code Effectiveness Grading Schedule and Community Rating System

The City of Benbrook currently uses the 2009 International Code Council building code series, along with the 2008 National Electric Code. The City adopted the 2009 International Code Council series in mid-2010. The City has a Building Code Effectiveness Grading System score of "4/4".

In the 2009 International Residential Code, the Code Council implemented several changes to the wind bracing requirements for residential structures. Some of these requirements included the requirement for metal hold downs, hurricane clips, the addition of more stringent shear walls externally and possibly internal shear walls located within the structure with concrete beams under the walls with additional anchorage. The new code also requires more stringent nailing patterns for all shear walls.

The City has participated in the Federal Emergency Management Agency's (FEMA's) Community Rating System (CRS) since 1990 and has a current CRS rating of"6".

II. Risk Assessment

Risk is the likelihood that a hazard may cause harm or damage and is commonly represented as a hazard's probability times its severity (Markiewicz, 2004). To help prioritize the natural hazard risks facing Benbrook, a risk assessment matrix was prepared using guidance from the U.S. Department of Defense's Standard Practice for System Safety (MIL-STD-882D, 2000.)

For this plan, the probability of risk is divided into five categories:

<u>Frequent</u> – Likely to occur at a frequency of at least once every year
<u>Probable</u> – Likely to occur at a frequency between once every year and once every five years

Occasional – Likely to occur at a frequency between once every five years and once every 100 years
Remote – Likely to occur less frequently than once every 100 years
Improbable – Unlikely to occur, but possible

The severity (or vulnerability) of a hazard is classified into four categories:

Catastrophic – Likely to result in death and serious injury or property loss may exceed $1 million per occurrence.
Critical – Likely to cause severe bodily injury or cause property damage between $200,000 and $1 million per occurrence.
Marginal – Likely to cause injury or cause property damage between $10,000 and $200,000 per occurrence.
Negligible – May cause minor injury or property damage less than $10,000 per occurrence.

Using these probabilities and severities, a risk assessment matrix was prepared as shown in Table 1:

Table 1. Risk Assessment Matrix

	Vulnerability/Impact			
Probability	Catastrophic	Critical	Marginal	Negligible
Frequent	1	3	7	13
Probable	2	5	9	16
Occasional	4	6	11	18
Remote	8	10	14	19
Improbable	12	15	17	20

Using this risk assessment matrix, the level of risk for each hazard is rated as follows:

Ranks 1-5	High
Ranks 6-9	Serious
Ranks 10-17	Medium
Ranks 18-20	Low

Each hazard was assessed using this criterion to determine its ranking. An estimate of annualized damages was also prepared for each hazard where data was available.

A. Natural Hazards Considered, Assessed and Ranked

As a starting point, the City reviewed the Multi-Hazard Risk Assessment for the North Central Texas area prepared by the North Central Texas Council of Governments (NCTCOG, 2004). The study identified 24 natural hazards that constitute the full range of hazards that could occur in the Benbrook area. Benbrook has excluded poor air quality from that list because we believe that it is a technological

hazard, rather than natural. The City also used data from the National Climatic Data Center's National Environmental Satellite, Data and Information Service website (www4.ncdc.noaa.gov), which tabulates weather-related events by location and/or County from January 1950 through February 2010. The City also used data from the Texas Hazard Mitigation Package (www.thmp.info) which tabulates weather and non-weather-related events on a County basis.

The City then applied the risk assessment methodology described above to provide a ranking of the risk of each hazard within Benbrook, as shown in Table 2 below. Frequency analysis was based on the expected return frequency of each event. Vulnerability was based on the expected damage that may result to existing development during each occurrence of a natural hazard. A narrative description follows for each of the hazards listed under each risk category.

Eight hazards (avalanches, coastal erosion, land subsidence, levee failures, sinkholes, storm surge, tsunamis, and volcanoes) were removed from further consideration because of their very low risk or lack of applicability to the Benbrook area.

Although there are a number of hazards of high, serious or medium risk within the City of Benbrook, many are not conducive to specific mitigation actions because the City has no control over the specific hazard or structure. On the other hand, we understand that we are required to provide at least two mitigation measures for each hazard that may be present. In other cases, the best course of action is primarily through public education.

Table 2. Ranking of Natural Hazard Risks in Benbrook

Hazard	Frequency	Vulnerability/ Impact	Risk Score
High Risks			
Wildland Fires	Probable	Catastrophic	2
Flooding	Frequent	Critical	3
Tornados	Occasional	Catastrophic	4
Serious Risk			
Dam failures	Remote	Catastrophic	8
Medium Risk			
Landslides	Remote	Critical	10
Lightning	Frequent	Negligible	13
Stream bank erosion	Frequent	Negligible	13
Severe Thunderstorms and High Winds	Frequent	Negligible	13

Expansive soils	Frequent	Negligible	13
Extreme heat	Frequent	Negligible	13
Severe winter ice storms	Probable	Negligible	16
Low Risk			
Droughts	Occasional	Negligible	18
Hail	Occasional	Negligible	18

The City of Benbrook is vulnerable to a number of natural hazards, each with its own level of risk. The City has established a priority for each hazard, based on its potential frequency and magnitude of damage during an event. Those risks that have a greater risk to life and health were given a greater priority than those which simply threaten property damage (i.e., flooding and tornadoes were given a higher priority than hail, expansive soils or stream bank erosion.) Hazards that have the potential to affect large numbers of structures during a single event were given a higher priority than those that may affect individual properties (i.e. flooding, tornadoes and hail were given a higher priority than expansive soils and stream bank erosion.)

1. Natural Hazards of High Risk

Of the 16 natural hazards with potential risk to Benbrook, three have been identified as having high risk because of their potentially high frequency of occurrence or high degree of vulnerability within the City of Benbrook. These include wildland fire, flooding, and tornadoes. The following is a discussion of the probability of occurrence, and the vulnerability for damage, for each of the high ranking natural hazards.

a) Wildland Fire

A wildland fire is the uncontrolled burning of vegetation. While wildland fires can damage agricultural resources, it is of most concern when it threatens urban structures such as homes. The most vulnerable location for wildland fire damage is the zone known as the wildland-urban interface.

Location: The City of Benbrook is bordered on the west and south with open grassland prairie, which is subject to grass fires on an annual or biennial basis. Most of these are small and can be isolated within the rural area, but sometimes they can threaten urban areas such as subdivisions. The map shown in Figure 1 below illustrates the potential fire risk zones in Benbrook, according to the Texas Forest Service.

Figure 2 shows the area of jurisdiction for the Benbrook Fire Department. The area shown in green hatch is the City Limits, while the remaining area in green is unincorporated area of Tarrant County where Benbrook provides fire services through the Emergency Services District No. 1.

Extent – Wildland fire can affect areas ranging from less than an acre to several hundred acres. The maps in Figure 3 and Figure 4 show the approximate extent and damage of a major grass fire that occurred in January 28, 2008, apparently caused by a discarded cigarette from a motorist along Interstate 20. NESDIS reports $5,000 in property damage from that fire. On January 28, 2008 the City of Benbrook's Fire Danger Rating was Level 2, or Moderate, as shown in Table 3.

Previous Occurrences - The National Environmental Satellite, Data, and Information Service (NESDIS) of the National Climatic Data Center provides data on various hazardous events, including "wild & forest fire." NESDIS identifies only three wild & forest fire events in Tarrant County between January 1, 1950 and February 28, 2010, and only one of which was in the vicinity of Benbrook. The Texas Hazard Mitigation Program (THMP) identified 6,852 outdoor fires in Tarrant County between 1995 and 2003, but doesn't specify their location in relation to Benbrook.

Probability of Future Events - Benbrook is included in the Prairies and Lakes Urban Wildfire Interface region, according to the State of Texas Mitigation Plan (2004). Benbrook has also been identified as a "Texas Community at Risk" as an Urban Wildland Interface Community by the Texas Forest Service (Kilgore and Gray, 2004). As a "Texas Community at Risk", future wildland fires in Benbrook are likely to occur at least once every five years. The U.S. Forest Service (USFS) and U.S. Geological Survey provides assistance to local

Figure 1. Urban-Wildland Interface

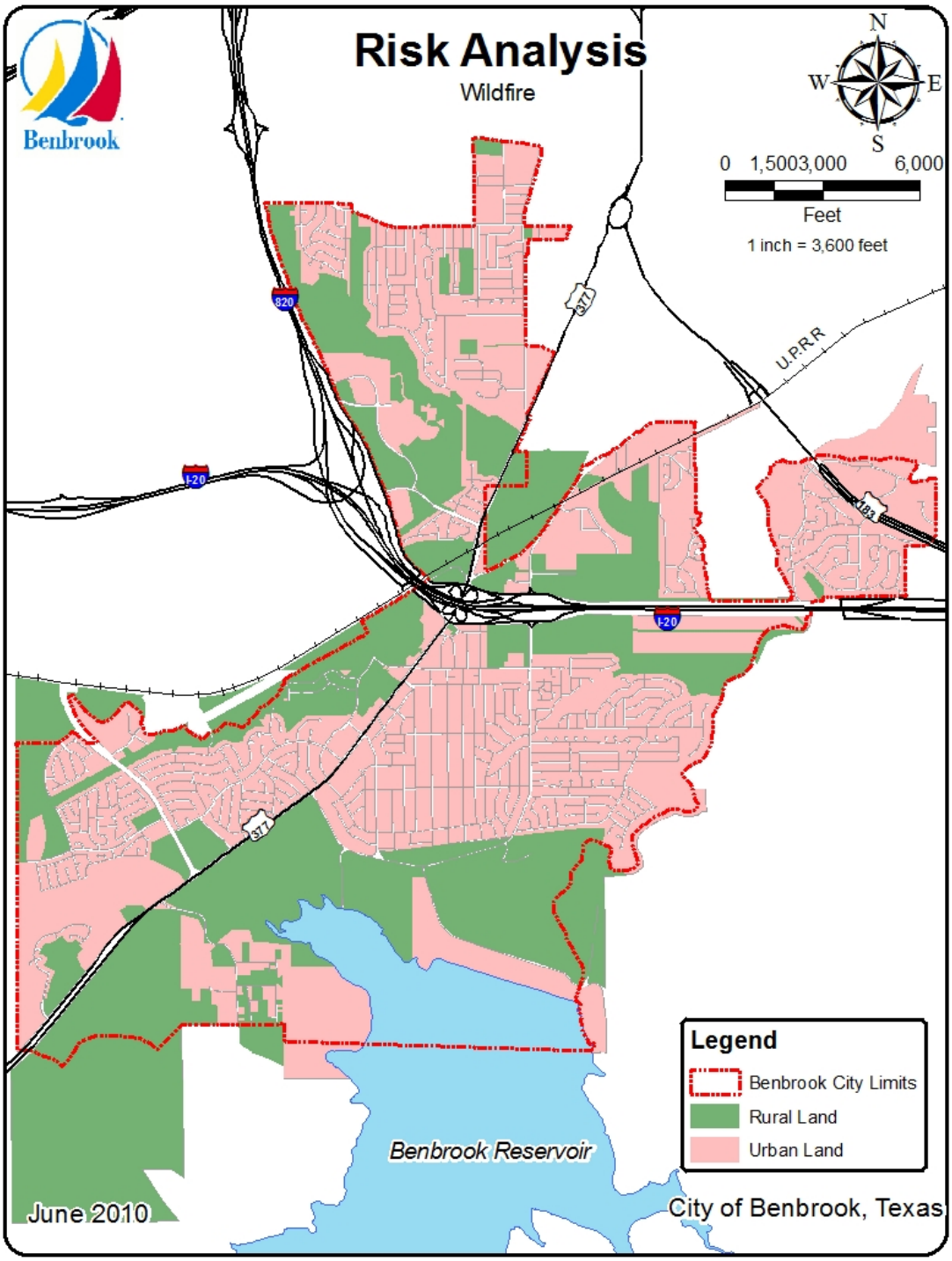
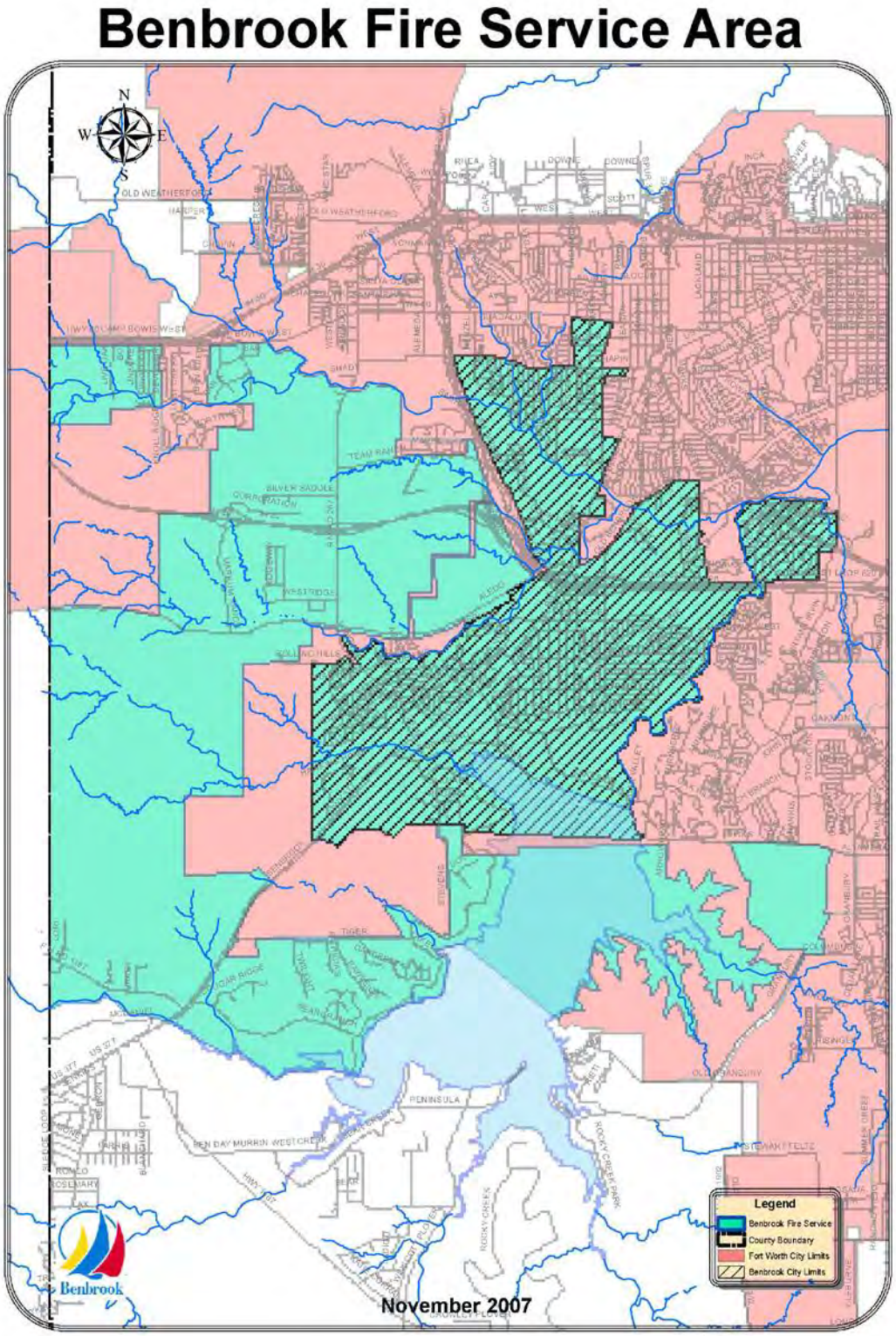


Figure 2. Benbrook Fire Service Area



***November 2007 map represents the Benbrook Fire Department's current 2010-2011 contract with the Texas Emergency Services District.**

Figure 3. Approximate extent of January 28, 2008 grass fire

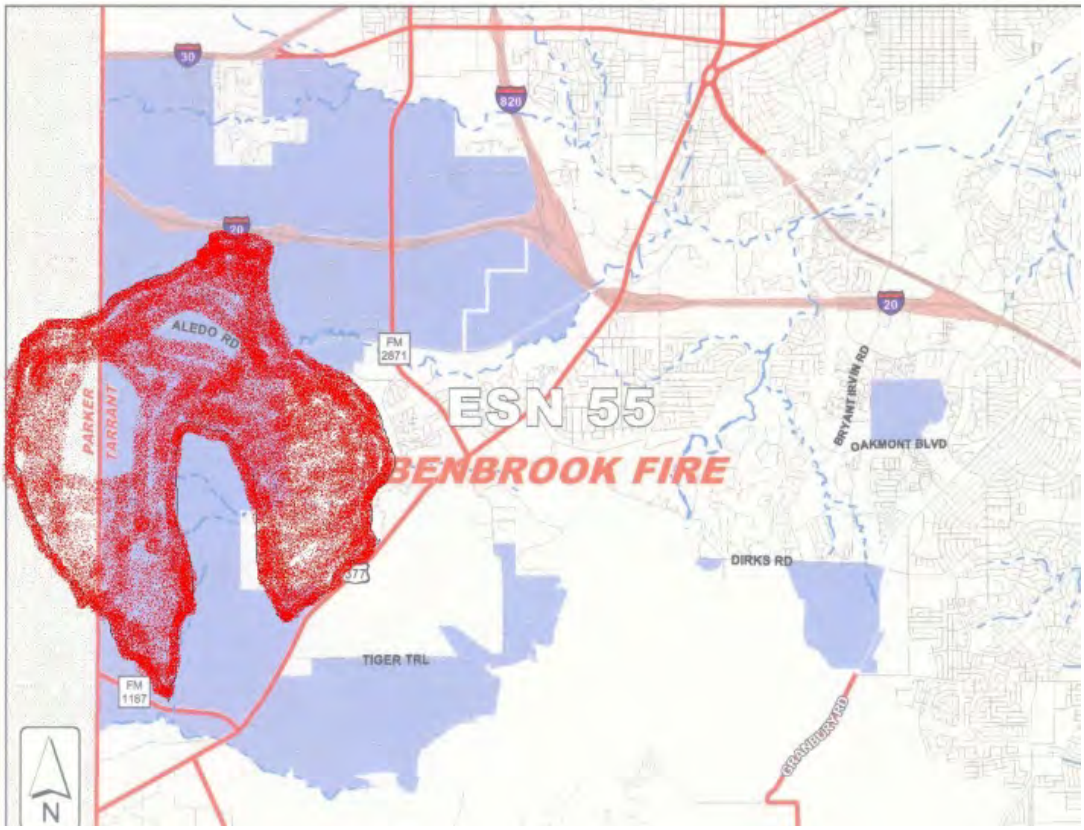


Figure 4. Aerial view of January 28, 2008 grass fire

governments by assessing the potential for wildland fire using the Fire Potential Index, which uses satellite data to evaluate vegetation data and weather conditions.

In addition, the USFS and the U.S. Geological Survey provide a Fire Danger Rating scale, which can be used by communities to assess their current fire danger, as shown in Table 3.

Table 3. Fire Danger Rating System

Rank	Classification	Color Code	Basic Description
1	Low Danger	Green	fires not easily started
2	Moderate Danger	Blue	fires start easily and spread at a moderate rate
3	High Danger	Yellow	fires start easily and spread at a rapid rate
4	Very High Danger	Orange	fires start very easily and spread at a very fast rate
5	Extreme Danger	Red	fire situation is explosive and can result in extensive property damage

source: http://www.wfas.net/content/view/34/51/

Vulnerability – Benbrook has a significant amount of rural-urban interface that is subject to Wildland fires which could potentially result in death, serious injury or major property loss. Potential damage to structures in Benbrook is limited through aggressive code enforcement, which requires that grass and weeds be mowed on large tracts within 100 feet adjacent to developed lots. By actively enforcing Benbrook's current high grass and weed ordinance, which requires that grass and weeds be mowed to a height of no greater than ten inches within 100 feet of a property line (Benbrook Municipal Code, Section 8.08.010), the City can reduce vulnerability to Wildland fires within urban areas.

Impact - Wildland fires can result in the need for rapid evacuations, casualties, loss of homes and businesses, and loss of wildlife habitat and recreational areas.

b) Flooding

A flood is a natural event for rivers and streams. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains. Several factors determine the severity of floods, including rainfall intensity and duration. A flash

flood is a rapid rise of water along a stream or low-lying urban area. Flash flooding occurs within six hours of a significant rain event and is usually caused by intense storms that produce heavy rainfall in a short amount of time.

Location – Approximately 1,573 acres of Benbrook is subject to flooding by a 100-year flood event. This comprises approximately 20 percent of the total area in the City of Benbrook. A “100-year flood event” is more properly described as an event that has a probability of occurring with a one percent chance in any given year. Figure 5 identifies structures within the floodplain. Figure 5 was created using the September 2009 which covers FIRM Panels 0295K, 0285K, 0290K and 0280K, all of which were effective on September 25, 2009.

Extent – According to City and Tarrant Appraisal District records, of the 8,600 households in Benbrook, there are 586 structures in the 100- year floodplain, assessed at $184,341,992. Almost all of these are privately owned. Approximately 1,022 acres (65 percent) of the floodplain are in public ownership or control, including Federal land, City-owned land, and restrictive floodplain easements. With the exception of a well site and a sewer lift station owned by the Benbrook Water Authority (BWA), there are no critical facilities in the 100-year floodplain. Flood incidents can range from minor flooding (1-3 inches) to maximum inundation in some areas. Figure 6 and Table 4 shows the extent of the 100-Year flood zone.

Previous Occurrences – The City of Benbrook has been subject to flooding in the past, with large floods on Mary’s Creek in April 1922 and May 1949. Flash flooding in the upper area of Timber Creek was common until the early 1980s, when the City constructed a concrete channel. Plantation East Creek was also subject to flash floods in August 1974, July 1975, May 1989, March 1990 and May 1990, but flooding has since been controlled by a channel project built by the City in 1991. Plantation West Creek continues to suffer from flash flooding, the most recent event being in June 2004. A list of recent flooding events in Benbrook is located on Table 5.

Table 4. Definitions of Flood Zones in Benbrook

Flood Zones		
Zone A	The 100-year or Base Floodplain. There are 6 types of A Zones	
	A	The base floodplain mapped by approximate methods, i.e. BFEs is not determined. This is often called an unnumbered A zone or an approximate A zone.
	A1-30	These are known as numbered A zones (e.g. A7 or A14). This is the base floodplain where the firm shows a BFE (old format).
	AE	The base floodplain where base flood elevations are provided. AE zones are now used on new format FIRMs instead of A1-30 zones.
	AO	The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.
	AH	Shallow flooding base floodplain. BFEs are provided.
	A99	Area to be protected from base flood by levees or federal flood protection systems under construction. BFEs are not determined.
	AR	The base floodplain that results from the de-certification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection.
Zone B and Zone X (shaded)	Area of moderate flooding hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains or lesser hazards, such as areas protected by levees from the 100-year flood or shallow flooding with average depths of less than one foot.	
Zone C and Zone X (unshaded)	Area of minimal flood hazard, usually depicting flood hazard areas as exceeding the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside of the 500-year floodplain.	
Zone D	Area of undetermined but possible flood hazards.	

