Flood Mitigation Plan
City of Bryan

May 2018

MITCHELL M&M MORGAN

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BACKGROUND

The City of Bryan is located in the center of Brazos County and shares a corporate boundary on the south with the City of College Station. Brazos County is located in South Central Texas, between the Brazos and Navasota Rivers and is bordered by Robertson, Madison, Grimes, Washington, and Burleson counties.

Several major metropolitan areas are easily accessible from the City of Bryan. Houston is located 95 miles southeast, Austin 104 miles west, San Antonio 166 miles southwest, and Dallas 180 miles north.

The area economy, once heavily dependent upon agriculture, has diversified greatly in the past twenty-five years. This diversification is due primarily to the expansion of the area's major employers; the Texas A&M University System, Blinn College, and CHI St. Joseph Health. Expansion of the local industrial base has also contributed to local employment and area population.

During the 1970's growth occurred in all directions. However, the majority of new development was toward the largest economic generator in the region, Texas A&M University. Most new residential and commercial development continued to occur in the southeast portion of Bryan along East 29th Street, Villa Maria Road, and Briarcrest Drive. During this period, a good deal of medium and high-density residential housing was constructed in response to the growing enrollment at Texas A&M University and Blinn College.

The construction of the Texas Highway 6 Bypass (SH6) in the late sixties influenced the migration of many businesses on Texas and South College Avenues, namely large scale retailers and car dealerships, from those central locations to the SH6 Bypass, a trend which continues today.

The consolidation of facilities on Blinn College's Bryan Campus in 1997 sparked considerable growth and traffic as the campus grew to accommodate its present student population of over 11,000. In close proximity to Blinn, St. Joseph Hospital, with its recent expansions, also drew traffic and peripheral development.

In the 1980s and 1990s, Bryan experienced significant growth in its commercial corridors, as well as infill and redevelopment opportunities in and around historic Downtown Bryan. The construction of a new major expressway corridor, State Highway 47, connecting State Highway 21 and Farm-to-Market Road 60, opened thousands of acres for development and created a new gateway to Bryan's west side. Traditions, a planned residential development and the host of the Texas A&M University varsity golf teams, began construction on the west side.

Along with Traditions, more recently the Texas A&M University Health Science Center campus and proposed biotechnology industries have and will continue to develop along the SH47 corridor.

The George Bush Presidential Library and Museum at Texas A&M University increased tourism opportunities for the Brazos Valley area. Significant new planned residential development occurred primarily on the east-west axis of the city including Tiffany Park, Park Hudson, Miramont, Bryan Town Center, and several new subdivisions around the new Rudder High School campus. Major redevelopment of the 2,000-acre historic Bryan Army Airfield (RELLIS) will create a new A&M campus that will combine the collaborative effort of all 11 Texas A&M

System Universities, Blinn College, and private industry. Construction is underway in the master-planned ATLAS Texas Town Center, and expansion of the acclaimed Traditions Club and Community. Having recently adopted a Health and Wellness Area Plan, CHI St. Joseph Regional Health Center has launched a major expansion of their facility in central Bryan. Within the last 10 years Bryan has invested in the rebirth of two long dormant community assets. Public reinvestment has facilitated the transformation of Downtown Bryan to one of the most charming and active downtowns of any city its size, and Coulter Field, the 70-year-old city-owned airport is beginning to display incredible potential as an airport hub.

Presently, Bryan encompasses an area of 45.56 square miles with an estimated 2018 population of 87,325.

Planning for this growth and development is extremely important to assure that it has a positive impact on the City. One factor of this positive development is to ensure that these new as well as existing investments are protected from flooding potential.

PURPOSE

This Flood Mitigation Plan has been prepared for the City of Bryan, Texas in an effort to create a strategy for implementing flood mitigation measures for the community. It has been prepared as a 5-year update to the second Plan that was adopted with the 2013 City of Bryan Comprehensive Plan Update. It is the intent that this plan, educate and encourage support for projects that will prevent new flooding problems, reduce losses and protect the beneficial functions of our floodplains.

PLANNING PROCESS

This plan has been prepared in accordance with the CRS Planning Process as seen in Appendix A. The CRS process consists of the following ten steps:

1. Organize
2. Involve the public
3. Coordinate with other agencies
4. Assess the hazard
5. Assess the problem
6. Set goals
7. Review possible activities
8. Draft an action plan
9. Adopt the plan
10. Implement, evaluate, and revise

In December 2017, the City of Bryan retained a professional engineering firm, Mitchell & Morgan, to help supplement their planning staff's efforts to coordinate a 5-year update of their Flood Mitigation Plan (FMP). The original Plan was written in 2007 and the first 5-year update was written and approved in 2013. Since 2013 the Plan was reviewed annually and a progress report was prepared with each annual recertification. (See Appendix B for Annual Progress Reports). This Plan update was led by City of Bryan City Engineer Paul Kaspar, P.E., CFM. (See resumes for staff and consultants involved in Plan update in Appendix C).

Step 1: Organize

The Plan was developed under the oversight and guidance of a nine (9) member City of Bryan Staff Committee with representatives from the planning (office responsible for the community's land use and comprehensive planning), engineering, building, parks and recreation, communications and marketing, public works departments, and emergency management. A twenty (20) member Public Planning Committee (PPC) was also established to guide the process. It included the Staff Committee, a local developer, a local homebuilder, a few local engineers, a Chamber of Commerce member, a Bryan Texas Utility employee, a local insurance agent, a member from a local home owners association, and a representative from a major employer. The Staff Committee also included a few former FMP Committee members that helped develop the 2013 Flood Mitigation Plan. The members were influential in providing history behind the original goals and objectives and the rationale of how and why they were developed for the 2013 Flood Mitigation Plan.

Table 1: Planning Committees

Staff Planning Committee	
Name	Affiliation
Greg Cox, CBO, CFM	Chief Building Official
Johnny Price, PE, CFM	Assistant City Engineer
Linda Cornelius	Parks and Recreation Director
Jerry Henry	Emergency Management Coordinator
Robert Willis	Streets and Drainage Supervisor
Kala McCain	Communications and Marketing Manager
Paul Kaspar, PE, CFM	City Engineer
Martin Zimmermann, AICP	Planning Manager
Delores Soto, CAP, CFM	Development Services Office Coordinator
Public Planning Committee	
Greg Cox, CBO, CFM	Chief Building Official
Johnny Price, PE, CFM	Assistant City Engineer
Linda Cornelius	Parks and Recreation Director
Jerry Henry	Emergency Management Coordinator
Robert Willis	Streets and Drainage Supervisor
Kala McCain	Communications and Marketing Manager
Paul Kaspar, PE, CFM	City Engineer
Martin Zimmermann, AICP	Planning Manager
Delores Soto, CAP, CFM	Development Services Office Coordinator
Bryan Reece	Reece Homes
Mark Carrabba	Carrabba Brother, Ltd.
Glenn Jones, PE, CFM	J4 Engineering
Rabon Metcalf, PE, CFM	RME Consulting Engineers
Jacob Torres, PhD, PE, CFM	Lockwood, Andrews, and Newnam
Ron Schmidt	Chamber of Commerce Member
Shawndra Curry, PE	Bryan Texas Utilities
Bruce Jones	Jones & Associates Insurance
Spencer Buchanan	TEXCON Contractors
Lisa Cantrell	CHI St. Joseph Health
Nick Turnham	Copperfield HOA

The Staff Committee met a total of 5 times over a four month period. The PPC met a total of 7 times over the same four month period from January 2018 until April 2018. The PPC meeting schedule was as follows:

- Kick-off meeting – January 17, 2018
- Assess the Hazard – February 7, 2018
- Assess the Problem – February 14, 2018
- Set the Goals – March 1, 2018
- Review Possible Activities – March 21, 2018
- Draft an Action Plan – April 11, 2018
- Review Draft Plan – April 25, 2018

Step 2: Involve the Public

All PPC meetings, except the January 17, 2018 kick-off meeting, were open to the public and agendas were posted publicly in accordance with the Texas Open Meetings Act. Public input meetings were also held and advertised. Advertisements can be seen in Appendix E. The public input meetings were held at the City of Bryan Municipal Office Building in Downtown Bryan which is centrally located to all of the affected areas. The public input meetings schedule was as follows:

- February 15, 2018
- March 1, 2018

A public meeting was also held near the end of the planning process on April 30, 2018 to review the Draft Plan. The Plan was taken to a City Council Workshop meeting on May 15, 2018 and approved by City Council during a regular meeting on June 12, 2018.

The City of Bryan also implemented many other public information activities to explain the planning process and encourage input from the citizens of Bryan. The City of Bryan website home page had a clickable banner during the entire planning process. The banner took you to an online page which had each PPC meeting and public input meeting date, time, and location. The page can be seen in Appendix E. The page also contained links to an online flooding concern survey, see Appendix E, a frequently asked questions regarding flooding page, and a link to the 2013 Flood Mitigation Plan. Multiple local news stations picked up the story and had television appearances as well as online articles, see Appendix E. Social media, including Facebook, Nextdoor, and Twitter, was also heavily used to advertise the public meetings. A few examples of each of the posts can be seen in Appendix E.

Step 3: Coordinate

Existing & Previous Studies

Brazos County Hazard Mitigation – Mitigating Risk: Protecting Brazos County from All Hazards 2017-2022

Brazos County Emergency Management recently undertook an update to their all hazards mitigation plan. This plan was reviewed and discussed with Brazos County officials to assure coordination between the entities. Flood mitigation strategies presented in both reports are consistent and complementary between the two agencies. The City of Bryan has decided to

follow the Brazos County All Hazard Plan for all hazards not included in the Flood Mitigation Plan.

Primary System Drainage Master Plans

In the fall of 1997, the City of Bryan adopted a Drainage Utility Fee which was assessed to all utility customers. Since its adoption, the funds collected to date have been used for watershed studies to more accurately determine floodplain locations, establish elevations in areas not previously studied by FEMA and provide floodway limits. In several of these master plans, recommendations for improvements within the basin were made in an effort to reduce flood hazards.

The use of these funds has helped the City assess the current status of drainage problems throughout the drainage basins and prioritize potential solutions. The use of these funds has now shifted from studies to the construction of drainage improvements to remedy current problems. The current program appears to be working effectively by identifying, prioritizing and then constructing necessary improvements. Studies have been completed on the following creeks within the city limits:

- Hudson Creek - complete
- Burton Creek – complete
- Briar Creek - complete
- Thompson's Branch – complete
- Turkey Creek - complete
- Carters Creek – complete
- Still Creek & Cottonwood Branch – complete

The recommendations made as part of each of these studies can be found in Appendix I and have been incorporated within this Plan and prioritized for action.

Secondary System Drainage Master Plan

In addition to utilizing the Drainage Utility Fee funds for the restudy of several major floodplains, the City of Bryan commissioned an overall Storm Water Master Plan study of their secondary drainage system. This study completed by Freese & Nichols in 2010 was titled the "City of Bryan - Stormwater Master Plan". The recommendations from that study revealed several areas where drainage systems are in need of repair or upgrade in order to prevent flooding conditions and damage. There were more than 122 projects identified at a cost of approximately $67 million. Of that $67 million, $40 million of those improvements were identified as reducing flooding and flood damage. The recommendations from this study are included in Appendix I and have been incorporated within this Plan.

2D Modeling

In addition to commissioning the City of Bryan Stormwater Master Plan, the City of Bryan retained Lockwood, Andrews, and Newnam, Inc. (LAN) to perform a 2-dimensional (2D) hydraulic model of the City of Bryan secondary drainage system. The model has been very beneficial to the city staff in determining if new development is being placed in areas of secondary drainage flooding or in overland flow paths as well as if the City may need to require open space preservation from new development. This 2D model has also helped staff identify secondary drainage problem areas and cross check them with citizen complaints. The results from this 2D model was used during the Flood Mitigation Plan Open Houses to allow citizens to

review and verify if modeling results matched their experience during heavy rain events. We found in many cases some of the repetitive loss parcels are not a result of riverine flooding but instead show up on the 2D modeling maps as a result of insufficient capacity in the secondary system.

Agency Coordination

A meeting with a several local agencies was held on March 13, 2018. The agencies invited include:

- City of Bryan Engineering Services
- City of Bryan Planning & Development Services
- City of Bryan Emergency Management Department
- City of College Station Development Services
- City of College Station Emergency Management Department
- City of College Station Public Works Department
- TxDOT
- Brazos County Emergency Management
- Brazos County Road and Bridge
- Brazos Valley Council of Governments
- Texas Water Development Board
- Bryan/College Station Metropolitan Planning Organization
- Blinn College

Representatives from all agencies with the exception of TxDOT, Brazos Valley Council of Governments, and Texas Water Development Board were all in attendance. Lengthy conversations were had regarding flooding and emergency access during the May 26, 2016 rain event and Hurricane Harvey in late August 2017. The agencies were asked to review their current procedures during and after flooding events. Each agency was asked for any data or information they had available regarding flooding and if they had ongoing activities that might affect flooding or properties within the flood prone areas. Brazos County discussed significant drainage concerns from citizens in the county due to these large rain events. A significant portion of the concerns were from the southern part of Brazos County near the confluence of the Navasota and Brazos Rivers. All agencies were given upcoming dates of all PPC and open house meetings and were encouraged to attend. They also agreed to review a copy of the Draft Plan before it was submitted to the City Council. Minutes from the meeting can be found in Appendix F.

Step 4: Assess the Hazard

Sources of Flooding

The City of Bryan is bounded on the east and west by two major river corridors in the State of Texas. These are the Navasota River on the east and the Brazos River on the west. The City of Bryan city limits does not contain the major floodplains from either of these rivers, but it does contain the floodplains associated with several major tributary sources to these two rivers.

The major flooding sources in the City of Bryan are from the following creeks and tributaries:

- *Carters Creek*
- *Burton Creek*
- *Briar Creek*
- *Hudson Creek*
- *Turkey Creek*
- *Still Creek*
- *Thompson's Branch*
- *Cottonwood Branch*

Exhibits 1-5, illustrate structures which are located within the floodplains of these creeks. Exhibit 1 is an Overall Structures within the Floodplain map with Exhibits 2-5 being subpanels of the same map reflecting larger detail. Structures are contained in each of the floodplains listed above, with the majority of structures located in the Burton, and Carters floodplains. This is not surprising, as structures contained in these two floodplains consist of several older developments constructed under older drainage regulations.

As seen on the exhibits, structures colored in green are those that are located within these floodplains but have elevation certificates on file with the City of Bryan that show they are elevated above the base flood elevation (BFE) and therefore not affected by frequent flood events. Noted in dark blue are structures located within the 100 year floodplain but there is no elevation certificate on file to determine if the finished floors are above, at or below the BFE and the homeowners have not submitted any drainage complaints to the City of Bryan. It is estimated that many of these dark blue structures are actually above the BFE, but there is no verification of this condition due to the lack of elevation certificates on file with the City of Bryan. Case in point is from the Briar Flood Study, wherein more than 100 structures are located within the floodplain, but when finished floors were surveyed as part of the Briar Flood Study only 28 structures actually had finished floor elevations lower than the BFE. The absence of flood complaints from residents in the Carter and Burton floodplains seem to reflect that this may be the case in those floodplains as well. Structures colored in red are located within the 100-year floodplain and have submitted drainage concerns to the City of Bryan. Lastly, structures colored in yellow are located within the 100-year floodplain, have elevation certificates on file with the City of Bryan but have submitted drainage complaints to the City of Bryan. This occurs at only two locations, when the elevation certificates were reviewed they indicated the structure lie below the BFE. This data correlated well with drainage complaints received by the property owners.

In addition to flooding from creeks, there is also localized flooding from undersized storm sewer systems. Several residential areas and a portion of the historical Downtown Bryan have experienced flooding due to inadequacies of the secondary drainage system and lack of overland flow paths. Although this flooding is usually not as deep as that from rising flood waters from the creeks, it is still significant enough to cause damage to structures. The 2D modeling effort by Lockwood, Andrews, Newnam created a similar Structures in the Flood Prone Areas map which can be seen in Exhibits 8-11. The Drainage Concerns maps in Appendix G also show areas where secondary drainage issues are present. Structures colored

magenta have reported flooding to the City of Bryan in the structure specifically. Structures colored green have submitted a flooding concern to the City of Bryan but did not have flooding within the structure or did not specifically report the structure flooding. The 2D model results do contain velocity of the secondary system stormwater as well as depth of flooding in these flood prone areas.

Less-Frequent Flood Hazards

Levees

The Brazos County All Hazards Plan does not identify any levees in Brazos County that could affect the City of Bryan.

Dams

The Brazos County All Hazards Plan also identifies several dams located in Brazos County, some of which would result in flooding of developed areas if they failed. These dams include Bryan Utilities Lake Dam, Country Club Lake Dam, and Finfeather Lake Dam. If the Bryan Utilities Lake Dam on Lake Bryan failed it would release 102,087 gallons of water and would flow 24 miles downstream. If County Club Lake Dam failed it would inundate one foot of water 2 city blocks downstream and would impact 279 citizens and 93 structures. Lastly, if Finfeather Lake Dam failed it would release 50.8-97.8 million gallons of water and flow 2.8 miles downstream. Inundation areas can be found in Appendix J.

Other Natural Hazards

The Brazos County All Hazards Plan identifies Bryan's vulnerability to hazards in terms of property damage where the classifications are as follows:

S=Substantial – "severity of impact may result in multiple deaths, complete shutdown of facilities for 30 or more days, or more than 50 percent of property destroyed or with major damage".
Maj=Major – "severity of impact may result in injuries or illnesses that result in permanent disability, complete shutdown of critical facilities for at least two weeks, or more than 25 percent of property destroyed or with major damage".
Min=Minor – "severity of impact may result in injuries or illnesses that do not result in permanent disability, a complete shutdown of critical facilities for more than one week, or more than 10 percent of property destroyed or with major damage".
L=Limited – "severity of impact may result in injuries or illnesses that are treatable with first aid, minor quality of life lost, shutdown of critical facilities and services for 24 hours or less, or less than 10 percent of property destroyed or with major damage".

Overall Summary Descriptions of the Participating Entities' Vulnerability to Hazards in the Planning Area in Terms of Property Damage (Source: Brazos County Hazard Mitigation Plan)

Jurisdiction	Dam Failure	Drought	Excessive Heat	Flood	Hail Storm	Severe Winter Storm	Thunderstorm	Tornado	Wildfire
Bryan	S	L	L	S	L	L	L	MAJ	L

Likely to Get Worse

Changes in Floodplain Development and Demographics

City of Bryan staff has been working to allow a portion of the required parkland dedication by new development to occur within the floodplain in order to preserve the floodplains. As seen in this report, there are several action statements that continue this endeavor. The City of Bryan is growing and there are several drainage regulations in effect through the City of Bryan Stormwater Design Guidelines (Appendix L) that give the City staff several regulatory tools to help assure that new development does not occur in flood prone areas.

Development in the Watershed

The City of Bryan Stormwater Design Guidelines, see Appendix L, allows City staff to regulate development both in and out of the floodplain in an effort to protect the watershed. Within these watersheds there are requirements for detention to mitigate new development increased impervious cover within the watersheds. As long as these rules are in place, development in the watershed should be controlling their increased runoff to pre-existing levels and not adversely affect the flood prone areas. The Development and Parks in the Floodplain Map shows the level of new development and parkland that is being developed in the floodplain. The development data shown is based upon a GIS query indicating platting actions and site plans that are occurring in the floodplain. This map can be seen in Exhibit 7.

Climate Change

During the Planning Committee meetings, historical rainfall was discussed. Many sources are indicating that given the more recent intense rainfall events that have occurred in Texas, the statistical data for rainfall events in Texas appears to indicate an increased frequency for larger storm events. Local meteorologists have encouraged the engineers in general to reevaluate their 1% recurrence storm interval based upon these new statistics. The City of Bryan has established an action statement to monitor and update statistical rainfall numbers as soon as they become available. See Table 2.

Historical Flooding

Below is a listing of flood events in the Brazos Valley Region reported to the National Weather Service and obtained from the report, “Brazos County Hazard Mitigation - Mitigating Risk: Protecting the Brazos Valley from All Hazards 2017-2022” by the Brazos Valley Council of Governments and Texas Engineering Extension Service (TEEX).

Reported Flood Events by County,
Brazos Valley Region
January 1, 1994, to September 1, 2017

Source: Brazos County All Hazards Plan

Type	Location	Date	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Flash flooding	Brazos	10/16/1994	0	0	$5.0M	$50K
Flash flooding/ flood	Brazos	12/15/1994	0	0	50K	5K
Flash flood	Bryan/ College Station	09/21/1995	0	0	5K	0
Flash flood	Countywide	02/20/1997	0	0	5K	0
Flash flood	North Portion	10/13/1997	0	0	5K	0
Flash flood	College Station	01/06/1998	0	0	5K	0
Flash flood	College Station	10/17/1998	0	0	5K	0
Flooding, riverine	County	10/17/1998	1	0	0	0
Flash flood	College Station	10/18/1998	0	0	2K	0
Flash flood	Countywide	10/18/1998	0	0	15K	0
Flooding, riverine	County	11/12/1998	0	0	0	0
Flash flood	Countywide	11/02/2000	0	0	1.0M	0
Flash flood	Countywide	11/03/2000	0	0	25K	0
Flash flood	Countywide	11/03/2000	0	0	25K	0
Flash flood	Countywide	11/03/2000	0	0	1.0M	0
Flash flood	Countywide	09/09/2001	0	0	50K	0
Flash flood	Bryan	07/14/2002	0	0	20K	0
Flash flood	Countywide	11/04/2002	0	0	95K	0
Flash flood	Countywide	02/20/2003	0	0	8K	0
Flash flood	Bryan	05/13/2004	0	0	250K	0

Source: Brazos County All Hazards Plan

Type	Location	Date	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Flash flood	College Station	06/15/2004	0	0	55K	0
Flash flood	Bryan	06/30/2004	0	0	15K	0
Flash flood	Countywide	11/22/2004	0	0	0	0
Flash flood	Bryan	05/01/2007	0	0	130K	0
Flash flood	Countywide	12/15/2007	0	0	5K	0
Flash flood	Bryan	04/25/2009	0	0	1K	0
Flash flood	Bryan	06/09/2010	0	0	1K	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	02/03/2012	0	0	100K	0
Flash flood	Bryan (Edge)	02/03/2012	0	0	2K	2K
Flash flood	Bryan	05/09/2013	0	0	10K	0
Flash flood	College Station	09/28/2013	0	0	0	0
Flash flood	Bryan	06/25/2014	0	0	0	0
Flash flood	College Station	07/17/2014	0	0	50K	0
Flash flood	Bryan	09/12/2014	0	0	3K	0
Flash flood	Bryan	05/25/2015	0	0	5K	0
Flash flood	Bryan	10/24/2015	0	0	0	0
Flash flood	College Station	12/27/2015	0	0	0	0
Flash flood	County Wide	05/26/2016	0	0	100K	0
Flood	County Wide	08/24/2017-08/28/2017	0	0	1.22M	0

The top 5 daily rainfalls in Bryan (as measured by Easterwood Airport rainfall gages) in the last 50 years are:

1. 1994, October 16 – 13.39 inches
2. 2017, August 27 – 7.45 inches (Hurricane Harvey)
3. 1983, May 20 – 6.23 inches
4. 1994, December 15 – 5.79 inches
5. 2016, May 26 – 5.76 inches

Step 5: Assess the Problem

Flooding potential poses risk of loss of life and property damage. It is important to understand and evaluate this potential in an effort to mitigate these impacts.

Life/Safety

Inundation of the major transportation corridors with flood waters could hamper evacuations and emergency services to several areas within the city. Although other routes may be passable for some of these corridors, emergency response times would not be desirable. It will be important to review these routes, the flood depths over these facilities and prioritize improvements to assure access to all areas of the city during emergency situations. Action statements have been added to consider citizens with functional or access needs. The City of Bryan will continue to work with organizations such as Brazos Valley Council on Independent Living and the Area Agency on Aging to maintain an inventory of active personal care homes and assisted living homes and review their accessibility during flood events. In addition, concerns were expressed regarding access to development on the east side of SH6. It appears that there are a few single access subdivisions cut off from access to the west side of SH6 during flooding events. This is of concern for emergency response to those areas. See Table 2.

Public Health

The PPC was conscious of public health issues throughout the planning process. They believed the most important way to protect the health and safety of the Bryan citizens was to educate them before and after a flood event. Action statements were written to develop and improve communication before, during, and after a rain event. This includes premade public service announcements to explain post flood hazards, flood risk and flood insurance education at events and through advertisements, and expanding flood warning systems.

Repetitive Loss Areas

The City of Bryan currently has 40 lots within its city limits which fall into the repetitive loss category. A listing and map of these structures can be found in Appendix K (for Government Use Only). Several of the flood studies previously discussed included recommendations that would reduce flood depths in an effort to remove as many structures as possible from the floodplain. However, several structures have finished floor elevations so far below the base flood elevation (100 year flood) that there were either no alternatives that could lower the base

flood elevation enough to protect the homes or the cost/benefit ratio to construct drainage improvements to lower the base flood elevations was not economically viable.

Critical Facilities

The City of Bryan has several critical facilities and major transportation routes that were identified based on their vulnerability to flood damage from rising water from the primary system. These facilities include municipal facilities, educational institutions, hospitals, major employers, utilities, major transportation corridors, transportation routes into single access subdivisions, transportation centers, and communications. A list of these follows.

Municipal/Government Facilities

- City offices
- Brazos County Offices
- Emergency Operations Center
- Sheriff's & Constable Offices
- Municipal Services Facility
- Police
- County Courthouse & Jail
- Prisons
- Fire Stations
- Emergency Shelters
- Animal Shelters
- TxDOT Offices
- DPS Office
- Brazos Valley Council of Governments
- Post Office
- National Guard Armories
- City of Bryan Municipal Building – City Hall
- Bryan Texas Utilities MOB
- Bryan Texas Utilities System Operations Buildings

Utilities

- Wastewater Treatment Facilities
    - Burton
    - Still
    - Thompsons
- Electrical Plants & Distribution Facilities
    - Dansby Power Plant
- Electrical Substations
    - Annex
    - Atkins
    - Briarcrest
    - Business Park
    - East
    - Industrial Park
    - Nall Lane
- Electrical Substations (continued)

    - North
    - Rayburn
    - Rodgers
    - Shady Lane
    - Silver Hill
    - South
    - Tabor
    - Thompsons Creek
    - Triangle Park
- Water Facilities
    - Well Locations
    - Pump Facilities
    - Interconnects
    - Storage Facilities
- Telephone Facilities

Educational Institutions

- Texas A&M University
- Texas A&M University – Health Science Center
- Blinn College
- Bryan High Schools
    - Bryan Collegiate High
    - Bryan High
    - Center for Alternative Programs
    - Hammond-Oliver Health Sciences Academy
    - MC Harris
    - Rudder High
- Bryan Middle Schools
    - Davila Middle School
    - Jane Long Intermediate School
    - Sam Rayburn Intermediate School
    - Stephen F. Austin Middle School
- Elementary Schools
    - Bonham Elementary
    - Bowen Elementary
    - Branch Elementary
    - Crockett Elementary
    - Fannin Elementary
    - Henderson Elementary
    - Houston Elementary
    - Johnson Elementary
    - Jones Elementary
    - Kemp-Carver Elementary
    - Mitchell Elementary
    - Navarro Elementary
    - Neal Elementary
    - Ross Elementary

- Private Schools
    - Allen Academy
    - Brazos Christian School
    - Cornerstone Christian Academy
    - St. Joseph Catholic School
    - St. Michaels Academy
    - Still Creek Christian School
- Charter Schools
    - Harmony Science Academy – Bryan
    - Brazos School for Inquiry and Creativity
- Day Cares
    - ABC Dual Language Learning Center
    - Adele Wright
    - After The Rain Christian Day Care
    - Aggieland Preschool Academy
    - All God's Children Day Care
    - AlphaBEST @ Bonham Elementary
    - AlphaBEST @ Bowen Elementary
    - AlphaBEST @ Branch Elementary
    - AlphaBest @ Carver Elementary
    - AlphaBEST @ Crockett Elementary
    - AlphaBEST @ Fannin Elementary
    - AlphaBEST @ Henderson Elementary
    - AlphaBEST @ Houston Elementary
    - AlphaBEST @ Johnson Elementary
    - AlphaBEST @ Milam Elementary
    - AlphaBEST @ Mitchell Elementary
    - AlphaBEST @ Navarro Elementary
    - AlphaBEST @ Ross Elementary
    - Barbara Palasota
    - Bethel Lutheran Preschool
    - Big Top Learning Center
    - Brazos Valley Kidz Academy
    - Bright Beginnings PreSchool
    - Bright Eyes & Giggles
    - Brinda K Masciale
    - Brittany Burnett
    - Bryan Child Development Center
    - Busy Bees Dayhome
    - BVCAA Early Head Start Center
    - Central Baptist Weekday School
    - Chubbys Child Care Center
    - Connie Kasner
    - Connie Stone
    - Cuddly Care Daycare
    - D A S P
    - Ernestine Carroll

- Day Cares (Continued)
    - Faith & Family Early Learning Center
    - First Presbyterian Childrens Center
    - Fit for Kids Too
    - Geraldine Polasek
    - Jewel Dean Kinney
    - Juanita Armstrong
    - Karlas Kare
    - Kiddie Castle Childrens Center I
    - Kinder Care 841
    - Kinder Care Learning Center 842
    - Kinder Ready Learning Center
    - Little Angels
    - Neal Child Development Center
    - New Beginnings Christian Child Development Home Day Care
    - Pamela Blackmon
    - Peggy Ayers
    - Quality Time Home Daycare
    - Rising Star Learning Center
    - Rosemary's My Care Day Care
    - Sonshine Station Christian Learning Center
    - St Michael's Episcopal School
    - St. Anthony Learning and Play Station
    - St. Joseph Catholic Early Learning Center
    - Texas Elite Learning Center
    - The Ark Preschool
    - The Family Montessori LLC
    - Thunder Elite Cheerleading and Gymnastics
    - Vanessa Smith

Medical Facilities

- Baylor Scott & White Clinic - Boonville
- Caprock Emergency
- CHI St Joseph Health Express Care
- CHI St Joseph Health Regional Hospital
- CHI St Joseph Health Rehabilitation Hospital
- CHI St. Joseph Health Emergency & Trauma Center
- CHI St. Joseph Health Primary Care Austin's Colony
- CHI St. Joseph Health Primary Care Bryan
- CHI St. Joseph Health Primary Care University Dr.
- CHI St. Joseph Health Primary Care W Villa Maria
- Physicians Premier
- The Physicians Centre Hospital

Elder Care Facilities

- Brazos Oaks Personal Care Center
- Broadmoor Place
- Carriage Inn - Bryan
- CHI St. Joseph Health Assisted Living
- Crestview Retirement Community
- Dansby House, Inc.
- Generations Center for Senior Living
- Hudson Creek Alzheimer's Special Care Center
- Isle at Watercrest Bryan
- Lampstand Health and Rehab of Bryan
- Waldonbroke Estates

Personal Care Homes

- B/CS Angels
- Brenham Outreach – Hillcrest Drive
- Brenham Outreach
- Brenham Outreach
- D&S Community Services – Avondale Avenue
- Private Care Homes – Fairway Drive
- The Grace Place
- Vintage Garden

Churches

- Abundant Life Assembly Of God
- Allen Chapel Methodist Church
- Antioch Community Church
- Assemblage Of Praise Church
- Baha'i Faith
- Beacon Baptist Church
- Bethel Evangelical Lutheran
- Bethel Temple Assembly Of God
- Brazos Valley Community Church
- Brazos Valley Family Worship Center
- Bryan United Pentecostal Church Of Bryan
- Calvary Baptist Church
- Castle Heights Baptist Church
- Cavitt Street Church Of Christ
- Central Baptist Church
- Central Church Of Christ
- Charity Missionary Baptist Church
- Christian Faith Baptist Church
- Christs Way Baptist Church
- Church Of The Nazarene

Churches (continued)

- Church Of The Nazarene
- College Heights Assembly Of God
- Congregation Beth Shalom
- Eagles Nest Praise & Worship Ministries
- East Texas District Pentecostal Church Of God
- Emmanuel Baptist Church
- Emmanuel Baptist Church
- Endtime Evangelistic Pentecostal Church
- Endtime Evangelistic Pentecostal Church
- Faith Bible Church
- Fellowship Church 11:11 Campus Service
- Fellowship Freewill Baptist Church
- First Baptist Church
- First Christian Church Of Bryan-College Station
- First Mexican Baptist Church
- First Presbyterian Church
- First United Methodist Church-Bryan
- Friendship Baptist Church
- Frontiers Of Faith Church
- Galilee Baptist Church
- Grace Missionary Baptist Church
- Greater Faith Fellowship Baptist Church
- Greater Tabernacle Baptist Church
- Halls Memorial Church Of God In Christ
- Hillcrest Baptist Church
- Hosanna Christian Fellowship Church
- Iglecia Bautista Jerusalem
- Jefferson Chapel United Meth Church
- Kannon Bible Church
- Kingdom Hall Of Jehovah's Witnesses
- La Senda De Luz Iglesia Pentecostal
- La Sulamita Congregational Church Of Bryan
- Lee Chapel United Methodist Church
- Lily Of The Valley Church Of God In Christ
- Martin Luther King Street Church Of Christ
- Ministerio Derestauracion Eben-Ezer
- Ministerios Internacionales La Roca De Bryan
- Morning Star Baptist Church
- Mt Nebo Baptist Church
- Mt Nebo Missionary Baptist Church
- Mt Olive Baptist Church
- Mt Vernon Baptist Church
- New Bethlehem Baptist Church
- New Chapel Baptist Church

Churches (continued)

- New Covenant Christian Ministries
- New Direction Worship Center Of Bryan
- New Jerusalem Baptist Church
- New Liberty Baptist Church
- New Life Church
- New Life In Christ Church Inc.
- New Life Tabernacle Church
- New Life Word Outreach Christian Center
- New St John Community Baptist Church
- New Testament Outreach Church
- New Testament Pentecostal Church
- New Zion Missionary Baptist Church
- North Bryan Baptist Church
- Northview Baptist Church
- Peaceful Rest Missionary
- Pilgrims Rest Baptist Church
- Pleasant Grove Baptist Church
- Pleasant Grove Baptist Church
- Restoration Church Bryan
- Saint Michaels
- Santa Teresa Catholic Church
- Santuario De Alabanza
- Shalom Ministries
- Shiloh Baptist Church
- St Andrews Episcopal Church
- St Anthony's Catholic Church
- St James Missionary
- St Joseph's Catholic Church
- Stearns Chapel Methodist Church
- Temple Freda
- Temple Trinity Holy
- Templo Buenas Nuevas Spanish Assembly Of God
- Templo Del Espiritu Santo United Methodist Church
- The Bridge Ministries Of Bryan
- The Church Of Jesus Christ Of Latter Day Saints
- The Saviours Temple
- Trinity Baptist Church
- True Vine Missionary Baptist Church
- United Missionary Baptist Church
- Victory Bible Church
- Way The Truth & The Life
- Wesley United Methodist Church
- West Oaks Baptist Church
- West Union Missionary Baptist Church

Churches (continued)

- Westminster Presbyterian Church
- Willing Workers Church Of The Living God
- Zion Church Of Kurten

Major Employers/Employment Centers

- Axis Pipe & Tubing
- Bryan Baking Inc
- CHI St Joseph Hospital System
- Colony Park
- GEM Microelectronic Materials LLC
- Kristen Distributing Co
- Pamela Enterprises LTD
- Park Hudson
- PlyGem
- Sanderson Farms
- TAMU
- Tejas Center
- Bryan Towne Center
- Verizon Communications Inc
- Walmart (two locations)

Major Transportation Corridors

- Broadmoor Drive
- FM158
- FM2818
- MLK Jr. Street/Old Reliance Road
- SH47
- SH6
- Villa Maria Road
- WJ Bryan Parkway

Transportation Centers

- Brazos Transit – Bus Transit
- Coulter Field Airport
- Easterwood Airport

Communication

- Television Stations
    - KAGS-TV
    - KAMU-TV
    - KBTX-TV
    - KRHD-TV
    - KYLE-TV

- Radio Stations
    - 99.5 Radio
    - iHeart Aggie 96 Radio
    - KEOS
    - KORA Radio
    - KRSR-FM
    - RED-C Catholic Radio
    - WTAW Radio
- Print Media
    - Insite Magazine
    - La Voz Hispana
    - The Battalion
    - The Eagle

Exhibit 6 illustrates the location of these critical facilities in relation to the 100 year floodplains. With the exception of transportation corridors and wastewater treatment plants, these critical facilities appear to be located in areas safe from significant flood potential thus minimizing the effect on the city economy and tax base as well as minimizing the expenses associated with individual property damage.

One would expect the wastewater treatment plants to be located within the 100 year floodplain based upon the gravity sanitary sewer system and the optimum location to serve a large area. Protection of this utility system should be provided to assure the plant is operable under the more frequent flood conditions without incurring a spill caused by rising floodwaters inundating the plant facilities. A spill and/or shutdown caused by these conditions would cost both time and money for the required cleanup operations.

Although the majority of the critical facilities appear to be protected from significant flood losses, there are still several areas of the city where flood losses are occurring to single family residential structures as well as small businesses. The majority of these losses are repetitive losses sustained from structures constructed years before floodplain regulations and good floodplain mapping. A listing of estimated dollar losses to these structures can be found in Appendix H (For Government Use ONLY).

The citizens and governmental officials recognize that as growth and development continues to occur throughout the community it will be important to plan and build wisely to avoid future flooding potential. In the next two decades, the needs of the anticipated population growth will require additional acreage for development.

Assuming a 2040 population of 117,219 a consistent vacant property rate and constant development rates and patterns, the need for land by use type will be as follows:

Projected Land Use		
Category	Existing Land Use (Current Pop.[1] 82,118)	Projected Land Use (2040 Pop.)
	Total Acres	Total Acres
Single Family	11,871	16,945
Two-Family	221	315
Townhome	57	81
Multi-Family	568	811
Manufactured Homes	1,765	2,519
Parks and Open Space	3,016	4,305
Public/Semi Public	3,830	5,467
Office	251	358
Retail	509	727
Commercial	2,233	3,187
Industrial	2,187	3,122
Right of Way	6,937	9,902
Vacant	76,448	62,194
Total	**109,933**	**109,933**

(1) U.S. Census

Table 32: Projected Land Use

Source: Blueprint 2040

If the scenario illustrated above is borne out, the greatest demand for land over the next twenty years will be for single-family lots, followed distantly by acreage for rights-of-way. Because of this growth forecast and its impact on the environment and drainage systems, there was discussion by the PPC regarding the preservation of some or all of the floodplains for parks, open space, greenways, habitats and flood control. There was also discussion regarding regional detention.

Step 6: Set Goals

The PPC began their process of goal setting by reviewing past goals from the previous 2013 FMP. In addition, they reviewed goals from Flood Mitigation Plans from similar cities in Texas. After review of these sample goals and the assessment of the problem, the PPC used the Nominal Group Technique (NGT) to capture representation of the entire group rather than allowing the over-influence from any single group or individual. This exercise gave the PPC members the opportunity to write their individual top six (6) goals and allow them to be ranked and sorted with the group. The goals were ranked by popularity and then refined into the four (4) goals below.

1. Develop and improve outreach and public awareness
2. Protect and enhance natural floodplain and storm water resources
3. Provide fiscally responsible funding
4. Protect the health and safety of the public

Step 7: Review Possible Activities

Given the goal setting accomplished in Step 6, the PPC began to brainstorm possible activities to accomplish those goals.

Preventive Activities

The City of Bryan Comprehensive Plan was discussed during a presentation by the City of Bryan Planning Manager. In 2016, the City of Bryan updated their Comprehensive Plan by adopting *Blueprint 2040*. *Blueprint 2040* includes many goals to create parks, recreation areas, open spaces, and trails. These goals have been mirrored in the Flood Mitigation Plan in order to help alleviate flooding with the use of open space preservation. The main focus of *Blueprint 2040* is to change the perception of Bryan by focusing on the "appearance of the community in the central city area and along major corridors".

The PPC heard a presentation by the Parks and Recreation Director who discussed preserving and protecting floodplain areas by revising the parkland dedication requirements in the City of Bryan Subdivision Ordinance. Currently, the Park Board is trying to balance the use of floodplain land as open space preservation areas within parkland dedicated to the City.

A copy of the current Unified Stormwater Design Guidelines is included in Appendix L. The PPC discussed these regulations and their ability to control increased runoff from new development and the ability for these regulations to limit new development in the floodplain. There was a gap in the regulations controlling floodplain reclamation so several new action plan items have been added by the PPC to accomplish this.

Property Protection

The PPC discussed activities related to property protection and their ability to achieve the four (4) goals from Step 6. These activities include: relocation, acquisition, building elevation, retrofitting, sewer backup protection, and flood insurance. The Review Possible Activities Worksheet is available for review in Appendix N.

Natural Resource Protection

The PPC discussed activities related to natural resource protection and their ability to achieve the four (4) goals from Step 6. These activities include: wetlands protection, erosion and sediment control, natural area preserved, natural area restoration, water quality improvement, coastal barrier protection, environmental corridors, and natural functions protection. The Review Possible Activities Worksheet is available for review in Appendix N.

Emergency Services

The PPC had a presentation by City of Bryan Streets and Drainage Supervisor regarding his procedures followed during flood events. The PPC heard the protocol used for barricading streets when flooded in regard to installation, monitoring, and removal of barricades. In addition, the City of Bryan Emergency Management Coordinator spoke regarding warning systems used during the rain event and follow-up assessment used after the flood event. The PPC discussed activities related to emergency services and their ability to achieve the four (4) goals from Step 6. These activities include: hazard threat recognition, hazard warning, hazard response operations, critical facilities protection, health and safety maintenance, and post-disaster

mitigation actions. The Review Possible Activities Worksheet is available for review in Appendix N.

Structural Projects

The PPC discussed activities related to structural projects and their ability to achieve the four (4) goals from Step 6. These activities include: reservoirs, levees and floodwalls, diversion, channel modifications, and storm drain improvements. The Review Possible Activities Worksheet is available for review in Appendix N.

Public Information

The PPC discussed at length activities related to public information and their ability to achieve the four (4) goals from Step 6. These activities include: real estate disclosures, secondary drainage problems, home builders, landscape companies, educating in schools, map information, outreach, and technical assistance. The Review Possible Activities Worksheet is available for review in Appendix N.

Step 8: Draft an Action Plan

In drafting an action plan, the PPC created the spreadsheet found in Table 2 which contains mitigation actions, priorities, cost, potential funding, timeframe, responsible departments, and goals. The action plan contains numerous recommendations under the following categories: preventive activities, property protection, natural resource protection, emergency services, structural projects, and public information.

Step 9: Adopt the Plan

The adoption of the City of Bryan Flood Mitigation Plan was considered during the City Council regular meeting of June 12, 2018. There were no public comments regarding the adoption of the Plan. A copy of Resolution No. 3761, officially adopting the City of Bryan Flood Mitigation Plan can be found in Appendix M.

Step 10: Implement, Evaluate, and Revise

The implementation of this Plan will be performed by the staff as outlined in Table 2.

An annual progress report will be prepared and submitted with the annual recertification. It is understood that failure to submit this report each year will result in loss of credit for this activity and because the City of Bryan is classified as a Category C repetitive loss community, failure to submit this report will result in a reclassification as a CRS Class 10 community. Currently, the City of Bryan has a CRS Rating of 6.

The report will cover the four items noted for Floodplain Management Planning and copies will be provided to the City Council, the media and made available to the public.

The fifth (5th) year report will be an update to the Plan. Again it is understood that failure to adopt the update will result in loss of credit for this activity and because Bryan is a Category C repetitive loss community, failure to complete and adopt this update will result in a reclassification to a CRS Class 10 community.

The criteria used for evaluation in the annual report will be the percent accomplishment of each action statements by the deadlines stated in Table 2.

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Table 2: Action Plan

Table 2: Action Plan

Summary of Mitigation Actions							FMP Goals			
	Mitigation Action	Priority	Cost Range	Potential Funding Source	Timeframe for Completion from Plan Adoption	Responsible Department	Develop and improve outreach and Public Awareness	Protect/enhance natural floodplain & stormwater resources	Provide fiscally responsible funding	Protect health & safety of public
1	**Preventive Activities**									
1.1	Continue Ongoing Preventive Activities									
1.1.a	Maintain GIS inventory of stormwater assets	High	0	General Fund	Ongoing	Engineering		x		x
1.1.b	Using the potential areas of high water information (2D model and public information) to make better planning decisions	High	0	General Fund	Ongoing	Engineering		x		x
1.1.c	Development review	High	0	General Fund	Ongoing	Engineering/ Building		x		x
1.2	Continue and improve stormwater maintenance program									
1.2.a	Add open channel inspections to regular maintenance programs	High	<$100k	General Fund	Year 2	Transportation/ Drainage			x	x
1.2.b	Perform a channel inventory including type, condition, and include in maintenance program	Medium	<$100k	General Fund/ Drainage Utility Fund	Ongoing/Year 5	Transportation/ Drainage		x	x	x
1.2.c	Establish a CCTV program for pipe inspections	High	<$250k	General Fund/ Drainage Utility Fund	Year 2	Transportation/ Drainage		x	x	x
1.2.d	Codify and continue requirement of detention pond bottom markers	High	0	General Fund	Year 2	Engineering		x		x
1.2.e	Annual review of detention ponds and require maintenance	High	<$50k	General Fund	Ongoing	Transportation/ Drainage		x		x
1.3	Expand floodplain mapping and data availability									
1.3.a	Add to and improve stormwater inventory and GIS data	High	0	General Fund	Ongoing	Transportation/ Engineering	x			x
1.3.b	Create flood risk overlays for areas outside the FEMA floodplain that are subject to the flooding (using the 2D model) and develop local regulations for those areas	High	<$250k	Drainage Utility Fund	Years 2-5	Engineering	x			x
1.3.c	Improve flood study mapping available to the public online	Medium	<$50k	General Fund	Year 3	Engineering	x			x
1.3.d	Review and update existing floodplain maps	High	<$250k	Drainage Utility Fund	Ongoing	Engineering		x		x
1.3.e	Adopt and implement sustainable flood-management policies	High	<$50k	General Fund/ Drainage Utility Fund	Year 5	Engineering		x		x
1.3.f	Monitor and update statistical rainfall numbers as soon as available	High	0	General Fund	As soon as data is available	Engineering				x
1.4	Open space preservation									
1.4.a	Coordinate open space opportunities with flood control needs for new developments and repetitive loss areas	Medium	0	General Fund	Ongoing	Engineering		x	x	x

Table 2: Action Plan

Summary of Mitigation Actions							FMP Goals			
	Mitigation Action	Priority	Cost Range	Potential Funding Source	Timeframe for Completion from Plan Adoption	Responsible Department	Develop and improve outreach and Public Awareness	Protect/enhance natural floodplain & stormwater resources	Provide fiscally responsible funding	Protect health & safety of public
2	**Property Protection**									
2.1	Provide educational opportunities to increase flood insurance participation									
2.1.a	Perform a detailed review of flood insurance on city owned properties	Medium	0	General Fund	Year 2	Engineering/Risk Management				x
2.2	Update information and links on flooding FAQ page									
2.3	Encourage relocation, acquisition, and capital improvement projects to reduce flood losses									
2.3.a	Develop a voluntary property acquisition plan and program for repetitive loss areas	High	<$5M	Grants/Drainage Utility Fund/ General Fund	Ongoing	Engineering			x	x
2.3.b	Pursue grants to complete property acquisition projects	High	0	General Fund	Ongoing	Engineering			x	x
2.3.c	Explore development of a program to assist property owners with elevation and relocation projects for residential structures	Medium	<$50k	Drainage Utility Fund	Year 5	Engineering	x		x	x
3	**Natural Resource Protection**									
3.1	Maintain current Natural Preserved areas									
3.1.a	Continue to allow and promote the dedication of some floodplain acreage toward parkland. Work with Parks Board to establish guidelines for the consistent allowance of this type of dedication	High	<$500k	General Fund/Park fees	Ongoing	Parks/ Development Services Staff/ Engineering		x		x
3.1.b	Train staff on maintenance practices that facilitate natural preservations	High	<$100k	General Fund	Year 3	Transportation/ Drainage		x		
3.1.c	Continue the practice of requiring private drainage easements on all creeks	High	0	General Fund	Ongoing	Engineering		x		x
3.2	Develop regulations focused on natural area preservation									
3.2.a	Explore developing ordinances/criteria in the Drainage Design Guidelines that require erosion buffers along creeks	High	0	General Fund	Year 1	Engineering		x		x
3.2.b	Explore providing incentives to developers to preserve natural areas	Medium	0	General Fund	Year 3	Engineering	x	x		
3.2.c	Explore the use of Natural Area Preserved zoning districts in Bryan	Medium	0	General Fund	Year 4	Planning		x		x
3.2.d	Explore developing guidelines/criteria for compensatory storage	Medium	0	General Fund	Year 4	Engineering		x		x

Table 2: Action Plan

Summary of Mitigation Actions							FMP Goals			
	Mitigation Action	Priority	Cost Range	Potential Funding Source	Timeframe for Completion from Plan Adoption	Responsible Department	Develop and improve outreach and Public Awareness	Protect/enhance natural floodplain & stormwater resources	Provide fiscally responsible funding	Protect health & safety of public
4	**Emergency Services**									
4.1	Continue ongoing emergency services									
4.1.a	Continue programs to conduct pre and post rain event inspections on known areas of issues	High	0	General Fund	Ongoing	Transportation/ Drainage		x		x
4.1.b	Continue to block streets that become flooded utilizing the flood prone streets list	High	0	General Fund	Ongoing	Transportation/ Traffic		x		x
4.1.c	Continue social media campaign through Twitter, Facebook, Next-door, City website to notify public of emergency situations	High	0	General Fund	Ongoing	Communication and Marketing	x			x
4.1.d	Protect critical facilities and flood prone areas from debris by expanding the maintenance program to include trash pick-up (including bulk) prior to forecasted large events	Medium	<$400k	General Fund/ Stormwater	Year 4	Transportation/ Drainage/ Stormwater		x		x
4.2	Expand flood warning system									
4.2.a	Expand social media program during flood events	Medium	0	General Fund	Year 2	Communication and Marketing	x			x
4.2.b	Explore use of city wide 2D model to consolidate rainfall data and produce real-time flood warning/forecasting system to notify residents and city staff for emergency access.	Medium	<$100k	General Fund/ Drainage Utility Fund/ Grant	Year 5	Police/Fire/ Engineering/ Traffic	x			x
4.2.c	Create public information campaign to encourage participation in Code Red	High	<$50k	General Fund	Ongoing	Fire	x			x
4.2.d	Explore installing "Street May Flood" signs to critical locations	High	<$500k	General Fund	Ongoing	Engineering/ Traffic/Street Drainage	x			x
4.3	Improve hazard response operations									
4.3.a	Investigate grant funding available for emergency services	Low	0	Grant/General Fund	Ongoing	Fire			x	x
4.4	Implement additional emergency operation plans and services for areas of high risk of flooding									
4.4.a	Work with organizations serving functional/access needs populations (elderly, wheelchair-bound, deaf, blind, such as Brazos Valley Council on Independent Living) that may require special assistance, that tie in with 9-1-1, GIS Systems, etc. so that vulnerable citizens can be checked on, notified, supported, or educated effectively in the event of disasters.	High	<$50k	General Fund	Year 4	Fire	x			x
4.4.b	Update and maintain the City of Bryan Hazard Mitigation website with information promoting hazard mitigation and disaster awareness	High	<$50k	General Fund	Year 2	Fire	x			x
4.4.c	Develop a pre-disaster recovery plan for hazard/disaster events	Medium	<$50k	General Fund	Year 3	Fire				x
4.4.d	Develop/review/update the debris management plan	Medium	<$50k	General Fund/ Solid Waste	Year 3	Solid Waste		x		x
4.4.e	Review and assess the use of the Brazos Center and other shelters during flooding events	High	<$50k	General Fund	Ongoing	Fire				x

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Summary of Mitigation Actions							FMP Goals			
	Mitigation Action	Priority	Cost Range	Potential Funding Source	Timeframe for Completion from Plan Adoption	Responsible Department	Develop and improve outreach and Public Awareness	Protect/enhance natural floodplain & stormwater resources	Provide fiscally responsible funding	Protect health & safety of public
5	**Structural Projects**									
5.1	Continue ongoing structural projects									
5.1.a	Continue to implement Stormwater Master Plan projects as funding allows	High	>$5M	Drainage Utility Fund/ Bonds/Grants	Ongoing	Engineering			x	x
5.2	Reduce flood risk through storm drain capital improvement projects									
5.2.a	Prioritize drainage studies and improvements to maximize flood risk reduction	High	0	General Fund	Ongoing	Engineering				x
5.2.b	Design, construct and maintain drainage improvement projects per the studies in Appendix I.	High	>$5M	Drainage Utility Fund/ Bonds/Grants	Ongoing	Engineering				x
5.2.c	Provide update of the Stormwater Masterplan including revisions to the ranking criteria every 5 years	High	<$250k	General Fund	Year 2	Engineering				x
5.3	Reduce flood impacts through detention									
5.3.a	Perform study to determine locations ideal for regional detention	High	<$100k	Drainage Utility Fund	Year 2	Engineering				x
5.3.b	Continue to construct local and regional stormwater detention facilities in flood prone areas	High	>$5M	Drainage Utility Fund/ Bonds	Ongoing	Engineering				x
5.3.c	Perform study to determine if lowering the lake level at Regional Park would be beneficial to reduce flooding	High	<$100k	Bonds	Year 1	Engineering				
5.4	Reduce flood risk at hazardous road crossings									
5.4.a	Develop a plan to upgrade existing low water crossings to improve service levels	Low	<$100k	General Fund/ Bonds/ Drainage Utility Fund	Year 5	Engineering				x
5.4.b	Increase capacity of existing culverts and bridges on major thoroughfares (Old Reliance Rd., Broadmoor low water bridge, W. Villa Maria between Cavitt and Texas Avenue) and single access subdivisions (see 2D Report list) to allow passage during 100-year event	High	>$5M	General Fund/ Bonds/ Drainage Utility Fund	Ongoing	Engineering				x
5.4.c	Explore list of roads flooded during 2016/2017 rainfalls and research emergency access availability to residents given these flooded conditions	High	0	General Fund	Year 2	Engineering				x
5.5	Pursue partnerships to complete stormwater projects									
5.5.a	Develop collaborative program between the stormwater and parks department to create opportunities for flood protection and recreation in open spaces	High	<$1M	Parks/Drainage Utility Fund	Ongoing	Engineering/ Parks			x	x
5.5.b	Explore creating a system for development incentives for improving city storm water infrastructure	Low	<$50k	General Fund	Year 5	Engineering/ Development Services			x	x
5.5.c	Continue to pursue partnerships with BISD to complete stormwater projects on school sites	Medium	<$500k	Parks/General Fund	Ongoing	Engineering/ Parks			x	x
5.5.d	Identify opportunities for public and private (developer) partnerships to complete needed storm improvements	Medium	<$500k	Drainage Utility Fund/ General Fund	Ongoing	Engineering/ Development Services				x

Table 2: Action Plan

Summary of Mitigation Actions							FMP Goals			
	Mitigation Action	Priority	Cost Range	Potential Funding Source	Timeframe for Completion from Plan Adoption	Responsible Department	Develop and improve outreach and Public Awareness	Protect/enhance natural floodplain & stormwater resources	Provide fiscally responsible funding	Protect health & safety of public
6	**Public Information**									
6.1	Continue ongoing public information activities									
6.2	Create targeted outreach program									
6.2.a	Direct mail of FEMA flood protection information to targeted areas of high flood risk	Medium	<$50k	General Fund	Ongoing	Engineering	x			x
6.2.b	Develop a dam safety public education and evacuation plan for at-risk areas of the community, including routes, transportation, and housing	High	<$100k	General Fund	Year 3	Engineering/ Communications/ Fire/Streets Drainage	x			x
6.2.c	Educate realtors regarding real estate disclosure as relates to flooding	High	0	General Fund	Ongoing/Year 2	Engineering	x			x
6.2.d	Educate builders and landscape companies on how to properly grade new homes to protect from flood damage	High	0	General Fund	Ongoing/Year 2	Engineering/ Building	x			x
6.3	Provide general outreach to community regarding flood risk									
6.3.a	Participate in First Fridays with flood risk educational material	Medium	<$50k	General Fund	Ongoing/Year 2	Engineering/ Communications and Marketing	x			x
6.3.b	Create Facebook group for stormwater	Medium	0	General Fund	Year 3	Communications and Marketing	x			
6.3.c	Hold a large community event dedicated to stormwater education annually (Earth Day)	High	<$50k	General Fund	Ongoing/Year 3	Engineering/ Streets and Drainage	x			x
6.3.d	Create adopt-an-inlet and adopt-a-creek programs	Medium	<$50k	General Fund	Year 5	Streets/Drainage	x	x		x
6.3.e	Continue to hold public meetings during stormwater capital improvement projects	High	0	General Fund	Ongoing	Engineering	x			
6.3.f	Become more active in flood awareness week through additional social media outlets and community events	Low	<$50k	General Fund	Year 5	Engineering/ Communications and Marketing	x			
6.3.g	Develop paid advertisements through public service announcements to educate the public about flood insurance and flood risk	Medium	<$50k	General Fund	Year 4	Engineering/ Communications and Marketing	x			
6.3.h	Develop and improve communication regarding preparedness and mitigation actions to better inform developers, engineers, builders, and the public about ways they can avoid flood damage.	Medium	<$50k	General Fund	Year 4	Engineering/ Communications avoid Marketing	x			
6.3.i	Develop and present citizen floodplain and flood insurance education programs	High	<$50k	General Fund/ Drainage Utility Fund	Year 2	Engineering	x			
6.3.j	Create educational program for flood risk to schools and youth	Low	<$50k	General Fund	Year 5	Engineering	x			x
6.3.k	Provide technical assistance to the public on how to interpret flood data	Medium	0	General Fund	Ongoing	Engineering	x			x
6.3.l	Create public information program to be used after flooding events that discusses the following: mold cleanup, hazards in the water, trash debris cleanup, mosquito/bug infestation, TADD, electrocution, and citizen safety	Medium	<$50k	General Fund	Year 2	Communications and Marketing	x			x

Appendix A: Section 510 – CRS Planning Checklist

510 FLOODPLAIN MANAGEMENT PLANNING CHECKLIST

Community: Bryan, Texas

City of Bryan Flood Mitigation Plan Update-2018

511.a Floodplain Management Planning (FMP)

Credit Points: *Enter the section or page number of the plan where each credited item can be found.*

CRS Step	Section/Page	Item Score	Step Total
1. Organize to prepare the plan. (max:15)			
a. Involvment of Office Responsible for Community Planning (4)	Step 1: Organize, Page 5	4	
b. Planning committee of department staff (9)	Step 1: Organize, Page 5	9	
c. Process formally created by the community's governing board (2)		0	13
2. Involve the public. (max: 120)			
a. Planning process conducted through a planning committee (60)	Step 2: Involve the Public, Page 6	60	
b. Public meetings held at the beginning of the planning process (15)	Step 2: Involve the Public, Page 6	15	
c. Public meeting held on draft plan (15)	Step 2: Involve the Public, Page 6	15	
d. Other public information activities to encourage input (Up to 30)	Step 2: Involve the Public, Page 6	15	105
3. Coordinate with other agencies. (max: 35)			
a. Review of existing studies and plans [REQUIRED] (5)	Step 3: Coordinate, Page 6	5	
b. Coordinating with communities and other agencies (Up to 30)	Step 3: Coordinate, Page 8	25	30
4. Assess the hazard. (max: 35)			
a. Plan includes an assessment of the flood hazard [REQUIRED] with:			
(1) A map of known flood hazards (5)	Exhibits 1-5	5	
(2) A description of known flood hazard (5)	Step 4: Assess the Hazard, Page 8	5	
(3) A discussion of past floods (5)	Step 4: Assess the Hazard, Page 11	5	
b. Plan includes assessment of less frequent floods (10)	Step 4: Assess the Hazard, Page 10	10	
c. Plan includes assessment of areas likely to flood (5)	Step 4: Assess the Hazard, Page 11	5	
d. The plan describes other natural hazards [REQUIRED FOR DMA] (5)	Step 4: Assess the Hazard, Page 10	5	35
5. Assess the problem. (max: 52)			
a. Summary of each hazard identified in the hazard assessment and their community impact [REQUIRED] (2)	Step 5: Assess the Problem, Page 14	2	
b. Description of the impact of the hazards on: (max: 25)			
(1) Life, safety, health, procedures for warning and evacuation (5)	Step 5: Assess the Problem, Page 14	5	

(2) Public health inlcuding health hazards to floodwaters/mold (5)	Step 5: Assess the Problem, Page 14	5	
(3) Critical facilities and infrastructure (5)	Step 5: Assess the Problem, Page 15	5	
(4) The community's economy and tax base (5)	Step 5: Assess the Problem, Page 15	5	
(5) Number and type of affected buildings (5)	Step 5: Assess the Problem, Page 14	5	
c. Review of all damaged buildings/flood insurance claims (5)		0	
d. Areas the provide natural floodplain functions (5)		0	
e. Development/redevelopment/Population Trends (7)	Step 5: Assess the Problem, Page 24	7	
f. Impact of future flooding conditions outline in Step 4, item c (5)		0	34
6. Set goals. [REQUIRED] (2)	Step 6: Set Goals, Page 24	2	2
7. Review possible activities. (max: 35)			
a. Preventive activities (5)	Step 7: Review Possible Activities, Page 25	5	
b. Floodplain Management Regulatory/current & future conditions (5)	Step 7: Review Possible Activities, Page 25	5	
c. Property protection activities (5)	Step 7: Review Possible Activities, Page 25	5	
d. Natural resource protection activities (5)	Step 7: Review Possible Activities, Page 25	5	
e. Emergency services activities (5)	Step 7: Review Possible Activities, Page 25	5	
f. Structural projects (5)	Step 7: Review Possible Activities, Page 25	5	
g. Public information activities (5)	Step 7: Review Possible Activities, Page 25	5	35
8. Draft an action plan. (max: 60)			
a. Actions must be prioritized [REQUIRED]			
(1) Recommendations for activities from two of the six categories (10)			
(2) Recommendations for activities from three of the six categories (20)			
(3) Recommendations for activities from four of the six categories (30)			
(4) Recommendations for activities from five of the six categories (45)	Step 8: Draft an Action Plan, Page 26	45	
b. Post-disaster mitigation policies and procedures (10)		0	
c. Action items for mitigation of other hazards (5)		0	45
9. Adopt the plan. (2)	Step 9: Adopt the Plan, Page 26	2	2
10. Implement, evaluate and revise. (max: 26)			
a. Procedures to monitor and recommend revisions [REQUIRED] (2)	Step 10: Implement, evaluate, revise, Pg. 26	2	
b. Same planning committee or successor committee that qualifies under Section 511.a.2 (a) does the evaluation (24)		0	2
Maximum Credit for 510 FMP = 382		**Plan Total:**	**303**

Appendix B: Annual Progress Reports

Memorandum

CITY OF BRYAN
The Good Life, Texas Style.