Source: Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA 386-2

Figure 5. Structures Within Floodplain

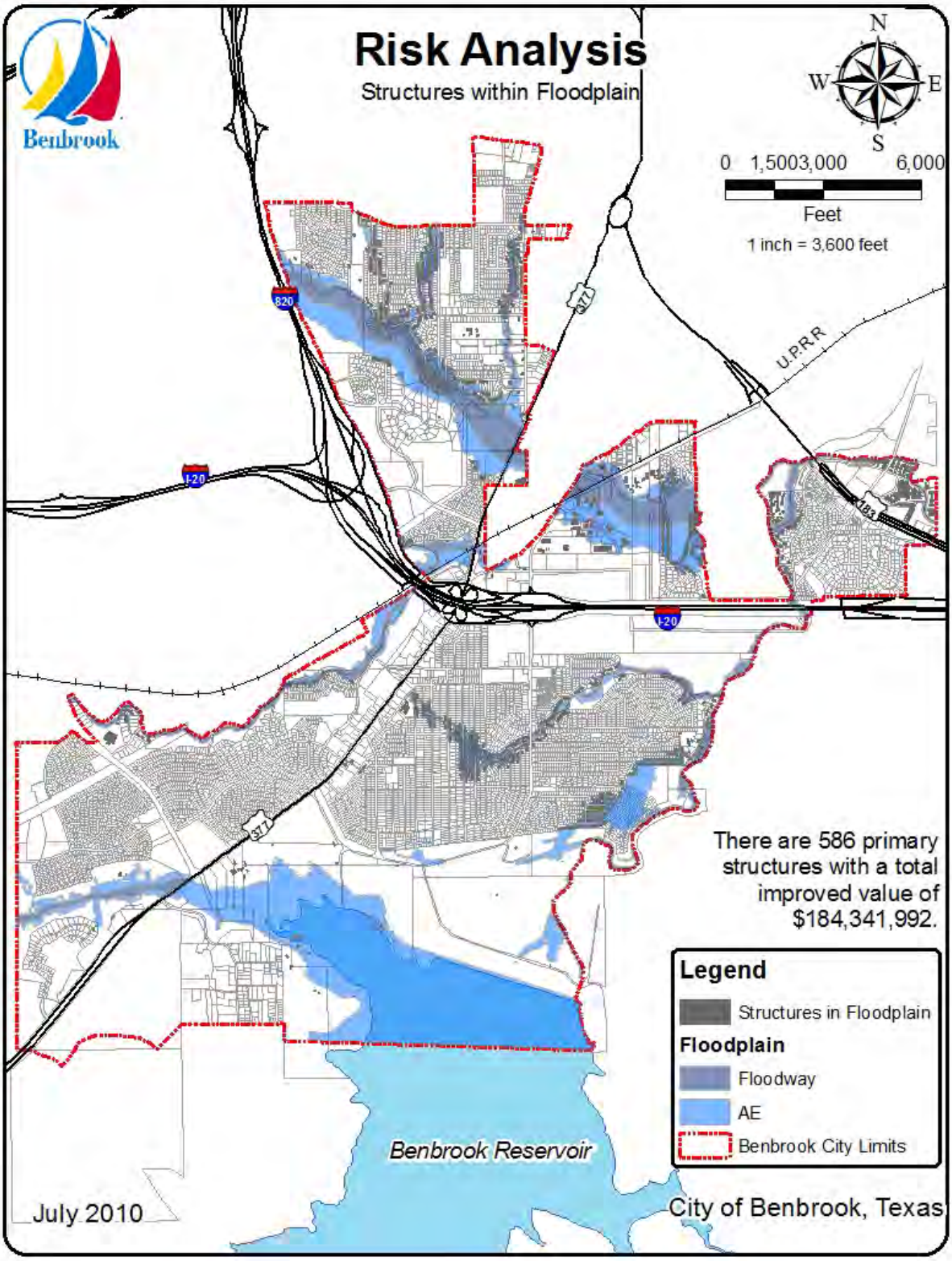


Figure 6. Extent of 100-Year Flood Zone

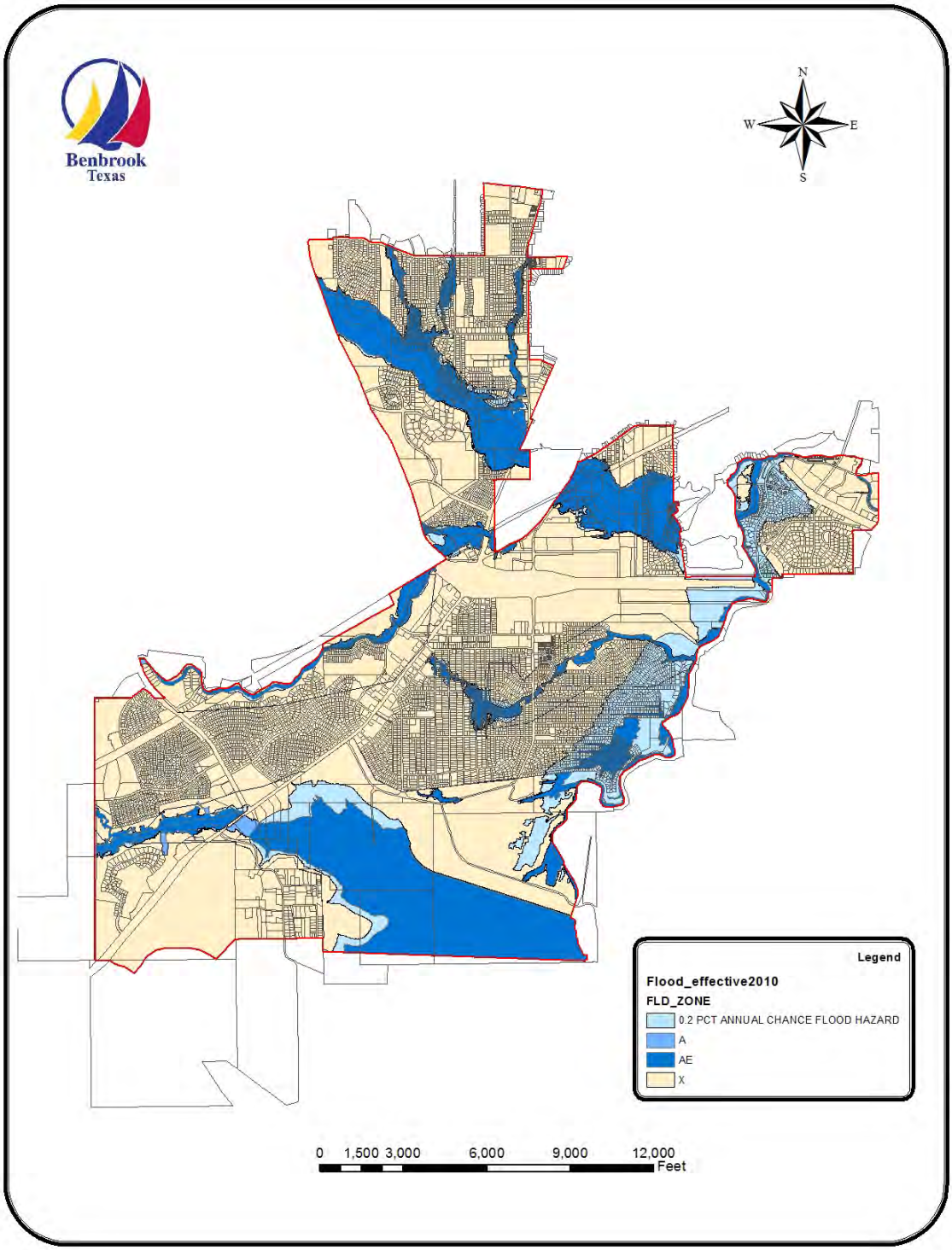


Table 5. Historical Flooding Events

Date-Time	Deaths or Injuries	Property Damage	Comments
10/12/1993 – 10:00 PM	0	0	Water over hoods of cars on Highway 80, Chapin Road, and Williams Road area
10/18/1993 – 5:05 PM	0	0	Blair Street (?) was reported as flooded.
5/5/1995 6:10 PM	1 fatality	0	21-year old man drowned while attempting to cross Mary's Creek at Link Hill Drive (upstream of Benbrook.)
3/16/1998 – 9:00 PM	0	0	Benbrook Lake flood – Rocky Creek Marina was flooded and destroyed.
6/4/2000 – 2:50 AM	0	0	Heavy thunderstorm and rain created flash flooding in the city.
7/1/2001 – 7:50 AM	0	0	Homes in east Benbrook, near the Trinity River, had to be sand bagged due to high water.
4/17/2008 – 7:27 PM	0	0	Cars were stalled in high water at the intersection of Bryant-Irvin and Interstate 20.
6/10/2009 – 6:23 PM	0	$1,000	Three feet of water was reported over the road at I-20 and Bryant-Irvin Road.

Source: www4.ncdc.noaa.gov, May 19, 2010
*All historical flood data is the result of the National Weather Service's results for Benbrook, TX

Probability of Future Events - There is a high probability of future flood events. Based on previous experience the City of Benbrook is likely to suffer frequent flooding, at least once every other year or so.

Vulnerability – The City of Benbrook is vulnerable to flooding, and floods in Benbrook are likely to cause severe bodily injury or property damage between $200,000 and $1 million per occurrence. The City of Benbrook has been a participant in the National Flood Insurance Program since 1974, and a participant in the Community Rating System since 1990 with a current rating of "6". In 2002, the City adopted amendments to its Subdivision Ordinance which prohibits new development within the 100-year floodplain, and requires new development to control runoff so that the peak runoff during the 100-year event does not exceed predevelopment conditions. These amendments will lower future vulnerability to flood damage. The City also has adopted the North Central Texas Council of Governments' Integrated Storm Water Management

(iSWM) program that includes additional design requirements to handle storm water discharges, further lowering the City's vulnerability to flooding.

The City of Benbrook has five FEMA repetitive loss properties, which are defined as those with two or more flood insurance claims of over $1,000. One residential structure on Dry Branch (two losses in 1981) was purchased by the City, demolished, and the building pad elevated above the 100-year base flood level and is no longer considered a repetitive loss property. Three recently-designated repetitive loss properties are located adjacent to Plantation West Creek in North Benbrook and suffered losses in 2000 and 2004. The City recently constructed a flood control project to protect these structures and the flood plain map amendments approved by FEMA in April 2010 removed two of the three houses from the 100-year floodplain. A residential structure on Plantation Drive (two losses in 1989) has been partially protected by the Plantation East Creek channel and culvert project and a second project was recently completed that should completely remove the structure from the 100-year floodplain.

Impact – Flooding can have devastating impacts on property damage and loss, human life and agriculture. Flood insurance can help to mitigate property loss in flooding. The almost 600 residential and commercial structures located within Benbrook's 100-year floodplain make flooding a major concern for the City. There are no critical facilities located within the 100 year floodplain. Critical infrastructure such as bridges and roads can be made more dangerous by flooding.

c) Tornadoes

A tornado is violently rotating column of air extending from a thunderstorm to the ground.

Location – Tornadoes are a city-wide hazard.

Extent – The City of Benbrook is subject to tornadoes of all magnitudes, including F5 tornadoes. Tornados are classified using the Fujita scale based on the damage that is caused and the estimated wind speeds. The original Fujita scale was developed in 1971 and classifies

tornados into six damage classifications, ranging from F0 to F5. In 2007, the scale was revised to reduce the subjective nature of damage estimates, as shown in Table 6.

Table 6. Comparisons of Old and New Fujita Scales

Old Fujita Scale		Current Enhanced Fujita Scale		
F Number	3-second wind gust (mph)	EF Number	3-second wind gust (mph)	Potential Damage
0	45-78	0	65-85	Light Damage: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
1	79-117	1	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
2	118-161	2	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
3	162-209	3	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
4	210-261	4	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
5	262-317	5	Over 200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

From previous records, the North Central Texas Council of Governments has identified a hypothetical “typical tornado” to be 10 miles long, 0.15 miles wide and cover 960 acres. Using this example on existing development in Benbrook, a typical tornado could damage as many as 847 existing structures, valued at $115,631,670 (see Figure 7.)

Previous Occurrences – The NESDIS data base reports 82 tornados in Tarrant County between January 1950 and February 2010, two of which were reported in or near Benbrook. The weather station at Benbrook Dam has recorded only one tornado in the Benbrook area during the period from 1949 to 1963 and 1982 to the present, that being in March 1956. The Texas Hazard Mitigation Program (THMP) has identified 70 tornadoes in Tarrant County between 1950 and 2003, four of which were classified as Category F3 or greater on the Fujita Scale (see below for explanation.) THMP places Tarrant County in Tornado Risk Zone 5, which means there has been an average of five recorded tornadoes per 1,000 square miles over the last 40 years. Table 7 records the historical tornado events in Benbrook.

Table 7. Historical Tornado Events

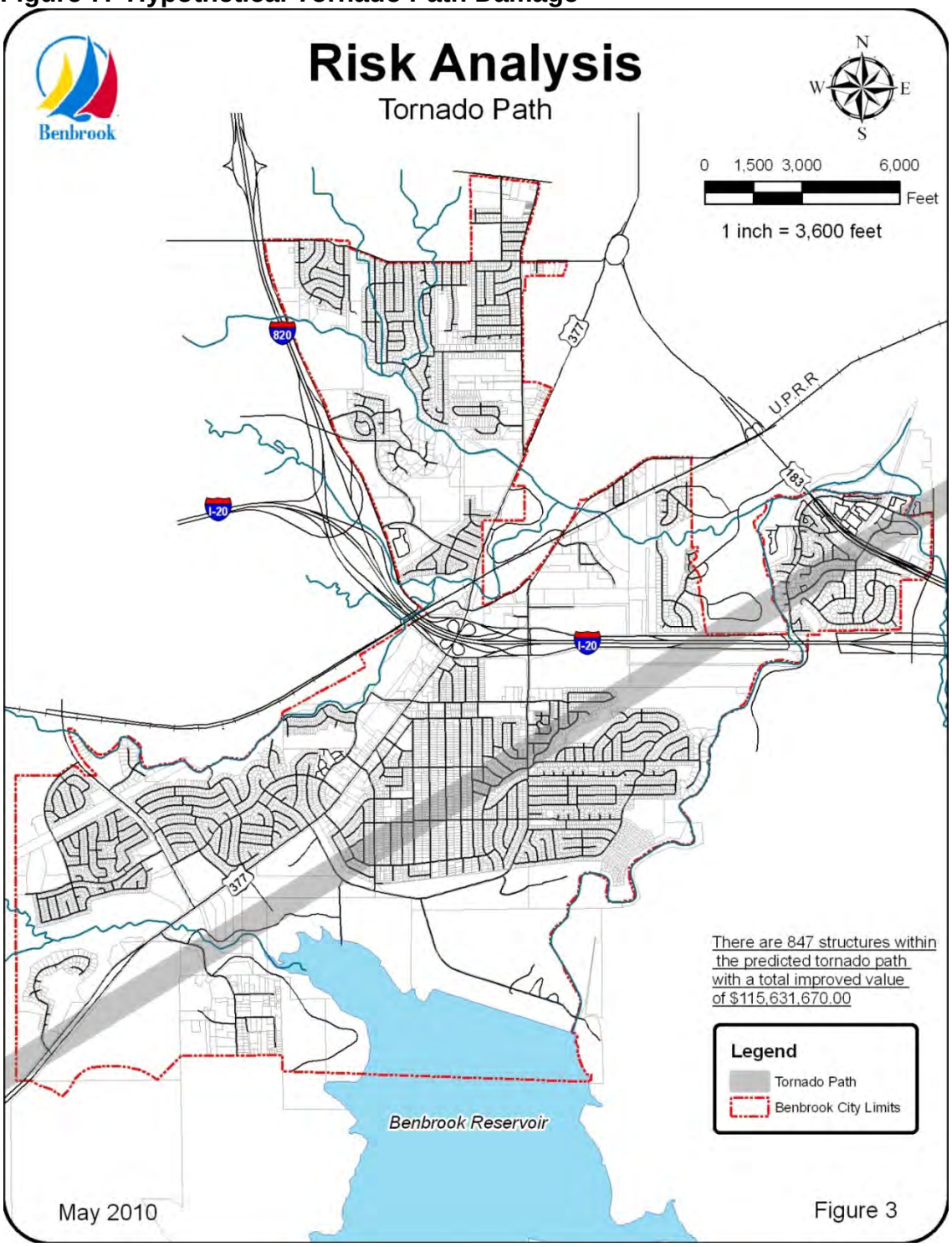
Date – Time	Magnitude	Deaths/ Injuries	Property Damage	Comments
2/20/1997 – 12:00 PM	F0	0	0	A weak tornado caused intermittent tree damage along a narrow path.
4/13/2007 – 5:55 PM	F0	0	$150,000	This tornado was captured on video by storm chasers. It touched down just west of Highway 377 and just south of Loop 820. It then travelled to Meadows West Park before dissipating. The tornado damaged fences, trees, and street signs. The façade of a business was also slightly damaged.

Source: www4.ncdc.noaa.gov, May 19, 2010.
*All historical flood data is the result of the National Weather Service's results for Benbrook, TX

Probability of Future Events – There is an occasional probability of future tornadoes, with tornadoes likely to occur in Benbrook between once every five years and once every one hundred years. The North Central Texas Council of Governments (NCTCOG) predicts that at least 200 tornadoes of various sizes will occur within their 17-county region by the Year 2030.

Vulnerability – Tornados can strike any location or stay in a particular geographical region, so it is impossible to predict what structures are most vulnerable to damage by a tornado. Tornadoes have the potential to cause catastrophic damage to the city. The City enforces the 2009 International Building Code (IBC) and International Residential Code (IRC), which requires that structures in Benbrook be designed to withstand a 90-mile-per-hour wind gust of up to three seconds.

Figure 7. Hypothetical Tornado Path Damage



Despite this, very few structures can withstand the effects of an F5 tornado. There are no manufactured buildings within Benbrook.

Impact – Tornadoes can cause injury, loss of life, property damage and property loss. Critical facilities such as police and fire stations, medical facilities, schools, roads and other critical infrastructure can be damaged or destroyed. The impacts of tornados will be most significant in residential and commercial areas where people and property are most concentrated.

2. Natural Hazards of Serious Risk

Benbrook staff has identified one natural hazard, dam failure, as Serious Risk because of its potential damage, even though the potential frequency is low.

a) Dam Failure

Dam failure is the catastrophic failure of an impoundment that results in the rapid and uncontrolled release of impounded water. Such a failure can threaten life and property downstream of the reservoir. Although the risk of dam failure could be considered both a technological and natural hazard, the City of Benbrook has decided to treat potential dam failure as a natural hazard, thus including it in the hazard mitigation plan.

Location – The City has one federally-owned dam (Benbrook Dam) and is aware of three privately-owned dams (one on Whitestone Golf Course, one on Mary's Creek, and one on the Clear Fork-Trinity River) within Benbrook. Figure 8 maps the locations of each dam. In the event of dam failure, the inundation from each of the three channel dams would be contained within the channels.

The most significant dam in Benbrook is Benbrook Dam, owned and operated by the U.S. Army Corps of Engineers (National Inventory of Dams No. TX00003). The 9,130-foot-long, 130-foot-high earthen dam was built from 1947 to 1952 for flood control and navigation purposes. Over the years, the navigation storage has been converted to water supply. The Tarrant Regional Water District (which sells water to Fort Worth and

Benbrook) and Weatherford obtain water directly from the Lake. The lake level is controlled by a service spillway, which provides releases for low flow maintenance, flood flows, and downstream releases to the City of Fort Worth.

A 500-foot long concrete uncontrolled spillway provides releases when the Lake exceeds 710.0 feet above mean sea level (msl). The Lake is expected to reach 710.0 feet msl on a 40-year frequency, reach 715.0 feet on a 100-year frequency, and reach 727.0 feet msl on a 500-year frequency. The top of the dam is at elevation 747 feet msl, so there does not appear to be any danger of overtopping the earthen structure, but the top of the concrete uncontrolled spillway is 724 feet msl, so there could be potential damage during the 500-year event.

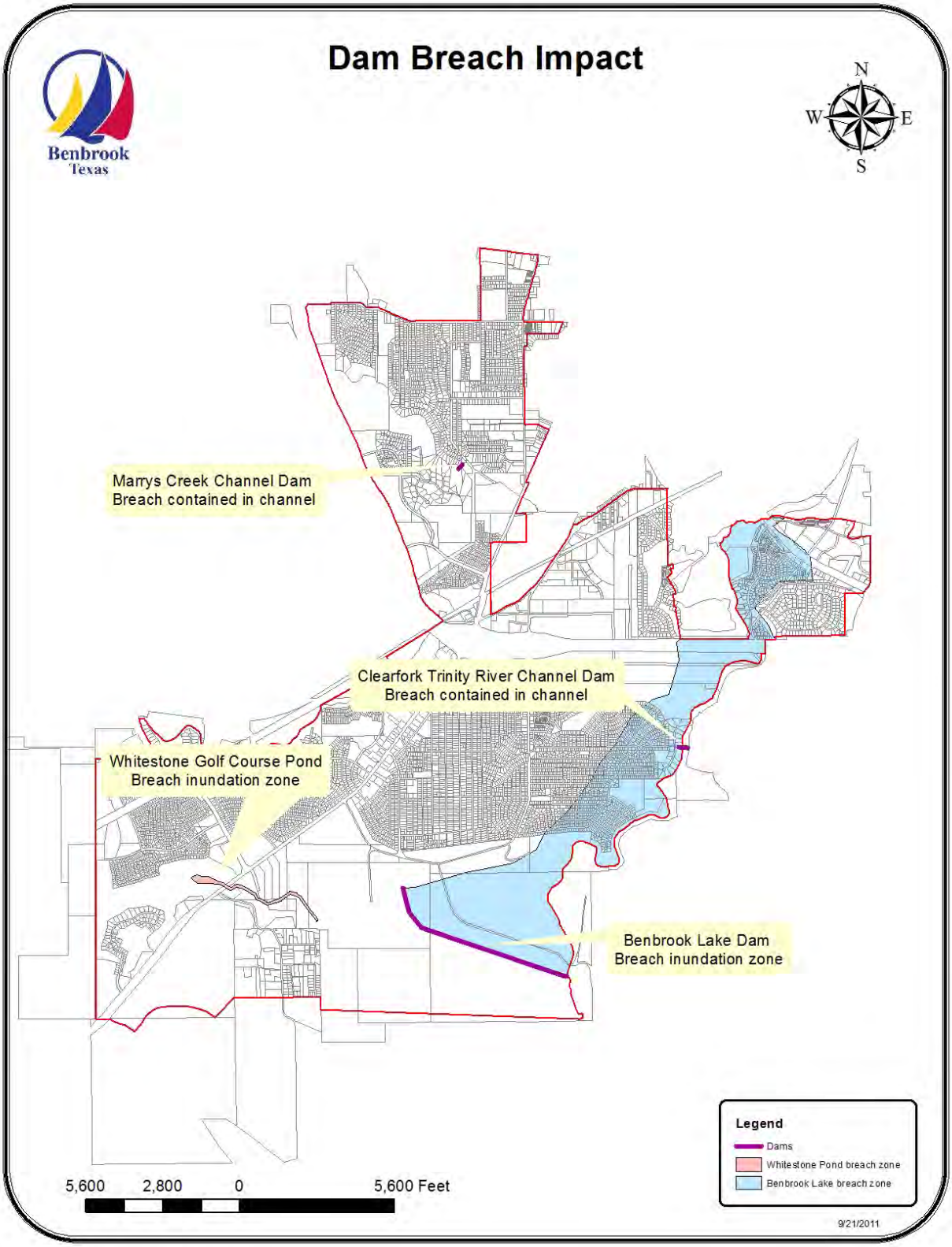
Extent – The U.S. Army Corps of Engineers has evaluated the potential impacts of a breach of Benbrook Dam, but does not release this information to the public. The City estimates that an event of this type would damage or destroy approximately 2,650 residential and commercial structures, with an aggregate value of $395,295,300.

None of the other smaller dams has been required to perform a breach analysis, but there is little expected damage based on the size of the dams and the downstream conditions. The City will work to independently estimate the potential water depths in inundation zones in the event of dam failure, and will use this information in the next update of the Hazard Mitigation Plan.

Previous Occurrences – There have been no previous occurrences of dam failure in the City of Benbrook.

Probability of Future Events – There is a remote chance of dam failure in Benbrook. Dam failure is expected to occur less frequently than once every 100 years.

Figure 8. Map of Dam Locations



Vulnerability – FEMA (2004) classifies the potential hazards from dam failure into three classifications: High (loss of life and property is probable), Significant (significant property or environmental damage likely), and Low (no life threatened and limited damage expected.) Both the Federal Government (U.S. Army Corps of Engineers) and State Government (Texas Commission on Environmental Quality) prohibit the release of specific dam hazard ratings to the public.

Benbrook Dam was last inspected in 2005 and was found to be in good condition. A Flood Emergency Plan has been prepared for the structure, but it is not available to the public.

Impact - The City estimates that an event of this type would damage or destroy approximately 2,650 residential and commercial structures, with an aggregate value of $395,295,300. None of the remaining three private dams would cause any significant damage downstream if they failed. Only the Whitestone Golf Course Dam on Dutch Branch is included in the State's database (National Inventory of Dams No. TX 09438). It is likely that the other two were not included because they did not exceed six feet in height. The City does not know when these structures were last inspected under the State's Dam Safety Program.

3. Natural Hazards of Medium Risk

Benbrook staff has identified seven natural hazards that are considered Medium Risk because of their potentially low frequency of occurrence or low degree of vulnerability within the City. These include landslides, lightning, stream bank erosion, severe thunderstorms and high winds, expansive soils, extreme heat, and severe winter ice storms. The following is a discussion of the probability of occurrence, and the vulnerability for damage, for each of the medium ranking natural hazards.

a) Landslides

Landslides are described as downward movement of a slope and materials under the force of gravity. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow

debris flows. The potential for landslides is a function of slope and geologic conditions.

Location – The map on Figure 9 illustrates the steep slopes in Benbrook where a landslide could potentially occur. Any development in these areas requires additional engineering to prevent foundation failures.

Extent – A landslide in Benbrook is estimated to produce light to no damage (Table 8).

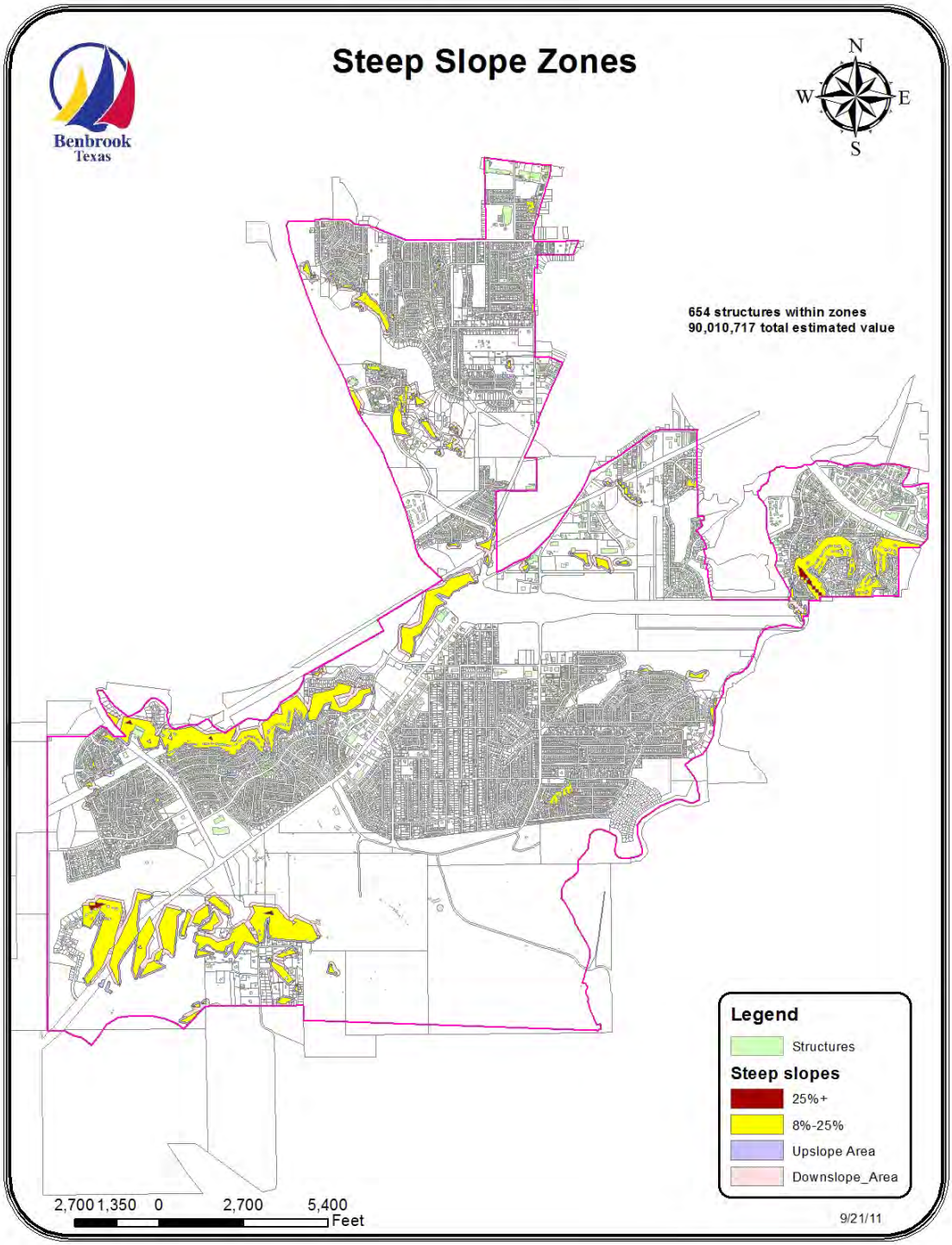
Previous Occurrences – There have been no recorded landslides in the City of Benbrook.

Table 8. Intensity Scale for Landslide Damage to Buildings

Rating	Damage	Description
0	None	Building is intact
1	Negligible	Hairline cracks in walls or structural members; no distortion of structure or detachment of external architectural details
2	Light	Buildings continue to be habitable; repair not urgent. Settlement of foundations, distortion of structure, and inclination of walls are not sufficient to compromise overall stability.
3	Moderate	Walls out of perpendicular by one or two degrees, or there has been substantial cracking in structural members, or the foundations have settled during differential subsidence of at least 15 cm; building requires evacuation and rapid attention to ensure its continued life.
4	Serious	Walls out of perpendicular by several degrees; open cracks in walls; fracture of structural members; fragmentation of masonry; differential settlement of at least 25 cm compromising foundations; floors may be inclined by one or two degrees or ruined by heave. Internal partition walls will need to be replaced; door and window frames are too distorted to use; occupants must be evacuated and major repairs carried out.
5	Very Serious	Walls out of plumb by five or six degrees; structure grossly distorted; differential settlement has seriously cracked floors and walls or caused major rotation or slewing of the building [wooden buildings are detached completely from their foundations]. Partition walls and brick infill will have at least partly collapsed; roofs may have partially collapsed; outhouses, porches, and patios may have been damaged more seriously than the principal structure itself. Occupants will need to be rehoused on a long-term basis, and rehabilitation of the building will probably not be feasible.
6	Partial Collapse	Requires immediate evacuation of the occupants and cordoning of the site to prevent accidents with falling masonry.
7	Total Collapse	Requires clearance of the site

Source: http://www.riskfrontiers.com/damage_scales13.html

Figure 9. Steep Slopes in Benbrook



Probability of Future Events – There is a remote probability of future landslides, and landslides in the City of Benbrook are likely to occur less than once every 100 years.

Vulnerability – The types of geologic formations that are most prone to slope failure (e.g. Woodbine, Austin Chalk, Taylor and Navarro geologic units) are not present in Benbrook. The City of Benbrook currently has little to no vulnerability to landslides.

Impact - A landslide could block roadways and railways as well as potentially damage structures and infrastructure. There are residential structures that could potentially be affected in the event of a landslide, but critical facilities or commercial structures are not at risk. Overall, landslides in Benbrook are not likely to have any kind of significant impact on any structures, residential or otherwise.

b) Lightning

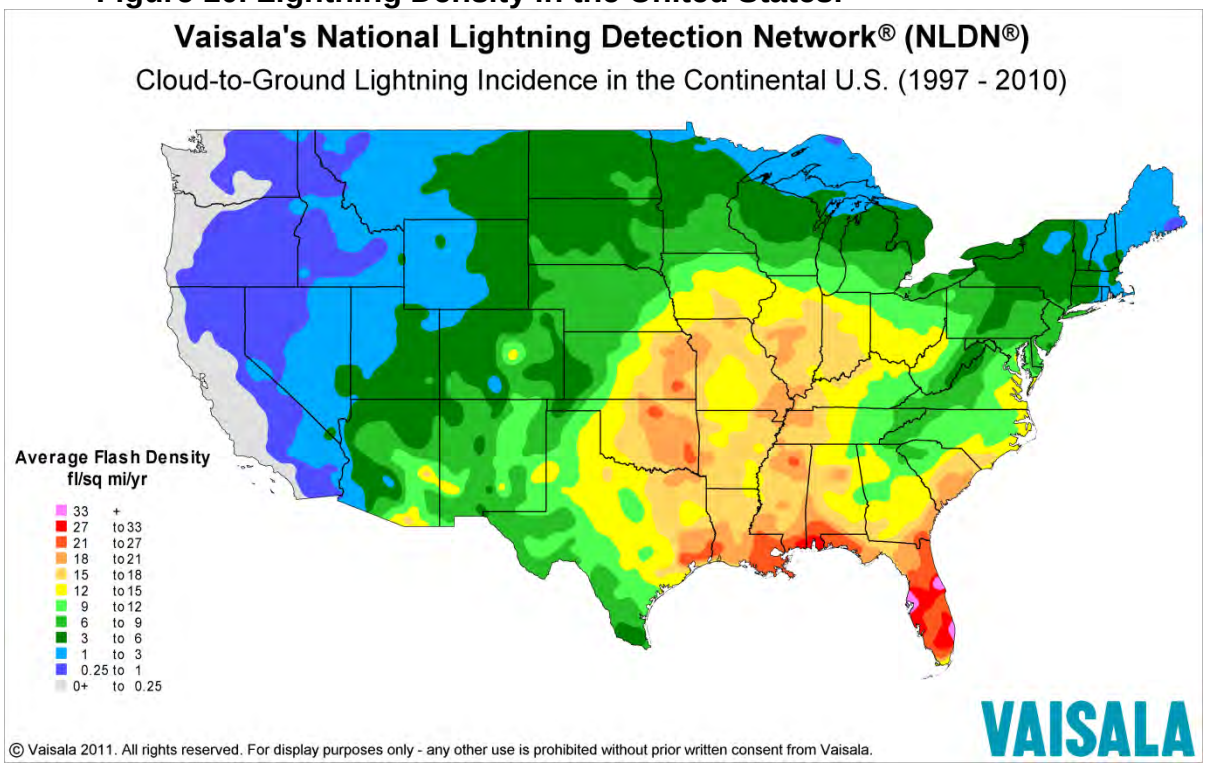
Lightning is an atmospheric discharge of electricity accompanied by thunder, which typically occurs during thunderstorms. Lightning is a gigantic electrostatic discharge between the cloud and the ground, other clouds or within a cloud. Lightning is generated by the buildup of charged ions in a thundercloud, and the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air channel of a lightning strike reaches temperatures higher than 50, 000 degrees Fahrenheit. The rapid heating and cooling of the air near the channel causes a shock wave, which produces thunder.

Location – Lightning is random and location cannot be predicted, therefore lightning is a city-wide hazard.

Extent – The City of Benbrook will experience approximately 15 to 18 lightning strikes per square mile in one year. The estimated range of strikes to structures, facilities or people is currently unavailable. The City will account for this data deficiency through Lightning Action Item #2 and use the data collected to more accurately predict the extent of lightning in the next Hazard Mitigation Plan update.

Previous Occurrences – The NESDIS reports 54 lightning events in Tarrant County from January 1950 through February 2010, but none were identified as specific to Benbrook. In June 2004, a lightning strike damaged the Jack-in-the-Box restaurant on Benbrook Boulevard (U.S. 377), causing severe damage to their electrical system. According to the National Weather Service, from 1995 – 2004 one person was killed and five were injured by lightning in Tarrant County. Throughout Texas, there were an estimated 23 million dollars in damages due to lightning from 1995 – 2004.

Figure 10. Lightning Density in the United States.



Source: Vaisala's NLDN
http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx

Probability of Future Events – Lightning is certain to occur at least once a year in Benbrook.

Extent - There is no empirical data available for the number of strikes per storm in the City of Benbrook. However, lightning is by definition associated with thunderstorms.

Vulnerability – The entire City of Benbrook is vulnerable to lightning. Vulnerability to lightning is increased by

being outside, and all structures are vulnerable to lightning. Lightning is unlikely to cause any significant amount of damage to critical structures or city infrastructure.

Impact – Although lightning is common, deaths and injuries related to lightning are uncommon. Lightning can cause fire and property damage, although the probability of this occurrence is unlikely as well. The Benbrook Fire Department responds to one to two fires associated with lightning strikes annually. In 2009, lightning struck an apartment building (Victorian Quarters) causing fire damage to the attic. In 2011, lightning struck a metal fence causing a grass fire. In June 2012, lightning struck the chimney of a house causing minor fire damage to the chimney and an interior wall. Lighting has caused occasional power outages to the Oncor electrical distribution system, particularly in the southwest section of town (Whitestone Ranch). The City also has received reports of damage to personal computers and appliances from lightning strikes. Lightning is more likely to affect those who work outside and those structures that conduct or attract lightning."

Stream Bank Erosion

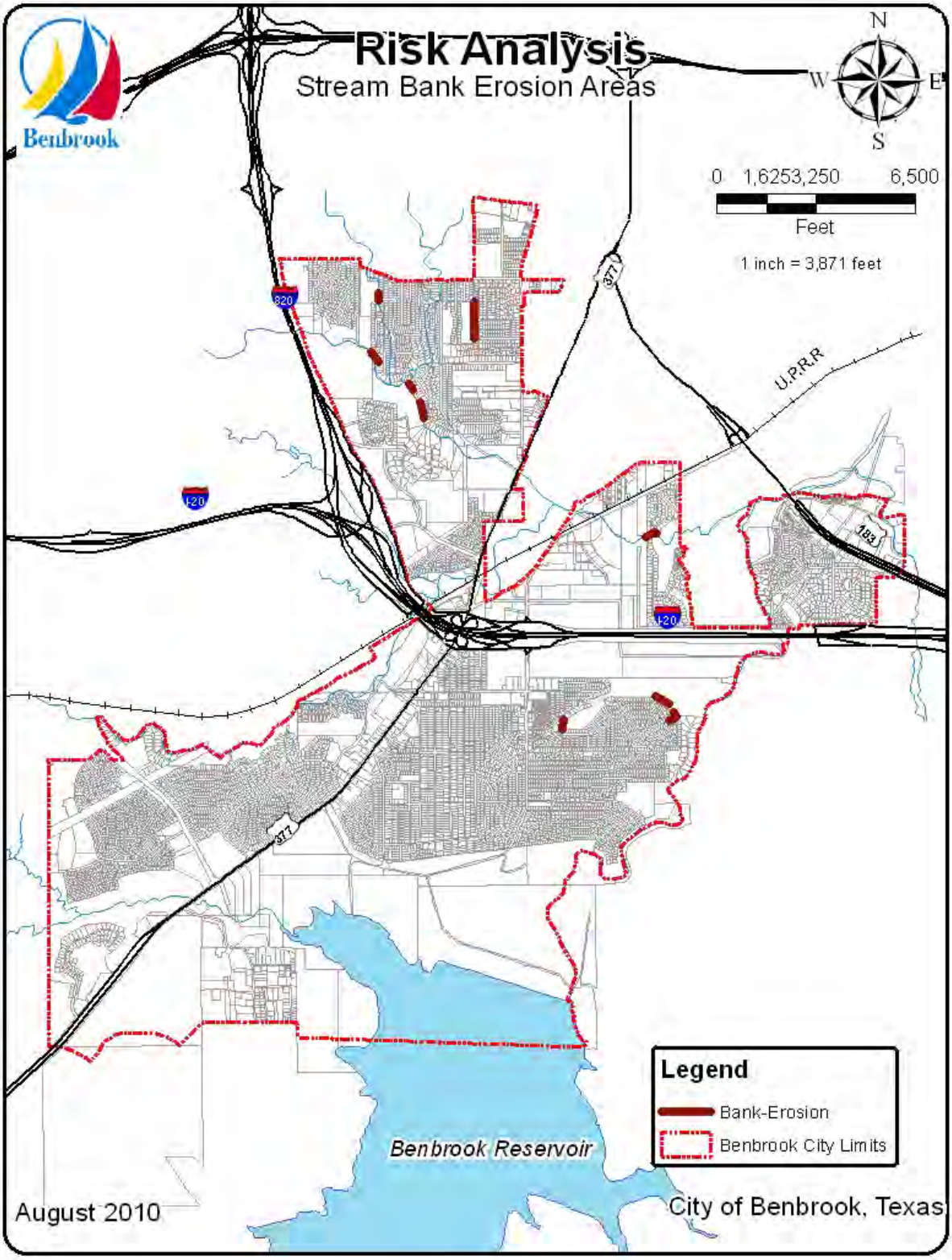
Stream bank erosion is the wearing away of the stream bank surface by detachment and movement of soil and rock fragments over a period of years, through the action of wind, water or other geological processes.

Location – Like most communities in the North Central Texas regions, some properties in Benbrook are threatened by stream bank erosion. This is most pronounced along Mary's Creek, and along the lower reaches of Timber Creek. The areas in Benbrook most affected by stream bank erosion are mapped in Figure 10.

Extent – The extent of stream bank erosion is currently unavailable, but stream banks can erode up to several feet after a flood event. The City will implement Stream Bank Erosion Action Item 6 to estimate the approximate amount of erosion per flood event and will provide this information in the 5-year update.

Previous Occurrences - Most of the damage is to the rear yards of residences that were built to back up to the stream bank. The principal damage has been the loss of soil and fences in the rear yard. No private structures have been known to have been damaged. In the past, it has been the general policy that erosion protection is the responsibility of the land owner, and the City will provide erosion protection only in association with flood control projects. Due to this, there is no official record of previous stream bank occurrences in the City of Benbrook. However, there are two recent occurrences where stream bank erosion has affected the city.

Figure 11. Areas of Stream Bank Erosion



In 2002, the City of Benbrook was forced to construct a gabion wall along Mary's Creek to protect the north end of Winding Way (a public street). In 2004, the Benbrook Water Authority had damage caused to one of its waterlines along and under Mary's Creek because of stream bank erosion. Other than these two instances, no critical facilities are currently threatened by stream bank erosion.

Probability of Future Events – There is a frequent probability of future stream bank erosion events. The City of Benbrook is certain to experience stream bank erosion in the future. However, future development is less threatened by stream bank erosion as a result of changes to Benbrook's development policies. In 2002, the Subdivision Ordinance was amended to require no additional encroachment into the 100-year floodplain (which establishes a de-facto buffer) and requires that homes be oriented so that they face the stream across a public street. The City has also been acquiring floodplain through parkland dedication, which further limits potential stream bank erosion to private property. Finally, the City has adopted the Integrated Storm Water Management (iSWM) program from the North Central Texas Council of Governments (NCTCOG), which requires new development to reduce their discharges during channel erosion events. All of these measures will reduce the probability of future stream bank erosion damage to new development.

Vulnerability – Some homes and businesses are vulnerable to stream bank erosion but property damage is unlikely to exceed $10,000,

Impact - Extreme stream bank erosion could destroy homes and businesses but such erosion is unlikely. Impact is likely to be limited to private properties, and hazard costs can be mitigated through preventative measures.

b) Severe Thunderstorm and High Winds

A thunderstorm is a rain shower during which you hear thunder. Since thunder comes from lightning, all thunderstorms have lightning. A thunderstorm is

classified as “severe” when it contains one or more of the following: hail three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or a tornado. High winds are classified as those exceeding 50-60 mph from any source. High winds are most often associated with severe thunderstorms.

Location – Thunderstorms and high winds are a city-wide hazard and are likely to occur simultaneously.

Extent – The City of Benbrook is unlikely to experience anything higher than “9” on the Beaufort Wind Scale (see Table 9.) Benbrook is subject to thunderstorms of all magnitudes.

Previous Occurrences – Benbrook has suffered damage from straight line high winds on several occasions (see Tables 10 and 11). Among them were May 1981, when high winds and hail damaged several houses and businesses along U.S. 377. In February 2001, high winds destroyed a house in south Benbrook and toppled many trees and fences, including the brick wall surrounding Trinity Estates. More recently, high winds in June 2004 damaged several homes (e.g. roof damage, chimney collapse) and brought down many trees and tree limbs. The weather station at Benbrook Dam has recorded seven days of high winds during the period from 1949 to 1963 and 1982 to the present.

Probability of Future Events - There is a high probability of future severe thunderstorms and high wind events. The City of Benbrook is likely to experience more than one severe thunderstorm and high wind event per year based on previous occurrences.

Vulnerability - Severe thunderstorms are the most common hazard in the planning area. Critical facilities, residential and commercial structures, and infrastructure are unlikely to be affected by severe thunderstorms. Severe thunderstorms accompanied by high winds can cause occasional, but likely negligible, impacts.

Impact – A severe thunderstorm is by definition accompanied by lightning hazards, but thunderstorms can also be accompanied by high winds, hail and tornadoes which can cause severe damage to structures. High winds alone or in addition to severe thunderstorms may cause damage to roofs, trees, fences and signage.