To: Jayson Barfknecht, PE, PhD, Director of Public Works

CC: Kean Register, City Manager; Bryan City Council

From: Brett McCully, PE, Floodplain Administrator

Date: 9/11/2014

Re: Flood Mitigation Plan Annual Report

On April 10, 2007 the City of Bryan adopted a Flood Mitigation Plan to create a strategy for implementing flood mitigation measures for the community. The plan identified several items for floodplain planning that the city has worked on implementing. These items include:

- Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage
- Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces within the City and its Extraterritorial Jurisdiction
- Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan

From late 2011 through 2012, the Public Works Department conducted an update process of the plan which included forming a Steering Committee comprised of city staff as well as local citizens, several public meetings, and evaluation and analysis of flooding impacts since the 2007 plan was adopted. The 2013 Flood Mitigation Plan was adopted by City Council on February 26, 2013.

Each year a progress report is prepared as part of the City's Community Rating System annual recertification process and copies of this report must be provided to the Bryan City Council and made available to the news media and the public. The reports are posted on the City's web page to facilitate this requirement.

The intent of this report is to give a brief update on the City's progress with respect to each of the plan items and to expand on the city's future activities. The goals and objectives listed below are from the Flood Mitigation Plan, with brief updates presented in bold italicized text after each item.

Goal #1: Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage.

Objective A: Address stormwater and drainage issues.

Action Statement 1 – Utilize the dedication of a buffer zone to reduce the loss of floodplains and to minimize flood damage caused by erosion.

On November 5, 2010, the City of Bryan adopted an updated Stormwater Ordinance, which among other things provided stronger protection for floodplains and floodways. Discussions have been taking place since that time with local stakeholders on more effective means of protecting the natural and beneficial states of floodplains, and to

reduce erosion-related impacts and damages. This process has joined with local water quality management processes and techniques being promoted by the Texas Commission on Environmental Quality (TCEQ), and combined planning and development proposals are being presented to both Bryan and College Station Planning and Zoning Commissions for discussion and consideration.

Action Statement 2 – Provide development incentives to assure the control and management of floodplains.

The Development Services staff continues to identify acceptable incentives to ensure the preservation and management of all existing floodplains. In addition to incentives, the Development staff is updating the City's Subdivision Ordinance to facilitate the protection of floodplains and floodways through green way preservation. As a result, several recent projects have been able to balance less development of floodplain areas with denser development on adjacent buildable property.

Action Statement 3 – Consider utilizing floodways and floodplains in order to assure proper drainage in a pleasing and accessible environment.

The current storm water regulations adopted by the City of Bryan are above the minimum regulations set forth by FEMA with regards to development in the floodplain. The Engineering Department continues to watch for and pursue opportunities to submit buy-out grant applications to buy properties that have experienced repetitive flooding throughout the years. These properties, once purchased, would be cleared and dedicated as park land. To date we have been unsuccessful in securing willing sellers and available grant funds at the same time. These funds are only made available at certain times and we will continue to apply for them when possible.

There are several Capital Improvement projects that are underway in design or construction which utilize less intense, and thus more aesthetic flood protection measures. Rock filled wire baskets called gabions are being used in many places to reduce hard concrete protection, and regional detention basins are being used instead of channel enlargement and lining.

Action Statement 4 – Continue to allow and promote the dedication of some floodplain acreage toward parkland. Work with Parks Board to establish guidelines for the consistent allowance of this type of dedication.

The Subdivision Ordinance currently requires parkland dedication and/or parkland dedication fees as part of the development process. Floodplain acreages are still acceptable for parkland in case by case situations where there is enough adjacent parkland located outside of the floodplain. Larger recent proposals, such as the Turkey Creek Trail system, have been able to foster more detailed discussions about the differences and similarities between the active parkland uses addressed by existing development fees and dedications, and the growth of interest in greenways, trails and other passive recreational areas.

Action Statement 5 – Develop and fund a comprehensive Capital Improvements Program from the recommended improvements identified in the Primary and Secondary Drainage Studies.

City Staff currently utilizes both a Storm Water Master Plan and a Capital Improvement Program. Using factors such as threats to structures, maintenance costs, and flooding potential, these projects were ranked in priority and will be incorporated into the capital project program as funding is available.

Action Statement 6 – Evaluate streets designated as emergency routes to identify where bridge or culvert size over creeks should be improved to assure access as evacuation or emergency services routes during major storm events.

The City of Bryan Unified Stormwater Design Guidelines currently require one lane in each direction to remain clear of water in the 100-yr storm event on arterial and parkway streets. This is the design guidelines for new streets. The Public Works Department staff has developed a response plan for assessing and marking existing emergency routes during large rain events. A facility's location on an emergency route also counted in the project ranking within the new Storm Water Master Plan so areas of limited access can be gradually eliminated. This year's comparable project is the replacement of the Still Creek Tributary Culvert under West 17th Street near the intersection with Boulevard Drive. This crossing has been identified as a critical route for community on the north side of the creek, and is subject to overtopping in significant rain events. The goal of the new culvert will be to protect this route to the 100 year event without increasing any adjacent flooding.

Objective B: Promote a regional stormwater detention system to assure coordination and lessen mutual impacts.

Action Statement 1 – Promote regional detention facilities and provide opportunities for their creation. Incorporate design guidelines encouraging the provision of regional detention facilities where they could be beneficial.

The City of Bryan currently requires detention mitigation on development projects that impact more than an acre of land. Developers have begun to explore the alternatives to standard small detention basins as the value of land continues to increase within commercial developments. In several capital projects in Carters, Still, Burton and Briar Creeks, the Engineering Department continues to address local drainage issues using a regional detention facility approaches. Private developers have also begun to realize the benefits of such facilities as multi-phase and/or regional facilities have been constructed.

Action Statement 2 – Explore reimbursement methods to help pay for regional detention facilities.

The Engineering Staff currently checks for funding opportunities through the Department of Emergency Management, FEMA, TWDB and others. As regional detention facility locations are identified, reimbursement regulations may be implemented such that developments taking advantage of the regional detention ponds would pay fees to the City to reimburse for the cost of that facility. The current Still

Creek Flood Protection Project has used Texas Water Development Board grant funds to study and develop a regional detention basin solution for significant repetitive flooding near the intersection of Old Hearne Road and Wilkes Street, and it is expected that this project will be highly ranked in consideration for a significant construction funding grant as well.

Goal #2 Reserved

Goal #3: Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces with the city and its extraterritorial jurisdiction.

Objective B: Establish mechanisms to acquire and preserve key open space.

Action Statement 1 – Investigate other sources of revenue including matching grants for specific projects, capital improvement funding and other public and private sources.

The Engineering Department continues to investigate and pursue funding from several state and federal agencies. The development and upkeep of the Storm Water Master Plan will assist in the development of grant applications and the existence of the plan will help our projects rank higher.

Action Statement 2 – Review existing development regulations to consider incorporating open space and greenway dedication.

Development Services staff is currently working on rewriting a number of its ordinances including the Subdivision Regulations to allow more flexibility in protecting sensitive areas.

Goal #4: Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan.

Objective A: Preserve green-belt linkages throughout the City and the region.

Action Statement 1 – Continue the planning for, acquisition and preservation of certain identified linear park corridors and greenbelts throughout the city using major greenbelts, creeks and drainage ways.

The City of Bryan's Comprehensive Plan addresses this item along with the Parks Department's Trail System Masterplan.

Action Statement 2 – Foster the development of parkways along greenbelts by developers as opposed to lots backing up to these green areas. Examine all mechanisms for accomplishing this including, but not limited to, dedication, donation, and conservation.

During the plan review process city staff looks at existing greenways and encourages park development and preservation of those greenways whenever possible. This will also be considered when rewriting ordinances. The recent Dominion Oaks project is an example of a successful negotiation that preserved the floodplain within a new park and trail area. Select landowners in the Turkey Creek watershed have started a process using the National Park Service as a meeting facilitator to evaluate the plan to protect 485 acres of greenbelt for recreation and conservation in the floodplain of 7.8 miles of Turkey Creek from Downtown Bryan to the Brazos River.

Action Statement 3 – Examine subdivision and drainage regulations to include requirements for dedication and conservation.

City staff is currently working on rewriting its subdivision ordinance. There is in place an existing plan that requires parkland dedication fee-in-lieu of land for all subdivision submittals.

Action Statement 4 – Continue efforts to develop a linear park along Carter Creek and work with the City of College Station and Brazos County to provide for a regional park facility.

The Park Hudson Trail System is a step in that direction. It is located along Hudson Creek which is a tributary to Carter Creek. Additionally the pond created recently with the Bryan Townecenter is located along Carters Creek and can be connected via a trail system to form the ultimate linear park envisioned above. Plans are also being drawn up to bridge a stream on the western end of this trail so we can connect to Veteran's Park in College Station. Staff has been in discussions with property owners in this area to acquire the needed easements for access. With the approaching approval of the updated floodplain maps along Carters and Still Creeks, staff will have better information on where flooding effects should be protected while still allowing and promoting joint passive uses.

Goal #5: Develop communication mechanisms to better inform developer, engineers, builders and the public about ways they can help prevent flood damage. (New for 2013)

Objective A: Create a communications outreach program for the public.

Action Statement 1: Create PSA's to inform public about self-imposed drainage problems (i.e. fences, flowerbeds). Utilize media tools such as Bryan public access channel, Bryan website, flyers or other distribution means.

City Staff has been gathering sample information and formats from other agencies in order to develop a message plan which will allow the larger flooding issue to be broken down into smaller, more media friendly, messages. City Staff has begun using pre-printed materials obtained from the Texas Floodplain Managers Association, as well as department newsletters to provide information to the public in general as well as the development community.

Action Statement 2: Create information and/or inspection mechanisms to allow drainage information/decisions to be communicated between the developer-builder-homeowner. Often decisions regarding drainage design on the lot made by the developer/engineer are not known by homebuilders or the end user the homeowner. Driveway design/construction often eliminates gutter capacity and allows stormwater to enter the property at the driveway.

City Staff has begun the process of gathering existing information and processes from other agencies to first evaluate what has and has not worked in other areas.

Objective B: Develop design parameters for better roadway and lot drainage design.

Action Statement 1: Develop drainage design criteria to help alleviate stormwater/flooding concerns at 90 degree turns and tee intersections. If not designed correctly, this is where stormwater tends to jump the curb into the lot at the bend or end of the roadway.

City Staff has begun the process of gathering existing information and processes from other agencies to first evaluate what has and has not worked in other areas. Engineering and Drainage Maintenance Staff have also been working closely together during and after rainfall events to isolate causative factors which may need to be addressed.

Action Statement 2: Begin to develop and inform developers/engineers about new design methods regarding Low Impact Development (LID) design criteria and conservation subdivision design.

City Staff has worked closely with the local development community on non-typical drainage designs which can incorporate LID criteria and objectives, and at the same time help financial results on trial projects.

End of Report

Memorandum

To: Paul Kaspar, City Engineer

CC: Jayson Barfknecht, PE, PhD, Director of Public Works; Kean Register, City Manager; Bryan City Council

From: Johnnie Price, PE, Floodplain Administrator

Date: 9/30/2015

Re: Flood Mitigation Plan Annual Report

On April 10, 2007 the City of Bryan adopted their first Flood Mitigation Plan to create a strategy for implementing flood mitigation measures for the community. The plan identified several items for floodplain planning that the city has worked on implementing. These items include:

- Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage
- Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces within the City and its Extraterritorial Jurisdiction
- Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan

The Flood Mitigation Plan has to be updated every 5 years and on February 26, 2013 the Bryan City Council adopted the 2013 Flood Mitigation Plan. Each year a progress report is prepared as part of the City's Community Rating System annual recertification process and copies of this report must be provided to the Bryan City Council and made available to the news media and the public. The reports are posted on the City's web page to facilitate this requirement.

The intent of this report is to give a brief update on the City's progress with respect to each of the plan items and to expand on the city's future activities. The goals and objectives listed below are from the Flood Mitigation Plan, with brief updates presented in bold italicized text after each item.

Goal #1: Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage.

Objective A: Address stormwater and drainage issues.

Action Statement 1 – Utilize the dedication of a buffer zone to reduce the loss of floodplains and to minimize flood damage caused by erosion.

The City has been working with various developers to incorporate the existing floodplain into their subdivision designs. Examples of these efforts can be seen with the Greenbrier, Edgewater and Traditions subdivisions where HOA common areas are preserving the natural floodplain.

Action Statement 2 – Provide development incentives to assure the control and

management of floodplains.

The Development Services staff continues to identify acceptable incentives to ensure the preservation and management of all existing floodplains. In addition to incentives, the Development staff is updating the City's Subdivision Ordinance to facilitate the protection of floodplains and floodways through green way preservation. As a result, several recent projects have been able to balance less development of floodplain areas with denser development on adjacent buildable property.

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Action Statement 5 – Develop and fund a comprehensive Capital Improvements Program from the recommended improvements identified in the Primary and Secondary Drainage Studies.

City Staff currently utilizes both a Storm Water Master Plan and a Capital Improvement Program (CIP). Using factors such as threats to structures, maintenance costs, and flooding potential, these projects were ranked in priority and will be incorporated into the capital project program as funding is available. The CIP is funded by various funding sources including bonds and drainage utility fee.

Action Statement 6 – Evaluate streets designated as emergency routes to identify where bridge or culvert size over creeks should be improved to assure access as evacuation or emergency services routes during major storm events.

The City of Bryan Unified Stormwater Design Guidelines currently require one lane in each direction to remain clear of water in the 100-yr storm event on arterial and parkway streets. This is the design guidelines for new streets. The Public Works Department staff has developed a response plan for assessing and marking existing emergency routes during large rain events. A facility's location on an emergency route also counted in the project ranking within the new Storm Water Master Plan so areas of limited access can be gradually eliminated. This year's comparable project is the replacement of the Still Creek Tributary Culvert under West 17th Street near the intersection with Boulevard Drive. This crossing has been identified as a critical route for community on the north side of the creek, and is subject to overtopping in significant rain events. The goal of the new culvert will be to protect this route to the 100 year event without increasing any adjacent flooding.

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Action Statement 2 – Explore reimbursement methods to help pay for regional detention facilities.

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Goal #2 Reserved

Goal #3: Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces with the city and its extraterritorial jurisdiction.

Objective B: Establish mechanisms to acquire and preserve key open space.

Action Statement 1 – Investigate other sources of revenue including matching grants for specific projects, capital improvement funding and other public and private sources.

The Engineering Department continues to investigate and pursue funding from several state and federal agencies. The development and upkeep of the Storm Water Master Plan will assist in the development of grant applications and the existence of the plan will help our projects rank higher.

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Goal #4: Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan.

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The City of Bryan's Comprehensive Plan addresses this item along with the Parks Department's Trail System Masterplan.

Action Statement 2 – Foster the development of parkways along greenbelts by developers as opposed to lots backing up to these green areas. Examine all mechanisms for accomplishing this including, but not limited to, dedication, donation, and conservation.

During the plan review process city staff looks at existing greenways and encourages park development and preservation of those greenways whenever possible. This will also be considered when rewriting ordinances. The recent Dominion Oaks project is an example of a successful negotiation that preserved the floodplain within a new park and trail area. Select landowners in the Turkey Creek watershed have completed a process using the National Park Service as a meeting facilitator to evaluate the plan to protect 485 acres of greenbelt for recreation and conservation in the floodplain of 7.8 miles of Turkey Creek from Downtown Bryan to the Brazos River.

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Goal #5: Develop communication mechanisms to better inform developer, engineers, builders and the public about ways they can help prevent flood damage. (New for 2013)

Objective A: Create a communications outreach program for the public.

Action Statement 1: Create PSA's to inform public about self-imposed drainage problems (i.e. fences, flowerbeds). Utilize media tools such as Bryan public access channel, Bryan website, flyers or other distribution means.

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Action Statement 2: Create information and/or inspection mechanisms to allow drainage information/decisions to be communicated between the developer-builder-homeowner. Often decisions regarding drainage design on the lot made by the developer/engineer are not known by homebuilders or the end user the homeowner. Driveway design/construction often eliminates gutter capacity and allows stormwater to enter the property at the driveway.

City Staff has reviewed existing information and processes from other agencies to first evaluate what has and has not worked in other areas. This goal will be an improvement item to work on for many years to come.

Objective B: Develop design parameters for better roadway and lot drainage design.

Action Statement 1: Develop drainage design criteria to help alleviate stormwater/flooding concerns at 90 degree turns and tee intersections. If not designed correctly, this is where stormwater tends to jump the curb into the lot at the bend or end of the roadway.

City Staff continues to evaluate existing information and processes from other agencies to determine what has and has not worked in other areas. Engineering and Drainage Maintenance Staff have also been working closely together during and after rainfall events to isolate causative factors which may need to be addressed.

Action Statement 2: Begin to develop and inform developers/engineers about new design methods regarding Low Impact Development (LID) design criteria and conservation subdivision design.

City Staff continues to work closely with the local development community on non-typical drainage designs which can incorporate LID criteria and objectives, and at the same time help financial results on trial projects.

End of Report

Memorandum

To: Paul Kaspar, City Engineer

CC: Jayson Barfknecht, PE, PhD, Director of Public Works; Kean Register, City Manager; Bryan City Council

From: Johnnie Price, PE, Floodplain Administrator

Date: 5/02/2016

Re: Flood Mitigation Plan Annual Report

On April 10, 2007 the City of Bryan adopted their first Flood Mitigation Plan to create a strategy for implementing flood mitigation measures for the community. The plan identified several items for floodplain planning that the city has worked on implementing. These items include:

- Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage
- Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces within the City and its Extraterritorial Jurisdiction
- Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan

The Flood Mitigation Plan has to be updated every 5 years and on February 26, 2013 the Bryan City Council adopted the 2013 Flood Mitigation Plan. Each year a progress report is prepared as part of the City's Community Rating System annual recertification process and copies of this report must be provided to the Bryan City Council and made available to the news media and the public. The reports are posted on the City's web page to facilitate this requirement.

The intent of this report is to give a brief update on the City's progress with respect to each of the plan items and to expand on the city's future activities. The goals and objectives listed below are from the Flood Mitigation Plan, with brief updates presented in bold italicized text after each item.

Goal #1: Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage.

Objective A: Address stormwater and drainage issues.

Action Statement 1 – Utilize the dedication of a buffer zone to reduce the loss of floodplains and to minimize flood damage caused by erosion.

The City has been working with various developers to incorporate the existing floodplain into their subdivision designs. Examples of these efforts can be seen with the Greenbrier, Edgewater and Traditions subdivisions where HOA common areas are preserving the natural floodplain.

Action Statement 2 – Provide development incentives to assure the control and management of floodplains.

The Development Services staff continues to identify acceptable incentives to ensure the preservation and management of all existing floodplains. In addition to incentives, the Development staff is updating the City's Subdivision Ordinance to facilitate the protection of floodplains and floodways through green way preservation. As a result, several recent projects have been able to balance less development of floodplain areas with denser development on adjacent buildable property.

Action Statement 3 – Consider utilizing floodways and floodplains in order to assure proper drainage in a pleasing and accessible environment.

The current storm water regulations adopted by the City of Bryan are above the minimum regulations set forth by FEMA with regards to development in the floodplain. The Engineering Department continues to watch for and pursue opportunities to submit buy-out grant applications to buy properties that have experienced repetitive flooding throughout the years. These properties, once purchased, would be cleared and dedicated as park land. To date we have been unsuccessful in securing willing sellers and available grant funds at the same time. These funds are only made available at certain times and we will continue to apply for them when possible.

There are several Capital Improvement projects that are underway in design or construction which utilize less intense and thus more aesthetic flood protection measures. More environmental friendly infrastructure is being used in many places to reduce hard concrete protection, and regional detention basins are being used instead of channel enlargement and lining.

Action Statement 4 – Continue to allow and promote the dedication of some floodplain acreage toward parkland. Work with Parks Board to establish guidelines for the consistent allowance of this type of dedication.

The Subdivision Ordinance currently requires parkland dedication and/or parkland dedication fees as part of the development process. Floodplain acreages are still acceptable for parkland in case by case situations where there is enough adjacent parkland located outside of the floodplain. Larger recent proposals, such as the Turkey Creek Trail system, have been able to foster more detailed discussions about the differences and similarities between the active parkland uses addressed by existing development fees and dedications, and the growth of interest in greenways, trails and other passive recreational areas.

Action Statement 5 – Develop and fund a comprehensive Capital Improvements Program from the recommended improvements identified in the Primary and Secondary Drainage Studies.

City Staff currently utilizes both a Storm Water Master Plan and a Capital Improvement Program (CIP). Using factors such as threats to structures, maintenance costs, and flooding potential, these projects were ranked in priority and will be incorporated into

the capital project program as funding is available. The CIP is funded by various funding sources including bonds and drainage utility fee.

Action Statement 6 – Evaluate streets designated as emergency routes to identify where bridge or culvert size over creeks should be improved to assure access as evacuation or emergency services routes during major storm events.

The City of Bryan Unified Stormwater Design Guidelines currently require one lane in each direction to remain clear of water in the 100-yr storm event on arterial and parkway streets. This is the design guidelines for new streets. The Public Works Department staff has developed a response plan for assessing and marking existing emergency routes during large rain events. A facility's location on an emergency route also counted in the project ranking within the new Storm Water Master Plan so areas of limited access can be gradually eliminated. This year's comparable project is the replacement of the Still Creek Tributary Culvert under West 17th Street near the intersection with Boulevard Drive. This crossing has been identified as a critical route for community on the north side of the creek, and is subject to overtopping in significant rain events. The goal of the new culvert will be to protect this route to the 100 year event without increasing any adjacent flooding.

Objective B: Promote a regional stormwater detention system to assure coordination and lessen mutual impacts.

Action Statement 1 – Promote regional detention facilities and provide opportunities for their creation. Incorporate design guidelines encouraging the provision of regional detention facilities where they could be beneficial.

The City of Bryan currently requires detention mitigation on development projects that impact more than an acre of land. Developers have begun to explore the alternatives to standard small detention basins as the value of land continues to increase within commercial developments. In several capital projects in Carters, Still, Burton and Briar Creeks, the Engineering Department continues to address local drainage issues using a regional detention facility approaches. Private developers have also begun to realize the benefits of such facilities as multi-phase and/or regional facilities have been constructed.

Action Statement 2 – Explore reimbursement methods to help pay for regional detention facilities.

The Engineering Staff currently checks for funding opportunities through the Department of Emergency Management, FEMA, TWDB and others. As regional detention facility locations are identified, reimbursement regulations may be implemented such that developments taking advantage of the regional detention ponds would pay fees to the City to reimburse for the cost of that facility. The current Still Creek Flood Protection Project has used Texas Water Development Board grant funds to study and develop a regional detention basin solution for significant repetitive flooding near the intersection of Old Hearne Road and Wilkes Street. The City pursued but was unsuccessful at obtaining outside construction funding for the project.

Goal #2 Reserved

Goal #3: Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces with the city and its extraterritorial jurisdiction.

Objective B: Establish mechanisms to acquire and preserve key open space.

Action Statement 1 – Investigate other sources of revenue including matching grants for specific projects, capital improvement funding and other public and private sources.

The Engineering Department continues to investigate and pursue funding from several state and federal agencies. The development and upkeep of the Storm Water Master Plan will assist in the development of grant applications and the existence of the plan will help our projects rank higher.

Action Statement 2 – Review existing development regulations to consider incorporating open space and greenway dedication.

Development Services staff is currently working on rewriting a number of its ordinances including the Subdivision Regulations to allow more flexibility in protecting sensitive areas.

Goal #4: Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan.

Objective A: Preserve green-belt linkages throughout the City and the region.

Action Statement 1 – Continue the planning for, acquisition and preservation of certain identified linear park corridors and greenbelts throughout the city using major greenbelts, creeks and drainage ways.

The City of Bryan's Comprehensive Plan addresses this item along with the Parks Department's Trail System Masterplan.

Action Statement 2 – Foster the development of parkways along greenbelts by developers as opposed to lots backing up to these green areas. Examine all mechanisms for accomplishing this including, but not limited to, dedication, donation, and conservation.

During the plan review process city staff looks at existing greenways and encourages park development and preservation of those greenways whenever possible. This will also be considered when rewriting ordinances. The recent Dominion Oaks project is an example of a successful negotiation that preserved the floodplain within a new park and trail area. Select landowners in the Turkey Creek watershed have completed a process using the National Park Service as a meeting facilitator to evaluate the plan to protect 485 acres of greenbelt for recreation and conservation in the floodplain of 7.8 miles of Turkey Creek from Downtown Bryan to the Brazos River.

Action Statement 3 – Examine subdivision and drainage regulations to include requirements for dedication and conservation.

City staff is currently working on rewriting its subdivision ordinance. Parkland dedication fee-in-lieu of land is an available option for all subdivision submittals.

Action Statement 4 – Continue efforts to develop a linear park along Carter Creek and work with the City of College Station and Brazos County to provide for a regional park facility.

The Park Hudson Trail System is a step in that direction. It is located along Hudson Creek which is a tributary to Carter Creek. Additionally the pond created recently with the Bryan Townecenter is located along Carters Creek and can be connected via a trail system to form the ultimate linear park envisioned above. Plans are also being drawn up to bridge a stream on the western end of this trail so we can connect to Veteran's Park in College Station. Staff has been in discussions with property owners in this area to acquire the needed easements for access.

Goal #5: Develop communication mechanisms to better inform developer, engineers, builders and the public about ways they can help prevent flood damage. (New for 2013)

Objective A: Create a communications outreach program for the public.

Action Statement 1: Create PSA's to inform public about self-imposed drainage problems (i.e. fences, flowerbeds). Utilize media tools such as Bryan public access channel, Bryan website, flyers or other distribution means.

City Staff has been gathering sample information and formats from other agencies in order to develop a message plan which will allow the larger flooding issue to be broken down into smaller, more media friendly, messages. City Staff has begun using preprinted materials obtained from the Texas Floodplain Managers Association, as well as department newsletters to provide information to the public in general as well as the development community.

Action Statement 2: Create information and/or inspection mechanisms to allow drainage information/decisions to be communicated between the developer-builder-homeowner. Often decisions regarding drainage design on the lot made by the developer/engineer are not known by homebuilders or the end user the homeowner. Driveway design/construction often eliminates gutter capacity and allows stormwater to enter the property at the driveway.

City Staff has reviewed existing information and processes from other agencies to first evaluate what has and has not worked in other areas. This goal will be an improvement item to work on for many years to come.

Objective B: Develop design parameters for better roadway and lot drainage design.

Action Statement 1: Develop drainage design criteria to help alleviate stormwater/flooding concerns at 90 degree turns and tee intersections. If not designed correctly, this is where stormwater tends to jump the curb into the lot at the bend or end of the roadway.