Table 9. Beaufort Wind Scale

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects On the Water	Appearance of Wind Effects on the Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, Smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves becoming longer, numerous whitecaps	Dust, leaves and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway, small tree branches move
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-20 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (13-20 ft) waves of greater length, edges of crests begin to break into spindrift, foams blown in streaks	Whole trees in motion, resistance felt walking against wind
9	41-47	Strong Gale	Strong Gale High waves (20 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (20-30 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (30-45 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Source: http://en.wikipedia.org/wiki/Beaufort_scale

Table 10. Historical High Wind Events

Date	Location	Impact
May 1981	U.S. 377	High winds and hail damaged several houses and businesses along U.S. 377
February 2001	Trinity Estates, South Benbrook	The brick wall surrounding Trinity Estates was blown down, a house in south Benbrook was destroyed along with many trees and fences
June 2004	Throughout the City of Benbrook	Several homes damaged – roof damage, chimney collapse; many trees and tree limbs damaged

*All historical flood data is the result of the National Weather Service's results for Benbrook, TX

Table 11. Historical Thunderstorm Wind Events

Date – Time	Wind Speed (knots)	Property Damage	Comments
4/25/1994 – 7:55 PM	0	$5,000	Wind damage to fences, trees, and signs was reported by the Benbrook Police Department.
5/5/1995 – 6:05 PM	0	0	Several trees were blown down along with some large tree limbs on the south end of Lake Benbrook.
8/19/1995 – 5:44 PM	61	0	High winds damaged the roof of a business in east Fort Worth.
6/12/1996 – 3:23 PM	50	0	
6/16/1997 – 10:54 PM	52	0	
2/24/2001 – 10:15 AM	0	$75,000	One house was destroyed and several homes were unroofed by high thunderstorm winds.
6/14/2001 – 7:21 PM	52	0	Signs were blown down by high thunderstorm winds.
5/5/2006 – 2:10 AM	50	0	8-inch tree limbs down at a traffic circle in Ridglea.
5/2/2007 – 5:20 PM	65	0	
5/2/2009 – 1:36 PM	56	$5,000	A storm spotter measured a 64 mph wind gust.

Source: www4.ncdc.noaa.gov, May 19, 2010.
*All historical flood data is the result of the National Weather Service's results for Benbrook, TX

c) Expansive Soil

Expansive soils are types of soil that shrink or swell as the moisture content decreases or increases. Structures built on these soils may experience shifting, cracking, and breaking damage as soils shrink and subside or expand. Like many areas within North Central Texas, the City of Benbrook has its share of foundation damage caused by expansive soils. Benbrook has a number of soil types with relatively high clay content, as exhibited by a moderate to high shrink-swell potential.

Location – The map in Figure 11 shows the areas in Benbrook with soils that have a moderate to high shrink-swell potential and the existing structures that are built upon them. Expansive soils zone covers much of the city, making expansive soil nearly a city-wide hazard. There are a total of 6,195 existing structures located in these areas that are potentially affected by expansive soils.

Extent – Expansive soils in Benbrook are subject to a 0-50% of change at any given time. The exact extent of expansive soils effects on Benbrook cannot be accurately predicted since soil expansion is reliant upon other factors, such as rainfall. In the event of heavy rainfall, areas on the expansive soil map that contain high clay content may be subject to between 51% to 130% shrink-swell potentials. Table 12 shows the extent of expansive soil damage.

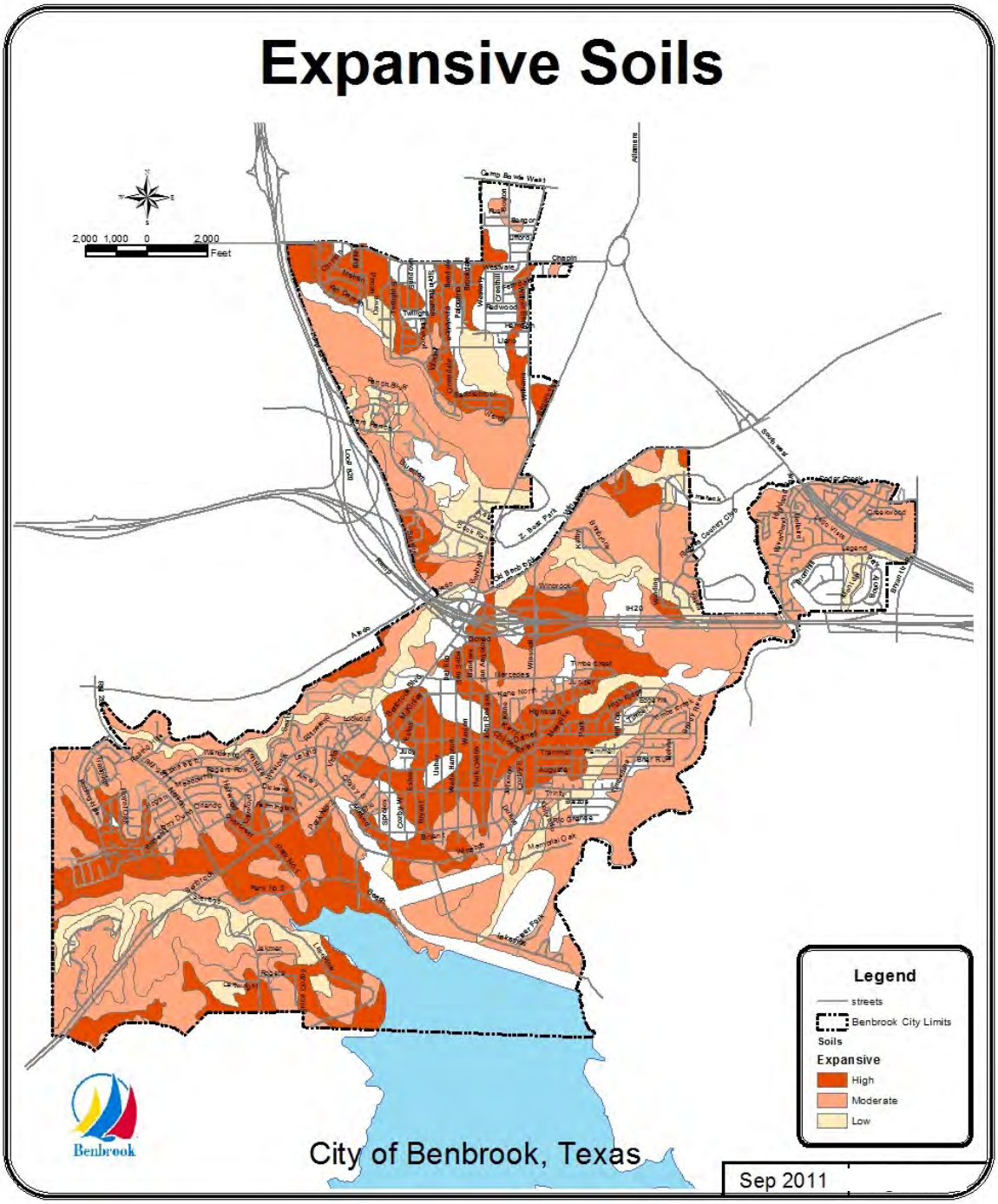
Table 12. Expansive Soils: Percent of Change

Percent of Expansion	Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

Previous Occurrences – There is no data available on previous occurrences of damage from expansive soils because it is not required to be reported, but there are 6,195 structures located within the expansive soils zone with a total value of $898,147,770 according to the Tarrant County Appraisal District (2009).

Probability of Future Events - There is a probability of frequent future occurrences of expansive soil. Almost all of Benbrook's critical facilities are located in areas of moderate to high expansive soils, however, all of the public buildings have had engineered foundations to reduce the chance of damage due to expansive soils on these facilities. Many of the areas where new development is occurring are located within areas of moderate to high shrink-swell soils.

Figure 12. Map of Expansive Soils in Benbrook



The City enforces the latest building codes adopted by the International Code Council, with the 2009 International Building Code and International Residential Code currently in effect which will lead to a lower incidence of expansive soil damage on future structures.

Vulnerability – Expansive soils can affect everyone in the City of Benbrook but the effects of expansive soils are generally economic. Expansive soils have caused foundational damage in the city, however, damage has been generally been limited to private structures and there have been no reports of significant damage to public facilities or infrastructure.

Impact – The impact of expansive soils ranges from cosmetic cracks in walls to substantial foundation and structural damage that can result in the need to demolish the building. Infrastructure such as pipelines can be damaged causing increased maintenance and repairs, damaged beyond repair requiring replacement, damaged to the point of failure.

d) Extreme Heat

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground.

Location – Extreme heat is a city-wide hazard.

Extent – Based on historical data, Benbrook is subject to extreme temperatures over 100 degrees for multiple days. Table 13 details the likelihood of heat disorders with prolonged exposure with consideration to the heat index.

Previous Occurrences - This is an annual occurrence. High temperatures are a common occurrence in the Benbrook area during the summer months. In 1980, there were 69 straight days with temperatures over 100 degrees. More recently in 2000, there were 46 days with temperatures over 100 degrees. The NESDIS has identified 11 excessive heat events in Tarrant County

between 1995 and the present, resulting in 64 deaths. None of these were specific to Benbrook and no deaths are known to have occurred in Benbrook as a result of high temperatures.

Probability of Future Events – High summer temperatures are certain to continue to occur annually in the City of Benbrook.

Table 13. Extreme Heat by Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Source: National Weather Service

Vulnerability – Extreme heat can occur anytime from April through October. The elderly, very young and those with poor health are the most at risk. People who work outside or people who live or work in un-air conditioned buildings area also at risk.

Impact - Extreme heat can cause electrical outages resulting in dangerous conditions, especially for at-risk populations. Extreme heat can have economic consequences on industries that require outdoor work, and agriculture can be affected. Extreme heat can cause heat stroke, but generally death and injury from extreme

conditions are unlikely if proper precautions are taken. The consequences associated with extreme heat are likely to have the most impact on groups who have been identified as vulnerable, as those groups are the most likely to be subjected to extreme heat.

e) Severe Winter and Ice Storms

Winter storms need three basic ingredients: cold air, lift and moisture. These ingredients create winter storm conditions consisting of snow, sleet and freezing rain. Winter storms can result in a blizzard, heavy snowfall, heavy sleet, extreme cold and/or ice.

Location – Winter storms are a city-wide hazard.

Extent –The Benbrook area is subject to severe winter storms approximately once every year to once every five years. Risk assessment calculates that Benbrook can expect 0.45 inches of frozen precipitation on a two-year frequency, 0.82 inches on a ten-year frequency, and 1.35 inches on a 100-year frequency.

Previous Occurrences – Severe winter storms are typically regional events that affect the entire Dallas-Fort Worth Metroplex. Winter storm data specific to Benbrook was unavailable, but Table 14 shows the events in the Dallas-Fort Worth area.

Probability of Future Events – Winter storms in Benbrook are probable, and are likely to occur between once every year to once every five years.

Vulnerability – The City of Benbrook is not particularly vulnerable to winter storms and any damage caused by winter storms would be negligible. Critical facilities, residential and commercial structures are unlikely to be affected by winter storms. Infrastructure such as roads or bridges may be temporarily affected by ice or snow, but severe issues related to winter storms are unlikely

Impact – Winter storms can make traveling on roads dangerous. Death and injury due to automobile accidents and slips or falls during ice storms are possible. Damage to residential structures due to frozen pipes is possible.

Severe winter storms often cause traffic disruption and power outages from broken tree limbs.

Table 14. Notable Snow/Ice Storms in the DFW Metroplex since 2005

Date	Impact
February 3-4, 2011	Snow began in the evening of February 3rd, moved north throughout the Metroplex. Averaged between 5 and 8 inches.
February 1, 2011	Heavy rain accompanied a strong arctic front. Up to 7 inches accumulated in the Metroplex.
January 9-10, 2011	Heavy rain transitioned to heavy snow. Light snow fell during the morning of January 10th. Snow remained on the ground for several days.
March 20-21, 2010	Unusually strong and cold upper level low moved along the Red River Valley, heavy snowfall mainly north of I-20.
February 23, 2010	The highest accumulations of 3 to 5 inches occurred south of I-20 near where the center of the upper low tracked
February 11-12, 2010	Record breaking snow fell across North Central Texas. Cold air was already in place when a slow moving upper level low approached.
December 24, 2009	A powerful upper level low brought near blizzard conditions to North Texas on Christmas Eve. Winds gusted to 40 to 50 mph while snow was falling resulting in very low visibilities and blowing snow.
March 3, 2008	An upper level low produced snow for most areas along and north of I-20 where amounts generally ranged from a trace to 3 inches.
March 27, 2005	An upper level low produced a very localized narrow band of 1-2 inches of snow from Graham to Weatherford to Benbrook to Cleburne in the predawn hours of Easter morning.

Source: National Weather Service, 2011
*Benbrook-specific data was unavailable from the National Weather Service, so region-specific data was used

4. Natural Hazards with Low Risk

The remaining natural hazards (droughts and hail) have been determined to be of low risk because of their relatively low probability of damage.

a) Drought

Drought is a water shortage caused by the natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length. It can be aggravated by other factors such as high temperatures, high winds, and low relative humidity.

Location – Droughts are a city-wide hazard, and occur simultaneously throughout the entire city.

Extent – The severity of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and

vegetation expected over an extended period of time, usually a season or more in length. The Palmer Drought Severity Index provides a standardized measurement of moisture conditions. The Palmer Drought Index is based on precipitation and temperature. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available. Using Table 15 and according to the National Weather Service, the City of Benbrook was at “Severe Drought” precipitation levels during the week of June 18, 2011. Figure 12, the U.S. Drought Monitor for June 16, 2011, shows Tarrant County as both “Abnormally Dry” and in a “Moderate Drought”. Tarrant County has experienced a range of droughts, and droughts have the potential to reach “Severe drought” or “Extreme drought” levels on the PDSI classification scale (Table 15).

Table 15. PDSI Classifications for Dry and Wet Periods

Index	Classification
4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

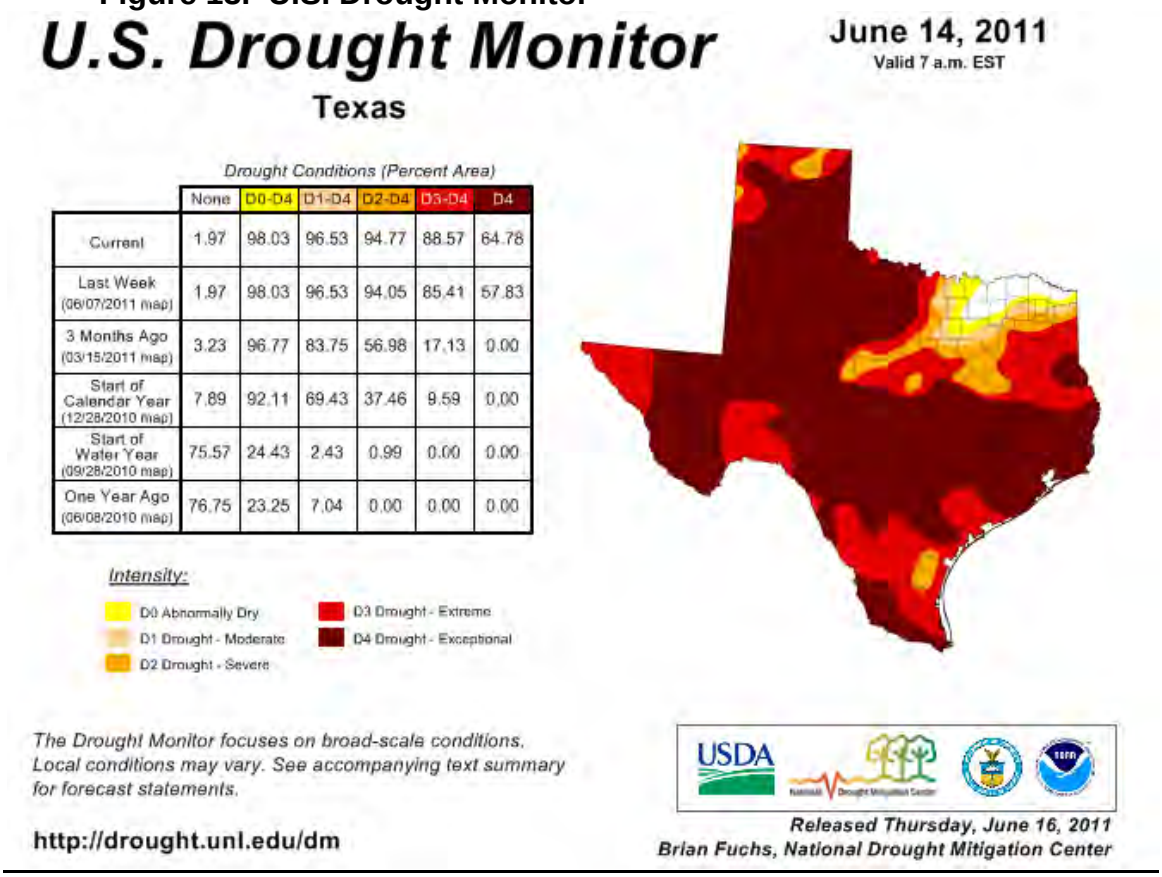
Previous Occurrences – Drought data specific to Benbrook was unavailable, but droughts are regional activities. Table 16 details of the longest number of consecutive days without measurable rain in the DFW Metroplex:

Probability of Future Events – Droughts in the City of Benbrook are fairly infrequent, but future droughts are likely. Droughts are likely to occur between once every five years and once every one hundred years.

Vulnerability – Droughts affect the entire city simultaneously, but are unlikely to cause property damage, injury or death. There are no critical facilities that are directly vulnerable to a drought. However,

droughts can increase the probability of Wildland fire and expansive soil damage which can potentially lead to property damage or loss.

Figure 13. U.S. Drought Monitor



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	1.97	98.03	96.53	94.77	88.57	64.78
Last Week (06/07/2011 map)	1.97	98.03	96.53	94.05	85.41	57.83
3 Months Ago (03/15/2011 map)	3.23	96.77	83.75	56.98	17.13	0.00
Start of Calendar Year (12/28/2010 map)	7.89	92.11	69.43	37.46	9.59	0.00
Start of Water Year (09/28/2010 map)	75.57	24.43	2.43	0.99	0.00	0.00
One Year Ago (06/08/2010 map)	76.75	23.25	7.04	0.00	0.00	0.00

Table 16. DFW Consecutive Days Without Measurable Rain

Rank	# of Days	Date
1	84	July 1 - Sep 22, 2000
2	58	Nov 4 - Dec 31, 1950
(tie)	58	May 25 - July 21, 1934
4	56	Jul 11 - Sep 4, 1999
5	54	Oct 7 - Nov 29, 1955
6	52	Dec 12, 1985 - Feb 1, 1986
7	48	Sep 20 - Nov 6, 1924
8	44	Dec 7, 1922 - Jan 19, 1923
(tie)	41	Sep 22 - Nov 1, 1975
(tie)	41	Jul 26 - Sep 4, 1929
(tie)	41	Jul 28 - Sep 6, 1913
9	41	Nov 1 - Dec 11, 1903

*Benbrook-specific data was unavailable from the National Weather Service, so region-specific data was used.

Impact – The most important consequence of drought is on the City's drinking water supply. The City's drinking water supply is provided and managed by a separate special district, the Benbrook Water Authority (BWA.) Benbrook obtains its water from Benbrook Lake and from a series of groundwater wells. The Authority has water rights to 22.7 percent of the safe yield of Benbrook Lake, but also has agreements with the Tarrant Regional Water District to purchase additional raw water and with the City of Fort Worth to purchase treated water. Of course, during a severe drought, these entities may also have limited surplus water resources. The Authority has a "Drought Contingency Plan" that has a four-tiered approach to water conservation measures, depending on the severity of the drought. Each stage is triggered by the demand in relationship to capacity. Table 17 shows the Benbrook Water Authority's Drought Stages chart.

In addition to affecting drinking water, drought can also trigger or affect other natural hazards such as expansive soils and wildland fires. A drought can lead to a loss of water for basic needs such as drinking and fire-fighting, but in general, droughts tend to impact landscaping and recreational uses and end before critical measures are necessary. The table below chronicles the City of Benbrook's drought contingency plan.

Table 17. Drought Stages

Stage	Trigger	Actions
1	85% of system capacity for 7 consecutive days	• Public education • Request public to voluntarily reduce water and to avoid irrigation water use between 10 AM and 6 PM
2	95% of system capacity for 3 consecutive days, or segments of system drop below 35 psi	• Installation of new landscaping will be discouraged • Irrigation water allowed only once every five days • Watering prohibited between 10 AM and 6 PM • Hosing off paved areas prohibited • Non-commercial car washing prohibited
3	98 % of system capacity for 3 consecutive days, or segments of system drop below 35 psi	• All outdoor landscape watering is prohibited • Hosing off paved areas is prohibited • Operation of ornamental fountains is prohibited • Draining or filling swimming pools is prohibited • Foundation watering only by hand using 5-day schedule • Vehicle washing is prohibited
4	Contamination, or failure of or damage to major system component, or demand exceeds supply	• Landscape watering prohibited • Installation of new landscaping prohibited • Hosing off paved areas prohibited • Operation of ornamental fountains prohibited • Draining or filling swimming pools prohibited • Foundation watering must be done by hand using five day schedule • Washing of vehicles prohibited

b) Hail

Hail is a form of precipitation that occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice.

Location – Hail is a city wide hazard.

Extent – The City of Benbrook is subject to the hazards of severe thunderstorms, including large hail. The largest recorded hail in Benbrook has been 2.75 inches in diameter, or 71.5 mm, which is an H7 on the TORRO Hail Scale. The TORRO Hail Scale in Table 18 shows the full extent of potential hail damage.

Previous Occurrences - The NESDIS records 740 hail events in Tarrant County from January 1950 through February 2010, with 27 being located in and around Benbrook. The weather station at Benbrook Dam records only one day of hail for the period from 1949 to the present, that being in February 1952. Of the 10 most costly storms in Texas from 1950 through 2010, five were hail storms that occurred in the North Central Texas region. Table 19 chronicles historical hail storm events in Benbrook.

Probability of Future Events – The probability of future hail storms in Benbrook is estimated to be a one to twenty percent chance in any given year.

Vulnerability - Severe thunderstorms and the associated hazard of large hail are a hazard event in the planning area. Most structures in the planning area can resist the effects of all but the most severe hailstorms. There are no manufactured buildings in the City of Benbrook. Critical facilities and infrastructure do not have a history of being vulnerable to hail.

Impact – Vehicle, specifically windshield damage, and home damage are the most likely effect of hail storms. Hail is by definition accompanied by severe thunderstorms and lighting, which can pose additional risks.