City Staff continues to evaluate existing information and processes from other agencies to determine what has and has not worked in other areas. Engineering and Drainage Maintenance Staff have also been working closely together during and after rainfall events to isolate causative factors which may need to be addressed.

Action Statement 2: Begin to develop and inform developers/engineers about new design methods regarding Low Impact Development (LID) design criteria and conservation subdivision design.

City Staff continues to work closely with the local development community on nontypical drainage designs which can incorporate LID criteria and objectives, and at the same time help financial results on trial projects.

End of Report

Memorandum

To: Jayson Barfknecht, PE, PhD, Director of Public Works

CC: Kean Register, City Manager; Bryan City Council

From: Johnnie Price, PE, Floodplain Administrator

Date: 10/06/2017

Re: Flood Mitigation Plan Annual Report

On April 10, 2007 the City of Bryan adopted a Flood Mitigation Plan to create a strategy for implementing flood mitigation measures for the community. The plan identified several items for floodplain planning that the city has worked on implementing. These items include:

- Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage
- Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces within the City and its Extraterritorial Jurisdiction
- Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan

From late 2011 through 2012, the Public Works Department conducted an update process of the plan which included forming a Steering Committee comprised of city staff as well as local citizens, several public meetings, and evaluation and analysis of flooding impacts since the 2007 plan was adopted. The 2013 Flood Mitigation Plan was adopted by City Council on February 26, 2013. The current plan will expire in 2018 at which time it will need to be updated.

Each year a progress report is prepared as part of the City's Community Rating System annual recertification process and copies of this report must be provided to the Bryan City Council and made available to the news media and the public. The reports are posted on the City's web page to facilitate this requirement.

The intent of this report is to give a brief update on the City's progress with respect to each of the plan items and to expand on the city's future activities. The goals and objectives listed below are from the Flood Mitigation Plan, with brief updates presented in bold italicized text after each item.

Goal #1: Minimize losses due to flooding and achieve a balance between natural open space and improvements for drainage.

Objective A: Address stormwater and drainage issues.

Action Statement 1 – Utilize the dedication of a buffer zone to reduce the loss of floodplains and to minimize flood damage caused by erosion.

On November 5, 2010, the City of Bryan adopted an updated Stormwater Ordinance, which among other things provided stronger protection for floodplains and floodways. Discussions have been taking place since that time with local stakeholders on more

effective means of protecting the natural and beneficial states of floodplains, and to reduce erosion-related impacts and damages. This process has joined with local water quality management processes and techniques being promoted by the Texas Commission on Environmental Quality (TCEQ), and combined planning and development proposals are being presented to both Bryan and College Station Planning and Zoning Commissions for discussion and consideration.

Action Statement 2 – Provide development incentives to assure the control and management of floodplains.

The Development Services staff continues to identify acceptable incentives to ensure the preservation and management of all existing floodplains. In addition to incentives, the Development staff is updating the City's Subdivision Ordinance to facilitate the protection of floodplains and floodways through green way preservation. As a result, several recent projects have been able to balance less development of floodplain areas with denser development on adjacent buildable property.

Action Statement 3 – Consider utilizing floodways and floodplains in order to assure proper drainage in a pleasing and accessible environment.

The current storm water regulations adopted by the City of Bryan are above the minimum regulations set forth by FEMA with regards to development in the floodplain. The Engineering Department continues to watch for and pursue opportunities to submit buy-out grant applications to buy properties that have experienced repetitive flooding throughout the years. These properties, once purchased, would be cleared and dedicated as park land. To date we have been unsuccessful in securing willing sellers and available grant funds at the same time. These funds are only made available at certain times and we will continue to apply for them when possible.

There are several Capital Improvement projects that are underway in design or construction which utilize less intense, and thus more aesthetic flood protection measures. Rock filled wire baskets called gabions are being used in many places to reduce hard concrete protection, and regional detention basins are being used instead of channel enlargement and lining. In addition to the above activities, the City of Bryan is conducting an Erosion Assessment on Briar and Burton Creeks to identify, prioritize and develop plans on addressing erosion/flood protection issues.

Action Statement 4 – Continue to allow and promote the dedication of some floodplain acreage toward parkland. Work with Parks Board to establish guidelines for the consistent allowance of this type of dedication.

The Subdivision Ordinance currently requires parkland dedication and/or parkland dedication fees as part of the development process. Floodplain acreages are still acceptable for parkland in case by case situations where there is enough adjacent parkland located outside of the floodplain. Larger recent proposals, such as the Turkey Creek Trail system, have been able to foster more detailed discussions about the differences and similarities between the active parkland uses addressed by existing development fees and dedications, and the growth of interest in greenways, trails and other passive recreational areas.

Action Statement 5 – Develop and fund a comprehensive Capital Improvements Program from the recommended improvements identified in the Primary and Secondary Drainage Studies.

City Staff currently utilizes both a Storm Water Master Plan and a Capital Improvement Program. Using factors such as threats to structures, maintenance costs, and flooding potential, these projects were ranked in priority and will be incorporated into the capital project program as funding is available.

Action Statement 6 – Evaluate streets designated as emergency routes to identify where bridge or culvert size over creeks should be improved to assure access as evacuation or emergency services routes during major storm events.

The City of Bryan Unified Stormwater Design Guidelines currently require one lane in each direction to remain clear of water in the 100-yr storm event on arterial and parkway streets. This is the design guidelines for new streets. The Public Works Department staff has developed a response plan for assessing and marking existing emergency routes during large rain events. A facility's location on an emergency route also counted in the project ranking within the new Storm Water Master Plan so areas of limited access can be gradually eliminated. Over the past year, a 2D analysis has been completed showing major roadways/emergency routes that are subject to flooding across the entire city. The analysis will help direct possible additional work that may be required to ensure the safety of our residents.

Objective B: Promote a regional stormwater detention system to assure coordination and lessen mutual impacts.

Action Statement 1 – Promote regional detention facilities and provide opportunities for their creation. Incorporate design guidelines encouraging the provision of regional detention facilities where they could be beneficial.

The City of Bryan currently requires detention mitigation on development projects that impact more than an acre of land. Developers have begun to explore the alternatives to standard small detention basins as the value of land continues to increase within commercial developments. In several capital projects in Carters, Still, Burton and Briar Creeks, the Engineering Department continues to address local drainage issues using a regional detention facility approaches. The Old Hearne Ph. 2 Project (currently under construction) includes a regional pond that will protect a large number of residents from the frequent flooding that has plagued them in the past. Private developers have also begun to realize the benefits of such facilities as multi-phase and/or regional facilities have been constructed.

Action Statement 2 – Explore reimbursement methods to help pay for regional detention facilities.

The Engineering Staff currently checks for funding opportunities through the Department of Emergency Management, FEMA, TWDB and others. As regional detention facility locations are identified, reimbursement regulations may be implemented such that developments taking advantage of the regional detention ponds would pay fees to the City to reimburse for the cost of that facility. The current Still Creek Flood Protection Project has used Texas Water Development Board grant funds

to study and develop a regional detention basin solution for significant repetitive flooding near the intersection of Old Hearne Road and Wilkes Street, currently being addressed with the construction of Old Hearne Ph. 2, in addition to a future regional detention pond in an adjacent area.

Goal #2 Reserved

Goal #3: Preserve and protect unique open spaces, river corridors, drainage corridors and green spaces with the city and its extraterritorial jurisdiction.

Objective B: Establish mechanisms to acquire and preserve key open space.

Action Statement 1 – Investigate other sources of revenue including matching grants for specific projects, capital improvement funding and other public and private sources.

The Engineering Department continues to investigate and pursue funding from several state and federal agencies. The development and upkeep of the Storm Water Master Plan will assist in the development of grant applications and the existence of the plan will help our projects rank higher.

Action Statement 2 – Review existing development regulations to consider incorporating open space and greenway dedication.

Development Services staff is currently working on rewriting a number of its ordinances including the Subdivision Regulations to allow more flexibility in protecting sensitive areas.

Goal #4: Develop a network of pedestrian and bicycle ways for hiking and cycling throughout Bryan.

Objective A: Preserve green-belt linkages throughout the City and the region.

Action Statement 1 – Continue the planning for, acquisition and preservation of certain identified linear park corridors and greenbelts throughout the city using major greenbelts, creeks and drainage ways.

The City of Bryan's Comprehensive Plan addresses this item along with the Parks Department's Trail System Masterplan.

Action Statement 2 – Foster the development of parkways along greenbelts by developers as opposed to lots backing up to these green areas. Examine all mechanisms for accomplishing this including, but not limited to, dedication, donation, and conservation.

During the plan review process city staff looks at existing greenways and encourages park development and preservation of those greenways whenever possible. This will also be considered when rewriting ordinances. The recent Dominion Oaks project is an example of a successful negotiation that preserved the floodplain within a new park and trail area. Select landowners in the Turkey Creek watershed have started a process using the National Park Service as a meeting facilitator to evaluate the plan to protect 485 acres of greenbelt for recreation and conservation in the floodplain of 7.8 miles of Turkey Creek from Downtown Bryan to the Brazos River.

Action Statement 3 – Examine subdivision and drainage regulations to include requirements for dedication and conservation.

City staff is currently working on rewriting its subdivision ordinance. There is in place an existing plan that requires parkland dedication fee-in-lieu of land for all subdivision submittals.

Action Statement 4 – Continue efforts to develop a linear park along Carter Creek and work with the City of College Station and Brazos County to provide for a regional park facility.

The Park Hudson Trail System is a step in that direction. It is located along Hudson Creek which is a tributary to Carter Creek. Additionally the pond created recently with the Bryan Townecenter is located along Carters Creek and can be connected via a trail system to form the ultimate linear park envisioned above. Plans are also being drawn up to bridge a stream on the western end of this trail so we can connect to Veteran's Park in College Station. Staff has been in discussions with property owners in this area to acquire the needed easements for access. With the approaching approval of the updated floodplain maps along Carters and Still Creeks, staff will have better information on where flooding effects should be protected while still allowing and promoting joint passive uses.

Goal #5: Develop communication mechanisms to better inform developer, engineers, builders and the public about ways they can help prevent flood damage. (New for 2013)

Objective A: Create a communications outreach program for the public.

Action Statement 1: Create PSA's to inform public about self-imposed drainage problems (i.e. fences, flowerbeds). Utilize media tools such as Bryan public access channel, Bryan website, flyers or other distribution means.

City Staff has been gathering sample information and formats from other agencies in order to develop a message plan which will allow the larger flooding issue to be broken down into smaller, more media friendly, messages. City Staff has begun using pre-printed materials obtained from the Texas Floodplain Managers Association, as well as department newsletters to provide information to the public in general as well as the development community. Additionally, with the recent flooding, we have made it easier for residents to post flooding concerns through "Help Bryan" on the Bryan website.

Action Statement 2: Create information and/or inspection mechanisms to allow drainage information/decisions to be communicated between the developer-builder-homeowner. Often decisions regarding drainage design on the lot made by the developer/engineer are not known by homebuilders or the end user the homeowner. Driveway design/construction often eliminates gutter capacity and allows stormwater to enter the property at the driveway.

City Staff has begun the process of gathering existing information and processes from other agencies to first evaluate what has and has not worked in other areas.

Objective B: Develop design parameters for better roadway and lot drainage design.

Action Statement 1: Develop drainage design criteria to help alleviate stormwater/flooding concerns at 90 degree turns and tee intersections. If not designed correctly, this is where stormwater tends to jump the curb into the lot at the bend or end of the roadway.

City Staff has begun the process of gathering existing information and processes from other agencies to first evaluate what has and has not worked in other areas. Engineering and Drainage Maintenance Staff have also been working closely together during and after rainfall events to isolate causative factors which may need to be addressed.

Action Statement 2: Begin to develop and inform developers/engineers about new design methods regarding Low Impact Development (LID) design criteria and conservation subdivision design.

City Staff has worked closely with the local development community on non-typical drainage designs which can incorporate LID criteria and objectives, and at the same time help financial results on trial projects.

End of Report

Appendix C: Resumes

Martin Zimmermann, AICP

611 S. Ennis St. Apt. 36 ◆ Bryan, Texas 77803 ◆ 979.224.2903 ◆ email: zmart_01@hotmail.com

PROFESSIONAL PROFILE

Experienced development manager with 15+ years of service in municipal government with progressively responsible experience in urban planning, building services, code enforcement, and community development, including 9+ years at the managerial level with personnel management and budgetary responsibility. Member of the American Institute of Certified Planners (AICP) and comfortable working in fast-paced deadline- and customer-oriented environments. Effective communicator with excellent writing and presentation skills. Fluent in German.

EMPLOYMENT HISTORY

Planning Manager (October 2015 – Present),
Planning Administrator (August 2008 – September 2015),
Code Enforcement Coordinator (September 2010 – July 2013),
Senior Planner (September 2006 – August 2008),
Project Planner (December 2005 – August 2006)
City of Bryan – Development Services Department, Bryan, Texas

Planner II (November 2004 – December 2005),
Planner I (January 2003 – November 2004),
Planning Intern (September 2002 – January 2003)
City of San Angelo – Planning Department, San Angelo, Texas

EDUCATION

M.A. International Studies
Angelo State University, San Angelo, Texas, August 2002

B.A. Government and English
Angelo State University, San Angelo, Texas, August 2000

Associate Degree (Magisterzwischenprüfung) Political Science and English
Universität Hannover, Hannover, Germany, 1998

RELATED SKILLS

Management/Supervision

- Manage employee relations for 14 full-time and two part-time employees in the Development Services Department, including hiring and termination authority, conducting staff meetings, employee mentoring and project accountability for the purpose of implementing departments' goals and objectives.
- Provide leadership and direction to ensure projects and programs follow approved action plans, comply with state regulations and city policy.
- Draft staff personal development plans and foster employee improvement.

- From 2010-13 managed activities for City's Code Enforcement Division, including supervisory responsibility for six full-time employees. Continue to provide support and advice on code enforcement activities, which are now coordinated by the Public Works Department.
- Experience with and oversee provision of support staff for the City's implementation of an online permitting software (TRACKiT).
- Coordinate activities and projects with multiple city departments and external agencies.
- Foster good relationships with local, regional and national development professionals, the public, key stakeholder groups and the local media.

Department Performance/Budgeting

- Assist in development of the Development Services Department's $1.6M annual budget proposal, including tracking performance measures and preparation of budget requests.
- Analyze monthly financial forecasts for oversight and strict adherence to budget allocations.
- Work with department director to analyze department's organizational structure and assist in the development and implementation of employee reorganization, to improve efficiency and effectiveness of operations and optimum customer service.
- Assist with tracking and responding to customer service surveys and keeping the department's online blog up to date.

Planning and Implementation

- Successfully determined ways to assess community need and gather input on citywide planning processes including experience with hosting public workshops, focus groups, charrettes, open houses, and other creative community engagement practices.
- Experienced in building consensus and momentum for projects and plans throughout the community by developing strong partnerships and presenting to community civic groups and organizations.
- Experience with or currently involved in formulation of the following plans: Comprehensive Plan 2006 and 2016 (BluePrint 2040), Southwest Bryan Highest and Best Use Study (2009), Public Planning Committee – Flood Mitigation Plan Update 2013 and 2018, Health and Wellness Area Plan (2014), RELLIS Area Annexation Feasibility and Strategy Study (2018).
- Gather input and build consensus on budgetary items, projects, and plan implementation through community presentations.
- Responsible for managing and executing specific projects to advance the goals and objectives of adopted city plans, e.g. RELLIS Area Annexation Feasibility and Strategy Study (2018) and substandard structure abatement process.
- Experience with and oversee provision of support staff for three matching grant programs: Downtown Improvements Matching Grant Program, Downtown Life Safety Grant Program, and Corridor Beautification Partnership Program.
- Assist in scoping and planning of Capital Improvement Plan (CIP) projects to help assure the implementation of adopted master plans and the Comprehensive Plan.
- Assist in resolving issues and questions concerning current development projects as part of the City's Site Development Review Committee process.
- Help coordinating development review activities with multiple city departments, citizens and community leaders and provide leadership as a case contact for key development projects.
- Act as case manager for higher profile, sensitive or unusual development projects.

Building Permitting/Inspections and Code Enforcement

- Managing the City's substandard structures abatement program, scheduling 60+ cases for Building and Standards Commission consideration and initiating the removal of 20+ substandard structures each year.
- Managing City's substandard structure demolition contractor contract.
- Assisted in the adoption of 2015 edition of the International Code Council's Family of Codes and the 2014 edition of the National Electrical Code.
- Streamlined the City's commercial plan review process to help guarantee City's stated goal of 10-business day review time for first submissions.
- Clarified code enforcement responsibilities and procedures and improved communication with other City departments that have community policing functions, emphasizing a team approach to enforcement to help achieve compliance or successful prosecution.
- Provided guidance to staff on code interpretations and finding successful avenues for enforcement.
- Managed City's mowing/lot clearing contracts (2010 -2013).

Boards and Commissions

- Oversee provision of support staff and/or act as liaison for numerous policy and advisory boards, commissions or committees, including: Planning and Zoning Commission, Zoning Board of Adjustment, Historic Landmark Commission, Building and Standards Commission, Board of Adjustment and Appeals, Design Review Board, Downtown Bryan Association Board of Trustees, and City Council.
- Guide professional staff in developing technical reports and formulating recommendations concerning development proposals.
- Prepare and/or review technical reports, plans, and present to the aforementioned boards, commissions and/or City Council.

PROFESSIONAL MEMBERSHIPS AND COMMUNITY ACTIVITIES

Memberships

- American Institute of Certified Planners (2008 – Present)
- American Planning Association (2003 – Present)
- Leadership Brazos Alumni Association (2016 – Present)

Awards, Recognitions & Professional Activities

- Bryan/College Station Chamber of Commerce Leadership Brazos Program, Class of 2016.
- American Planning Association – Central Texas Section
    - Director-Elect (2017 – present)
    - Certification Maintenance Officer (2015 – 2017)
    - Treasurer (2009 – 2015)
- Submitted successful applications for American Planning Association – Texas Chapter Achievement for Planning Excellence Award for the City of Bryan's Development Services Department (2016 and 2017).

- American Planning Association – Central Texas Section Innovative Planning Award for *Developer's Guide: A Guide to Building and Development in the City of Bryan, Texas* (July 2008).
- American Planning Association Texas Chapter annual conference attendee since 2003.
- American Planning Association national conference attendee in 2006 (San Antonio), 2008 (Las Vegas), 2011 (Boston), 2014 (Atlanta), and 2017 (New York).
- Periodically coordinate and teach graduate and/or undergraduate planning classes at Texas A&M University's Department of Landscape Architecture and Urban Planning.
- Periodically coordinate and teach an undergraduate planning class at Blinn College Bryan Campus.
- Periodically present current development topics and the city's development process to various groups, including neighborhood organizations, Association of Student Planners at Texas A&M University, and the Bryan/College Station Association of Realtors.
- Attended *Complete Management Course for Planning Directors* from Zucker Systems, Inc. (2007).
- Recipient of Angelo State University College of Liberal and Fine Arts Distinguished Graduate Student Award (2002).
- Honor Medal of the German Army (Deutsche Bundeswehr) for "exemplary fulfillment of duties" during compulsory military service (1995).

William Paul Kaspar, P.E., CFM

901 Munson, College Station, Texas 77840

Phone: 979-574-3185 Email: pkaspar@bryantx.gov

Professional Experience

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Jayson Barfknecht, PE, PhD
Public Works Director

City Engineer
January 14, 2013 to Present

- Lead a 12 employee Engineering Division including Engineers, Inspectors, CAD/GIS technicians and administrative assistants
- Develop and oversee a $1.2 Million Engineering Division Budget
- Lead a 10 employee Traffic Operations Division including Engineers and other field personnel in charge of traffic signals, signage and pavement markings as well as traffic related planning and control.
- Develop and oversee a $1.6 Million Traffic Operations Division Budget
- Manage the development and execution of the City of Bryan's 5 Year Capital Improvement Program (annual average cost of 8 to 15 Million dollars)
- Construction Inspection and administration of approximately 60 projects (development and capital) throughout the City each year.
- Oversee the review of development related infrastructure plans and City Masterplan implementation
- ADA Coordinator for City of Bryan
- Floodplain Administration
- Right of Way Construction Management
- Chair of the B/CS Metropolitan Planning Organization Technical Advisory Committee – 2016-Present
- Apply for state and federal grants to support Capital Improvement Program
- Maintain design guidelines and standards (jointly with City of College Station)
- Assist the City Council, Bryan Business Council, BCSMPO, and the Planning & Zoning Commission, making presentations on technical issues
- Prepare and update City Ordinances and administer existing ordinances

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Jayson Barfknecht, PE, PhD
Public Works Director

City Engineer
December 1, 2010 to January 14, 2013

- Lead a 12-14 employee Division including Engineers, Inspectors, CAD/GIS technicians and administrative assistants
- Develop and oversee a $1.2 Million Engineering Division Budget
- Manage the development and execution of the City of Bryan's 5 Year Capital Improvement Program (annual average cost of 10 to 15 Million dollars)
- Construction Inspection and administration of approximately 60 projects (development and capital) throughout the City each year.
- Oversee the review of development related infrastructure plans and City Masterplan implementation
- Floodplain Administration
- Oversee the City's annual street maintenance contracts through construction
- Apply for state and federal grants to support Capital Improvement Program
- Maintain design guidelines and standards (jointly with City of College Station)
- Assist the City Council, Bryan Business Council and the Planning & Zoning Commission, making presentations on technical issues
- Prepare and update City Ordinances and administer existing ordinances

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Linda Huff, P.E.
Director of Public Works

City Engineer
July 16, 2007 to December 1, 2010

- Lead daily activities of a 18 employee Division with a $1.2 Million Engineering Division Budget
- Manage the development and execution of the City of Bryan's 5 Year Capital Improvement Program (annual average cost of 20 to 25 Million dollars)
- Construction Inspection and administration of approximately 90 projects (development and capital) throughout the City each year.
- Oversee the review of development related infrastructure plans and City Masterplan implementation
- Serve as Floodplain Administrator for the City
- Assist Transportation Division in preparation of the City's annual street maintenance contracts through construction
- Apply for state and federal grants to support Capital Improvement Program
- Maintain design guidelines and standards (jointly with City of College Station)
- Assist the City Council, Bryan Business Council and the Planning & Zoning Commission, making presentations on technical issues
- Prepare and update City Ordinances and administer existing ordinances

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Linda Huff, P.E.
Director of Engineering and Building Services

Assistant City Engineer
January 1, 2002 to July 16, 2007

- Supervise daily activities of 4 employees including 3 CAD technicians and 1 Engineering Assistant
- Assist Director of Engineering in assigning workload duties & budget preparation
- Assist Director of Engineering and Director of Transportation in preparation of the City's annual street maintenance contracts
- Direct the design of Capital Improvement Projects, supervising the design work of 3 Graduate Civil Engineers
- Manage Capital Improvement Projects
- Oversee development of City maps
- Administer the development of a city-wide Geographic Information System
- Apply for federal grants for pedestrian street improvements
- Maintain design guidelines and standards
- Assist the City Council and the Planning & Zoning Commission, making presentations on technical issues
- Prepare City Ordinances and administer existing ordinances

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Linda Huff, P.E.
Interim Development Services Director

Interim City Engineer
January 1, 2000 to January 2002

- Supervise daily activities of a 14 employee Division
- Develop and manage a $1.0 Million departmental budget
- Direct the design of capital improvement projects (annual average cost of 8 to 12 Million dollars)
- Oversee the review of development related infrastructure plans
- Serve as Floodplain Administrator for the City
- Assist Transportation Services Director in preparing annual street maintenance contracts and developed a Pavement Management System
- Attend Metropolitan Planning Organization Meetings coordinating with the Texas Department of Transportation
- Administer Infrastructure Masterplans
- Oversee the development of City maps
- Maintain and administer City's Drainage and Oil & Gas Ordinances
- Maintain design guidelines and standards

- Assist the City Council and the Planning & Zoning Commission
- Prepare City Ordinances and interpret existing ordinances

City of Bryan
P.O. Box 1000
Bryan, Texas 77805
979-209-5030

Supervisor:
Linda Huff, P.E.
City Engineer

Graduate Civil Engineer

September 23, 1998 – December 31, 1999

- Design Capital Improvement Projects (streets, water, sewer, drainage)
- Review commercial and residential subdivision engineering construction plans
- Review drainage reports related to development
- Administer the City's Floodplain and Drainage ordinance
- Assist the Planning & Zoning Commission and City Council
- Assist planning staff in infrastructure master planning
- Coordinate driveway and utility permits with Texas Department of Transportation

City of College Station
1101 Texas Avenue
College Station, TX 77845
979-764-3570

Supervisors:
Kent Laza, P.E.
Veronica Morgan, P.E.

Graduate Civil Engineer

April 15, 1997 - September 18, 1998

- Review commercial and residential subdivision engineering construction plans
- Design culverts and parking lots
- Review drainage reports related to development
- Administer the City's Floodplain and Drainage ordinance
- Prepare reports for and assist the Planning & Zoning Commission and the City Council
- Assist planning staff in infrastructure master planning
- Prepare City Ordinances and interpret existing ordinances
- Administer the City's Oil and Gas Operation Ordinance
- Coordinate driveway and utility permits with TxDOT

W. S. Allen & Associates
405 Mitchell Street
Bryan, Texas 77801
979-779-2398

Supervisor:
Dr. Calvin Woods, P.E.

Graduate Civil Engineer

August 1994 – April 11, 1997

- Design commercial and residential foundations (post-tensioned and conventionally reinforced)
- Analyze and design storm water run-off structural controls
- Design public and site utilities
- Design sanitary sewage lift station
- Prepare subdivision and survey plats
- Supervise surveying crew
- Design various city government regulations in Texas and Louisiana
- Review and compose specifications
- Review shop drawings
- Serve as computer network administrator

Licenses/Certifications

Licensed Professional Engineer (#86293), Texas Board of Professional Engineers

Nationally Certified Floodplain Manager (#0118-98N), Texas Floodplain Managers Association

Education

High Performance Leadership, University of Chicago Booth School of Business, Chicago, Illinois – Completed November, 2016

Master of Engineering Degree in Civil Engineering, Texas A&M University, College Station, TX - Graduated August, 1997

Bachelor of Science Degree in Civil Engineering, Texas A&M University, College Station, TX - Graduated May, 1994

Awards and Grants

Transportation Alternatives Set Aside Program 2017 – $1.9M Grant for sidewalks, shared use paths, and bike lanes

Transportation Alternatives Program 2015 – $3.7M Grant for sidewalks and safety lighting

Texas Public Works Project of the Year 2012 – Bryan/Beck Rehabilitation, Bryan Texas – Texas Public Works Association

Flood Protection Planning Grant for the Still Creek Watershed – April 2010 – Texas Water Development Board

Safe Routes to School Sidewalk Grants – 2009 and 2011

Texas Public Works Project of the Year 2009 – Phase 2 Downtown Renovation, Bryan Texas – Texas Public Works Association

Best Public Improvement of the Year 2008 – Downtown Bryan Infrastructure Improvements – Texas Downtown Association

Floodplain Manager of the Year Award 2007 - Texas Floodplain Manager's Association

Engineer of the Year Award 2007 - Brazos Chapter of the Texas Society of Professional Engineers

ESRI Homeland Security Grant Series Critical Data Infrastructure Program in the amount of $125,000 for software and training – City of Bryan 2002.

Young Engineer of the Year Award 2000, Brazos Chapter of Texas Society of Professional Engineers.

Publications / Presentations

Environmental, Societal and Economic Impacts of Civil Engineering Projects – Texas A&M University Civil Engineering Professional Practice Class – Guest Lecturer each Fall / Spring – 2010 – 2014

Panelist for ASFPM Texas Flood Symposium – May 2013

Floodplain Management and FEMA Map Modernization – Texas Water Development Board Basic Floodplain Management Training – March 30, 2010

The City of Bryan's Sustainable Capital Improvement Program for Community-Based Results - Fall 2009 Meeting of Texas Section ASCE – Best of Session Award & June 2010 TPWA Meeting

Local Government Floodplain Management and Coordination – Spring 2007 Plenary Session Texas Floodplain Manager's Association

Professional Organizations

American Public Works Association, 2001 - Present

American Planning Association, 2001 - 2010

Texas Floodplain Managers Association, 1998 - Present

National Society of Professional Engineers, 1998 - Present

Texas Society of Professional Engineers, 1998 – Present

- President Elect Brazos Branch, 2011
- President Brazos Branch, 2012

American Society of Civil Engineers, 1993 - Present

- President of Brazos Branch, 2000- 2001
- Vice President of Brazos Branch, 1998 - 2000
- Secretary/Treasurer of Brazos Branch, 1997-1998

Chi Epsilon (National Civil Engineering Honor Society), 1993 - Present

Other Service

Children's Museum of the Brazos Valley Board of Directors (Past President)

Judge for Texas BEST (Boosting Engineering, Science, and Technology) Robotics competition at Texas A&M University 2000-2003

Judge and Proctor for MathCounts (annually)

- Mathcounts Volunteer, 1997-Present
- Mathcounts Coordinator, 2012-2014
- Mathcounts Grading Room, 2017-Present

Judge for National Steel Bridge Competition at Texas A&M – May 2011

References

Available upon request

Johnnie L. Price Jr., P.E., CFM
1006 Benedict, Caldwell, TX 77836 - (979) 209-5030 jprice@bryantx.gov

SUMMARY OF QUALIFICATIONS AND ACCOMPLISHMENTS

- Professional Engineer with over 30 years of experience in the field of civil engineering. Certified Flood Plain Manager; member of the Texas Floodplain Manager's Association.
- Over 40 years of experience working in drainage system maintenance and design; ranging from storm sewer systems and residential flood protection to major public works projects such as the Waller Creek Tunnel, Austin Texas.
- Sponsored several high profile projects and communicates well commissions and boards; relates important technical information efficiently with non-technical staff/customers. Interact with the public, presenting complex engineering principles and ideas in terms that are easily understandable.
- Works well in a team environment and provides thorough technical reviews for complex engineering designs. Frequently asked to provide information on engineering methods unfamiliar to others due tomy expertise in hydrology and hydraulics.
- Works well with planning staff, correlating rules/regulations with the engineering – technical aspects and interpretations. Very competent in the review of plans and specifications for compliance with accepted engineering practices and assorted guidelines; ensuring public safety through regulatory compliance.
- Very familiar with Low Impact Development and Green Infrastructure and how such techniques relate with more common grey infrastructure.
- Experienced in the reworking of codes/criteria, able to see the big picture of how regulation in areas can have far reaching or unanticipated effects. Have served as staff advisor on drainage principles and policies regarding flood hazard mitigation, easement requirements, stream erosion mitigation, water quality enhancement infrastructure, and best management practices.
- Certified Cooperating Technical Partner through the Emergency Management Institute; Certified Floodplain Manager and have received extensive training in areas ranging from residential flood protection, retrofitting existing structures to structural channelization of large riverine systems.
- Very technical proficient in the use of H&H software packages; intimately familiar with the theory and calculations associated with various packages and understand the limitations of each.
- Proficient in various hydrologic and hydraulic computer modeling tools including: HEC-1, HEC-2, HEC-5, HEC-RAS, HEC-HMS, PondPack, EPA SWMM, TR20, TR55, HydroCAD, FlowMaster, StomNET, CulvertMaster, CivilStorm, KYPipe, Cybernet and WaterCAD, A&M Watershed Model, open channel flow models written in FORTRAN, Autocad and Civil 3D, cogoPC Plus, Windows, a wide variety of Windows applications, ArcGIS, ArcMap, ArcInfo, and InfoWorks
- Have experience leading both technical and non-technical staff throughout the project lifespan, from preliminary to implementation stages. Qualified updating masterplans, CIP forecasting and budgeting. Lead training programs for responsible staff.

WORK EXPERIENCE

City of Bryan January 2015 to Present
Asst. City Engineer
Served as Floodplain Administrator; lead engineer for development projects and as well as drainage specialist for development, CIP and citizen requests. Also served as lead engineer on residential building

permit issues such as structures located in the floodplain, foundation review and general drainage concerns.

City of Austin August 1998 to January 2015
Engineer
Austin, TX
Watershed Protection - Creek Hazard Flood Mitigation group team lead. Since April 2009, has been lead Engineer C responsible for supervising three Professional Engineers; acts as project sponsor/project manager on various CIP projects; provides technical support regarding hydrology and hydraulics to the entire department. Reviews and initiates various code and criteria changes, reviews proposed annexation and regional stormwater management plans, provides support for easement releases and license agreements, and evaluates various proposed projects including generating preliminary information/reports. As Engineering Reviewer, reviewed engineering work on preliminary plans, subdivision plats, subdivision construction plans, site plans, and various real estate and project determinations. Gained proficiency in roadway design and hydrologic and hydraulic design, including detention pond design, watershed analysis, floodplain analysis, and drainage easement analysis. Also gained experience working with the Land Development Code, various criteria manuals and the development process. While working in the Development Assistance Center, I gained skills working with the public and balancing their needs with our regulations.

City of Odessa August 1996 to August 1998
Associate Engineer
Odessa, TX
Engineering Division - Lead designer and specifications writer on a variety of projects, including paving and drainage projects, park projects, and CIP water and sewer replacement projects. Experience gained in plat reviews, flood permits and FEMA and NFIP guidelines. Managed the City's water distribution model and served as Public Works LAN Administrator. Read and used surveying notes.

Caldwell Design Service April 1995 to May 1996
Engineer
Caldwell, TX
Designed different types of projects ranging from civil to structural to mechanical, including modeling water distribution systems, and designing various platforms and walkways in an industrial environment. Worked with material handling projects including Hapman conveyors and raw screw feeders.

Texas A&M University January 1993 to May 1994
Teaching Assistant
College Station, TX
Civil Engineering Department

City of Caldwell May 1980 to April 1995
Laborer
Caldwell, TX

Part Time 1980 – January, 1987; January, 1993 – May, 1994
Full Time 1987 – January, 1993; May, 1994 – April, 1995
City of Caldwell, TX, Street Department - Gained practical experience in storm sewer installation, road design, and other engineering practices.

EDUCATION
Texas A&M University December 1992
B.S.: Civil Engineering
College Station, TX
Graduated Cum Laude

REFERENCES
Available upon request

Appendix D: Publicly Posted Agendas

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: February 7, 2018 – 3:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

To understand at meeting conclusion the magnitude and location of the hazard.

II. Agenda

1. Approve Public Planning Committee Meeting Minutes from January 17, 2018
2. Assess the Hazard:
    - I. Show and discuss the Floodplain maps
    - II. Show and discuss structures in the floodplain and spreadsheet of structures
    - III. Less-frequent flood hazards – dams and levees
    - IV. Likely to get worse
        - a. Changes in the floodplain development and demographics
        - b. Development in the watershed
        - c. Climate change
    - V. Other hazards, such as earthquakes, wildfires, and tornados
3. 2013 Goals and action plans
4. 2015 Annual Report

III. Homework Reminder

IV. Other Business

V. Adjourn

The next regular meeting of the Public Planning Committee is scheduled for Wednesday, February 14, 2018 at 3:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: February 14, 2018 – 3:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

To understand at meeting conclusion the problem and impact the hazards have on the community.

II. Agenda

1. Approve Public Planning Committee Meeting Minutes from February 7, 2018
2. Assess the Problem:
    a. Review draft of City's flood prone areas
    b. 2-D Model discussion by Jacob Torres
    c. Brainstorm impact of flooding on the features below
        i. Life safety and need for warning and evacuating residents and visitors
        ii. Public health including health hazards to individuals from flood waters and mold
        iii. Critical facilities and infrastructure
        iv. Community's economy and major employers
        v. The number and types of affected buildings
    d. Review drainage complaints from citizens
    e. Discuss the ability to "require or incentivize" floodplain dedication for preservation. – City preference – Martin, Linda, Paul
    f. Description of development, redevelopment, and population trends and a discussion of what the future brings for development and redevelopment in the community, the watershed, and the natural resource areas. - Martin
    g. Description of impact of the future flooding conditions on people, property, and natural floodplain functions.

III. Homework Reminder

IV. Other Business

V. Adjourn

The first open house is scheduled for Thursday, February 15, 2018 at 6:00 p.m.
The next regular meeting of the Public Planning Committee is scheduled for Thursday, March 1, 2018 at 4:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Open House #1

Meeting Date and Time: February 15, 2018 – 6:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

To listen to citizens' concerns and questions with regard to flooding and/or drainage in the City of Bryan.

II. Agenda

1. Explain the maps and Flood Mitigation Plan Update project
2. Separate into groups to look at maps and show drainage or flooding concerns

III. Other Business

IV. Adjourn

The next regular meeting of the Public Planning Committee is scheduled for Thursday, March 1, 2018 at 4:00 p.m.

The next open house is scheduled for Thursday, March 1, 2018 at 6:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: March 1, 2018 – 4:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

Work to produce a list of goals for the Flood Mitigation Plan Update.

II. Agenda

1. Approve Meeting Minutes from February 14
2. Assess the Hazard
    a. Likely to get worse
        i. Climate Change
3. Assess the Problem
    a. Discuss the ability to "require or incentivize" floodplain dedication for preservation. – City preference – Martin, Linda, Paul
    b. Description of development, redevelopment, and population trends and a discussion of what the future brings for development and redevelopment in the community, the watershed, and the natural resource areas. – Martin
    c. Description of impact of the future flooding conditions on people, property, and natural floodplain functions.
4. Set the goals

III. Homework Reminder

IV. Other Business

V. Adjourn

The second open house is scheduled for Thursday, March 1, 2018 at 6:00 p.m.
The next regular meeting of the Public Planning Committee is scheduled for Thursday, March 21, 2018 at 3:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Open House #2

Meeting Date and Time: March 1, 2018 – 6:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

To listen to citizens' concerns and questions with regard to flooding and/or drainage in the City of Bryan.

II. Agenda

1. Explain the maps and Flood Mitigation Plan Update project
2. Separate into groups to look at maps and show drainage or flooding concerns

III. Other Business

IV. Adjourn

The next regular meeting of the Public Planning Committee is scheduled for Thursday, March 21, 2018 at 3:00 p.m.

The next open house is scheduled for Monday, April 16 at 6:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: March 21, 2018 – 3:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

By meeting's conclusion, draft a list of goals, and review possible activites.

II. Agenda

1. Approve Meeting Minutes from March 1
2. Discuss the ability to "require or incentivize" floodplain dedication for preservation. – City preference – Martin, Linda, Paul
3. Review possible activities
   a. Preventive
   b. Property protection
   c. Natural resource protection
   d. Emergency services
   e. Structural projects
   f. Public information

III. Homework Reminder

IV. Other Business

V. Adjourn

The next regular meeting of the Public Planning Committee is scheduled for Wednesday April 11, 2018 at 3:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: April 11, 2018 – 3:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

By meeting's conclusion, finalize a list of goals, finish review possible activities worksheet, and draft a list of action statements for each goal.

II. Agenda

1. Approve Meeting Minutes from March 1 and March 21
2. Review and accept goals
3. Review possible activities worksheet
4. Draft Action Plan

III. Homework Reminder

IV. Other Business

V. Adjourn

The next regular meeting of the Public Planning Committee is scheduled for Wednesday April 25, 2018 at 3:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Meeting Agenda

Project Name: City of Bryan Flood Mitigation Plan Update – Public Planning Committee Meeting

Meeting Date and Time: April 25, 2018 – 3:00 P.M.

Meeting Location: Basement Training Room, Bryan Municipal Building, 300 South Texas Avenue, Bryan, Tx

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I. Purpose

By meeting's conclusion, the PPC will review and comment on the Draft Plan.

II. Agenda

1. Approve Meeting Minutes from April 11
2. Review Draft Plan

III. Homework Reminder

IV. Other Business

V. Adjourn

The next open house where citizens can review the Draft Plan is scheduled for Monday, April 30, 2018 at 6:00 p.m.

FOR INFORMATION ON SIGN LANGUAGE INTERPRETATION, TDD OR OTHER TRANSLATION OR ACCESSIBILITY INFORMATION, PLEASE CONTACT THE CITY OF BRYAN CITY SECRETARY'S OFFICE AT 979-209-5002 AT LEAST 48 HOURS BEFORE THE SCHEDULED TIME OF THE MEETING SO THAT YOUR REQUEST MAY BE ACCOMMODATED.

Para información en la interpretación de lenguaje por señas, TDD o otra información de traducción o accesibilidad, por favor contacte la Oficina de la Secretaria de la Ciudad de Bryan al 979-209-5002 por lo menos 48 horas antes del tiempo planificado de la reunión para que su petición pueda ser acomodada.

Appendix E: Advertisements

City of Bryan wants to hear from residents on flooding issues in the city

By Michael Oder | Posted: Tue 3:31 PM, Jan 30, 2018

BRYAN, Tex. (KBTX) - The City of Bryan is holding a series of public meetings to discuss flooding in the city.

Parts of the city saw substantial flooding in 2017. City officials are looking to get feedback as they review the Flood Mitigation Plan.

The meetings have been scheduled for the following dates:
February 7th - 3 PM
February 14th - 3 PM
February 15th - 6 PM
March 1st - 4 PM
March 1st - 6 PM
March 21st - 3 PM
April 11th - 3 PM

They will be held in the basement training room at the City of Bryan Municipal Office Building at 300 S. Texas Avenue.

The information gathered from citizens will be used in the process to update the current Flood Mitigation Plan. There are some frequently asked questions online. You can check them out in the Related Links section.

This Week's Circulars

http://www.theeagle.com/news/local/city-of-bryan-holding-meetings-starting-next-week-to-hear/article_c1644390-e1ef-56d5-a2cf-b20431c4d2bf.html

City of Bryan holding meetings starting next week to hear resident input on flooding

By CAITLIN CLARK caitlin.clark@theeagle.com Feb 1, 2018

The city of Bryan is hoping to hear from residents and business owners who have experienced flooding on their properties at a series of upcoming meetings.

Seven meetings will be held starting next week as part of the five-year update to the city's Flood Mitigation Plan, which is required in order for Bryan to participate in the Community Rating System, a voluntary program for communities that participate in the Federal Emergency Management Agency's National Flood Insurance Program.

The plan, which was most recently updated in 2013, was first adopted in 2007 to create a strategy for implementing flood mitigation measures. Assistant City Engineer Johnnie Price said it's used as a planning tool to help guide future development and identify ways the city can prevent future flooding and reduce losses. To help with the process, the city needs to collect data from property owners to compile flooding history for locations across the city.

Price said the meetings likely will consist of different stations attendees can visit to learn more and visit with staff members about issues they've experienced.

"We want to hear from everybody," he said, from people who have "nuisance flooding" in front of their property to those who routinely have large amounts of water in their homes after rain events.

"Hopefully we have a lot of people kind of giving voice to some of the concerns about different areas of the city that we really need to address," Price said.

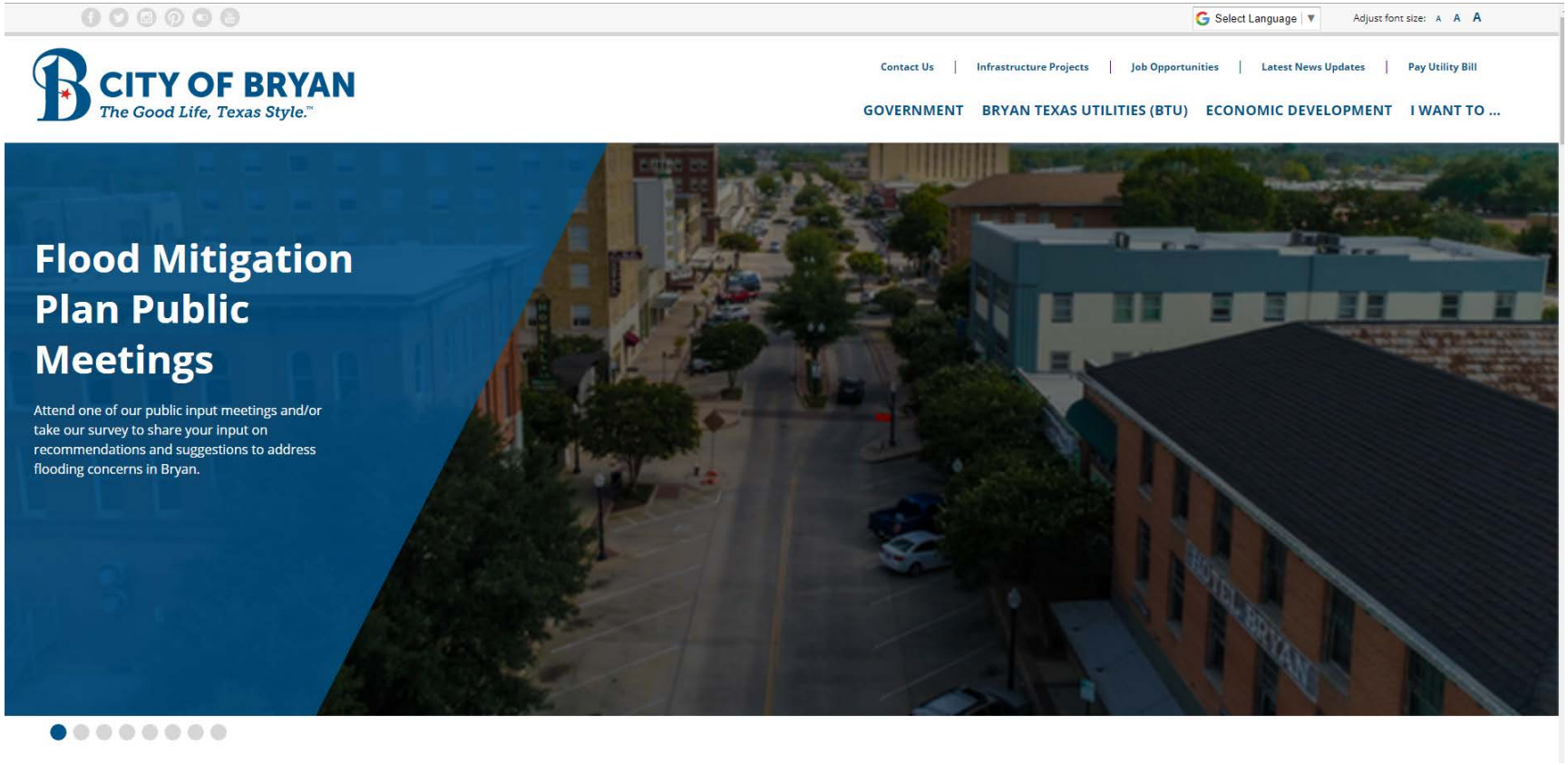
The update to the Flood Mitigation Plan will be developed with the guidance of a committee that will include engineers, business owners, insurance agents and other stakeholders. Rather than focusing on specific projects such as fixing culverts or clearing out channels, Price said he expects the plan update to emphasize big-picture issues and potential funding sources for flood mitigation.

Flood prevention has been a subject of many City Council meetings over the past few years. Funding sources and potential projects have been discussed several times, buyouts have been pursued for severe repetitive loss properties, and residents of District 2's Castle Heights neighborhood have been particularly persistent in asking for the city to do something about the flooding there.

The meetings will be held in the basement training room of Bryan's Municipal Office Building. They are scheduled for the following times: 3 p.m. Wednesday; 3 p.m. Feb. 14; 6 p.m. Feb. 15; 4 p.m. and 6 p.m. March 1; 3 p.m. March 21; and 3 p.m. April 11.

For those who can't attend one of the meetings in person, an online survey can be found at weblink.bryantx.gov/Forms/FMP through March 14. Price can also be contacted at 209-5030.

The City of Bryan website home page banner



The City of Bryan link from banner

March 23, 2018

Home / Articles / Press Releases / City Hosts Series of Public Meetings on Flood Mitigation Plan

City Hosts Series of Public Meetings on Flood Mitigation Plan

The City of Bryan is currently reviewing the Flood Mitigation Plan and as a part of this review, would like your input about flooding issues within our City limits. Residents are invited to attend the public meetings to listen to the discussion between City Staff and the Public Planning Committee as well as provide input at any of the three public input meetings. Please see the full schedule of public meetings and public input meetings noted below:

WHAT: Flood Mitigation Plan Public Meetings

WHEN:

February 7th – 3 PM

February 14th – 3 PM

March 1st – 4 PM

March 21st – 3 PM

April 11th – 3 PM

April 25th – 3 PM

WHERE: City of Bryan Municipal Office Building – 300 South Texas Avenue – Basement Training Room

WHAT: Flood Mitigation Plan Public Input Meetings

WHEN:

February 15th – 6 PM

March 1st – 6 PM

April 30th – 6 PM

WHERE: City of Bryan Municipal Office Building – 300 South Texas Avenue – Basement Training Room

The current Flood Mitigation Plan and a series of Frequently Asked Questions are available for viewing here.

The information gathered from citizens will be used in the process to update the current Flood Mitigation Plan maintained by the City of Bryan. If you are unable to attend any of the public input meetings but would still like to share your thoughts, please complete the **Flood Mitigation Plan Input Survey** or contact Johnnie Price, Assistant City Engineer, at 979.209.5030. Survey responses will be received through Wednesday, March 14, 2018.

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The City of Bryan Facebook posts

FEB
7

Flood Mitigation Plan Public Meeting: February 7th

Public · Hosted by City of Bryan - Government

Interested | Going | ...

Wednesday, February 7 at 3 PM - 5 PM
about 1 month ago

City of Bryan - Government
300 South Texas Avenue, Bryan, Texas 77803

Show Map

City of Bryan - Government added an event.
March 23 at 1:39pm ·

The City of Bryan is currently reviewing the Flood Mitigation Plan and as a part of this review, would like your input about flooding issues within our City limits. Residents are invited to attend a discussion with City Staff and the Public Planning Committee.

The current Flood Mitigation Plan and a series of Frequently Asked Questions are available for viewing online at bryantx.gov/fmp. The information gathered from citizens will be used in the process to update the current... See More

APR
30

Flood Mitigation Plan Public Input Meet...
Mon 6 PM CDT · City of Bryan - Government · Br...
Ashley and Lauren like this place

Interested

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The City of Bryan Nextdoor post

UPDATE: City Hosts Series of Public Meetings on Flood Mitigation Plan

Communications & Marketing Manager Kala McCain from City of Bryan · 5 Feb

The City of Bryan is currently reviewing the Flood Mitigation Plan and as a part of this review, would like your input about flooding issues within our City limits. Residents are invited to attend the public meetings to listen to the discussion between City Staff and the Public Planning Committee as well as provide input at any of the three public input meetings. Please see the full schedule of public meetings and public input meetings noted below:

WHAT: Flood Mitigation Plan Public Meetings

WHEN:
February 7th – 3 PM
February 14th – 3 PM
March 1st – 4 PM
March 21st – 3 PM
April 11th – 3 PM

WHERE: City of Bryan Municipal Office Building – 300 South Texas Avenue – Basement Training Room

---

WHAT: Flood Mitigation Plan Public Input Meetings

WHEN:
February 15th – 6 PM
March 1st – 6 PM
April 16th – 6 PM

WHERE: City of Bryan Municipal Office Building – 300 South Texas Avenue – Basement Training Room

The current Flood Mitigation Plan and a series of Frequently Asked Questions are available for viewing online at bryantx.gov/fmp. The information gathered from citizens will be used in the process to update the current Flood Mitigation Plan maintained by the City of Bryan. If you are unable to attend any of the public input meetings but would still like to share your thoughts, please complete the Flood Mitigation Plan Input Survey at bryantx.gov/fmp or contact Johnnie Price, Assistant City Engineer, at 979.209.5030. Survey responses will be received through Wednesday, March 14, 2018.

5 Feb · Subscribers of City of Bryan in General

THANK | 2 REPLY

The City of Bryan Twitter posts

City of Bryan @CityofBryan · Feb 15

Reminder! First public input meeting on Flood Mitigation Plan is this evening, 6 PM, basement training room of the Bryan Municipal Office Building (MOB). Details at bit.ly/2GtGWVr. #FMP #BryanTX #BetterInBryan #PublicInput #CitizenEngagement

Bryan Fire Dept., Bryan Police Dept., Brazos CEOC and Bryan ISD

City of Bryan @CityofBryan · Mar 1

Tonight! Second public input meeting for the Flood Mitigation Plan is tonight, March 1st, 6 to 8 PM. #BryanTX #BetterInBryan #FMP

1 1

Appendix F: Meeting Minutes

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Veronica Morgan, Kerry Pillow, Taylor Rose
Date:	January 10, 2018
Re:	City of Bryan Flood Mitigation Plan Update - Staff Committee Kickoff Meeting

---

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Staff Committee Kickoff meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnnie Price, PE, CFM, City of Bryan Assistant City Engineer
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP

Members not present

- Greg Cox, CBO, CFM, City of Bryan Chief Building Offical
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Kala McCain, City of Bryan Communications and Marketing Manager

Purpose:

- Discuss the upcoming meetings and timeline of events as well as the duties of the City of Bryan Staff Committee members.

Discussion Items:

- Veronica opened the meeting by presenting the background information on the flood mitigation plan and the flood insurance program for the City of Bryan. Mitchell & Morgan has completed the last two plans for the City of Bryan in 2007 and 2013. The 5-year update of the flood mitigation plan is due in 2018.

- Paul stated that the City of Bryan is currently a “Level 6” city. Paul said that he would like to stay at a “Level 6” but if the City were to go to a “Level 7” that would be okay, but he is not okay with the City falling to a “Level 8” or higher.
- Paul is currently not interested in pursuing a “Level 5” status if it involves a large expenditure of money for the City.
- Veronica discussed a few of the major changes to the CRS Coordinator’s Manual.
- The timeline for future meetings was discussed and Wednesday mornings were agreed upon for staff planning meetings and public planning meetings.
- March 14th was marked as a possible reschedule due to spring break.
- Open houses were agreed to be held in February most likely in the basement at the City of Bryan.
- The plan is to go to City Council on May 22nd and council workshop on April 24th.
- A draft of the plan will go on the City’s website for citizens to view.
- Johnnie reminded Mitchell & Morgan that there is a 2D model map created by the City of Bryan which shows velocities and depth of floodplain waters. Mitchell & Morgan agreed to make a separate map for this modeling effort.
- Jerry Henry discussed his list of critical facilities and Mitchell & Morgan will check the critical facilities map against his list.
- The Critical facilities and structures in the floodplain maps were reviewed.
    - Where are the critical facilities?
    - Can we get to them during an emergency?
    - Where are the biggest employers?
    - Where are group home facilities?
    - Jerry Henry to provide Mitchell & Morgan with his map information.
    - Horizontal disclaimer language
    - Structures may be elevated out of the floodplain
    - Single access subdivisions
    - Send critical facilities map to Jerry digitally
    - Separate map for flood prone drainage structures not in the floodplain
    - Add disclaimer
- Mitchell & Morgan to provide all committee members Meeting Minutes from each meeting that showcases the highlights and minutes for the meeting in case someone is unable to attend.
- How many meetings are we required to have with each committee for this FMP update?
- Projected Schedule Dates:
    - Committee Meetings are tentatively scheduled for Wednesdays from 11AM – 1PM, the City of Bryan will provide lunch for committee members.
    - Staff Committee / Public Planning Committee Meeting Dates
        - January 17th – (11:30AM – 1PM) (Location TBD) Public Planning Committee Kickoff Meeting
        - January 31st – Staff Committee Meeting
        - February 14th – Public Planning Committee Meeting
        - February 28th – Staff Committee Meeting
        - March 14th (Spring Break; need to pick an alternate day) – Public Planning Committee Meeting
        - March 28th – Staff Committee Meeting
        - April 11th – Public Planning Committee Meeting
        - April 25th – Staff Committee Meeting
    - Mitchell & Morgan to schedule two (2) Open Houses
    - April 24th – Council Workshop
    - April 24th – May 1st – Comment period
    - May 7th – Mitchell & Morgan to submit final report to Paul Kaspar
    - May 22nd – Projected Council Adoption
- Mitchell & Morgan to send out “homework assignments” to committee members.
- Email request for recurring monthly meeting dates to Public Planning Committee Members:
    - Maybe use doodle poll.

Follow-up Items:

- Mitchell & Morgan to update timeline and email to all committee members.
- Mitchell & Morgan to send recurring calendar events for all meetings.
- Mitchell & Morgan to send list of critical facilities to Jerry Henry.
- Mitchell & Morgan to send base maps to all Staff Committee Members.
- City of Bryan to provide lunch at all Committee meetings.
- Jerry Henry to provide Mitchell & Morgan with information regarding cri
- Mitchell & Morgan to send out "homework assignments" to committee members.
- Mitchell & Morgan to provide all committee members Meeting Minutes from each meeting that showcases the highlights and minutes for the meeting in case someone is unable to attend.
- Mitchell & Morgan to schedule two (2) Open Houses

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Nick Turnham, Spencer Buchannan, Lisa Cantrell
Date:	January 17, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Kickoff Meeting

---

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC Kickoff meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Glenn Jones, PE, CFM, J4 Engineering
- Rabon Metcalf, PE, CFM, RME
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Shawndra Curry, PE, Bryan Texas Utilities
- Bruce Jones, Jones & Associates Insurance
- Spencer Buchannan, TEXCON Contractors
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP

Members not present

- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Kala McCain, Communications and Marketing Manager
- Bryan Reece, Reece Homes
- Mark Carrabba, Carrabba Brothers, Ltd.
- Nick Turnham, Copperfield HOA
- Lisa Cantrell, CHI St. Joseph Hospital

- Kerry Pillow, Mitchell & Morgan, LLP

Purpose:

- Work to produce the five year update to the Flood Mitigation Plan at the end of this 5 month process.

Discussion Items:

- Paul opened the meeting by having everyone go around the room and introduce themselves.
- Veronica discussed the National Flood Insurance Program (NFIP) and the Community Rating System (CRS) which is a national program developed by FEMA that allows citizens of participating communities reduce their flood insurance premiums. Each community receives a CRS rating of 1-10 with 1 being the highest discounted community. Right now Bryan is a level 6 community. The goal of this update is to stay at a level 6 or 7. The point of the CRS program is to have no flood loss in your community. The Flood Mitigation Plan is just a piece of the CRS rating program. This plan is intended to be a public input plan and not a plan written by the city staff.
- The Public Planning Committee (PPC) was introduced as being stakeholders of different areas within the community each representing a different group of citizens.
- The PPC is required to have 5 meetings open to the public which means that based on the timeline presented we needed to add 2 more meetings to our schedule.
- At the PPC meetings FEMA requires at least ½ of the attendees be stakeholders.
- The timeline was discussed at length and Wednesday afternoon at 3pm was decided to be a good time for everyone. Meetings were moved to
    - February 7 at 3pm
    - February 14 at 3pm
    - March 1 at 4pm with Open House #2 immediately following at 6pm
    - March 21 at 3pm and;
    - April 11 at 3pm
- There are currently 2 open houses for the public to comment on the plan which occur near the beginning of the process but a 3rd open house was discussed to occur at the end of the process. Mitchell & Morgan to check the CRS requirements on an open house at the end of the process.
- Veronica defined flooding to be when water has entered homes or cars. She reminded everyone that streets are designed to carry storm water.
- Most of flooding issues occur from extreme rain storms and weather events such as Hurricane Harvey and the May 26, 2016 tornado.
- The list of problem drainage areas was assigned as homework to the PPC.
- Veronica defined critical facilities as waste water treatment plants, water plants, power plants, emergency management facilities, evacuation centers, bridges crossing major channels that allow citizens to evacuate and emergency vehicles to enter.
- An education program for citizens regarding flood insurance and flooding was suggested.
- Paul showed everyone the City of Bryan website that discusses flooding and flood insurance. It was suggested as homework for everyone to look at the website and the FAQ page. https://www.bryantx.gov/engineering-services/flooding/
- Mitchell & Morgan to provide the PPC with the last 5 year FMP update meeting minutes
- Paul also spoke about the annual report done by the City of Bryan for the CRS program. https://docs.bryantx.gov/engineering/Annual%20Progress%20Report%20on%20Flood%20Mitigation%20Plan%202015.pdf
- Jacob Torres talked about his modeling work with the City of Bryan that used LIDAR data and city storm sewer data to model flooding problems associated with the secondary drainage system. Paul reminded us that the TxDOT culverts were not shown on the maps and therefore the data is not perfect but does a good job seeing big picture problems.
- The critical facilities map and structures in the floodplain maps were reviewed by the group.