Table 18. TORRO Hail Intensity Scale

Size Code	Maximum Diameter (mm)	Approximate Size	Typical Damage Impacts
H0	5-9	Pea	No damage
H1	10-15	Mothball	Slight damage to crops, plants
H2	16-20	Marble, grape	Significant damage to fruit, crops, vegetation
H3	21-30	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	31-40	Pigeon's egg > squash ball	Widespread glass damage, vehicle bodywork damage
H5	41-50	Golf ball > Pullet's egg	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	51-60	Hen's egg	Bodywork of grounded aircraft dented, brick walls pitted
H7	61-75	Tennis ball > cricket ball	Severe roof damage, risk of serious injuries
H8	76-90	Large orange > Soft ball	Severe damage to aircraft bodywork
H9	91-100	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	>100	Melon	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: http://www.torro.org.uk/site/hscale.php

Table 19. Historical Hail Storm Events

Date – Time	Size of Hail (inches)	Property Damage	Comments
5/1/1993 – 10:10 PM	0.88	0	
10/17/1993 – 10:30 PM	0.88	0	Trees were uprooted, and signs were blown down. Fences and a brick wall were blown down by thunderstorm winds.
4/20/1994-2:51 PM	1.00	0	Strong winds blew power lines down in southwestern Fort Worth.
4/25/1994 – 6:15-6:25 PM	1.75	0	Golf ball sized hail reported at the intersection of Highways 121 and 183.
4/25/1994 – 7:35 – 7:55 PM	1.75	0	Wind damage to fences, trees, and signs was reported by Benbrook Police Department. Two-inch diameter hail was reported at the intersection of Loop 820 and McCart.
8/7/1994 – 4:03 PM	0.75	0	Dime-sized hail occurred in western Tarrant County 3 miles west of Benbrook on Interstate 20.
4/10/1995 – 12:41 PM	0.75	0	
4/29/1995 – 7:05 PM	0.88	0	Flight cancellations from over 100 damaged aircraft out of service.
5/5/1995 – 6:05 PM	2.75	0	Several trees were blown down along with some large tree limbs on the south end of Lake Benbrook.
4/12/1996 – 10:20 AM	1.75	0	
10/21/1996 – 11:38 AM	0.75	0	
4/20/1997 – 9:00 PM	0.75	0	
2/25/1998 – 7:22 PM	1.00	0	
5/4/1999 – 11:40 AM	1.00	0	
5/17/1999 – 10:40 AM	1.00	0	
3/26/2000 – 1:25 AM	0.88	0	
4/29/2002 – 7:50 PM	1.00	0	
5/8/2002 – 7:54 PM	1.00	0	
6/6/2004 – 10:00 PM	0.75	0	
4/25/2005 – 2:37 PM	0.88	0	
4/19/2006 – 11:38 PM	1.00	0	
4/3/2007 – 5:44 -6:58 PM	1.00 – 2.75	$15,000	Baseball-size hail reported in town.
2/15/2008 – 11:26 PM	1.00	0	Hail between nickel and golfball-size was a common occurrence.
4/9/2008 – 1:09 – 1:15 AM	1.00 – 1.75	$5,000	
5/2/2009 – 1:36 – 1:47 PM	0.88 – 1.00	0	Penny to nickel to quarter size in and west of Benbrook.
5/26/2009 – 6:15 – 6:24 PM	1.00	0	Quarter size hail fell in north Benbrook. Nickel to Quarter size hail fell at the intersection of Loop 820 and Team Ranch Rd in southwest Ft. Worth. Quarter size hail fell in Benbrook. A trained spotter reported quarter size hail just east of the intersection of Highway 183 and West Vickery in Ft. Worth.
10/25/2009	0.88	0	Nickel size hail was reported along Interstate 20 north of Benbrook.

Source: www4.ncdc.noaa.gov, May 19, 2010

B. Risk to Critical Facilities

Benbrook has identified 12 critical facilities within the city limits. Critical facilities in this case are defined as structures that are essential to the health and welfare of the whole population and are especially important following hazard events. Essential facilities in Benbrook include the police and fire station, essential public works facilities, schools, buildings that house special needs populations, including the elderly and emergency shelters. Benbrook does not have any hospitals or emergency medical facilities. Benbrook's primary emergency operation center is in the fire station, with a secondary emergency operation center in the police department.

This list of critical facilities does not include city infrastructure, utility systems, building stock, and other structures that are vital to the daily life of Benbrook since such extensive data is currently unavailable for the purposes of this plan. The five year update will include a more extensive list of structures and facilities that could be affected in the event of a disaster.

The only hazard that poses a serious threat to any critical facility is the risk of tornadoes. The risk of wildland fires or flooding is unlikely to affect any of the City of Benbrook's critical facilities, and lower-risk hazards are unlikely to impose serious damage or service interruption of Benbrook's critical facilities. Table 20 identifies Benbrook's critical facilities.

C. Risk to New Development

Benbrook has an estimated population of 21,234 people in 2010 (U.S. Census Bureau, 2010), which represents a slow growth rate over the 2000 Census population of 20,208 and the 1990 Census population of 19,564. The reason for this slow growth has been the result of real estate recessions and the closure (and subsequent reopening) of a major employer (Carswell Air Force Base, now known as Naval Air Station Fort Worth Joint Reserve Base). The City believes that more substantial growth will return, as evidenced by the 210 new dwelling units built during the last three years.

Benbrook is surrounded on all sides by the City of Fort Worth, so its ultimate population is limited to approximately 47,000. Most of this additional new growth will occur in the far southwest portion of the City and along the I-20 and Loop 820 corridors. Figure 13 is a map of the Future Land Use Plan in Benbrook.

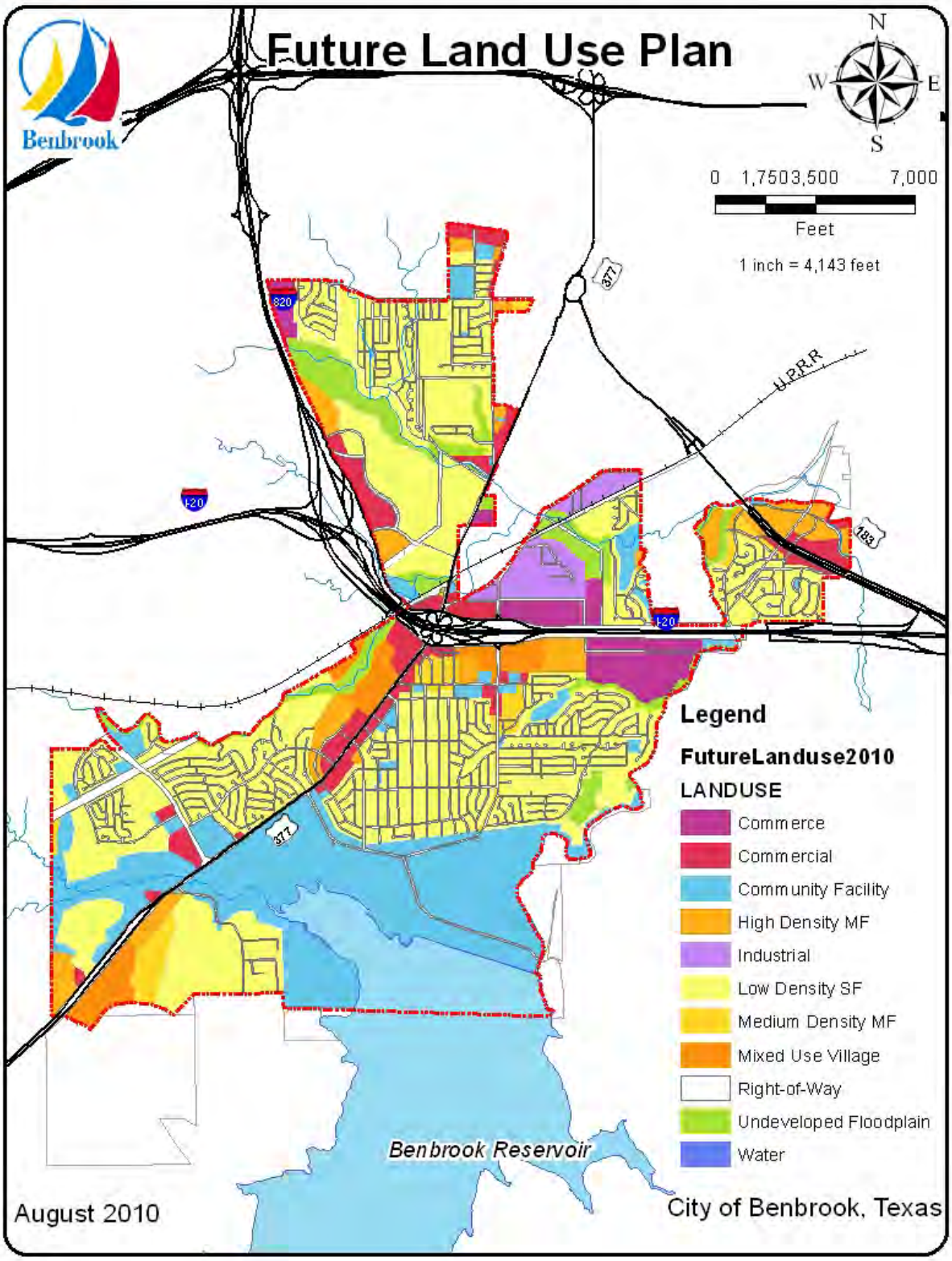
Table 20. Critical Structures Identified

Structure	Type	Address	Year Built	Square Footage
Benbrook Water Authority	Public Works	1121 Mercedes St.	1986	9, 264
Benbrook Elementary	School Shelter	800 Mercedes St.	1987	61, 700
Westpark Elementary	School Shelter	10117 Westpark Dr.	1988	46, 600
Western Hills High School	School Shelter	3600 Boston Ave.	1970	N/A
Benbrook United Methodist	Shelter	1122 Bryant St.	1993	14, 819
First Baptist Benbrook	Shelter	1015 McKinley St.	1970	3, 600
Benbrook Middle School*	Shelter School	201 Overcrest Dr.	2011	175,600
Benbrook Community Center/YMCA	Shelter	1899 Winscott Rd.	2000	32,600
Mirabella Retirement Center	Special Needs Housing	4242 Bryant Irvin Rd.	1984	149,749
Renaissance Park	Special Needs Housing	4252 Bryant Irvin Rd.	2000	37, 995
Benbrook Rehab & Nursing Center	Special Needs Housing	1000 McKinley St.	1969	29, 096
Benbrook Police Station & Benbrook Jail	Emergency Response	1080 Mercedes St.	1987	14,998
Benbrook Fire Department	Emergency Response	528 Mercedes St.	1980	13,140

*Benbrook Middle School is set to open in August 2011. The emergency shelter status of Benbrook Middle School has an agreement pending with the American Red Cross.

New development will be protected from flooding, stream bank erosion, and dam failures by the City's prohibition of new development within the 100-year floodplain. Many of the areas to be developed lie within areas of high shrink-swell soils, but it is impractical to prohibit growth in these areas for that reason. All other hazards (hail, high winds, lightning, severe winter storms, extreme heat, drought, poor air quality, and tornadoes) are not geographically specific, so new development is not at any greater risk than existing development.

Figure 14. Future Land Use Plan in Benbrook



III. Development of Mitigation Goals

The City of Benbrook's Hazard Mitigation Goals were developed to comply with the City of Benbrook's Comprehensive Plan, which outlines the City's overall planning tenet, as well as specific goals and objectives to be accomplished within the next five years. The City's goals were designed to reduce or avoid the effects of the profiled hazards addressed in the risk assessment, and they represent a long-term vision for hazard reduction and enhancement of mitigation capabilities. The City's goals were also developed in accordance with the Texas Hazard Mitigation Plan and the Federal Emergency Management Agency's strategic goals.

The City of Benbrook's overall planning tenet is "*to have a safe, comfortable and enjoyable community in which to live and work*," as defined by Chapter 5 of the Benbrook Comprehensive Plan. Chapter 5 of the Comprehensive Plan consists of the City's strategic plan in the first section, followed by generalized and specific planning tenets and principles in the second section. Hazard mitigation efforts are a vital element in providing a safe, comfortable and enjoyable community. The City of Benbrook's hazard mitigation goals were developed from the City's overall planning tenets, as well as specific goals and objectives from the City's 2009 Strategic Plan.

The City's 2009 Strategic Plan includes specific goals and objectives to be accomplished within the next five years. Under the general Goal 5: Provide Appropriate Community Facilities is the following sub-goal and objective:

Subgoal 5E. Construct small storm drainage improvement projects to reduce flooding

Objective 5E1. Construct at least one small storm drainage project annually

Strategy: Identify projects, prepare plans, and oversee construction

Responsible Person: Public Services Director
Resources Required: Construction cost = $100,000 annually from Storm Water Utility fund
Milestone Date: Annual construction completion by September of each year

The City's Comprehensive Plan Tenet 1 (see above) is supported by Principle 1.6 and three supporting principles, which read:

"PRINCIPLE 1.6: The City should protect homes and businesses from flooding.

Principle 1.6.1: The City should restrict and regulate development within floodways and floodplains to minimize future flooding.

Principle 1.6.2: Existing development within flood prone areas should be relocated or protected to the degree practical."
Principle 1.6.3: Existing development along stream channels should be periodically evaluated for potential structural damage from stream bank erosion, and mitigation actions should be explored.

A. Mitigation Goals

By adopting this Hazard Mitigation Plan, the City adopts the following additional mitigation goals:

1. Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage
   A. Encourage storm resistant construction
   B. Assist at-risk populations in mitigating hazards when possible.

2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment
   A. Protect homes and businesses from flooding
   B. Restrict and regulate floodplain and floodway development
   C. Existing development within flood prone areas should be relocated and protected when practical
   D. Encourage the reduction of fuel build up near structures to reduce wildland fire risks

3. Enhance public education concerning hazard mitigation preparedness
   A. Evaluate the public's awareness and satisfaction with the City's warning systems and shelters and make improvements and adjustments as necessary
   B. Promote severe weather warning systems and severe weather emergency shelters

4. Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters.
   A. Enhance the City's mitigation capabilities by conducting regular hazard vulnerability assessments
   B. Periodically evaluate existing properties along stream channels for damage and continue to explore and develop action items for stream bank erosion
   C. Identify and implement feasible hazard mitigation projects and sources of project funding

These goals will be incorporated into the City's Comprehensive Plan during the next regular update. These goals are consistent with the City's overall planning tenet, as well as with the State Goals and Strategies laid out by the State of Texas Mitigation Plan, and FEMA's Strategic Plan Goal 1.

B. National Flood Insurance Program (NFIP) Compliance

The City of Benbrook has participated in the National Flood Insurance Program since 1977 (Community Number 480586.) The City's flood development regulations (codified as Chapter 15.40 of the Benbrook Municipal Code) meet or exceed the requirements established by the Federal Emergency Management Agency (FEMA).

The City of Benbrook has participated in the Community Rating System (CRS) since October 1991. The Community Rating System recognizes the additional efforts taken by the City to reduce flooding risks within the community. The City current has a CRS rating of "6", which entitles flood insurance policy holders within the 100-year floodplain to a 20-percent discount on their premiums.

The City Council adopted provisions to the Subdivision Ordinance which prohibits new development within the 100-year floodplain, and requires no adverse impact on existing floodplains. The City of Benbrook continues to acquire property from developers through its Parkland Dedication Policy, and often this property is targeted to acquiring property within the 100-year floodplain as parkland. The City's policy of prohibiting future land development within the 100-year floodplain also serves to protect the floodplain as private or public open space.

The City of Benbrook has maintained a comprehensive Drainage Plan for the City as part of the Comprehensive Plan (Chapter 9) since 1991. The complete text can be found at http://www.cityofbenbrook.com/filestorage/56/117/160/CP9-DRAItext_020206.pdf, while the drainage plan maps can be found at http://www.cityofbenbrook.com/content/56/117/160/936.aspx. The goal of the Drainage Plan is to remove all existing houses from the 100-year floodplain through structural controls (see NFIP Strategy Number 2). The plan identified almost $26 million (1991 dollars) in necessary improvements. Since that time, the City has constructed over $7 million in drainage improvements that have protected over 200 homes from flooding.

As part of its CRS activities, the City of Benbrook conducts an annual public education campaign to notify residents of the hazards of living within the 100-year floodplain and the importance of flood insurance.

The City also maintains floodplain management documents in the Benbrook Public Library, and has disseminated FEMA flood maps via the Internet (see Interactive Maps on City's home page at www.ci.benbrook.tx.us.

C. North Central Texas Council of Governments

The City of Benbrook has been a participant through the North Central Texas Council of Governments (NCTCOG) in the development of the regional Integrated Storm Water Management (iSWM) design manual, and was one of the first cities to adopt the manual. The manual provides credits for protecting natural waterways, and requires storm water detention to meet goals for water quality protection, stream bank protection and flood protection. Future structures are protected from flooding by implementation of the City's ordinances and policies to prevent future encroachment into the 100-year floodplain, and the requirement for new development to provide floodwater detention so that the 100-year flood peak does not increase over current conditions.

D. Previous and Ongoing Hazard Mitigation Efforts

1. Notification of Hazardous Events

When activated, the Emergency Operations Center (EOC) is located at the Benbrook Fire Station located at 528 Mercedes Street. It was constructed in 1980 using concrete tilt-wall techniques and is located above the 500-year floodplain. The alternate EOC is located at the Police and Courts Building at 1080 Mercedes Street. The building was constructed in 1987 using concrete tilt-wall techniques and is located above the 500-year floodplain.

- The City has a system of seven warning sirens located throughout Benbrook in the event of severe weather or hazards.
- The City has partnered with the National Weather Service to become a certified Storm Ready Community. According to the National Weather Service, Storm Ready "helps communities better prepare for and mitigate effects of extreme weather-related events. Storm Ready also helps establish a commitment to creating an infrastructure and systems that will save lives and protect property."
- The City purchased NOAA all-hazards radios for all public buildings (including Fort Worth ISD schools located in Benbrook) in 2004 when it joined the National Weather Service's Storm Ready Community program.

- The City installed a reverse 911 telephone system known as “Code Red” that can directly dial residents’ telephones within the City or within a specific geographic area of the City in 2009. The City recently added a severe weather warning package to its “Code Red” system. This system allows us to telephone all or targeted areas of the City in case of an emergency situation that requires immediate action (such as a boil-water notice, severe weather warning, missing child or evacuation notices). Code Red is able to dial 60,000 telephone numbers within one hour, allowing the City of Benbrook to alert the entire population of an emergency situation within an hour.
- The City can also use the cable TV system to broadcast warnings.
- The City has implemented an email alert system as part of its web page.
- The City has the capability for route alerts through vehicle sirens and public address systems and door-to-door notification.
- There are seven emergency shelter facilities located within the City, including one City-owned facility, three schools, and two churches. All but two of these facilities have agreements with the American Red Cross (ARC), who will operate each facility during a declared emergency. Table 21 lists the Emergency Shelters in Benbrook.

Figure 14 maps all special facilities in relation to the 100-Year Floodplain. Figure 15 maps the warning siren network in Benbrook. The City is considering the possibility of adding an additional warning siren by 2012.

Table 21. Emergency Shelters in Benbrook

Name	Estimated capacity	Estimated feeding capacity	Number of toilets	Number of showers	Emergency generator	Shelter agreement
Benbrook Community Center/YMCA 1899 Winscott	250	250	9	6	No	ARC
Benbrook Elementary School 800 Mercedes	750	750	12	4	Yes	ARC
Westpark Elementary School 10117 Westpark	750	750	36	4	No	ARC
Western Hills High School 3600 Boston	1500	1500	30	24	No	ARC
Benbrook United Methodist Church 1122 Bryant	100	100	12	4	No	ARC
First Baptist Church of Benbrook 1015 McKinley	500	500	8	0	No	No
Benbrook Middle School* 201 Overcrest Dr.	N/A	N/A	N/A	N/A	Yes	Pending

*Benbrook Middle School is set to open in August 2011. A shelter agreement with the American Red Cross is currently pending. Emergency shelter capacities will be updated upon opening.

Figure 15. Special Facilities in Relation to the 100 Year Floodplain

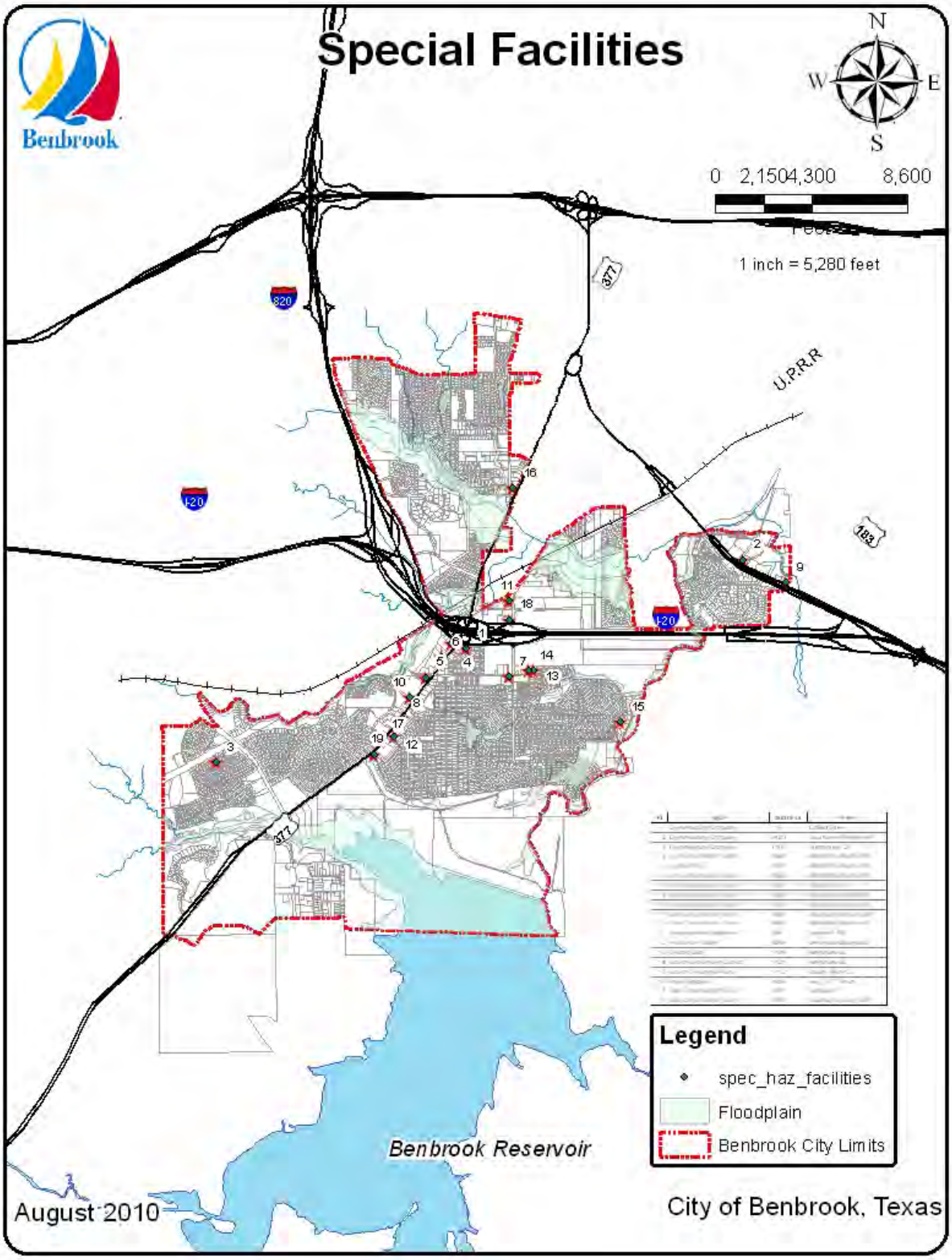
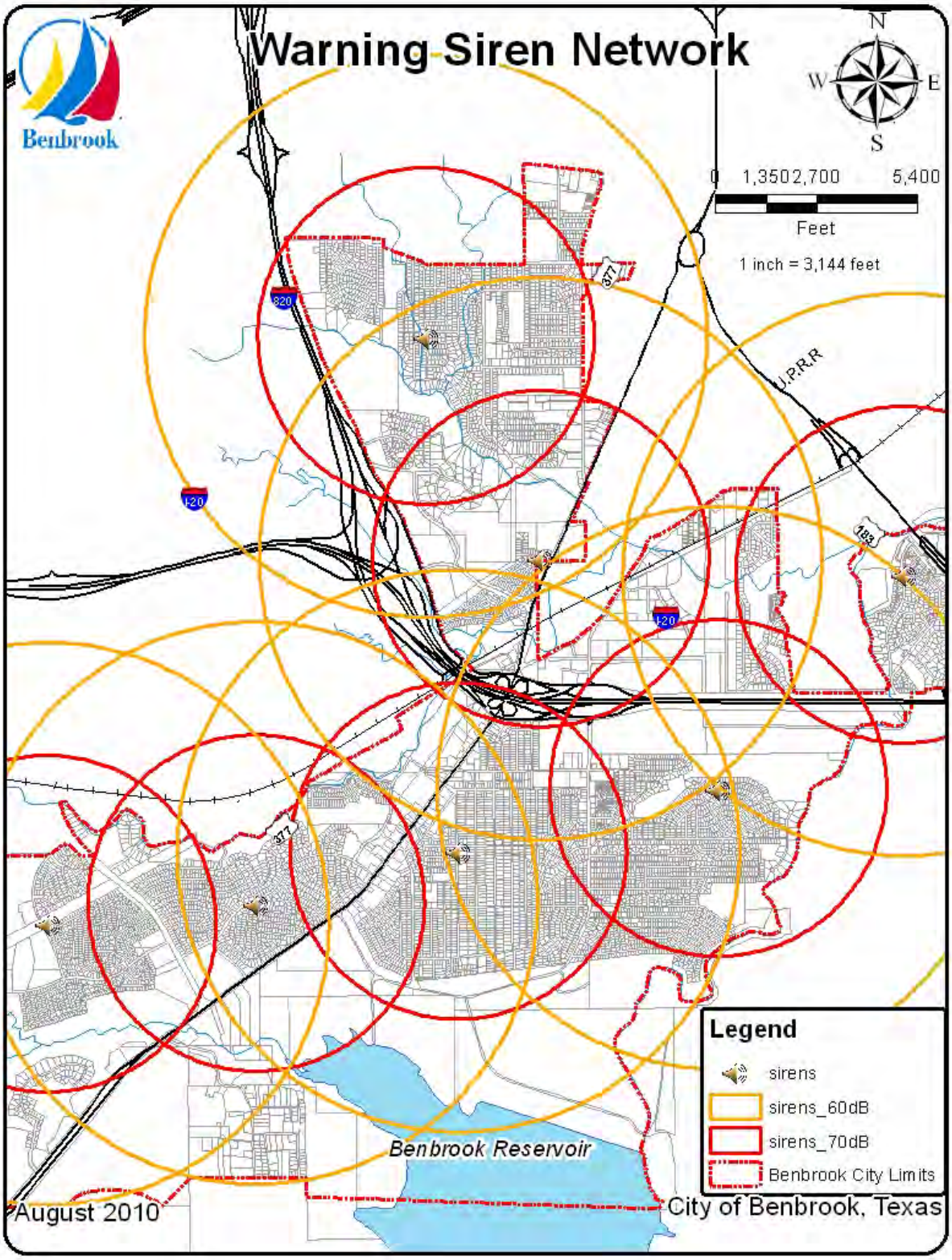