Follow-up Items:

- Mitchell & Morgan to update timeline and email to all committee members.
- Mitchell & Morgan to send recurring calendar events for all meetings.
- Mitchell & Morgan to send out “homework assignments” to committee members.
- PPC members to review the City of Bryan website and annual report for the CRS program.
- PPC members to fill out List of Problem Drainage Areas worksheet.
- Mitchell & Morgan to review CRS requirements regarding a 3rd open house at the end of the process.
- Staff members reminded to complete staff homework by next staff meeting January 31.
- Mitchell & Morgan to provide all committee members Meeting Minutes from each meeting that showcases the highlights and minutes for the meeting in case someone is unable to attend.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose
Date:	January 31, 2018
Re:	City of Bryan Flood Mitigation Plan Update - Staff Committee Meeting

---

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Staff Committee Meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Kala McCain, City of Bryan Communications and Marketing Manager
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP

Members not present

- Jerry Henry, City of Bryan Emergency Management Coordinator

Purpose:

- To discuss agenda for next PPC meeting on February 7, 2018 and compile homework assigned.

Discussion Items:

- Veronica opened the meeting by introducing the binders Mitchell & Morgan provided for everyone to keep their documents safe and organized.
- The Staff Committee approved the meeting minutes from January 10, 2018.
- The surveys went up on Tuesday, January 30, 2018 and the City has already received 6-8 survey responses from citizens and it was agreed that Johnny would send these responses once a week.

- Kala gave an update regarding the website and Public Meeting advertisements. Many avenues are being used to get the word out to the citizens including: news stories, Facebook events, Twitter posts, NextDoor events, radio advertisements, and television commercials. Johnny is scheduled to complete an interview on January 31, 2018 with The Eagle.
- The group discussed the protocol for public input. The public PPC meetings will be a time for citizens to listen to the discussions and the public will be allowed to give written comment at the PPC meeting and verbal comments will be at the open houses. Work stations during the open houses were agreed upon to be the easiest way for citizens to voice their opinions. This will be discussed with the PPC.
- Mitchell & Morgan will draft public PPC Meeting agendas for the City of Bryan to post 72-hours prior to each public meeting.
    - Mitchell & Morgan will submit each draft agenda no later than 96-hours prior to the posting deadline.
    - The draft agendas shall be submitted to Delores
    - Each agenda shall include the time, location, title, language translation notice, and agenda. The City of Bryan will provide Mitchell & Morgan will a previous agenda that we can use as a template for each agenda.
- Kala and Kerry will compile public outreach synopses, news stories, articles, and webpages for use in the final report.
- City of Bryan to provide Mitchell & Morgan with Laserfiche documentation for drainage complaints of historical damage to buildings and will check with Robin Archer-Kidd to see if the spreadsheet used in the 2013 FMP is being updated to include everything from Laserfiche.
- Robert Willis will ask if the City of Bryan Public Works office can fill out standard flooding complaint form during the survey period but also use the complaint information to complete the survey form issued with the FMP.
- The PPC agenda for February 7, 2018 was discussed. All agreed that the hazard for the FMP is flooding. The other hazards, earthquake, tornado, wildfires, will be addressed in the Brazos County All Hazards Plan. This will be discussed with the PPC to get their concurrence.
- City of Bryan to send most recent copy of All Hazards plan and a link to this will be shared with the PPC.
- February 7, 2018 PPC meeting is Assess the hazard and February 14, 2018 PPC meeting is Assess the Problem. Assess the problem is a large step so it will probably happen at both meetings.
- The GIS structures in the floodplain layer does not show elevations but City of Bryan does have another layer which shows if a parcel has an associated elevation certificate. Therefore, if there are two or more structures on one parcel there could be only one elevation certificate for one structure but not the other.
- Mitchell & Morgan to revise structures in the floodplain map and draft coinciding spreadsheet to show which structures have elevation certificates that show they are out of the floodplain vertically and which structures have had complaints that prove they have been flooded previously.
- City of Bryan to draft disclaimer language to put on the floodplain map to explain the elevation data and discussing limitations of the data.
- The City of Bryan does have a few TCEQ regulated dams with action plans for Lake Bryan and Country Club Lake. Less-frequent flooding hazards and dams will be addressed to the best of our ability. To the Staff Committee's knowledge, there are no levees in the City of Bryan.
- Mitchell & Morgan to call TCEQ to see if they have some data about dams in the Brazos County and more specifically in the City of Bryan.
- The CRS Manual "likely to get worse" section was discussed. Climate change is among that section. It was agreed that Mitchell & Morgan would look into TxDOT IDF Curves and ATLAS for climate change data.
- Paul mentioned a presentation he listened to at CECON that was presented bu Dr. John Nielson-Gammon. Dr. Nielson-Gammon had some interesting slides implying climate change and the need for engineers to address new higher storm events.
- Veronica asked the question how we use floodplains for natural purposes.

- There was discussion about documenting how the City has used floodplain property in regards to park development and/or greenspace. Subdivision examples that were discussed included Austin's Colony, Edgewater, and Green Briar
- Mitchell & Morgan will produce a map of all the development in the floodplain including parks and greenspace.
- City of Bryan to draft a discussion of how the LOMR data is added to the floodplain in GIS.
- Johnny to send Mitchell & Morgan the 2016 annual report for the 2013 FMP.
- Incomplete homework is shown on the meeting agenda in red.
- Staff homework was discussed and clarified.
- A third open house was added to the calendar at the end of the plan update – April 16, 2018 at 6:00pm.
- Mitchell & Morgan to review Blueprint 2040 the City of Bryan's 2016 Comprehensive Plan.

Follow-up Items:

- City of Bryan to update public outreach advertisements to specify public input and public attendance meetings. – Kala and Delores
- Mitchell & Morgan to draft public agendas for the public meetings that need to be delivered to City of Bryan 96 hours prior to meeting.
- Kala and Kerry will compile public outreach synopses, news stories, articles, and webpages for use in the final report.
- City of Bryan to provide Mitchell & Morgan with Laserfiche documentation for drainage complaints of historical damage to buildings and check with Robin to see if the spreadsheet used in the 2013 FMP is being updated to include everything from Laserfiche. – Paul, Johnny and Delores
- Robert Willis will ask if the City of Bryan Public Works office can fill out standard flooding complaint form during the survey period but also use the complaint information to complete the survey form issued with the FMP.
- City of Bryan to send most recent copy of All Hazards plan.
- City of Bryan to draft disclaimer language to put on the floodplain map to explain the elevation data and discussing limitations of the data. – Delores
- Mitchell & Morgan to revise structures in the floodplain map and draft coinciding spreadsheet.
- Mitchell & Morgan to call TCEQ to see if they have some data about dams in the Brazos County.
- Mitchell & Morgan to get in touch with Dr. Neilson-Gammon regarding his CECON presentation.
- Mitchell & Morgan to make a map of all the development in the floodplain including parks and greenspace.
- City of Bryan to draft a discussion of how the LOMR data is added to the floodplain in GIS. - Johnny
- City of Bryan to send Mitchell & Morgan the 2016 annual report for the 2013 FMP. - Johnny
- City of Bryan staff to continue working on assigned homework from January 10, 2018 meeting.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Nick Turnham, Spencer Buchannan, Lisa Cantrell
Date:	February 7, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Meeting

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Kala McCain, Communications and Marketing Manager
- Glenn Jones, PE, CFM, J4 Engineering
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Shawndra Curry, PE, Bryan Texas Utilities
- Bruce Jones, Jones & Associates Insurance
- Spencer Buchanan, TEXCON Contractors
- Lisa Cantrell, CHI St. Joseph Hospital
- Mark Carrabba, Carrabba Brothers, Ltd.
- Bob Stipanovic, Parkway Terrace HOA (representing Nick Turnham)
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP

Members not present

- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Bryan Reece, Reece Homes

- Rabon Metcalf, PE, CFM, RME

Purpose:

- To understand at meeting conclusion the magnitude and location of the hazard.

Discussion Items:

- Veronica Morgan opened the meeting by introducing the public to the Flood Mitigation Plan and gave a brief explanation of what the purpose of this meeting was.
- The first item on the agenda was to approve the meeting minutes from January 17, 2018. Ron Schmidt moved to approve the minutes and Lisa Cantrell seconded. Motion passed.
- This meeting and the next meeting (February 14) will be to discuss the hazard and identifying the problem. The first open house will be Thursday, February 15 at 6:00 pm.
- Ron Schmidt asked how often FEMA updates the floodplain. Veronica Morgan and Paul Kaspar explained that they don't have a structured timeline but they have been updating more regularly within the late decade. LOMR and LOMAs were explained and have been updated on the maps shown. City of Bryan has drainage ordinances that requires developers to update when affecting floodplains.
- The structures in the floodplain maps were shown to help the PPC find the locations of the problem.
- The PPC was reminded that structure flooding is not just from floodplains. Some flooding could be from secondary drainage (i.e. streets, storm sewers, culverts, etc.). This is why some data points shown that have structure flooding are not close to a creek. Jacob Torres will discuss his 2D model that helps find these problems on February 14.
- The flooding event table from the Brazos County All Hazards plan was shown.
- There are 3 dams in Bryan that are considered to be of high hazard. Bryan Utilities Dam, Country Club Lake Dam, and Finfeather Lake Dam.
- Bryan Utilities Dam holds 13,647 feet of water and if a breach occurred the water would travel 24 miles downstream.
- If Country Club Lake Dam were to breach it would travel about 2 city blocks downstream and impact 279 people or 93 structures.
- Finfeather Lake Dam holds about 50.8-97.8 million gallons and if a breach were to occur the water would travel 2.8 miles downstream.
- The group was reminded that the city and TCEQ require yearly inspections for all high hazard dams that require a report to be completed and maintenance to be done to keep the dams functioning.
- When discussing development in the watershed, as a reminder the CRS Manual is written for all communities. Bryan is considered to be on the sophisticated side because we already have a drainage ordinance in place which helps protect the watershed and allows the City to monitor the development in the floodplain.
- Climate change has been added to the problems likely to get worse since the 2013 FMP. Discussion of this item was pushed to a later meeting because Mitchell & Morgan is working on getting some data from TAMU meteorology professor, Dr. Nielsen-Gammon.
- The Development and Parks in the Floodplain map was shown. This map shows how much development and parkland we are developing in the floodplain.
- The City of Bryan does not want all of their parkland in the floodplain but it is a great way to ensure the area stays as greenspace which allows those flood waters to pass through it.
- The development data shown is based upon a GIS querry to be only platting actions and site plans in the floodplain.
- A repetitive loss property is "any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within a rolling ten-year period". Therefore, any home that does not have flood insurance will not show up on any repetitive loss list regardless of flood damage.
- Tables of SRL and RL data vs. elevation certificates and/or drainage complaints were shown. These tables correspond with the structures in the floodplain maps. Paul Kaspar reminded everyone this information is confidential.

- A Venn diagram was shown to explain how the data was compiled and related.
- An elevation certificate is a certificate completed by a surveyor that shows the elevation of the foundation, the area around the home, and the floodplain in that area. It is used by the City to confirm that a home that is in the floodplain is built high enough so that the home is unlikely to flood. Also used to determine your flood insurance premium based on your risk of flooding. For example, if you are 2 feet above the floodplain elevation your premium would be less expensive than a homeowner whose house is 2 feet below the floodplain elevation.
- Ron Schmidt asked about the maintenance of detention ponds required by the City. Paul Kaspar explained that typically the City uses interns to help inspect all of the ponds. Since many of the detention ponds are privately owned letters are written to the owners to remind them about the importance of maintenance. Paul Kaspar also mentioned that some of the newer ponds have included an elevation benchmark at the bottom of the pond to determine the amount of silt buildup. This topic will likely be discussed further at our "set goals" meeting on March 1.
- Ron Schmidt also asked about wetlands not in floodplain areas. Wetlands are defined by environmental scientists who test the soil to see if they are hydric soils. Just because a creek crosses your property does not mean it has a wetland on it. Wetlands can also be isolated or not contiguous with the creek channel.
- Veronica Morgan reminded everyone to write down any flooding problems they see in the City so we can discuss them at our "set goals" meeting on March 1.
- PPC and public looked at all the maps and were able to ask questions and talk about areas with drainage issues. The public was also able to write down their comments for Mitchell & Morgan to review.
- Ron Schmidt asked how you mitigate flooding in homes that were built before the floodplain maps were used. Veronica Morgan stated that some of the problems are so expensive that the expense to fix the problem is much greater than the worth of the homes protected. Some homes will be so deep in the floodplain that a buyout is the most cost effective option.
- Paul Kaspar discussed the active hazard mitigation grant held by the City of Bryan. They have applied for 4 homes to be bought in the floodplain and are waiting for information from the state. The funds are 75% federal funds and 25% city funds. All four of the homes they are targeting for buyout are on the repetitive loss list. Once the homes are bought they will be demolished and returned to the natural topography, must remain vacant, and are maintained by the City.
- Paul Kaspar brought up stream bank erosion that might be so severe that a house is going to fall into the creek. It was agreed that that issue should be considered in the floodplain mitigation plan update and will be discussed at a later meeting.

Follow-up Items:

- PPC to write down any flooding problems they see in the City so we can discuss them at the next meeting on February 14 and our "set goals" meeting on March 1. If you do have a problem you want to discuss please email me at michele@mitchellandmorgan.com so we can provide some data that would help us find where that problem is located within the city.
- Mitchell & Morgan to modify maps to have more street names.
- Jacob Torres to be prepared to give a 15-20 minute presentation to discuss the 2D Model at the February 14th PPC Meeting.
- Mitchell & Morgan to provide more data at the next meeting to help find where the problems are located.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Nick Turnham, Spencer Buchannan, Lisa Cantrell
Date:	February 14, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Meeting

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Kala McCain, Communications and Marketing Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Glenn Jones, PE, CFM, J4 Engineering
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Shawndra Curry, PE, Bryan Texas Utilities
- Bruce Jones, Jones & Associates Insurance
- Spencer Buchanan, TEXCON Contractors
- Lisa Cantrell, CHI St. Joseph Hospital
- Mark Carrabba, Carrabba Brothers, Ltd.
- Rabon Metcalf, PE, CFM, RME
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP

Members not present

- Linda Cornelius, City of Bryan Parks & Recreation Director
- Bryan Reece, Reece Homes
- Nick Turnham, Copperfield HOA

Purpose:

- By the meeting's conclusion, the goal was to better understand identified problems and the impact that these hazards have on the community.

Discussion Items:

- Veronica Morgan showed a list of flood prone areas drafted by Mitchell & Morgan. PPC members were encouraged to add any areas to the list. There were none added at that time.
- The bulk of this meeting was to brainstorm the problems and impact the hazards have on the community. The hazards have been identified in the last two (2) meetings as flooding from rising creek waters, erosion of creeks, non-functional detention ponds, and flooding from secondary drainage systems.
- The next step for the PPC is to create a list of goals to help mitigate the problems we identified.
- The impact of flooding on life safety, public health, critical facilities, major employers, and the number and types of affected buildings were all discussed so that the PPC could brainstorm in small groups.
- Robert Willis spoke regarding the City of Bryan's roadway maintenance procedures and policies during storms. He explained there are proactive responses and reactive responses to how the City responds during a storm event. Hurricane Harvey was a proactive response because they knew it was coming and were able to set up barricades at flood prone intersections (a list itemizing known flood prone intersections was provided to the PPC). The May 2016 tornado was a reactive response and the City's Public Works Department was called out to set up barricades after the storm had already started. During that particular storm event, the Public Works Department ran out of barricades and called out any City departments that were able to help. They parked trucks with lights to block the flooded roads to wait until the water receded to six-inches (6") or less.
- Jerry Henry spoke about the City of Bryan's emergency management protocols. The National Weather Service sends emails to the Emergency Management Group when severe weather is expected in this area. Jerry Henry then forwards those email to City officials. The fire and police department dispatchers have been very good at calling the emergency management team when something does happen that was not expected. The City also has a reverse 911 system which allows a specific area to be selected and automatically calls all landlines in that location with a severe weather alert. To modernize this system, Code Red was created which sends automatic texts, calls, and/or emails for emergencies in Brazos County to Citizens that are signed up. The Community Emergency Operations Center (CEOC) is made up of representatives from the City of Bryan, the City of College Station, Brazos County, and Texas A&M University which provides a unique group that works together to create emergency management plans. Jerry Henry also brought the Brazos County Interjurisdictional Emergency Management Plans for the PPC to look at. Public Information Officers from police, fire, and both cities post on social media to alert citizens of emergency situations. During the May 2016 storm, Community Emergency Response Team (CERT) groups were utilized to help during the emergency. CERT is a class which informs citizens about hazards and things they can do around their home to protect themselves.
- Jacob Torres spoke about the 2-Dimensional (2D) drainage model created by LAN for the City of Bryan. The models represent the storm events to identify issues so that the problems can be solved. A 1-Dimensional (1D) model is water flowing through a channel in one direction. The floodplain maps are considered 1D modeling. A 2D model operates where the topography is made up of grid-cells and then rain is dumped on that area. The model maps where the water goes in all directions 2D modeling is similar to pouring syrup on a waffle. The 2D models created by LAN were used to determine secondary drainage issues throughout the city. The 2D models are helpful for sheet flow patterns in urban areas like Bryan. This model has been used by the planning and development group to find problems with secondary drainage but also to look at future planning areas that may have flooding issues. Paul Kaspar noted that this model is not available for the public because the model is not yet perfect; There are some culverts (TxDOT, private driveways, etc.) that are not in the data and therefore not in the model. Therefore, the

model may show flooding issues in an area where in real life the water is carried by the missing culvert. Paul Kaspar discussed that a citizen could come to Johnny Price or himself with questions regarding a certain property and they would be willing to show them the 2D model and discuss its findings with them. Jacob Torres briefly mentioned the increase in the 100-year storm event from NOAA preliminary graphs. It would increase the 100-year storm event in the Bryan/College Station area by one to two-inches (1"-2"). This will be discussed further at a future meeting. Jacob Torres gave a real-world example of how the 100-year storm is calculated by finding the one percent (1%) tallest height in a group of ten (10) people. To get the one percent (1%) height, we line everyone up from shortest to tallest and then the tallest person of the ten (10) people is considered to be the one percent (1%). Now if three (3) more people join the room in order to get the correct one percent (1%) of people in the room you would have to line everyone up again and find the tallest person. This is why the 100-year storm event could be larger now than it has been in the past.

- Veronica Morgan gave definitions for repetitive loss and severe repetitive loss according to the CRS:
  - A repetitive loss property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten (10) year period.
  - Severe repetitive loss properties are those buildings that either have four or more claims of $5,000 or more, or have at least two (2) claims that cumulatively exceed the building's value.
- Three (3) teams were created to brainstorm through the impact of flooding on the community. The lists have been provided with these meeting minutes as an attachment. Each team shared their ideas.
- Veronica Morgan explained that these lists are going to be used to create our goals for the next five (5) years in the Flood Mitigation Plan. The PPC should be thinking about these items and bring any more ideas to the next PPC meeting.
- Paul Kaspar asked if these more general ideas are going to be more defined or if the more specific ideas are going to be more generalized. Veronica Morgan and Michele Sullivan explained that the ideas are going to be made more general to be an overall goal and then a little more defined for a few objectives under the goal and then even more specific for the action plans. PPC members were reminded to look at the goals and actions plans from the 2013 FMP provided in your binders.
- Michele Sullivan reminded everyone that the agenda items d, e, and f were moved to a future agenda.
- Veronica Morgan reminded everyone that the first public open house is Thursday, February 15, 2018 at 6:00pm.

Follow-up Items:

- PPC members to write down any ideas that would fit into the brainstorm activity "What to fix" list.
- PPC members to look at the goals and actions plans from the 2013 FMP provided in their binders.
- Jacob Torres and Mitchell & Morgan to work together to create an overlay map of the 2D model and the structures in the floodplain map.
- City of Bryan staff members to continue their homework assignments from January 31st meeting.
- Mitchell & Morgan to bring critical facilities maps, repetitive area maps, and drainage complaints maps to all open houses.

If you have any questions or comments, please feel free to contact me at 979-260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose
Date:	February 28, 2018
Re:	City of Bryan Flood Mitigation Plan Update - Staff Committee Meeting

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Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Staff Committee Meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Ken Smith (representing Kala McCain), City of Bryan Web Communications Specialist
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP

Members not present

- Linda Cornelius, City of Bryan Parks & Recreation Director

Purpose:

- To discuss agenda for next PPC meeting on March 1, 2018 and compile homework assigned.

Discussion Items:

- Veronica Morgan opened the meeting at 10:35 am.
- The meeting minutes from January 31st staff meeting were approved.
- Kala McCain sent out an email prior to the meeting to update everyone on the media outreach. The radio station is still putting more emphasis on the PPC meetings rather than the open houses. Kala McCain has reached out to them to fix the issue.
- Ken Smith also updated the group regarding media relations including Nextdoor, Facebook, Twitter, Instagram, radio interviews, and email press release.

- The PPC meeting agenda for March 1st meeting was reviewed. The PPC meeting will focus on setting goals for the Flood Mitigation Plan.
- Paul Kaspar stated that the Flood Mitigation Plan will be moved off of the April 24th City Council Workshop agenda and the City Council Meeting on May 22nd. He will provide the corrected dates as soon as possible.
- Veronica Morgan stressed the need for Linda Cornelius or a representative from the Parks & Recreation Department to speak at the March 21st meeting regarding floodplain dedication for preservation. She noted that there is only one more planning meeting for the PPC before Mitchell & Morgan starts drafting the plan. Therefore, there is a possibility of another PPC planning meeting if the PPC members do not finish goals, objectives, and action statements during the March 21st meeting.
- Michele Sullivan discussed the ideas Mitchell & Morgan had for engaging the PPC members and setting goals for the plan at the March 1st meeting. She reviewed the Example Goals that were compiled from other communities' Flood Mitigation Plans. The goals are to be used as kick-starts for the PPC members to understand what is expected of them.
- Paul Kaspar suggested that Mitchell & Morgan provide a template for the PPC members to understand what the flood mitigation plan should look like at the end of the "Set Goals" meeting on March 1st and the "Review Activities" meeting on March 21st.
- Mitchell & Morgan to provide a copy of a few cities objectives and action statements for the PPC to review.
- City of Bryan to confirm City Council dates for workshop and adoption of the Flood Mitigation Plan.
- Veronica Morgan questioned the need for the discussion on climate change at the PPC meeting. She stated that the statistical data for rainfall over the last few decades has seen an increase creating larger event storms more frequently than historical data suggests. She and Paul Kaspar agreed that this is the basic takeaway regarding climate change. Veronica Morgan noted that Jacob Torres' presentation on February 14th explained this concept in great detail which is enough for the PPC members to understand the problem.

Follow-up Items:

- Mitchell & Morgan to draft public agendas for the public meetings that need to be delivered to City of Bryan 96 hours prior to meeting.
- Kala and Kerry will compile public outreach synopses, news stories, articles, and webpages for use in the final report.
- Mitchell & Morgan to call TCEQ to see if they have some data about dams in the Brazos County.
- City of Bryan to draft a discussion of how the LOMR data is added to the floodplain in GIS. – Johnny
- City of Bryan to confirm City Council dates for workshop and adoption of the Flood Mitigation Plan.
- City of Bryan staff to continue working on assigned homework from January 31, 2018 meeting.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Nick Turnham, Spencer Buchannan, Lisa Cantrell
Date:	March 1, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Meeting

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Kala McCain, Communications and Marketing Manager
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Shawndra Curry, PE, Bryan Texas Utilities
- Bruce Jones, Jones & Associates Insurance
- Spencer Buchanan, TEXCON Contractors
- Mark Carrabba, Carrabba Brothers, Ltd.
- Rabon Metcalf, PE, CFM, RME
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP

Members not present

- Glenn Jones, PE, CFM, J4 Engineering
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Lisa Cantrell, CHI St. Joseph Hospital
- Bryan Reece, Reece Homes
- Nick Turnham, Copperfield HOA

Purpose:

- The goal of the meeting was to, by the meetings conclusion, produce a list of potential goals for the City of Bryan Flood Mitigation plan.

Discussion Items:

- Veronica Morgan opened the meeting by introducing the Mitchell & Morgan staff, the PPC members, and the Flood Mitigation Plan to the members of the public in attendance at the meeting.
- Michele Sullivan led the rest of the meeting.
- Ron Schmidt moved to approve the meeting minutes from February 14, 2018. Martin Zimmermann seconded the motion. The motion passed unanimously.
- Martin Zimmermann discussed the new development around the City of Bryan which lie near a creek or in the floodplain. These developments included The Ranch at Riverside Parkway, Edgewater, Regency Gardens, Forest Pines Apartments, Hawthorne at Traditions Apartments, Austin's Colony, Greenbrier, Oakmont, and Saladiner.
- Martin Zimmermann mentioned that the City of Bryan is expected to hit 100,000 citizens by 2025 which means an increase of about 18,000 residents in the next seven (7) years. He concluded that this growth is occurring on the East and West sides of the city and will continue to occur.
- Johnny Price noted that detention at the bottom third (3rd) of the watershed is detrimental to properties upstream. In the BCS Unified Design Guidelines detention is not required in the bottom third (3rd) of the watershed. At the top third (3rd) of the watershed detention is required and in the middle a No Adverse Impact Report is required for the development.
- Paul Kaspar explained on-stream detention which allows the development to create storage on the stream itself rather than building a separate pond.
- Veronica Morgan asked about how to protect the on-stream detention pond from collecting silt and losing necessary capacity. Paul Kaspar explained the City of Bryan's new standard of placing "grade marks" in the bottom of the pond so that an inspector can dig down to the concrete mark and require the owner to excavate the silt from the pond. Johnny Price also mentioned placing a flood marker in the pond to mark height of water in the pond.
- Veronica Morgan mentioned the "assess the hazard" topic of climate change which was skipped on the February 7 meeting. The statistical data for rainfall events in Texas over the last few decades has seen an increase, creating larger events storms more frequently than historical data suggests. Jacob Torres discussed the topic in depth during his presentation on February 14. Meteorologists have encouraged the engineering administrations to redesign the 100-year storm based on these statistics.
- Michele Sullivan explained the Example Goals handout and the Setting Goals activity to the PPC. The PPC then had 15 minutes to write down six (6) goals, on the provided sticky notes, which they would like to see in the FMP. The goals were posted on the board and were categorized by the six (6) categories of floodplain management activities in the CRS Manual (preventive, property protection, natural resource protection, emergency services, structural projects, and public information).
- The common goals were read aloud and a list of goals brought up during the activity are attached.
- Each table picked two (2) categories to discuss action statements for the goals discussed. More of this will be done at the March 21st meeting.
- Mitchell & Morgan reminded PPC members that there is only one more planning meeting before Mitchell & Morgan will have to draft the plan. If the PPC does not create a list of goals, objectives, and action plans at the March 21st meeting another meeting will be held to finish the list. Mitchell & Morgan is going to schedule a tentative extra PPC meeting so that it is on everyone's calendar and will cancel the meeting if it is not necessary.

Follow-up Items:

- PPC members to write down any ideas for action statements.
- PPC members to look at the goals and actions plans from the 2013 FMP provided in the provided binders.
- Mitchell & Morgan to discuss an additional PPC meeting at the March 21st meeting.
- Mitchell & Morgan to compile all the goals written during the goal activity.

If you have any questions or comments, please feel free to contact me at 979-260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Michele Meade, Jason Ware, Richard O'Malley, Bart Benthul, Megan Lott, Prarthana Banerji, Emily Fisher, Brian Hilton, Carol Cotter, Chad Bohne, Michael Parks, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Spencer Buchannan, Lisa Cantrell
Date:	March 13, 2018
Re:	City of Bryan Flood Mitigation Plan Update – Agency Coordination Meeting

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Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Agency Meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Michele Meade, Brazos County Emergency Management
- Jason Ware, Brazos County Emergency Management
- Richard O'Malley, Blinn College
- Bart Benthul, Bryan/College Station Metropolitan Planning Organization
- Megan Lott, CFM, Brazos County Road & Bridge
- Prarthana Banerji, Brazos County Road & Bridge
- Emily Fisher, City of College Station Public Works
- Brain Hilton, City of College Station Emergency Management
- Carol Cotter, PE, City of College Station City Engineer
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP

Agencies not present

- TxDOT
- Brazos Valley Council of Governments

Purpose:

Coordinate with agencies and organizations outside the community's governmental structure to be involved in the planning of the City of Bryan Flood Mitigation Plan 5 year Update.