Figure 16. Warning Siren Network



E. Prioritization of Mitigation Actions

The City of Benbrook prioritized our mitigation actions using the STAPLE+E criteria, a planning tool used and recommended by FEMA to evaluate alternative actions. Following is an explanation of the STAPLEE criteria:

S Social - Mitigation actions are acceptable to the community if they do not adversely affect a particular segment of the population, do not cause relocation of lower income people, and if they are compatible with the community's social and cultural values.

T Technical - Mitigation actions are technically most effective if they provide long term reduction of losses and have minimal secondary adverse impacts.

A Administrative - Mitigation actions are easier to implement if the jurisdiction has the necessary staffing and funding.

P Political - Mitigation actions can truly be successful if all stakeholders have been offered an opportunity to participate in the planning process and if there is public support for the action.

L Legal - It is critical that the jurisdiction or implementing agency have the legal authority to implement and enforce a mitigation action.

E Economic - Budget constraints can significantly deter the implementation of mitigation actions. Hence, it is important to evaluate whether an action is cost-effective, as determined by a cost benefit review, and possible to fund.

E Environmental - Sustainable mitigation actions that do not have an adverse effect on the environment, that comply with Federal, State, and local environmental regulations, and that are consistent with the community's environmental goals, have mitigation benefits while being environmentally sound.

Based on the criteria above, actions were assigned a High, Medium, or Low priority according to the following definitions:

High Priority – Action should be implemented as soon as possible. This action will immediately reduce the risk to life and property. Vulnerability will be reduced. Community and political support is high. Funding is available.

Medium Priority – Action should be implemented in the near future. Lives and property will be protected. Community and political support is high. Funding may be available.

Low Priority – Action should be implemented over the long term. Cost of the project may render it unfeasible. There may be political, historical, or environmental issues.

F. Previous and Ongoing Flood Prevention Efforts

In September 2007, the City implemented a storm water utility to generate additional dedicated funds for drainage improvements and flood protection. While the majority of the revenue is being used to reduce previously-issued debt for drainage projects, approximately $100,000 is allocated annually for small drainage projects. Among the drainage projects completed in the last five years that have provided significant flood protection are:

1) Timber Creek Channel Improvements, from Hilltop Pass to the confluence with the Clear Fork Trinity River: This $900,000 bond project was a channel widening project completed in 2006. The project removed approximately 80 houses from the Special Flood Hazard Area.
2) Plantation West Creek drainage improvements: This $1.6 million project provided drainage improvements along Plantation West Creek in North Benbrook, an area of periodic flooding. The project was completed in 2008 and removed approximately 40 homes from the 100-year floodplain.
3) Timber Creek Culvert Improvements: The City completed a $225,000 culvert improvement project under Winscott Road in 2006 that removed a constriction in the middle watershed of Timber Creek. The project removed approximately 20 homes from the 100-year floodplain.
4) Plantation East Creek drainage improvements: In 1991, the City completed a $1.8 million drainage project that substantially reduced flooding in the Plantation Drive and Tara Drive area of North Benbrook, but the project was unable to remove all of the homes (including one Repetitive Loss Property) from the 100-year floodplain. A second and final project was completed in 2010 that will remove a number of homes from the floodplain in this area (including one repetitive loss property.)
5) Acquisition of 913 Timberline Drive: Upon the completion of the Timber Creek Channel Improvements (see paragraph 1) above), it was determined that two properties located along Dry Branch would not be removed from the 100-year floodplain by the project, One of these properties (913 Timberline Drive) was designated as a Repetitive Loss property by FEMA. In

2006, the City purchased the property, demolished the existing structure, raised the building pad two feet above the base flood elevation, and process a LOMR-F to remove the lot from the 100-year floodplain (at a total cost of $218,000.) Purchase of the property also provided an opportunity for the City to remove an encroachment into the Dry Branch channel that adversely affected the flood flows. The City has considered selling the lot for redevelopment, but is currently waiting until market conditions improve.

G. Previous Stream Bank Erosion Efforts

In 2002, the City completed a $157,500 gabion project to protect the north end of Winding Way from collapse.

IV. Hazard Mitigation Action Plans

The following sections describe the hazard mitigation action plans that the City of Benbrook will undertake for each of the identified hazards.

A. Wildland Fire

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Wildland Fire Mitigation Action #1	Review and modify the City of Benbrook's Municipal Code, if necessary, to restrict excessive fuel build up, including tree trimmings, brush and cuttings to reduce wildland fire risk in residential areas
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2D.Encourage the reduction of fuel build up near structures to reduce wildland fire risks
Priority	High
Estimated Cost	Undetermined – staff time only
Potential Funding Sources	NA
Potential Matching Funding Sources	NA
Responsible Agency	Code Compliance
Estimated Completion Time Frame	Six Months
Effect on New Buildings	New residential structures will be subject to fuel build up restrictions.
Effect on Existing Buildings	Existing residential structures will be subject to fuel build up restrictions.
Cost Effectiveness	This action is cost effective, and would require no additional funding other than staff time. The reduction of potential wildland fire fuel sources near residences will reduce the risk of property damage and destruction.
Discussion: This action would prevent fuel build up near residential structures in order to reduce the hazards associated with the rapid spread of wildland fire.	

Wildland Fire Mitigation Action #2	Conduct a wildland fire risk awareness campaign during the summer months by posting wildland fire preparedness and mitigation techniques on the City website, in City's newsletter and in public buildings.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	Medium
Estimated Cost	$500 or less
Potential Funding Sources	City Funds
Potential Matching Funding Sources	Hazard Mitigation Grants
Responsible Agency	Benbrook Fire Department
Estimated Completion Time Frame	Three Months
Effect on New Buildings	This action will have no specific effect on new buildings; it serves to increase public awareness regarding personal wildland fire mitigation actions.
Effect on Existing Buildings	Increased public awareness about wildland fire mitigation actions increases the likelihood that existing buildings would be better protected against wildland fires.
Cost Effectiveness	This low-cost action would call attention to the risks and dangers associated with wildland fires while requiring little action on the part of the City.
Discussion: The risks associated with wildland fires are not widely publicized, and much of the damage caused by wildland fires is to private property. Increased awareness will reduce casualties and property damage associated with wildland fires.	

B. Flooding

This section describes the top seven mitigation actions identified by the City. The City will continue to monitor and implement the remaining 200 projects identified in the Drainage element of the City's Comprehensive Plan as funds become available.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Flood Mitigation Action #1	Mary's Creek Channel Improvements – North Benbrook
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2A. Protect homes and businesses from flooding 2B. Restrict and regulate floodplain and floodway development
Priority	High
Estimated Cost	$8,377,000
Potential Funding Sources	Hazard Mitigation Grants Flood Mitigation Grants Corps of Engineers Section 205 Funds
Potential Matching Funding Sources	Local Drainage Bonds Storm Water Utility Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development along Mary's Creek Drive would be protected from the risk of flooding
Effect on Existing Buildings	91 homes along Mary's Creek Drive would be removed from the 100-year floodplain
Cost Effectiveness	Cost Effective – This measure would protect 91 homes against the threat of flooding which would otherwise be severely damaged. This action also protects repetitive loss properties, making it cost effective.

Discussion:
This project would include approximately 5,600 linear feet of earthen channel improvements along Mary's Creek so that the 100-year flood is contained within the channel. The new earthen channel would have a 150-foot to 225-foot wide bottom, 15 to 18 feet in depth, and 2:1 side slopes. Figure 16 maps the location of this project.
Alternatives Considered:
1) One option is to purchase each of the vulnerable properties, at an estimated cost of $27 million.
2) Another option is construct some type of upstream regional detention facility, but the facility would most-likely need to be located in Fort Worth and the City of Fort Worth has not been receptive to this option.

Figure 17. Flood Mitigation Project No. 1

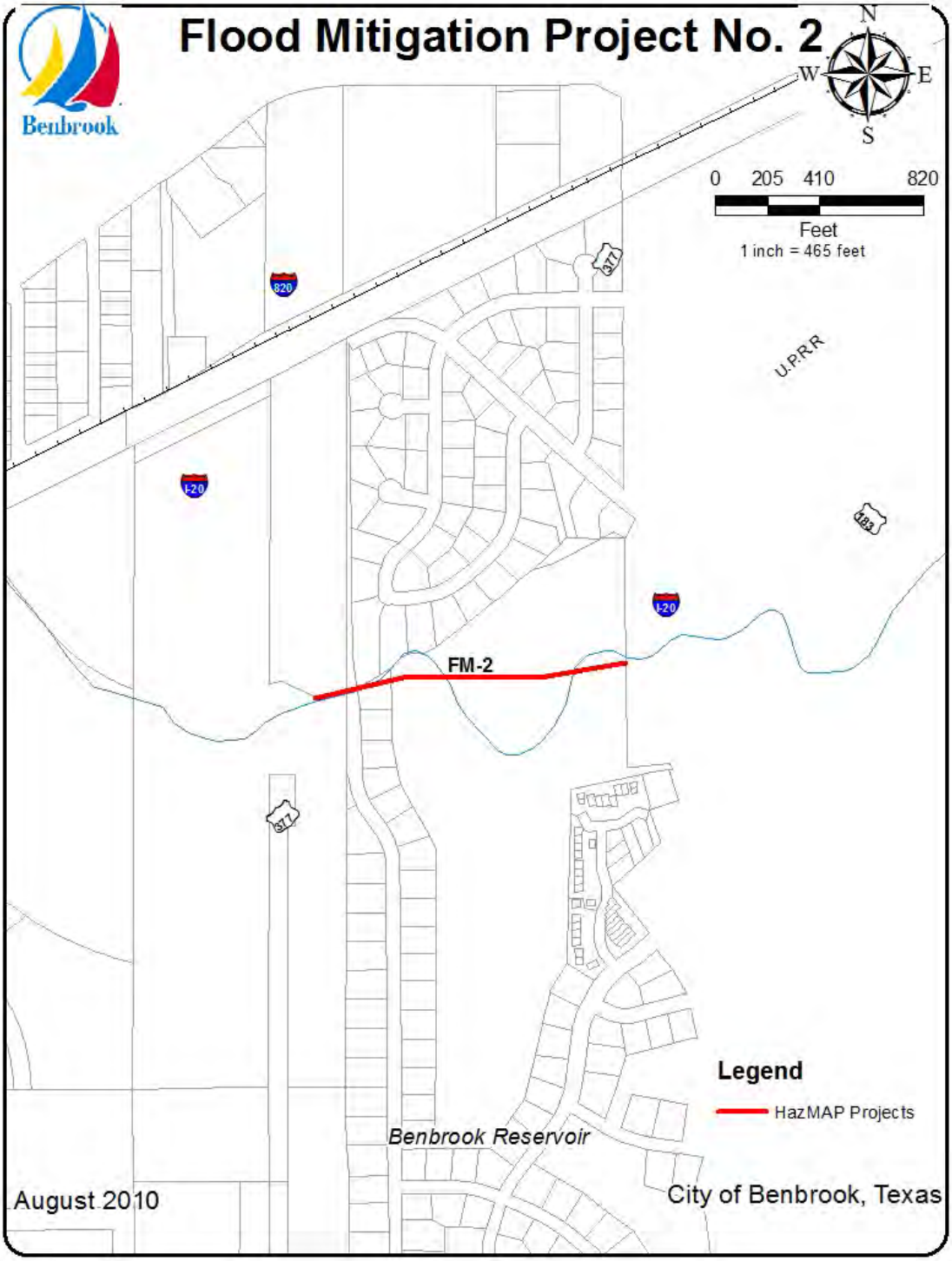
Flood Mitigation Action #2	Mary's Creek Channel Improvements – Ridglea Country Club Estates
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2A. Protect homes and businesses from flooding 2B. Restrict and regulate floodplain and floodway development
Priority	High
Estimated Cost	$1,580,800
Potential Funding Sources	Hazard Mitigation Grants Flood Mitigation Grants Corps of Engineers Section 205 Funds
Potential Matching Funding Sources	Local Drainage Bonds Storm Water Utility Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development along Mary's Creek in Ridglea Country Club Estates and Benbrook Industrial Park would be protected against flooding.
Effect on Existing Buildings	Remove 76 homes and 11 commercial/industrial buildings along Mary's Creek in Ridglea Country Club Estates and Benbrook Industrial Park from the 100-year floodplain.
Cost Effectiveness	Cost Effective – this measure removes 87 residential and commercial structures from the 100-year floodplain.

Discussion:
This project would include approximately 1,000 linear feet of earthen channel improvements along Mary's Creek so that the 100-year flood is contained within the channel. The new earthen channel would have a 175-foot wide bottom, 18 feet in depth, and 2:1 side slopes. Figure 17 maps the location of this project.

One option is to purchase each of the vulnerable properties, at an estimated cost of $28.6 million.

Another option is construct some type of upstream regional detention facility, but the facility would most-likely need to be located in Fort Worth and the City of Fort Worth has not been receptive to this option.

Figure 18. Flood Mitigation Project No. 2



Flood Mitigation Action #3	Bryant-Usher Storm Drain
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2A. Protect homes and businesses from flooding 2B. Restrict and regulate floodplain and floodway development
Priority	High
Estimated Cost	$167,200
Potential Funding Sources	Hazard Mitigation Grants Flood Mitigation Grants
Potential Matching Funding Sources	Local Drainage Bonds Storm Water Utility Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	Any new buildings or renovated buildings along Bryant and Usher streets would be protected from street flooding
Effect on Existing Buildings	Protect approximately 22 homes along Bryant and Usher Streets from street flooding.
Cost Effectiveness	This measure is cost effective – 22 homes would be protected from street flooding. Without this measure, the cost of damage to 22 homes due to flooding would be much higher than the cost of this project.
Discussion: This project would include approximately 900 linear feet of 24 and 36-inch underground storm drain and associated curb inlets. Most of this area was removed from the 100-year floodplain by the September 2009 FIRM maps. Figure 18 maps the location of this project. This action is related to Benbrook's continued compliance with the NFIP.	

Figure 19. Flood Mitigation Project No. 3

Flood Mitigation Action #4	Mildred/Vernon Castle Storm Drain
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2A. Protect homes and businesses from flooding 2B. Restrict and regulate floodplain and floodway development
Priority	Low
Estimated Cost	$1,650,600
Potential Funding Sources	Hazard Mitigation Grants Flood Mitigation Grants
Potential Matching Funding Sources	Local Drainage Bonds Storm Water Utility Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development along Mildred Avenue and Vernon Castle Avenue would be protected against the threat of flooding.
Effect on Existing Buildings	Protect approximately 20 homes along Mildred Avenue and Vernon Castle Avenues from street flooding
Cost Effectiveness	Cost effective – this measure is expensive, but in the event that funding presents itself, it would be cost effective to protect 20 residential structures from the threat of flooding.
Discussion: This project would include approximately 4,500 linear feet of underground storm drain ranging in size from 24-inch to 72-inch in diameter, along with associated curb inlets. Most of this area was removed from the 100-year floodplain by the September 2009 FIRM maps. Figure 19 maps the location of this project. This action is related to Benbrook's continued compliance with the NFIP.	

Figure 20. Flood Mitigation Project No. 4

Flood Mitigation Action #5	Sundown/Twilight Drive Storm Drain
Mitigation Goal/Objective	2. Reduce the adverse effects of hazards that have been identified as 'high risk' by the risk assessment 2A. Protect homes and businesses from flooding 2B. Restrict and regulate floodplain and floodway development
Priority	High
Estimated Cost	$227,902
Potential Funding Sources	Hazard Mitigation Grants Local Drainage Bonds
Potential Matching Funding Sources	Storm Water Utility Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development along Sundown Avenue and Twilight Drive will be protected against street flooding.
Effect on Existing Buildings	Approximately 17 homes along Sundown Avenue and Twilight Drive will be protected from street flooding.
Cost Effectiveness	This measure is cost effective – the comparatively low cost of protecting 17 homes from street flooding makes this project worthwhile.
Discussion: This project would include approximately 1,100 linear feet of underground storm drain, ranging in size from 24-inch to 36-inch in diameter, along with associated curb inlets. Figure 20 maps the location of this project.	

Figure 21. Flood Mitigation Project No. 5

Flood Mitigation Action #6	Develop flood mitigation materials specific to the City of Benbrook to be distributed both digitally and available in City buildings.
Mitigation Goal/Objective	3. Enhance public education concerning hazard mitigation preparedness
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Community Development
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New buildings will not be affected by public awareness campaigns.
Effect on Existing Buildings	Existing buildings may be better protected from flooding due to expanded public awareness.
Cost Effectiveness	This measure is cost effective – Benbrook is prone to flooding and increased awareness could result in less damage.
Discussion: This action will increase awareness of flood prevention and mitigation techniques for all Benbrook citizens.	

C. Tornadoes

The City has identified two mitigation projects designed to reduce the risk associated with tornadoes.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Tornado Mitigation Action #1	Assist multi-family residential structures and/or facilities that house at-risk special needs populations (e.g. nursing homes) with funding for building tornado safe rooms or in-ground shelters.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction 1B. Assist at-risk populations in mitigating hazards when possible
Priority	Medium
Estimated Cost	$200,000 (25 safe rooms at $8,000 each)
Potential Funding Sources	Hazard Mitigation Grant Programs Private Foundations Community Development Block Grants
Potential Matching Funding Sources	Building or Facility Owner
Responsible Agency	Community Development
Estimated Completion Time Frame	Two Years
Effect on New Buildings	New multi-family buildings or special facilities will have the opportunity to apply for safe room or in-ground shelter subsidies and will increase the building's storm resistance.
Effect on Existing Buildings	Existing multi-family buildings or special facilities will have the opportunity to apply for safe room or in-ground shelter subsidies and will increase the building's storm resistance.
Cost Effectiveness	Safe rooms and in-ground shelters have been proven to reduce injury and loss of life in the event of a tornado. Injury and loss of life are impossible to assign a cost value to,
Discussion: Multi-family residential structures, such as apartment buildings with multiple floors, are proven to be more dangerous in the event of a tornado. Taking shelter on the ground floor is a basic emergency tornado precaution, and multi-family, multi-level residential facilities often do not offer basic tornado shelters to residents on higher floors. This subsidy would allow landlords or building owners to provide emergency protection for their residents. The specific eligibility guidelines for safe room subsidies would be left to the responsible agency.	

Tornado Mitigation Action #2	Evaluate the public's awareness and satisfaction with the City's warning systems and emergency shelters, and make improvements and adjustments as necessary.
Mitigation Goal/Objective	4) Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters. 4A. Enhance the City's mitigation capabilities by conducting regular hazard vulnerability assessments
Priority	Medium
Estimated Cost	Undetermined
Potential Funding Sources	Hazard Mitigation Grants City Funds
Potential Matching Funding Sources	Hazard Mitigation Grants
Responsible Agency	Fire Department
Estimated Completion Time Frame	Six Months
Effect on New Buildings	New buildings will not be affected by a public awareness survey.
Effect on Existing Buildings	Existing buildings will not be affected by this action.
Cost Effectiveness	Cost Effective - much of the cost associated with this project will be staff time spent developing methods to measure citizen's awareness and satisfaction to emergency warning systems. Further costs will depend on the survey's responses.
Discussion: The public's knowledge, awareness and satisfaction of the City's warning systems is vital to reducing loss of life and reducing injuries caused by tornados. In the event of a tornado, it is necessary that the City is able to alert all citizens in a timely and effective manner. Evaluating the public awareness and satisfaction in regards to the warning system will allow the City to recognize deficiencies in the alert system before an emergency occurs, and can potentially save lives and reduce injuries.	

D. Dam Failure

Though authority for developing action plans for the Benbrook Dam lies with the U.S. Army Corps of Engineers, the City has identified two actions that could help with awareness regarding the effects of a dam failure.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Dam Failure Mitigation Action #1	Develop a public awareness and education campaign that emphasizes safety procedures in the event of a flood.
Mitigation Goal/Objective	4) Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters.
Priority	Medium
Estimated Cost	Undetermined – Possibly Staff Time Only
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Community Development
Estimated Completion Time Frame	Three months
Effect on New Buildings	This mitigation action is related to public education and will have no effect on new buildings.
Effect on Existing Buildings	Better informed citizens may be able to implement flood safety techniques that could reduce the amount of damage to a building in the event of dam failure.
Cost Effectiveness	This measure is cost effective.
Discussion: Since the inundation maps related to the City's dams are confidential, it is important to educate citizens about steps to reduce the loss of life and property in the event of an unexpected flood. Residents and businesses who are not directly in the floodplain may be less educated about flood safety and/or the possibility of dam failure.	

Dam Failure Mitigation Action #2	Evaluate vulnerable areas that could potentially be at risk in the event of Benbrook Dam failure, as well as the extent of potential damage in the event of dam failure, using the 500-year flood limits as a surrogate for the confidential U.S. Army Corps of Engineers data.
Mitigation Goal/Objective	4. Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters. A. Enhance the City's mitigation capabilities by conducting regular hazard vulnerability assessments
Priority	High
Estimated Cost	Undetermined – Possibly Staff Time Only
Potential Funding Sources	Hazard Mitigation Grants Federal funds
Potential Matching Funding Sources	City Funds
Responsible Agency	Planning and Development
Estimated Completion Time Frame	One year
Effect on New Buildings	This action may help to protect buildings that have not yet been developed in the event of dam failure.
Effect on Existing Buildings	The vulnerability of existing buildings will be assessed and subsequent actions can be taken to mitigate the effects of potential dam failure.
Cost Effectiveness	This measure is cost effective – by identifying and assessing potential dam failure using the City's available resources, such as the 500-year floodplain, the City will be able to mitigate future flooding and dam failure hazards.
Discussion: Information related to dam and dam failure is not under the City of Benbrook's jurisdiction, and independent research and analysis will be required to determine areas vulnerable to Benbrook Dam failure. By assessing the hazard using community resources, the City will be able to better mitigate dam failure hazards as well as address the deficiency in available documentation related to dam failure. Specifically, the City will independently estimate the water depths in the inundation zones in the event of dam failure, and this information will be used in the next update of the City's Hazard Mitigation Plan.	

E. Landslides

No Vulnerability: Benbrook has few areas with steep slopes that would be capable of a landslide (see Figure 8.) The City has identified two actions that could reduce risk associated with landslides. Landslide hazards will continue to be reviewed annually and the City of Benbrook will continue to look for areas with landslide potential during hazard surveys.

NOTE: All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.

Landslide Mitigation Action #1	Require engineered foundations and retaining walls in areas of moderate to steep slopes.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage landslide resistant construction
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Three months
Effect on New Buildings	New buildings will be required to comply with current codes and have engineered foundations during the building process.
Effect on Existing Buildings	Existing building will probably not be affected.
Cost Effectiveness	This measure is cost effective – if one building is better protected against the devastating impacts of landslide and/or retaining wall collapse then the measure will have been worth it. There is also potential to distribute landslide mitigation requirements digitally through Benbrook's new online permitting system, which would drastically lower the cost.
Discussion: Landslide mitigation requirements will be included in building permit packets.	

Landslide Mitigation Action #2	Provide public information regarding the hazards of landslide and retaining wall collapse to citizens.
Mitigation Goal/Objective	4. Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters.
Priority	Medium
Estimated Cost	Undetermined
Potential Funding Sources	City Funds
Potential Matching Funding Sources	Insurance Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	One Year
Effect on New Buildings	Information will be provided to new residents regarding the hazards of landslide and retaining wall collapse.
Effect on Existing Buildings	Existing buildings may benefit by information on foundation and retaining wall inspections and maintenance.
Cost Effectiveness	Cost effective – this measure will reduce the City infrastructure's vulnerability to the damaging and unpredictable effects of landslides.
Discussion: The City will provide an information piece that describes the hazards of landslide and retaining wall collapse, proper design, and proper maintenance practices.	

F. Lightning

The City has identified two actions that can reduce the risk of lightning.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Lightning Mitigation Action #1	Provide lightning mitigation information materials with building permits to promote lightning-resistant construction.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Three months
Effect on New Buildings	New buildings will be encouraged to install lightning resistant materials during the building process.
Effect on Existing Buildings	Buildings that are being remodeled will be encouraged to install lightning resistant materials during the permit process.
Cost Effectiveness	This measure is cost effective – if one building is better protected against the random and often devastating impacts of lightning then the measure will have been worth it. There is also potential to distribute lightning mitigation materials digitally through Benbrook's new online permitting system, which would drastically lower the cost.
Discussion: Lightning mitigation materials will be included in building permit packets.	

Lightning Mitigation Action #2	Assess the extent of lightning strikes on city structures, facilities and people. Use this data to subsequently assess City infrastructure's vulnerability to lightning and upgrade to lightning resistant construction when necessary and possible.
Mitigation Goal/Objective	4. Identify and implement hazard mitigation projects to reduce the impact of hazard events and disasters. 4A. Enhance the City's mitigation capabilities by conducting regular hazard vulnerability assessments
Priority	Medium
Estimated Cost	Undetermined
Potential Funding Sources	Hazard Mitigation Funds City Funds
Potential Matching Funding Sources	Insurance Funds
Responsible Agency	Benbrook Fire Department
Estimated Completion Time Frame	One Year
Effect on New Buildings	New buildings will be subject to lightning assessments and lightning mitigation measures will be taken during the construction.
Effect on Existing Buildings	Existing buildings will be assessed for lightning vulnerability and upgrades and adjustments will be implemented when necessary and/or possible.
Cost Effectiveness	Cost effective – this measure will reduce the City infrastructure's vulnerability to the damaging and unpredictable effects of lightning.
Discussion: Assessing lightning hazards related to City buildings is worthwhile and necessary. Thunderstorms are the most common hazard in North Texas, and assessing the City infrastructure and making necessary adjustments is a long-term action which will reduce lightning risks for years to come. In order to overcome the current data deficiency related to the extent of lightning strikes, the City will assess the extent of lightning strikes and provide the subsequent information in the 5-year update of this plan.	

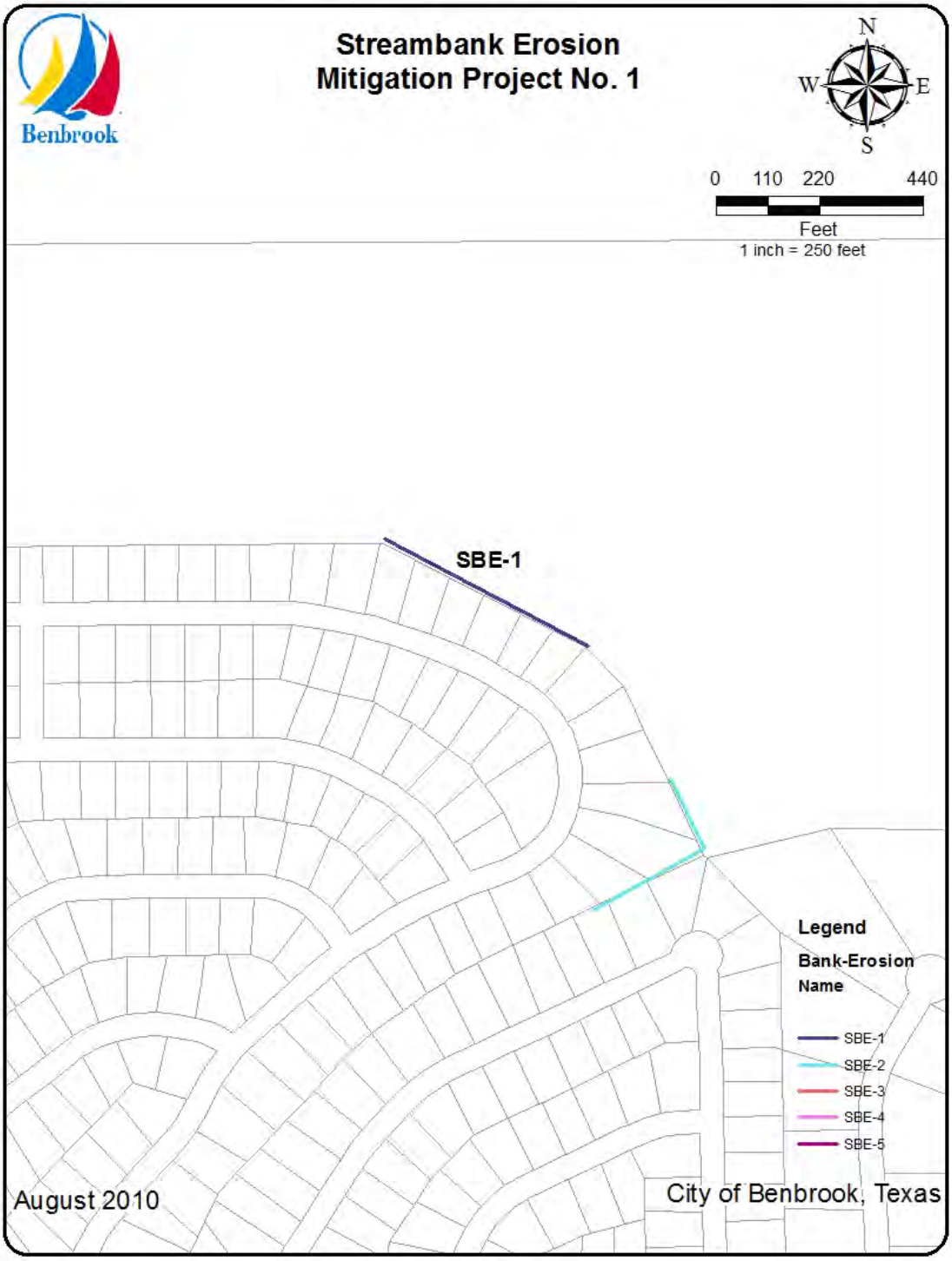
G. Stream Bank Erosion

The City has identified six projects where stream bank erosion is threatening private property.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

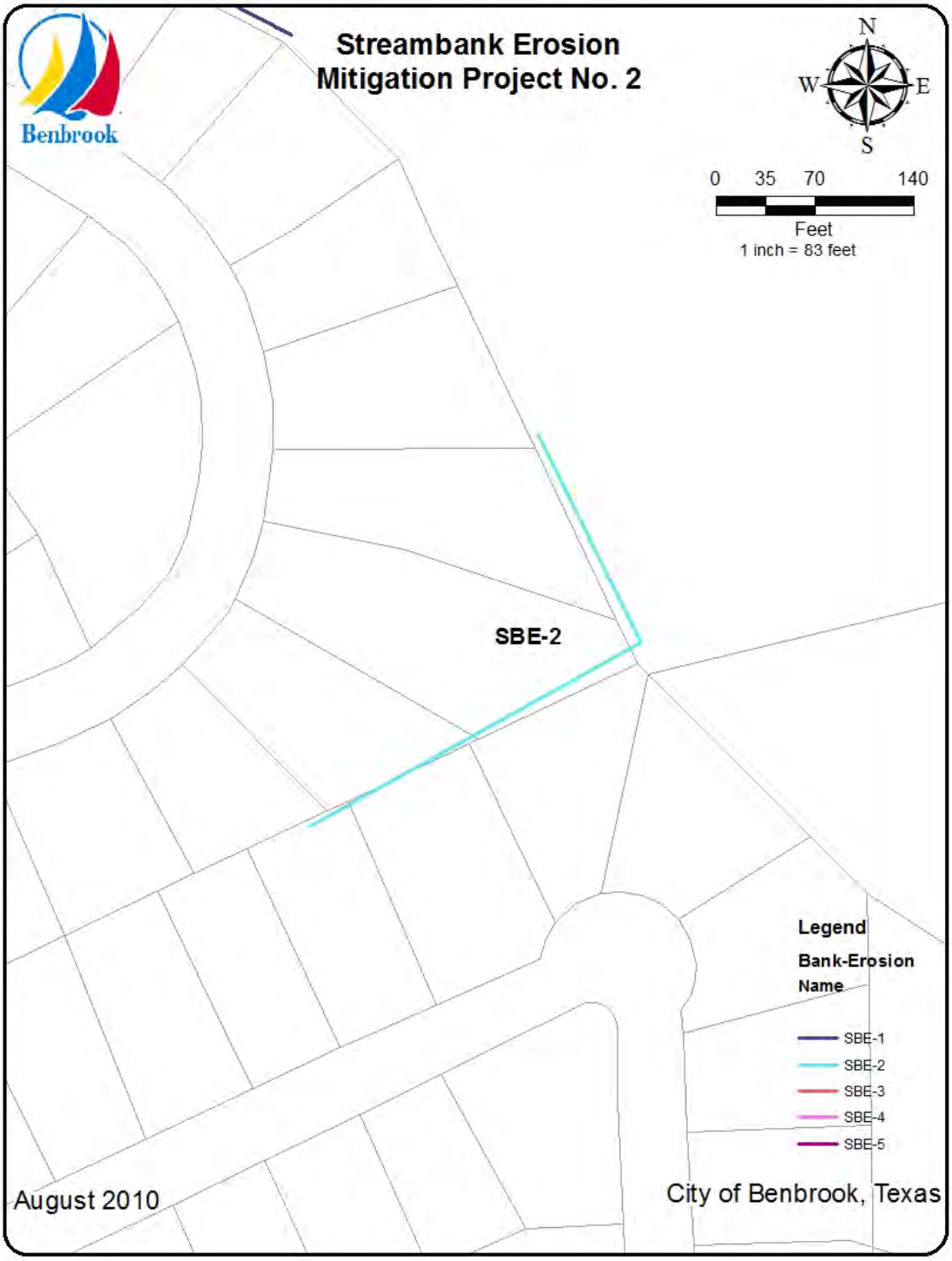
Stream Bank Erosion Mitigation Action #1	Modular concrete blocks or other suitable protection will be placed at 1809-1829 Timberline Drive
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$240,000
Potential Funding Sources	Hazard Mitigation Grants Storm Water Utility Funds
Potential Matching Funding Sources	Property owner contributions City Funds Insurance Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development along Timber Creek would be protected from stream bank erosion.
Effect on Existing Buildings	This project would protect approximately six homes along Timber Creek from stream bank erosion.
Cost Effectiveness	Cost effective – this measure's comparatively low cost will mitigate against stream bank erosion and subsequently, the threat of flooding along Timber Creek.
Discussion: This project would include approximately 500 linear feet of 10-foot high modular concrete block walls. Figure 21 maps the location of this project.	

Figure 22. Streambank Erosion Mitigation Project No. 1



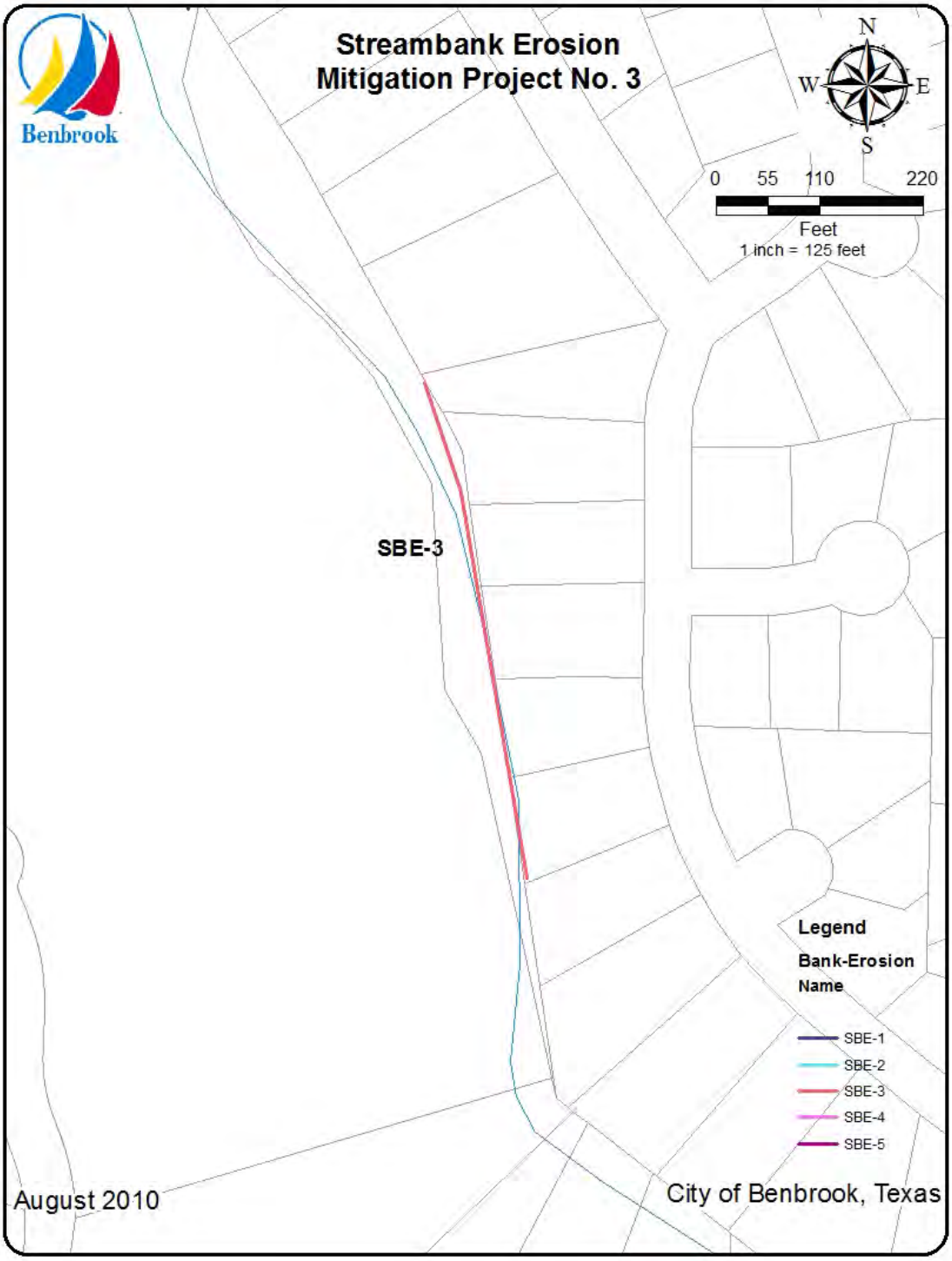
Stream Bank Erosion Mitigation Action #2	Modular concrete blocks or other suitable protection will be placed at the confluence of Dry Branch and Timber Creek
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$153,600
Potential Funding Sources	Hazard Mitigation Grants Storm water utility funds
Potential Matching Funding Sources	Property owner contributions City Funds Insurance Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	New development/renovated homes along Timber Creek would be protected from stream bank erosion.
Effect on Existing Buildings	This project would protect approximately three homes along Timber Creek from stream bank erosion
Cost Effectiveness	Cost effective - the comparatively low cost of this project is worthwhile considering the costly damage that can be caused by stream bank erosion and subsequent flooding.
Discussion: This project would include approximately 400 linear feet of 8-foot high modular concrete block walls. Figure 22 maps the location of this project.	

Figure 23. Streambank Erosion Mitigation Project No. 2



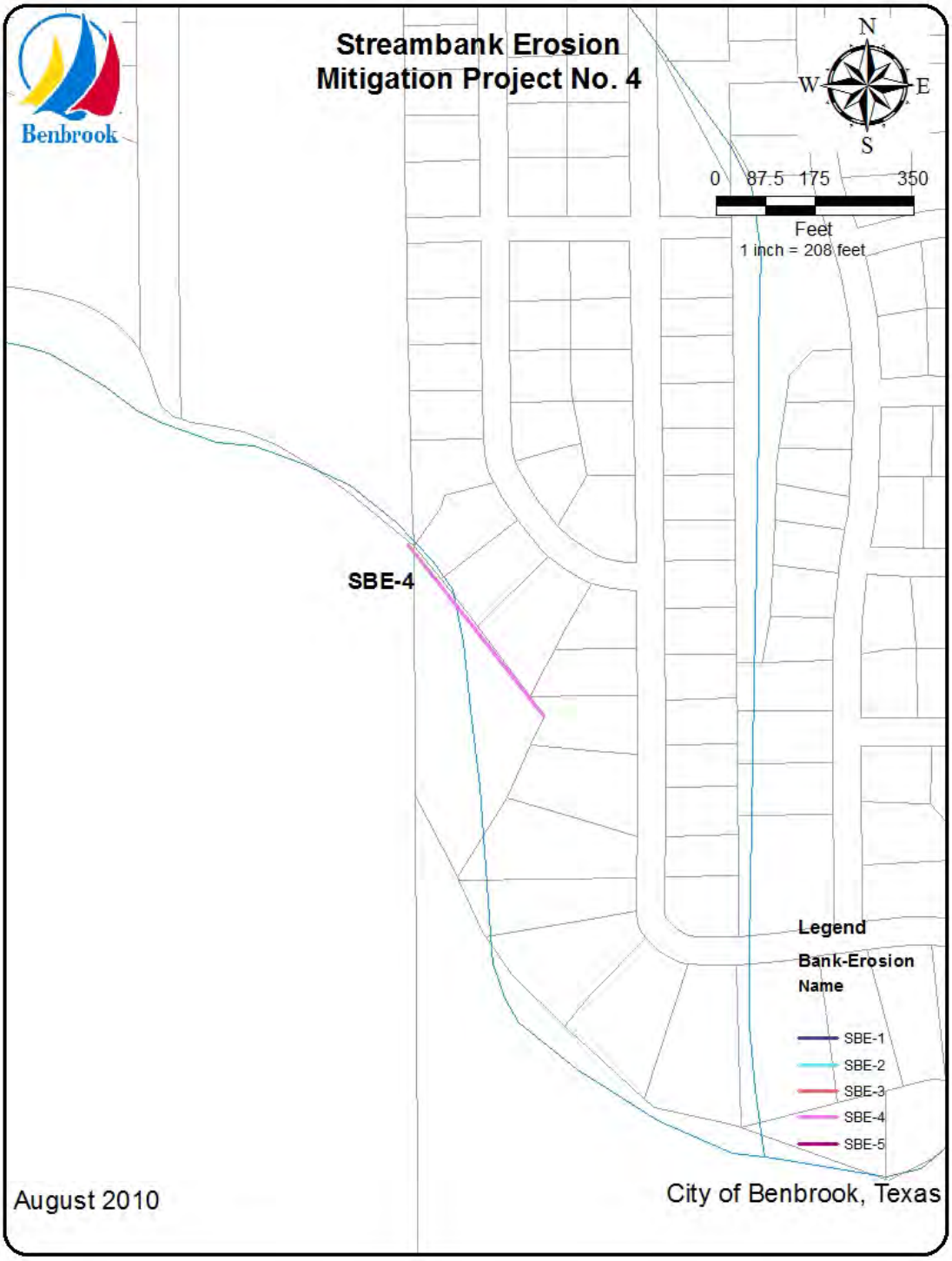
Stream Bank Erosion Mitigation Action #3	Modular concrete blocks or other suitable protection will be placed at 8437-8453 Mary's Creek Drive
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Low
Estimated Cost	$384,000
Potential Funding Sources	Hazard Mitigation Grants Storm Water Utility Funds
Potential Matching Funding Sources	Property owner contributions City Funds Insurance Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	This project would protect new development along Mary's Creek from stream bank erosion.
Effect on Existing Buildings	This project would protect approximately five homes along Mary's Creek from stream bank erosion.
Cost Effectiveness	Cost effective – this measure would protect five homes from the costly and damaging effects of stream bank erosion and subsequent flooding.
Discussion: This project would include approximately 500 linear feet of 16-foot high modular concrete block walls. Figure 23 maps the location of this project.	