Discussion Items:

- Veronica Morgan began the meeting by introducing the Flood Mitigation Plan and explaining what the purpose of this meeting was.
- The City of Bryan has a large number of repetitive loss (>10) which requires the City to develop either a floodplain management plan or a repetitive loss area analysis that covers all of its repetitive loss areas. The City of College Station does not pass the threshold and therefore uses the Brazos County All Hazards Plan to be designated as a CRS community. Bryan is rated as a six (6) community and College Station is a seven (7) community.
- Veronica Morgan explained the Public Planning Committee (PPC) and gave an update of the group's progress towards setting the goals for the plan.
- Veronica Morgan mentioned the critical facilities discussion had with the PPC and the only issue seen at the time was the lack of access and emergency services on the east side of Bryan. During the May 2016 flood event the only non-flooded crossing over Carters Creek and Highway 6 was William D. Fitch Parkway in South College Station.
- Michele Meade commented on the May 2016 flood event in regards to the entire county. She said that the only reason the same flooding did not occur during Hurricane Harvey was because of how the rain fell. During Hurricane Harvey around 60 county roads were shut down due to flooding and 3 major roads coming into the county were shut down. Brazos County has to meet a threshold to be eligible for reimbursement from FEMA. They have met the threshold in 2015 and 2016 and are awaiting evaluations by FEMA. This poses a huge threat to the future of the County in regards to flooding.
- Discussions were had between Paul Kaspar and Megan Lott regarding real-time updates to the roadways during a storm event. The City of Bryan keeps a list internally that names all of the known roads with flooding concerns however, that list is not published online nor does it have a real-time online presence. The information for the citizens during flood events is relayed through the City of Bryan Communications and Marketing group.
- The group mentioned that there is not a good crossing of Wickson Creek.
- Michele Meade brought up a big concern of flooding in the southern portions of the county in the rural areas due to increased development in Bryan/College Station.
- Veronica Morgan mentioned increased high intensity rain events and the statistical reports that show that the 100-year event could see an increase in rainfall.
- Discussions were had regarding how to regulate in Zone A FEMA Floodplain as well as how development affects property downstream.
- Paul Kaspar asked the agencies present if the increased runoff or faster runoff is studied when they build or renovate a roadway.
- Emily Fisher mentioned that the City does not have ownership of a lot of the creeks which decreases their ability to maintain the creek. Veronica Morgan also mentioned the politics within the issue with City Council constantly changing and policies changing with each new regime.
- Currently all entities require a private drainage easement to be dedicated on any new plat with a creek.
- Veronica Morgan, Johnny Price, and Carol Cotter discussed the NAP-Natural Areas Protected and NAR-Natural Areas Reserved zonings in the City of College Station which allows for the floodplain to be protected by zoning. This is something that the City of Bryan does not have on their land use plan.
- Veronica Morgan reminded the attendees of the next PPC meetings held in the Municipal Office Building Basement Training Room.
    - March 21st at 3:00 pm
    - April 11th at 3:00 pm
    - April 25th at 3:00 pm – Review of the draft plan
    - Open House #3 – Review of the draft plan – April 30th at 6:00 pm

Follow-up Items:

- Richard O'Malley to discuss with Shawn Welch to see if Blinn College had any flooding concerns during the May 2016 flood event.
- Mitchell & Morgan to schedule an additional meeting with TxDOT.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Spencer Buchannan, Lisa Cantrell
Date:	March 21, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Meeting

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Glenn Jones, PE, CFM, J4 Engineering
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Shawndra Curry, PE, Bryan Texas Utilities
- Bruce Jones, Jones & Associates Insurance
- Spencer Buchanan, TEXCON Contractors
- Mark Carrabba, Carrabba Brothers, Ltd.
- Lisa Cantrell, CHI St. Joseph Hospital
- Bryan Reece, Reece Homes
- Rabon Metcalf, PE, CFM, RME
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP
- Kerry Pillow, Mitchell & Morgan, LLP

Members not present

- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Kala McCain, Communications and Marketing Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP

Purpose:

- The goal of the meeting was to, by the meetings conclusion, produce a set of goals and review possible activities.

Discussion Items:

- Michele Sullivan opened the meeting by welcoming the public and reminding them to fill out a comment card with any problems or suggestions for the PPC.
- A PPC meeting was added on April 25th and the 3rd open house has been moved to April 30th. An updated timeline was provided to the PPC members at the meeting.
- Michele Sullivan ran thru a schedule for the meeting to keep the meeting on time.
- Linda Cornelius discussed different communities' floodplain dedication tactics to use as parkland. She brought the PowerPoint presented to the City of Bryan Parks Board with the conclusion from the Park Board that the City of Bryan should implement a new ordinance which defines rules for dedicating floodplain areas for preservation.
- The PPC members were split into six groups which each had a different topic from the Goals Activity Responses from the March 1st meeting. The groups had to write a goal which combined the example goals pertaining to the topic assigned to the table. The goals were posted on the walls and read aloud for the group to discuss. The group all agreed on the following goals:
    - Develop and improve communication mechanism to provide outreach and public awareness regarding preparedness and mitigation actions to better inform developers, engineers, builders, and the public about ways they can avoid flood damage.
    - Protect and enhance natural floodplain and storm water resources by adopting and implementing sustainable flood-management policies.
    - Provide fiscally responsible funding, without overburdening citizenry, to implement projects, programs, and services outlined in the Flood Mitigation Plan.
    - Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to flood and flash flood hazards.
    - Reduce, and where possible, eliminate repetitive damage, loss of life, and loss of property caused by disaster and flooding.
    - Identify the needs and implement additional emergency operation plans and services for areas at high risk of flooding.
    - Leverages city wide 2D Model to consolidate rainfall data and produce real-time flood warning/forecasting system to notify residents and city staff for emergency access.
- Michele Sullivan introduced the next step which is Review Possible Activities. Each group picked one of the six (6) credited categories (Preventive, Property Protection, Natural Resource Protection, Emergency Services, Structural Projects, and Public Information). The categories were then reviewed against each goal for applicability, pros, and cons for each activity listed under the category. Each table was given a worksheet to help with this step. The worksheet responses are attached.

Follow-up Items:

- Mitchell & Morgan to send updated calendar invites to match the updated timeline.

If you have any questions or comments, please feel free to contact me at 979-260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose
Date:	March 28, 2018
Re:	City of Bryan Flood Mitigation Plan Update - Staff Committee Meeting

---

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Staff Committee Meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Kerry Pillow, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP

Members not present

- Linda Cornelius, City of Bryan Parks & Recreation Director
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Kala McCain, City of Bryan Communications and Marketing Manager
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP

Purpose:

- To discuss goals set by PPC at March 21st meeting, agenda for next PPC meeting on April 11, and compile homework assigned.

Discussion Items:

- Michele Sullivan opened the meeting at 10:36 am.
- Delores Soto reminded Michele Sullivan to send meeting minutes from the February 28th meeting. Approving the meeting minutes from February 28th has been moved to the next agenda.
- Michele Sullivan discussed the agency meeting and will send the meeting minutes from that meeting once they are read over by Veronica Morgan.
- The group discussed the goal and review possible activity group worksheet that was done at the March 21st PPC meeting. Everyone agreed that the goals need some tweaking to make sure they

are able to be used by City of Bryan in the future. The group also agreed that the "review possible activities" worksheet was not completed correctly by all tables so at the next PPC meeting we will need to complete the worksheets.

- The group reviewed the PPC agenda for April 11th and added two items to the agenda; review and accept goals and review possible activities worksheet.
- Another staff planning meeting will be added on April 18th to go over the draft of the Flood Mitigation Plan before the PPC meeting on April 25th.

Follow-up Items:

- Mitchell & Morgan to draft public agendas for the public meetings that need to be delivered to City of Bryan 96 hours prior to meeting.
- Kala and Kerry to continue to compile public outreach synopses, news stories, articles, and webpages for use in the final report.
- City of Bryan to draft a discussion of how the LOMR data is added to the floodplain in GIS. – Johnny
- Mitchell & Morgan to send meeting minutes from February 28th meeting.
- Mitchell & Morgan to send meeting minutes from agency meeting on March 13th.
- Mitchell & Morgan to compile a list of the current FMP goals, the PPC goals, and possible action statements corresponding to each PPC goal.
- City of Bryan to review list of goals and possible action statements and return to Mitchell & Morgan by 10 am on Friday, April 6th.
- Mitchell & Morgan to write objectives and action statement examples for the revised goals from the City of Bryan and return to City of Bryan for review by April 10th.
- Mitchell & Morgan to send calendar invites for the additional staff meeting on April 18th at 10:30 am.
- City of Bryan staff to continue working on assigned homework.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow, Taylor Rose, Bryan Reece, Mark Carrabba, Glenn Jones, Rabon Metcalf, Jacob Torres, Ron Schmidt, Shawndra Curry, Bruce Jones, Spencer Buchannan, Lisa Cantrell
Date:	April 11, 2018
Re:	City of Bryan Flood Mitigation Plan Update - PPC Meeting

Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update PPC meeting

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Glenn Jones, PE, CFM, J4 Engineering
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Jacob Torres, PhD, PE, CFM, LAN
- Ron Schmidt, Chamber of Commerce
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Shawndra Curry, PE, Bryan Texas Utilities
- Spencer Buchanan, TEXCON Contractors
- Mark Carrabba, Carrabba Brothers, Ltd.
- Lisa Cantrell, CHI St. Joseph Hospital
- Rabon Metcalf, PE, CFM, RME
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP
- Taylor Rose, Mitchell & Morgan, LLP

Members not present

- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Kala McCain, Communications and Marketing Manager
- Bryan Reece, Reece Homes
- Bruce Jones, Jones & Associates Insurance
- Kerry Pillow, Mitchell & Morgan, LLP

Purpose:

- By meeting's conclusion, finalize a list of goals, finish review possible activities worksheet, and draft a list of action statements for each goal.

Discussion Items:

- Michele Sullivan opened the meeting by welcoming the public and reminding them to fill out a comment card with any problems or suggestions for the PPC.
- Michele Sullivan ran thru a schedule for the meeting to keep the meeting on time.
- The meeting minutes from March 1st and March 21st were approved.
- The revised goals were reviewed and approved by the PPC. The goals are as follows:
    - Develop and improve outreach and public awareness
    - Protect and enhance natural floodplain and storm water resources
    - Provide fiscally responsible funding
    - Protect the health and safety of the public
- Michele Sullivan discussed the review possible activities worksheet that was started during the March 21st meeting. The members were asked to sit with the same group from the last meeting so they could continue their discussion topics. Each group reviewed the categories against each goal for applicability, pros, and cons for each activity listed under the category. The updated worksheet responses are attached.
- Each group then discussed the staffs action statements listed under the goals and were asked to make correlations between the action statements and other goals as well as create any new action statements. The responses will be used to write the plan.

Follow-up Items:

- Mitchell & Morgan to draft flood mitigation plan and review with city staff
- Mitchell & Morgan to send draft of plan to PPC prior to the next meeting on April 25th.

If you have any questions or comments, please feel free to contact me at 979-260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Meeting Minutes

To:	Paul Kaspar, PE, CFM
From:	Michele Sullivan, EIT
CC:	Johnny Price, Linda Cornelius, Jerry Henry, Robert Willis, Martin Zimmerman, Greg Cox, Kala McCain, Delores Soto, Veronica Morgan, Kerry Pillow
Date:	April 18, 2018
Re:	City of Bryan Flood Mitigation Plan Update - Staff Committee Meeting

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Dear Mr. Kaspar,

Provided below are meeting minutes for the Flood Mitigation Plan Update Staff Committee Meeting:

Attendees

- Paul Kaspar, PE, CFM, City of Bryan City Engineer
- Johnny Price, PE, CFM, City of Bryan Assistant City Engineer
- Jerry Henry, City of Bryan Emergency Management Coordinator
- Robert Willis, City of Bryan Streets & Drainage Supervisor
- Greg Cox, CBO, CFM, City of Bryan Chief Building Official
- Veronica Morgan, PE, CFM, Mitchell & Morgan, LLP
- Michele Sullivan, Mitchell & Morgan, LLP

Members not present

- Martin Zimmermann, AICP, City of Bryan Planning Manager
- Linda Cornelius, City of Bryan Parks & Recreation Director
- Delores Soto, CAP, CFM, City of Bryan Development Services Office Coordinator
- Kala McCain, City of Bryan Communications and Marketing Manager
- Kerry Pillow, Mitchell & Morgan, LLP

Purpose:

- To review the draft plan prepared by Mitchell & Morgan and discuss the action plan table.

Discussion Items:

- Veronica Morgan introduced the draft plan and the action plan table.
- The group went through the action plan table and discussed activities highlighted in yellow. City of Bryan staff to help with the priorities, cost, responsible department, timeframe, and potential funding source for each activity. City of Bryan to return revised action plan table and draft plan to Mitchell & Morgan by Monday April 23.
- The group reviewed the maps that will be used in the plan.
- The April 25th staff meeting was cancelled.

Follow-up Items:

- City of Bryan staff to review action plan table and draft plan and return to Mitchell & Morgan by Monday April 23rd.
- Mitchell & Morgan to email appendices and maps to all staff members.
- Johnny to send Mitchell & Morgan annual reports from 2014 and 2017.
- Mitchell & Morgan to email questions regarding plan to staff members as necessary.
- Mitchell & Morgan to email digital copies of draft plan and action plan table when completed.

If you have any questions or comments, please feel free to contact me at 260-6963. Thank You.

Sincerely,

Michele Sullivan, EIT
Graduate Engineer

Appendix G: Citizen Drainage Concerns and Maps (panels 1-4)

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
4100 Knightsbridge Ln			1-2"										Spoke to owner William Mcglothin, 1-2 inches in house, Drainage under ground on right side of lot was overwhelmed Has had Robert Willis out right before storm, Depth first floor 8 inches drainage ditch between houses, water came in front
2414 Wilkes St													Sand bags at back door. No visible water marks
3503 Broad Oak Cr			1-2"										Some water in entry way. Less than 1/2 inch.
4207 Meadowbrook Dr													Water line below slab/floor in backyard, No one home
4208 Meadowbrook Dr	5/26/2016	Y	10	Doorways and weep holes, rising water from creek	N		1	N	N	N	Y	$ 13,300.00	10", No flood insurance, Home insured, Owner says there are lots of debris blocking creek beside his house (Form filled out at Flood Mtg 8/2/16 &also website)
5646 E SH 21													Back mobile home-Skirting blown out, 8 inch water mark on HVAC compressor and back storage shed. Does not look like water got into homes or screen shop office. Affected on mobile homes. Minor on sheds.
2715 Colony Village Dr			8										8 inches
2713 Colony Village Dr			9										9 inches
2711 Colony Village Dr			9										9 inches
2704 Wood Ct													
3404 Sandra Dr			3										3 inches of water in structure, poor site drainage, has flooded before
3104 Louisiana Av			8										8 inch water mark on front door
2707 Colony Village Dr			3										3 inches, insured
1907 Mockingbird Rd			12										Has flood insurance, has flooded before, 12 inches in living area, spoke to son
2807 Althea Ct			4										4 inches, not insured
3910 Windowmere St			1.5										1.5 inches of water, Very minor, some water came into back of house, back yard drains towards back of house, renter
3007 Rustling Oaks Drive			2										2 inches
3504 Oak Valley Cr			2										Owner not home,2 inch water mark in house
1809 Wayside Dr			3										3 inches
4215 Willow Oak St			2-3"										No flood insurance, Water came in back of house from boonville, 2-3 inches
2901 Briarcreek Ct			2										2 inches
2917 Louisiana Ave			6										6 inches of water
4200 Autumn Cr													No water in house, Concerned about major erosion in back yard Due to creek
1101 Allen Forest Dr			2										2 inchest
2114 Nuches Ln			1										Maybe 1 inch of water
3500 Oak Valley Cr			13										13 inches of water, Flood insured
1606 Henry St			0.5										0.5 inches
315 Tee Dr													***NO FLOOD DAMAGE*** Water came through back door of garage, did not get into living area of house, no water marks, would like city to look into why more water comes through her backyard from street and apartments behind her
3617 Mahan St #B			10										10 inches
3200 Boonville Rd			12										Commercial: 12 inches of water inside C-Store and Gas
2915 Louisiana Av			4										4 inchest of water per home owner
2706 Silver Maple Dr													Only one on road - high. These are questionable due to location. Not in low area.
7200 Wood Oaks Dr			19										19 inches, not insured
3102 Louisiana Av	5/26/2016	Y	36	tremendous rainfall, rising water from the street and nearby creek	Y		3	Y	N	N	Y	$ 18,000.00	Not occupied. Filled out Form at Flood MTG 8/2/16
3501 Broad Oak Cr			5										5 inches of water in house, No flood insurance, Homeowners insured
3625 Wellborn Rd #1109			0.5										0.5 inches of water, Saddlewood Apt, All units will be affected, not measurable where water seeps in for the most part and has been an ongoing issue do to poor site drainage, damaged downspouts and bad landscaping practices
4203 Meadowbrook Dr													Garage low- driveway slopes towards garage from street No water marks visible No one home
4101 Green Valley Dr													Water in enclosed garage, minor flooding
4103 Green Valley Dr													water in attached guest house, minor flooding
4205 Autumn Cr													***NO FLOOD DAMAGE***
2311 Truman Av			3										Fourplex, two units downstairs two upstairs, multifamily, no one home, water marks on back indicate 3 inches inside, carpet pulled out
2806 Althea Ct			4										4 inches, not insured
2508 Willow Bend Dr		Y	24-36	Creek	Y	5/1/2015			Y	Y	N		Request Form Filled out at Flood Mtg on 8/2/2016
7160 Wood Oaks Dr		Y	18	Doors	N				Y	Y	N		75K figure for permit repairs, not from LC or IA. Estimate from homeowner
3502 Oak Valley Cr		Y	5-6"	rising water from street in the front and rising water from creek in back	N				Y	Y	Y	$ 120,000.00	8 inches & 18 inches in accessory structure, Flood insured
3501 Oak Valley Cr			4										Aggieland apartment finders 693-4900, 4 inches, Flood insured per contractor
3908 Windowmere St			0.5										0.5 inches, Very minor, some water came into back of house, back yard drains towards back of house, renters, has happened before
3906 Windowmere St			0.5										0.5 inches, Very minor, some water came into back of house, back yard drains towards back of house, renter, has happened before

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
3620 Mahan St #A			22										22""
5303 Bloomsbury Wy													
4741 Tiffany Park Cr													
816 Tanglewood Dr		Y	1-2"	riding water from street overflow. Created stream from curb to rear of house. Happens every time we have heavy rain	Y				N		N		Florring curbside/possible remodel
821 Vine St													
826 Vine St													Questionable (possible remodel)
731 Inwood Dr													
915 Stanfield Cr													
917 Stanfield Cr													carpet/flooring curbside
7180 Wood Oaks Dr			6										6 inches
7140 Wood Oaks Dr		Y	18-24	rising water from dry creek	N				N	Y	N		Claim was filed but they were told there was so coverage for flood; 12 inches, not insured
7252 Wood Oaks Dr			12										12 inches, insured
5605 Chelsea Cr			2										2 inches affected garage, House is pier and beam
2410 Quail Hollow Dr													carpet/flooring curbside
2818 Cherry Creek Cr			1-2"										1-2 inches water interior
2816 Cherry Creek Cr			2										2 inches water interior, spoke with resident
2814 Cherry Creek Cr			12										Estimate of about 1+ feet interior
2812 Cherry Creek Cr			12										Estimate of about 1+ feet interior
2810 Cherry Creek Cr			12										Estimate of about 1+ feet interior
2808 Cherry Creek Cr			12										Estimate of about 1+ feet interior
2806 Cherry Creek Cr		Y	12	rising water from creek and street	N				N		Y	$ 8,000.00	Estimate of about 1+ feet interior
2804 Cherry Creek Cr			12										Estimate of about 1+ feet interior
2803 Cherry Creek Cr			1										1 foot water interior, spoke with resident
2801 Cherry Creek Cr			24-36										2-3 feet water interior, spoke with resident
2813 Apple Creek Cr		Y	12	Roof, doors, windows	Y	7/3/1905			Y		Y		carpet/flooring curbside, homeowner has excessive damage to roof & interior of home and property, insurance adjuster claims all from rising water & will not cover the damage
2809 Apple Creek Cr													carpet/flooring curbside
715 Garden Acres Bl													Questionable (possible remodel)
827 Vine St													Questionable (possible remodel)
824 Vine St													Questionable (possible remodel)
825 Vine St													Questionable (possible remodel)
2901 Chapparral Cr													Possible sink hole
2405 Carter Creek Pw		Y	4	Rising water through back door & through weep holes on back side, flowed from neighboring property into back yard	Y				N		Y	$ 1,497,617.00	3 inches, carpet padding dranched
2612 Melba Cr			6										6 inches
2306 Avon St			1.5										1.5 Inches
2510 Willow Bend Dr		Y	38	Creek	Y	5/1/2015			Y	Y	N		5 feet
2517 Willow Bend Dr													
2315 Wayside Dr													email
2206 Sharon Dr		Y	3-4"	water overflowed the street in front, flooded the yard and came in under the front door	Y	5/1/2014			Y	Y	N		
1000 Esther Bl													
2100 Sharon Dr													
1815 Wayside Dr													
1405 Woodland Dr													
1906 Mockingbird Rd			2-12"										2 inches of water, accessory structure 12 inches, has flooded before, has flood insurance
708 Suncrest St			6										6 inchest of water - water mark on front door. Let flood insurance expire a few years ago. House in poor condition. Low Income
2304 Franklin St			3										Spoke with tenant, 3 inches of water in house, water mark by front door, happens often, carpet in street drying, does not think owner has flood insurance, would like city to clean out ditches in the area, carpet being replaced
2303 Franklin St			0.5										Tenant 2304 says that water got in house, no water marks visible, possible it flowed in from the back as the back yards drain towards houses. 1/2"
2305 Franklin St			0.5										Tenant 2304 says that water got in house, no water marks visible, possible it flowed in from the back as the back yards drain towards houses. 1/2"
2307 Franklin St			0.5										Tenant 2304 says that water got in house, no water marks visible, possible it flowed in from the back as the back yards drain towards houses. 1/2"
3008 Kim St		N	0	no structure	N				N		N		No one home. Back corner lot that washed away under fence

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
2317 Franklin St			0.5										Tenant said water came into back of house, back yard slopes toward house, also requires ditches to be cleaned out. 1/2"
3610 Major St #A			24										24""
3610 Major St #B			24										24""
3611 Major St #A			24										24""
3611 Major St #B			24										24""
4006 Stafford Point			6										6""
3612 Comanche St #A			15										15""
3612 Comanche St #B			15										15""
3615 Comanche St #A			1										1""
3615 Comanche St #B			1										1""
3616 Choctaw St #A			4										4""
3616 Choctaw St #B			4										4""
3620 Choctaw St #A			19										19""
3620 Choctaw St #B			19										19""
3700 Choctaw St #A			21										21""
3700 Choctaw St #B			21										21""
3702 Choctaw St #A			27										27""
3702 Choctaw St #B			27										27""
3704 Choctaw St #A			21										21""
3704 Choctaw St #B			21										21""
3706 Choctaw St #A			15										15""
3706 Choctaw St #B			15										15""
3705 Choctaw St #A		Y	1-9"	back bedroom	N				N		N		I am a renter but my computer was ruined-plus I am spending $400/week at Value Place to live
3705 Choctaw St #B			17										17""
3703 Choctaw St #A			2										2""
3703 Choctaw St #B			2										2""
3701 Choctaw St #A			9										9""
3701 Choctaw St #B			9										9""
3700 Elliott St #A			10										10""
3700 Elliott St #B			10										10""
3702 Elliott St #A			14										14""
3702 Elliott St #B			14										14""
3704 Elliott St #A		Y	20	Water rising from road and drainage ditch	N				N		N		16""
3704 Elliott St #B			16										16""
3706 Elliott St #A			17										17""
3706 Elliott St #B		Y	24	Rising water from street	N				N		N		24
3708 Elliott St #A			13										13""
3708 Elliott St #B			13										13""
3709 Elliott St #A			11										11""
3709 Elliott St #B			11										11""
3707 Elliott St #A			12										12""
3707 Elliott St #B			12										12""
3705 Elliott St #A			12										12""
3705 Elliott St #B			12										12""
3703 Elliott St #A		Y	11	rising water from outside	N				N		N		11""
3703 Elliott St #B			11										11""
3701 Elliott St #A			12										12""
3701 Elliott St #B			12										12""
3611 Mohawk St			4										4""
3613 Mohawk St			7										7""
3619 Elliott St #A			8										8""
3619 Elliott St #B			8										8""
3617 Elliott St #A			5										5""
3617 Elliott St #B			5										5""
3614 Elliott St #A			4										4
3614 Elliott St #B			4										4""
3616 Elliott St #A			12										12""
3616 Elliott St #B			12										12""
3611 Western St #A			4										4""
3612 Western St #A			18										18""
3611 Western St #B			4										4""
3612 Western St #B			18										18""

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
3613 Western St #A			11										11""
3613 Western St #B			11										11""
3610 Western St #A			2										2""
3610 Western St #B			2										2""
3614 Mahan St #A			16										16""
3614 Mahan St #B			16										16""
3617 Mahan St #A		Y	12	rising water from creek	N				N		N		10""
3616 Mahan St #A			23										23""
3616 Mahan St #B			23										23""
3618 Mahan St #A			22										22""
3618 Mahan St #B			22										22""
3620 Mahan St #B			22										22""
3618 Choctaw St #A			4										4""
3618 Choctaw St #B			4										4""
3403 Timberline Ct			1										1 inch water under front door
911 McAshan St		Y	2	Slab and structure	Y	3/1/2016			N		N		
3500 Broad Oak Cr			12										Water in accessory structure only, house is okay, 12 inches in accessory structure, no flood insurance
3302 Santa Fe Tr													
3925 Sierra Ct			0.5										0.5 inchest, Back yard drains towards house, some water came in back door, no one home
4303 Woodbrair Dr			0.5										0.5 inches, Per owner. Also had water from flood. Back yard slopes towards house. Like 4305, Says house is total loss due to tree falling into it. They are moving out
4105 Willow Oak St			0.5										0.5 inches, Drainage inlet in street got overwhelmed. To right of house, Williams, No flood insurance, Water came in front door, garage and front bedroom, Front yard slopes towards house , 1 inch of water
3610 Oak Ridge Dr		Y	1	weep hole from exterior	Y	5/21/2016			N		N		
4406 Winchester Dr		Y	1	unclear, but did not come through roof	N				N		Y	$ 3,000.00	
2804 Althea Ct													
3917 Sierra Ct		Y	1-2"	Rising water from neighbors	Y				N		Y		1 inch, Owner is Beachy, Says some water came in back door, Backyard slopes towards house
203 Pierce St													
5700 Chelsea Cr	5/26/2016	N		drainage from the city street flooded the back yard and left massive debris	N			N	N		N		I have spent small fortunes rebuilding my yard, grass, soil in an effort to protect the value of my property.
4316 Maywood Dr		Y	1	came in through the wall	Y	7/7/1905			N		Y		Amount of estimate: Landlord would be the one to contact for this information
705 Ethel Bl													
306 W 24th St		Y	1	came from the roof and air condition vent	N				N		Y	$ 4,000.00	
3728 Ravenwood Dr													***NO FLOOD DAMAGE***, water was from roof damage per owners son
4112 Coventry Ct													
2914 Prairie FLower Cr			0.5										two story four plex multi family, carpet at curb, front parking slopes towards building, crews on site re working drainage at front of building. 1\2"
4305 Woodbriar Dr			0.5										0.5 inches, Looks like water came in back door -back yard slopes towards house. - confirmed with neighbor, No one home, Some roof damage
902 Esther Bl		Y	23	Rising water from the creek	Y	5/26/2016			Y	Y	N		
912 Stanfield Cr		N	0	Water in the yard	N	5/26/2016			Y	N			No claim will be filed
3601 Old Oaks Dr		Y	6	Came in through the front door	Y				N		N		Date of previous flood: May 21 & 26 2016 both days
3615 Mahan St #A			5										Not rented, About 5" water inside
3615 Mahan St #B			5										No insurance, About 5" water inside
3100 Louisiana Av		Y	30	Because of rising water from the street and creek by my house	Y	7/7/1905			N		N		
3919 Old Oaks Dr													
4720 Williamsburg Dr													
3207 Bonham Dr													
3100 Tennessee Av		Y	6	Wtr rising from street, nearby creek, neighboring property. From the bottom of the house thru the foundation and doors.	Y	3/1/2015			Y	Y	N	$ 20,000.00	
2305 Avon St													
4112 Meadowbrook Dr													Accessory Structure, No water in house, Backyard and pool flooded, Accessory structure flooded, 2 feet or more in back yard, No flood insurance
4101 Willow Oak St			0.5										0.5 inches, Front yard slopes towards house, driveway slopes towards house, street is higher, water seeped in under walls and garage per neighbor, no one answered door
4103 Willow Oak St			0.5										0.5 inches, No flood insurance, water seeped in under walls in front bedrooms
4511 Northwood Dr		Y	2	front doors and fountation. Water came in from the street.	Y				Y		N		February 4, 2012 from the street into the house but the homeowners did not cover the damage.