Figure 24. Streambank Erosion Mitigation Project No. 3



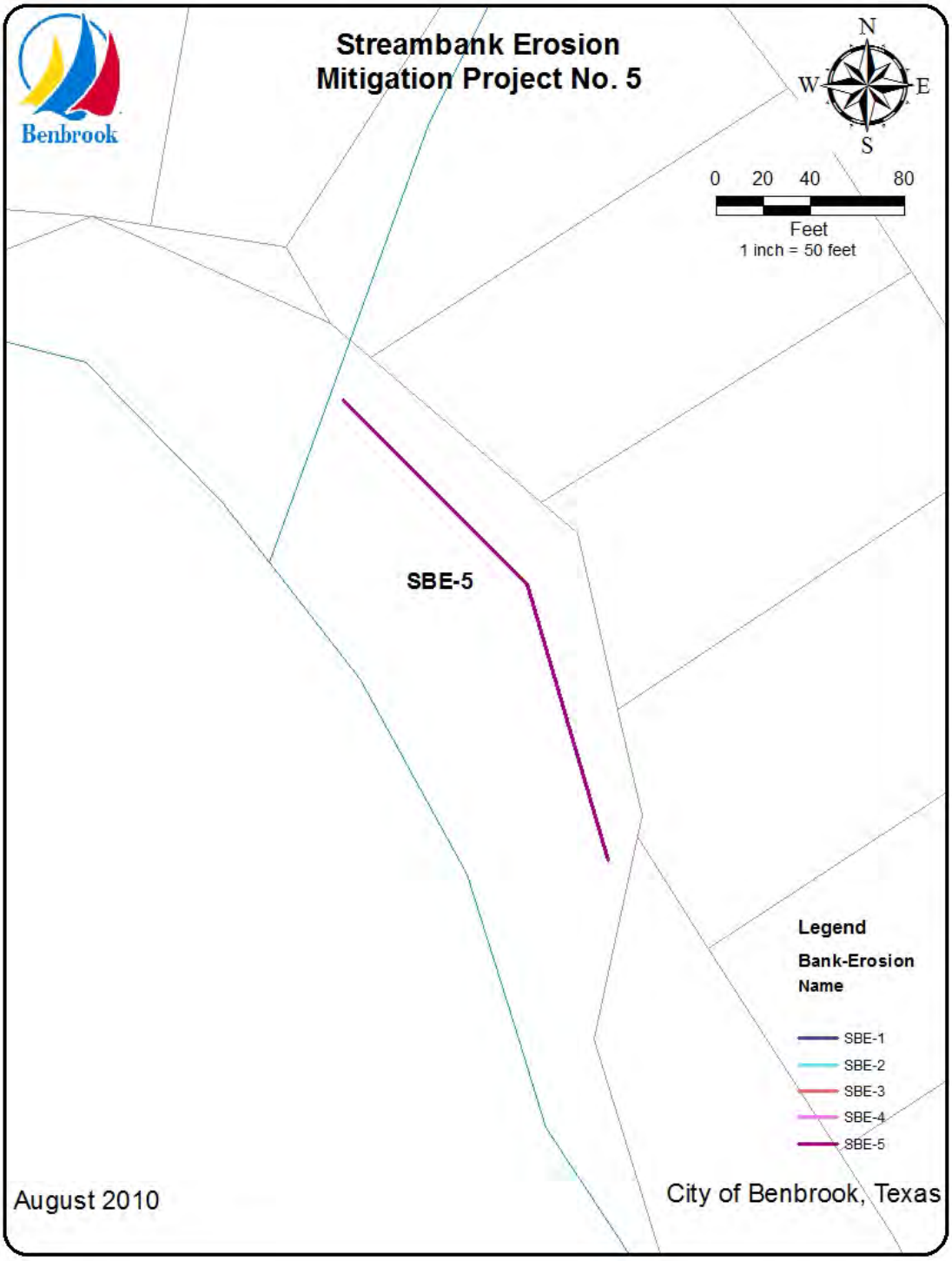
Stream Bank Erosion Mitigation Action #4	Modular concrete blocks or other suitable protection will be placed at 4216-4228 Dawn Drive
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Low
Estimated Cost	$537,600
Potential Funding Sources	Hazard Mitigation Grants Storm Water Utility Funds
Potential Matching Funding Sources	City Funds Property owner contributions Insurance Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	Renovations or additional development on these four homes would be protected from stream bank erosion.
Effect on Existing Buildings	Protect approximately four homes along Timber Creek from stream bank erosion
Cost Effectiveness	This measure is cost effective – the high cost of stream bank erosion damage and the subsequent threat of flooding is enough to justify this project.
Discussion: This project would include approximately 400 linear feet of 28-foot high modular concrete block walls. Figure 24 maps the location of this project.	

Figure 25. Streambank Erosion Mitigation Project No. 4



Stream Bank Erosion Mitigation Action #5	Modular concrete blocks or other suitable protection will be placed at 8521-8601 Mary's Creek Drive
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$345,600
Potential Funding Sources	Hazard Mitigation Grants Storm Water Utility Funds
Potential Matching Funding Sources	Property Owner Contributions City Funds Insurance Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Undetermined
Effect on New Buildings	This project will protect renovations or additions to four homes along Mary's Creek from stream bank erosion.
Effect on Existing Buildings	This project protects approximately four homes along Mary's Creek from stream bank erosion.
Cost Effectiveness	This measure is cost effective – the high cost of stream bank erosion damage and subsequent threat of flooding is enough to justify this project.
Discussion: This project would include approximately 400 linear feet of 18-foot high modular concrete block walls. Figure 25 maps the location of this project.	

Figure 26. Streambank Erosion Mitigation Project No. 5



Stream Bank Erosion Mitigation Action #6	The City will record instances of stream bank erosion after flood events to quantify the possible extent of this hazard. This data will be included in the 5-year update. This information will also be used to warn developers of the risks and additional costs associated with stream bank erosion risk areas during the permitting process.
Mitigation Goal/Objective	3. Enhance public education concerning hazard mitigation preparedness 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New development in stream bank erosion risk zones will be aware of the risks associated with that property and will be encouraged to put mitigation measures in place from the beginning stages of development.
Effect on Existing Buildings	Existing development that is being updated or remodeled in stream bank erosion risk zones will be aware of the risks associated with that property and will be encouraged to put mitigation measures in place from the beginning stages of development.
Cost Effectiveness	This measure is cost effective – the inexpensive cost of public awareness can encourage steps to prevent and mitigate stream bank erosion damage before it ever occurs.
Discussion: This action will inform developers of stream bank erosion risks before development begins, so that property owners are aware of the risks and responsibilities associated with owning stream bank erosion-prone property from the beginning. By recording instances of stream bank erosion to predict the extent of future events, the City will be able to better inform developers of the risks associated with stream bank erosion, and the current stream bank erosion data deficiency will be corrected in the 5-year update.	

H. Severe Thunderstorms and High Winds

The City has identified two projects that could reduce the risk associated with severe thunderstorms and high winds.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Severe Thunderstorms and High Wind Mitigation Action #1	Assess the durability of city roofing and make repairs and adjustments as necessary.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$5,000
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	One Year
Effect on New Buildings	New city buildings will be inspected for adequate roofing and storm resistant construction.
Effect on Existing Buildings	Existing building's roofing will be inspected and repairs will be made as necessary.
Cost Effectiveness	This measure is cost effective – if faulty roofing exists in city buildings, it is more cost effective to preemptively repair it rather than it failing due to severe weather.
Discussion:	

Severe Thunderstorms and High Wind Mitigation Action #2	Provide storm-resistant mitigation materials in building permit packets.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New buildings will be encouraged to install storm resistant measures, such as “hurricane clips” and weather resistant roofing.
Effect on Existing Buildings	Existing buildings that are being renovated or updated will be encouraged to install storm resistant measures, such as “hurricane clips” and weather resistant roofing.
Cost Effectiveness	This measure is low cost, and will encourage new construction to mitigate against severe thunderstorm and high wind.
Discussion: Weather resistant roofing and hurricane clips will reinforce structures against damaging high winds and thunderstorms that can potentially damage property and cause injury.	

I. Severe Winter and Ice Storms

The City has identified two projects that could reduce the risk associated with severe winter and ice storms.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Severe Winter and Ice Storms Mitigation Action #1	Improve the warning system and city communication during severe winter and ice storms.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	High
Estimated Cost	Undetermined, < $500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Public Works
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New buildings will not be affected by public education actions.
Effect on Existing Buildings	With improved warning of severe winter and ice storms, as well as better communication regarding City measures during severe winter and ice storms, existing buildings may be better protected against the hazardous effects of harsh temperatures and freezing rain.
Cost Effectiveness	This measure is cost effective – developing a better communication system will likely only take staff time and resources.
Discussion: Severe winter and ice storms are likely to occur in Benbrook; however they are not often expected by the general public due to North Texas' typically warm climate. Increasing communication in regards to community services such as trash pick-up during a winter storm and road sanding measures taken by the City will help citizens better navigate unfamiliar weather conditions. In addition, promoting winter storm precautions before a storm hits will allow citizens to be better prepared and protected in the event of a severe winter storm.	

Severe Winter and Ice Storms Mitigation Action #2	Improve the City's response time to winter/ice storms through sanding capacity, tree limb pick up and other City services.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage
Priority	Medium
Estimated Cost	$10,000
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Public Services
Estimated Completion Time Frame	One Year
Effect on New Buildings	Public Services projects do not directly affect new buildings; however, services such as improved street sanding capacity will assist the entire city in the event of a severe winter or ice storm.
Effect on Existing Buildings	Public Services projects do not directly affect existing buildings; however services such as improved street sanding capacity will assist the entire city in the event of a severe winter or ice storm.
Cost Effectiveness	This project is cost effective – improved street sanding capacity and other improved public works services will keep the City functioning smoothly in the event of a severe winter storm.
Discussion: North Texas is not typically adequately prepared for winter and ice storms, and North Texas drivers are not generally accustomed to driving in hazardous winter conditions. Expanding Benbrook's winter public works capacity will keep citizens safe in winter and ice storms.	

Severe Winter and Ice Storms Mitigation Action #3	Develop a public awareness campaign regarding severe winter and ice storm preparedness to be implemented in the late fall and early winter months.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	Medium
Estimated Cost	Undetermined, < $500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Public Services
Estimated Completion Time Frame	Three months
Effect on New Buildings	Public Awareness projects do not directly affect new buildings.
Effect on Existing Buildings	Improved Public Awareness regarding winter and ice storm preparedness will reduce the vulnerability of existing buildings to severe weather by improving property owner's knowledge of hazard mitigation.
Cost Effectiveness	This project is cost effective – providing information to the public is low-cost. If citizens are better informed about protecting their property from severe winter and ice storms, the potential costs of damage from storms will be lowered.
Discussion: North Texas is not typically adequately prepared for winter and ice storms, and some North Texans are not well acquainted with basic winter and ice storm preparedness techniques, such as dripping faucets to prevent pipes from freezing. Dispersing these kind of techniques and information through City-wide e-mails or in the community newspaper could prevent damage from severe winter weather that Texans are generally unaccustomed to.	

J. Expansive Soils

The City has identified two actions that could reduce the risk associated with expansive soils.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Expansive Soils Mitigation Action #1	Improve foundation building codes to account for expansive soil damage
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Low
Estimated Cost	Staff Time Only
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Six Months
Effect on New Buildings	New buildings will be subject to stricter building codes that mitigate against the damage caused by expansive soils.
Effect on Existing Buildings	Existing buildings will not be subject to stricter building codes, but buildings that are being updated or renovated will be subject to building codes that mitigate against the damage caused by expansive soils.
Cost Effectiveness	Cost effective – this measure will have negligible costs for the city. Staff time only will be required.
Discussion: By introducing stricter building codes for foundations, the damage caused by expansive soils will be minimal, with little to no negative costs or impacts.	

Expansive Soils Mitigation Action #2	Educate the public and property owners about the effects of expansive soil on structures so that they can better protect their property.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Six Months
Effect on New Buildings	New buildings will be educated about the effect of expansive soils on structures, as well as steps that builders can take to mitigate the impact of expansive soils, reducing the damage associated with them.
Effect on Existing Buildings	Existing buildings will be educated about the effects of expansive soils on structures, as well as steps that property owners can take to mitigate the impact of expansive soils, reducing the damage associated with them.
Cost Effectiveness	This measure is cost effective, and the estimated cost may decrease if the City chooses to digitally distribute expansive soil information.
Discussion: Expansive soils are often not considered a risk by property owners, and many property owners are unaware of the foundational impact of expansive soil on their property. This action will increase public awareness about what can be a hidden and costly hazard to property.	

K. Extreme Heat

The City has identified two actions that could reduce the risk associated with extreme heat.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Extreme Heat Mitigation Action #1	Develop a city program to distribute fans to at-risk or elderly populations who do not have access to air conditioning in the summer months.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury, or cause property damage. 1B. Assist at-risk populations in mitigating hazards when possible.
Priority	High
Estimated Cost	$2,000 (100 fans at $20 each)
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	Potential subsidies from non-profit or medical organizations
Responsible Agency	Benbrook Fire Department Community Development
Estimated Completion Time Frame	Ongoing
Effect on New Buildings	This action directly impacts citizens in their homes, and extreme heat generally does not have an impact on structures.
Effect on Existing Buildings	Existing buildings that house populations without air conditioning have the opportunity to receive fans that will provide relief in the summer months.
Cost Effectiveness	This action is cost effective - the cost of the fans has potential to fluctuate based on potential subsidies from other non profit or medical organizations, as well as the City's potential to purchase fans in bulk directly from a supplier. Even without these cost efficient measures, this project has potential to mitigate human injury caused by natural risks, which alone warrants the cost of this project.
Discussion: Extreme summer temperatures have the potential to cause dehydration, heat stroke and loss of life in the worst circumstances. The simple presence of air conditioning during exceptionally hot days can mitigate the potentially devastating health impacts of extreme temperatures. The City of Benbrook should work with local non profit and medical organizations to identify and assess need in the community for air conditioning during the summer months,	

Extreme Heat Mitigation Action #2	Conduct a public awareness campaign in the late spring and early summer months regarding the dangers of extreme heat, and steps that can be taken to mitigate the effects of extreme temperatures.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	Medium
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Community Development
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New buildings will not be affected by this action
Effect on Existing Buildings	Existing buildings will not be affected by this action.
Cost Effectiveness	Cost effective – the cost of this action is warranted by the increased public awareness of extreme temperatures.
Discussion: Most public awareness measures are spent on high profile hazards, such as thunderstorms, tornadoes, and wildland fires, but extreme heat is a recurring issue in North Texas and the hazards associated with extreme temperatures are often taken for granted. A public awareness campaign will call attention to the dangers of extreme temperatures and help the public protect themselves against such risks.	

L. Drought

Although most of the authority for water conservation lies with the independent Benbrook Water Authority, the City has identified two actions that can reduce the risks associated with drought.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Drought Mitigation Action #1	Adopt a water conservation oriented approach to City landscaping techniques, including public buildings and City landscaping and promote conservation-oriented landscaping to the community.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Medium
Estimated Cost	Undetermined, may reduce existing landscaping costs
Potential Funding Sources	City Funds
Potential Matching Funding Sources	N/A
Responsible Agency	Benbrook Water Authority Community Development
Estimated Completion Time Frame	Three Months
Effect on New Buildings	Public awareness campaigns and drought risks and hazards do not have any effect on new buildings.
Effect on Existing Buildings	Public awareness campaigns and drought risks and hazards generally do not have any effect on existing buildings.
Cost Effectiveness	By reducing water usage year round, the City is likely to save money. Although the project will require additional staff time, the staff time devoted to this project is likely to be negligible, making this project cost effective, and could potentially reduce costs associated with landscaping.
Discussion: Landscape irrigation is one of the most prominent water uses in a City. In the event of a drought, the first action the City takes is calling for voluntary irrigation reduction. As the largest landscaper in the City, and in an effort to lead by example and reduce the harmful effects of drought before it occurs, the City of Benbrook will adopt sustainable and conservative landscaping and irrigation techniques year-round. Examples of sustainable landscaping and irrigation techniques include planting trees, shrubbery and plants that are native to Texas and naturally require less water to survive, manually turning on irrigation systems in order to avoid watering on days when it is unnecessary, irrigating the landscape during non-peak hours in the early morning or late evening, and reducing the amount of water used to irrigate when possible.	

Drought Mitigation Action #2	Provide public information on the BWA's Drought Action Plan and water conservation techniques.
Mitigation Goal/Objective	3) Enhance public education concerning hazard mitigation preparedness
Priority	Low
Estimated Cost	Negligible, less than $100
Potential Funding Sources	Staff Time Only City Funds
Potential Matching Funding Sources	N/A
Responsible Agency	Benbrook Water Authority Community Development
Estimated Completion Time Frame	Three months
Effect on New Buildings	New buildings will not be affected by a public awareness campaign.
Effect on Existing Buildings	Existing structures are not generally affected by droughts, and will not be affected by this action.
Cost Effectiveness	This action is cost effective – $100 is a maximum estimate, and will likely cost little to nothing, outside of staff time, to implement a public awareness campaign that would already need to be implemented in the early onset of a drought.
Discussion: The late spring and early months of summer are the beginning months of dry season in Texas. By implementing a public education campaign which reminds citizens to get in the habit of conserving water and irrigating responsibly, the City is reducing the effects of potential drought in the future, as well as promoting sustainable practices within the City.	

M. Hail

The City has identified two actions that could reduce the risk associated with hail.

NOTE: *All projects are subject to availability of federal and local funding as well as availability of local staff to administer the project.*

Hail Mitigation Action #1	Evaluate city buildings for hail resistance and determine the necessity and feasibility of installing hail resistant roofing and windows.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Low
Estimated Cost	Undetermined
Potential Funding Sources	Hazard Mitigation Grants Insurance
Potential Matching Funding Sources	Insurance
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	One Year
Effect on New Buildings	New buildings will be subject to hail resistant measures.
Effect on Existing Buildings	Existing buildings will be evaluated for hail resistance and adjusted as necessary and/or practical.
Cost Effectiveness	The cost of this measure depends largely on the resistance of existing City buildings to hail. Additional costs may arise based on the assessment.
Discussion: Hail can severely affect City vehicles, and special attention ought to be given to structures which house City vehicles, and ways to protect vehicles in the event of a hailstorm. Hail resistant measures regarding City buildings may include improved roofing and reinforcing windows.	

Hail Mitigation Action #2	Include information regarding “hail resistant” roofing construction techniques in all building permit packets.
Mitigation Goal/Objective	1) Reduce or eliminate hazardous conditions that cause the loss of life, inflict injury or cause property damage. 1A. Encourage storm resistant construction
Priority	Low
Estimated Cost	$500
Potential Funding Sources	Hazard Mitigation Grants
Potential Matching Funding Sources	City Funds
Responsible Agency	Permits and Inspections
Estimated Completion Time Frame	Three Months
Effect on New Buildings	New buildings will be encouraged to install hail resistant roofing measures.
Effect on Existing Buildings	Existing buildings that are being renovated or upgraded will be encouraged to install hail resistant roofing measures.
Cost Effectiveness	This action is cost effective, and the cost may be significantly lowered if the City chooses to distribute digital information regarding hail resistant roofing using the City of Benbrook’s new online permitting process.
Discussion: Distributing information regarding hail resistant roofing during with the building permit packet will raise awareness about the importance of hail resistance as well as increase the likelihood that builders will implement hail mitigation in their buildings.	

V. Resolution of Adoption

The Benbrook City Council has adopted this Plan, as exhibited by the Resolution included in *Exhibit A*.

VI. References Cited

FEMA, 2004. Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams. April 2004.

Kilgore, Karen and Rich Gray, 2004. Texas Communities at Risk. Texas Forest Service. September 3, 2004.

Markiewicz, Dan, 2004. "Setting Risk Response Priorities, keep it simple to get agreement." Industrial Safety and Health News, August 2004.

North Central Texas Council of Governments, 2004. Multi-Hazard Risk Assessment, Hazard Mitigation Action Planning, 2003-2004 Planning Cycle.

EXHIBIT A

RESOLUTION NO. 2011-____

A RESOLUTION ADOPTING THE HAZARD MITIGATION PLAN FOR THE CITY OF BENBROOK, TEXAS

WHEREAS, natural hazards such as flooding and tornadoes in the City of Benbrook historically have caused significant disasters with losses of life and property and damage to natural resources; and

WHEREAS, the Federal Disaster Mitigation Act of 2000 and the Federal Emergency Management Agency (FEMA) require communities to adopt a hazard mitigation action plan (HazMAP) to be eligible for pre-disaster and post-disaster federal funding for mitigation purposes; and

WHEREAS, a Hazard Mitigation Plan has been developed by the city staff and has incorporated comments from the public at public hearings on _____, and _____; and

WHEREAS, the Plan recommends several hazard mitigation actions that will protect the people and property affected by the natural hazards that face Benbrook; and

WHEREAS, Benbrook's HazMAP is an extension of its Emergency Operations Plan; and

WHEREAS, Benbrook's HazMAP is a record of the community's potential risks and hazards and commitment to reducing the long-term consequences of natural hazards. The HazMAP outlines mitigation goals, identifies risk reduction strategies for hazards that threaten the area, and discusses the ongoing risk reduction strategies to be undertaken within Benbrook.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF BENBROOK, TEXAS:

1. The Hazard Mitigation Plan for the City of Benbrook is hereby adopted as an official plan of Benbrook.

2. The City of Benbrook will pursue available funding opportunities for implementation of the proposals designated therein, and will, upon receipt of such funding or other necessary resources, seek to implement the actions contained in the mitigation strategies.

3. The City of Benbrook will report progress toward implementing the Plan as required by FEMA and the Governor's Division of Emergency Management (GDEM).

4. This resolution is in effect immediately.

PASSED AND ADOPTED this ____ day of _____, 2011.

APPROVED

_____
Mayor

ATTEST:

_____
City Secretary

NOTE: Regarding Dam Failure Risk Assessment

The Benbrook Dam is under the jurisdiction of the U.S. Army Corp of Engineers. Access to information regarding the Benbrook Dam, potential dam failure and inundation maps is restricted to the general public and cannot be included in the public version Benbrook's Hazard Mitigation Plan. The Army Corp of Engineers has agreed to allow the City to include information regarding the Benbrook Dam as long as the information is restricted to government officials. The inundation maps from the Army Corp of Engineers are attached as a non-public addendum to the Dam Failure Risk Assessment. This information gives the extent and location of inundation in the unlikely event of dam failure.

The Army Corp of Engineers Inundation Map for the Benbrook Dam is attached. This map is restricted for use by government officials only.