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
2411 McHaney Dr	5/26/2016	Y	9	All around house	Y		3	Y	Y	Y	Y	Part. 860	City removed Louisiana St Culvert on side of hse-within Last 12 mons. 3408 Vacant Lot. Informed of Bonham Detention Pond. Form Filled out at Flood Mtg 8/2/2016
2716 Camelot Dr													
2918 Fairchild Dr		N	2	Came thru the toilet and bathroom.	N				N		N		
4102 Settler's Wy		N		backyard fence damaged	N				N		N		
2905 Louisiana Av													
2903 Hillside Dr		Y	1	Through back door and weep holes in brick	Y	5/26/2016			N		N		
3602 Oak Ridge Dr		Y	1	through front door	Y	5/17/2016			Y	Y	N		
2904 Camelot Dr													
3202 Wilderness Rd		N							N		N	$ 5,500.00	run off from hill washed out the back yard
3704 Elaine Dr													Carpet & pad along road
207 Davis St #A & #B													
303 Fairway Dr													Carpet removed
3102 Tennessee Av													
3104 Tennessee Av	5/26/2016	Y	12-24"	rising water, live right by the culvert	Y	5/1/2015	3		Y	Y	Y	$ 14,000.00	Brenda Elledge (Tenant) elledge1217@yahoo.com 2 ft in house(rec. 2/13/2017)
2204 Wilkes St													
2310 Woodward Dr													
2908 Missouri Av													Carpet Removed
303 Missouri Av													Hardwood flooring removed
3010 Kim St													No one home, carpet and flooring piled in yard
3108 Bonham Dr													
2906 Old Hearne Rd													
3023 N Texas Av													
505 W 15th St													Questionable
1202 Hall St													
1403 N Sims Av													
1308 N Sims Av													
4203 Autumn Cr		Y	0.5	0.5 of water came in back door, poor site drainage and alley behind fence backed up					N				Meet with owner this morning. 6/7/16 No flood insurance
1004 E 26th St													
107 N Brewer Dr													
1400 Skrivanek Dr													
1207 Garden Ln													
1313 Garden Ln													
1306 Esther Bl													
910 E 32nd St													
2357 N Earl Rudder Fw			1										1""
2373 N Earl Rudder Fw			1										1""
2377 N Earl Rudder Fw			3										3""
112 Moss St													These are questionable due to location. Not in low area.
1002 Dumas													These are questionable due to location. Not in low area.
1106 Dale St													
1107 Orlean St													These are questionable due to location. Not in low area.
904 N Preston Av													Carpet
1308 E 21st St													Flooring? Wood. These are questionable due to location. Not in low area.
1110 E 21st St													These are questionable due to location. Not in low area.
2602 Cypress Cr													Only one on road. These are questionable due to location. Not in low area.
800 Braeswood Cr													
1109 Sage Av													These are questionable due to location. Not in low area.
802 W 24th St													
2308 Berger Dr													Sandbags
2310 Berger Dr													Sandbags
2434 Berger Dr													Sandbags
2432 Berger Dr													Sandbags
2204 Lobo Dr		Y		rising water	Y				N		N		How many inches: minimal - Not as much as before. Date of flood: Saturday before 5/26/16
3602 Old Oaks Dr		Y	0.5	rising water, at the bottom of the hill	Y	4/5/2015			N		N		
4401 Warwick Ln		Y	8-12"	came in through creek	Y	4/5/2016			Y	Y	Y	$ 3,019.15	
140 Watson			5										5 inches water inside, no insurance
2303 Truman Av													
1116 Terrace Dr		Y	2	seeped through foundation from creek nearby	Y	3/4/2015			N		N		
1902 Fawnwood													

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
1215 Bittle Ln													
2304 Sandy Ln													
2315 Sandy Ln													
2308 Cindy Ln													
524 W Carson St													
402 W Carson St													
4600 Castle Av													
1303 Douglas St													
1305 Douglas St													
1313 Douglas St													
1100 Carter Creek Pw													Water in Church Per Cody
1101 Clark St													
1100 Clark St													
4604 Castle Av													Updated Info from Flooding request form at 8/2/2016 Mtg
844 N Harvey Mitchell Pw													
409 St Louis St													No flood insurance
404 St Louis St													Carpet outside
1902 W MLK St													
1708 Bellview Cr													
605 Boulevard St	5/26/2016												
1707 Bluebonnet St													
4773 FM 1179		Y	2	Tornado blew shingles off roof, water came in through roof	Y	7/5/1905			N		Y	$ 13,000.00	
2409 McHaney Dr	5/26/2016	Y	8	The water entered through doorways front and back of the home	Y	2014, 2015	3	Y	Y	Y	Y	Approx 38K	Water in the house ranged form 4 inches to 4 feet of flooding. The adjuster has been out but home owner-N Est Yet. They estimate the damages may exceed more $35,000 but no confirmation as of yet. Filled out Form at Flood Meeting 8/2/16
1709 Luza St													
4303 Apache Ct		Y	1	rising water	Y	5/19/2018			N		N		
2713 Silver Maple Dr													Water came in from driveway/street into garage then seeped into master bedroom/closet
2807 Wildflower Dr #6		Y	1	through front door	Y				Y		N		
4029 Austin's Landing		Y	0.5	Through double doors	N				N		N		
3009 Rustling Oaks Dr													
2526 Arbor Dr		Y	6	Rising water	Y	7/5/1905			N		N		
2302 Wilkes St		Y	2-3"	not home at time but assumed through the doors	N				N		N		
3727 Ravenwood Dr		Y	1	roof damaged from tornado	N				N		Y	$ 70,000.00	70,000 on house structure, but not on contents and yard yet to be assessed
4101 Milton St #D		Y	1 1.5	door and foundation	Y	3/1/2016			N		N		
3010 Red Robin Lo													
4204 Cheyenne Cr													
4205 Cheyenne Cr		N	0	Rising water	Y				Y				April 2016 the house had flooding due to run off from the neighbors. Seems to be a major problem in that whole neighboorhood due to improper drainage in the area. The policy will not be affective until July 2016. An adjuster has come out and is curre
3613 Sierra Dr		Y	2	through roof	N				N		Y	$ 13,000.00	
3911 Brighton Dr													
1812 Rose St													
1518 Boone St		Y	8	utility and beedroom walls, tree fell on power line	N				N	N	N		
3405 TImberline Ct													No one home
2807 Wildflower Dr #7													No one home, water through front door due to drainage, probably a couple of inches
3801 Laura Ln		Y	1	rising water from neighbors, through the walls of back porch	Y	11/1/2015			N		N		
2709 Apple Creek Cr		Y	3	Creek in back	Y	1999 2000			N		N		
2205 Oak Grove Ln		N		Water flooding into backyard from surrounding properties and rising into house	Y	10/1/2013			N		N		
2906 Westwood Main		Y	3	weep holes and foundation	Y	5/1/2016			Y		Y		Would not cover damage because they said it was from ground water. Homeowners insurance will not cover because it is considered ""raising ""water"".
4106 Willow Oak St		Y	2	All the above except for roof leak	Y	5/21/2016			N		N		
3606 Meadow Oaks Ln		Y	1	Water entered through the Front door, some entered through the garage	Y	7/7/1905			N		N		
2916 Louisiana Av		Y	1-2"	Rising water from drainage ditch. From the roof, walls and foundation areas.	Y	7/7/1905			N		N		

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
3721 Brighton Dr		Y	3-4"	Enter through weep holes and foundation, walls and roof	Y	4/1/2016			N		Y	$ 25,000.00	Insurance did not give estimate for flood damage but they did get estimatte for roof and walls. That estimate roof and walls was $25,000. No flood money because considered "raising water".
2111 LaBrisa		N		Massive errosion from all the water running through the yard & drainage ditch in the back, causing much errosion that is affecting the front, side & back of yard	N				N		N		
2908 Finfeather Rd		Y	3		Y	7/1/2014			N	N	N	pending	
4602 N Texas Ave		Y	2	Floods garage anytime there's rain. Came in house when Snook had tornado yrs ago	Y				N		N		2" in garage & kitchen, Also in living rm, dining rm, & front bedrm but not as deep
2303 Kent St		Y		being able to drain quickly enough into the street. I am going to remove an additional 1-2"" from the bottom of the front double gate to aid in water drainage from the right-side (looking from street) of the house & back the yard.	Y	6/1/2014			N		N		Water came in from between the brick wall and foundation as there was 5-6 inches of water against the right-side of the house. This was caused by excess water draining into right-side of yard from several neighborsâ€™ yards into mine and the water no
4324 Meadowbrook Dr		Y		through roof from tornado damage	N				N		N		entered roof and caused ceiling to fall in on room. Water damage in another room
3601 Park Oak Dr		Y	2	Roof damage from tornado	N				Y	Y	Y	$ 40,000.00	
4001 Woodbriar Dr		Y	0	Rood leak from wind blown shingles	N				N		Y	$ 40,000.00	
4005 Woodcrest Dr		Y		Through rood-made ceilings collapse so I don't know how much water	N				N		Y	$ 48,000.00	
4221 Willow Oak St		Y	0	Leaked slightly through doorway	Y				N		Y		New roof needed due to tornado damage
4210 Willow Oak St		Y		Water leaking throughout the entire roof	N				N		Y		Waiting on estimate totals
3605 Park Oak Dr		Y			N				N		Y	$ 40,000.00	
2363 N Earl Rudder Fw Unit		Y	2	Rising water	N				N		N		
3600 Brighton Dr		N			N				N		Y	$ 8,900.00	
4016 Woodbriar Dr		Y	1-2"	Rising water from backyard	Y	12/1/2015			N		N		
3506 Oak Ridge Dr	5/26/2016	Y	5	Street	Y	4/1/2015	6	N	N		N		I must construct a dam of cinder blocks across the driveway each time there is a heavy rainstorm.
4207 Woodcrest Dr		Y		Hole in the roof caused by a tree, and around damaged fireplace	N				N		Y	$ 5,389.91	
4018 Woodbriar Dr		Y	2	Neighboring property	Y	5/26/2015			N		N		
4208 Woodcrest Dr		Y	0.5	Leak in fireplace	N				N		Y	$ 10,000.00	
809 S Rosemary Dr		Y	4-5"	Culvert is too small on S Rosemary Dr, so the creek backs up & overflows. Spoke with Paul Kaspar most recently in April 2015 about concerns	Y	10/1/2013			Y	N	N		
4513 Taft Ct		Y	1	came from neighboring property, enter through the weep holes of the brik	Y	5/14/2016			Y	Y	Y	$ 10,000.00	
2103 Manning Wy		Y	2	Rising water from creek & street	N				N		N		
4318 Meadowbrook Dr		Y		Through holes in roof and broken windows	N				N		Y	$ 37,000.00	All damage attributed to wind, no flood damage
3919 Brighton Dr		Y	3-4"	Rising water	N				N		N		
3604 Dawn Ct		Y	2	Through roof due to tornado	N				N		Y		Estimate is in process, but have not received the actual estimate at this date
4105 Woodcrest Dr		Y	5-6"	Large hole where tornado ripped off roof	N				N		Y	$ 4.00	
411 Pease St		Y	2	Roof back door	N				N		Y	$ 8,500.00	
5419 Woodbend Dr		Y	1-2"	Rising water, source is backyard	N				N		N		
4211 Willow Oak St		Y	1-2"	Tornado took part of roof,parts of the back of house, chimney blew off house exposing parts of inside	N						N		Still waiting on insurance adjusters estimate
1507 Maglothin Ct		Y	3	Front & back door & through the walls-The whole downstairs	Y				N		N		
1307 Barak Ln		Y	<1	From backyard	Y	3/15/2018			N		N		
2512 Willow Bend Dr		Y	2	rising water from the creek behind our house that is not maintained	Y	7/7/1905			Y	N	N		One year ago -- don't keep the exact date as it happens yearly. No, we just live with it.
1012 E 25th St		Y	0	roof damage	N				N		N		

Citizen Drainage Concerns

Address	Flooding Date	Water in House	Inches of Water in Structure	How water came into Structure	Previously Flooded	Date of Previous Flood	Number of Times Flooded	Property located within 100-year Floodplain	Flood Insurance	Flood Claim	Assess Estimate	Amount Estimated to Fix	Comment
3600 Oak Ridge Dr		Y	1	Water from the street rose above the curb and flowed down our driveway into the garage and house	Y	5/21/2018			N		N		
2505 Oak Cr		Y	1-2"	rising water on the back patio, appears to come through cold joint into enclosed patio	Y	7/8/1905			N		N		maybe 1-2 (about 50 gallons), earlier this year (2016)
803 Mary Lake Dr	10/13/2016	Y	?	Through doors and garage	Y		1	N	Y	Y	Y		Prior Owner had damage Claim. The neighbors, 811 Mary Lake have the water entering their house by the sewers and now 807 Mary Lake had water enter home by the sewer on this last fast rain in Oct. Asked to ck sewer viabilty. Wants contact from City.
1404 George St													Added By Relative from form at 8/2/2016 Mtg
7297 Oak Forest Dr	5/5/2016	N	none	Rear erosion and fld,Last 5 yrs-experienced more flooding. Neighborhoods east added concrete, which does not allow wtr to sink into ground. They have replaced 2 culverts-back yard still overflo-with hard rain. Told to keep clean. Holds wtr&mosquitos	N			N	N	N	N		Spoke to City more than once.Carl Nelson, TXDOT came out&looked. Gave lots excuses&suggestions "we" could do, we did not cause the problem, the bldg did. Carl: Our Design Sect. has determ that an addit pipe can be added at the ex. FM 1179 Struc (RO
5700 Chelsea Cr	1/23/2016	N	3'-4'	backyard flooding	N			N	N		N		I believe with the cities help clearing and deepening farther downstream will solve this multiple time problem each year
3104 Tennessee Av	5/26/2016	Y	24	rising water from nearby creek	Y	6/1/2014	3		N				We have been through three floods in three years he is disabled and its been so hard. The ditch nearby needs some work you can see by just looking at it why water dont drain
501 Olive St	7/12/2011	Y	2	over-topped slab	N		3	N	N	N			imprmts cont. tried to seal the runoff from uphill from fence to yard instead of house.
5700 Chelsea Cr	8/26/2017	N	0	it did not enter	N			N	N		N		private issue. These homes should have never been built on this horrific drainage. The city put in the drainage that floods our yard and left us to deal. Having anyone contact me does no good. they say its my problem and do not care
3020 Kim St	9/2/2017	Y	1	rising water from street and drainage swale	Y		4 yearly	N			N		(4 times years since owned) Owner has taken several actions to aleviate problems, but yard keeps eroding

Drainage Concerns
City of Bryan
April 2018
Quadrant 1

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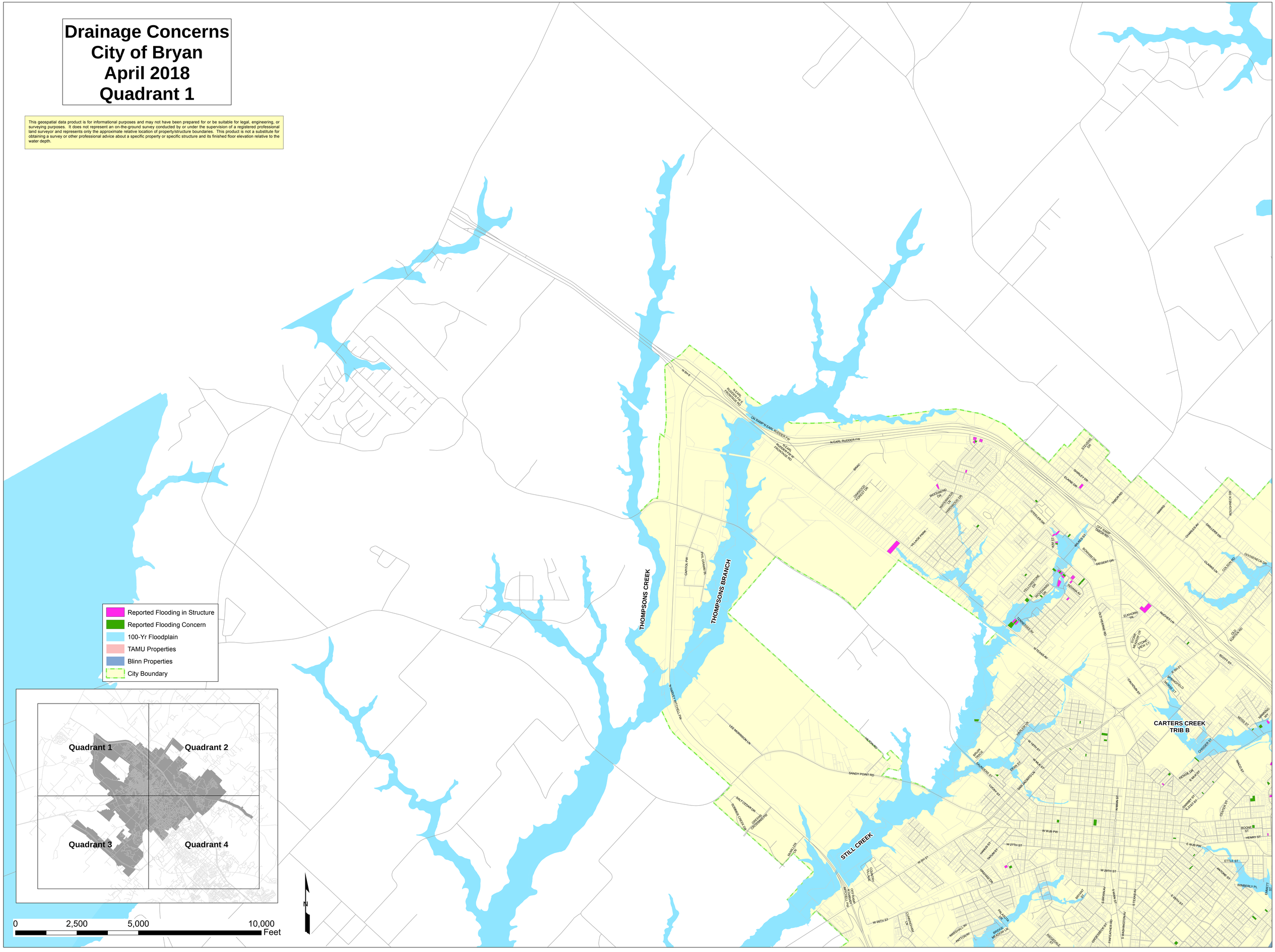
Reported Flooding in Structure
Reported Flooding Concern
100-Yr Floodplain
TAMU Properties
Blinn Properties
City Boundary
Quadrant 1
Quadrant 2
Quadrant 3
Quadrant 4
0
2,500
5,000
10,000
Feet
N
THOMPSONS CREEK
THOMPSONS BRANCH
STILL CREEK
CARTERS CREEK TRIB B
N EARL RUDDER FW
N BIH E
N EARL RUDDER FW FRONTAGE RD
ON RAMP N EARL RUDDER FW
BMC
CAPITOL PW
PHIL GRAMM BT
N HARVEY MITCHELL PW
LEE MORRISON LN
HILBURND RD
SANDY POINT RD
SALT CEDAR DR
SUMMER CREEK DR
GREEN CROSSING PW
MARLON LN
COUNTRY VILLAGE
OFFICE CENTER HARVEY MITCHELL PW
W 28TH ST
CUNNINGHAM LN
MARSHALL PW
HINTON LN
PALOMINO DR
BRIDGE MEADOW LN
ROSEDALE ST
GREENBRICK ST
FIREFLIGHTER RD
S WASHINGTON AV
S STEVENS AV
BRYANT ST
S BRYAN AV
S MAIN ST
E 29TH ST
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E 6TH

Drainage Concerns
City of Bryan
April 2018
Quadrant 2

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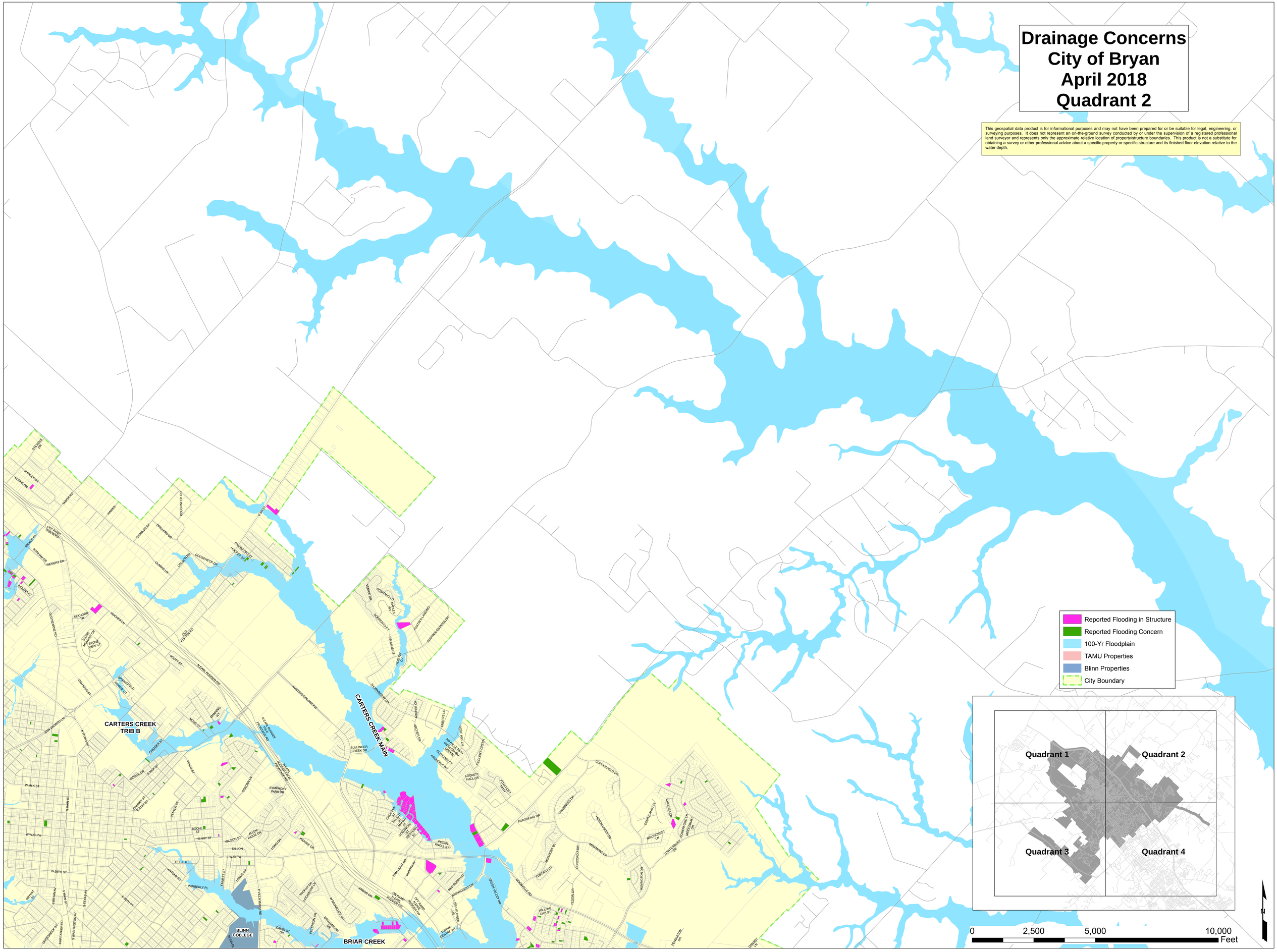

Drainage Concerns
City of Bryan
April 2018
Quadrant 3

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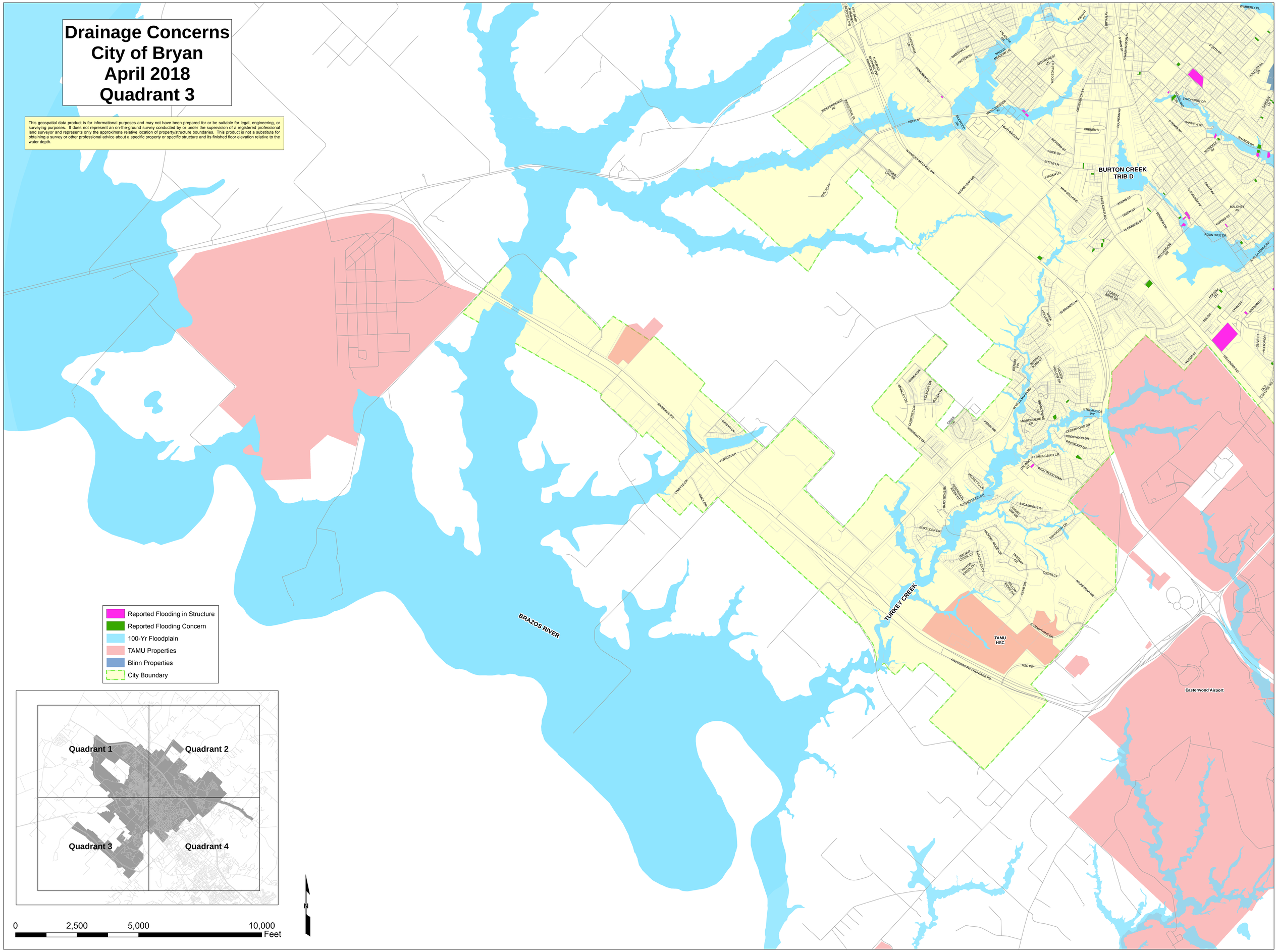

Drainage Concerns
City of Bryan
April 2018
Quadrant 4

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BLINN COLLEGE
BRIAR CREEK
HUDSON CREEK
BURTON CREEK TRIB D
BURTON CREEK MAIN
CARTERS CREEK MAIN
BURTON CREEK TRIB C
TAMU Campus
Easterwood Airport

Reported Flooding in Structure
Reported Flooding Concern
100-Yr Floodplain
TAMU Properties
Blinn Properties
City Boundary

Quadrant 1
Quadrant 2
Quadrant 3
Quadrant 4

0 2,500 5,000 10,000 Feet

N

Appendix H: Citizen Survey and Responses

City of Bryan Flooding Survey

The City of Bryan is working on the five-year update to the Flood Mitigation Plan that is required in order to participate in the Community Rating System administered by the Federal Emergency Management Agency (FEMA). The City is interested in collecting flooding data from residents and businesses to compile specific flooding histories. The results of this survey will be helpful in identifying areas of flooding concern in the City of Bryan. **Please complete this survey by Wednesday, March 14, 2018.**

If you have any pictures of flooding, other relevant flooding data, or any questions, please feel free to contact Johnnie Price, Assistant City Engineer, at (979)-209-5030.

1. Name:_____
2. Address: _____
3. Phone number: _____
4. Please check the following boxes concerning your "property":
   - ❑ Residential -or- ❑ Commercial
   - ❑ Owner -or- ❑ Renter

	Yes	No
Have purchased flood insurance for this "property"	❑	❑

5. How long have you owned/resided at this property?

   _____

6. If you have experienced a flooding problem, was it due to:
   - ❑ Flooding from the street over the curb and yard
   - ❑ Improper drainage on your lot or your neighbor's lot
   - ❑ Low driveway receiving water from the street
   - ❑ Flowerbed/landscaping filled against house/business above weep holes
   - ❑ The creek rising out of the creek banks
   - ❑ Other, i.e. appliance or roof leak: _____

7. If your main structure or garage has ever flooded please check and provide date and depth above the slab. Example: (Nov 1998, 2.5 feet) and (Oct 2010, 4 feet)
   - ❑ Main structure: _____
   - ❑ Garage: _____
   - ❑ Other: _____

8. Additional information on flooding history:

   _____
   _____
   _____

9. Other flooding problems in other areas that you may wish to describe: (please include location, date, cause of flooding, etc.)

   _____
   _____

Citizen Flooding Survey

Name	Address	Phone	Residential or Commercial	Owner or Renter	Flood Insurance	Time lived at this address	How did it flood	Main Structure Flooding	Garage Structure Flooding	Other Structure Flooding	Additional Information	Other Problem Areas
Virginia Smith	203 College View, Bryan	9798460997	Residential	Owner	No	35 years	See note below					Concern about potential flooding of properties along Brookside
Robert Pool	1005 Oak Knoll Pl, Bryan	9797797550	Residential	Owner	No	18 years	Flooding from the street over the curb and yard				May 26, 2016 Intersection of Bennett St and Oak Knoll Place	
Judy Winn	7200 Wood Oaks Dr., Bryan	9797765573	Residential	Owner	Yes	34 years	The creek rising out of the creek banks	May 2016, 20 inches	May 2016, 24 inches	May 2016, 3.5 feet	Our property had never flooded until May 2016. What was different this time was the effect of housing development, paving, and an inadequate stormwater drainage system in the watershed of Carter Creek, all of which occurred in the last few years. We also learned at a city meeting that the creek channel under Booneville Rd. is inadequate.	I would like to state that the City should partner with flood mitigation experts from the AgriLife Extension Service at Texas A&M in developing future plans for development. My husband and I met with those experts and introduced them to city councilmen and city staff in the summer of 2016, but apparently the City chose not to follow up to receive this free, expert help.
Rosa Ledezma	1133 Steamboat Run, Bryan	9795719201	Residential	Owner	No	2 years	Flooding in roads leading to our neighborhood					Flooding on Saunders Street/Mumford Road at intersection of Bruin Trace. Behind the Kemp-Carver Elementary School. May 2016 the intersection flooded due to heavy rains and passing through the intersection was impossible. Mumford Road was also blocked due to flooding on the other side by Harvey Mitchell Parkway (next to the VTI of Texas company) in the same rains of May 2016. Rains during Hurricane Harvey also caused flooding in the same areas. These floods interrupt access to and from the neighborhoods in these areas.
James “Jim” Murphy	4009 Tanglewood Dr, Bryan	9792042076	Residential	Owner	Yes	4 years	The creek rising out of the creek banks				Next door neighbor (4011 Tanglewood) on corner of Tanglewood & Carter Creek experienced flooding several years ago when the Burton Creek tributary (back of our lots) overflowed. Water reached the bottom of our foundation.	The intersection of Tanglewood & Carter Creek roads regularly floods during heavy rains, at times requiring barricades. However, there are no flood gauges installed at that intersection to warn drivers of the actual water level.
Phillip Hodges	2319 Woodville rd, Bryan	9797783493	Residential	Owner	Yes	31 years	Flooding from the street over the curb and yard	5 times over last10 years not sure of dates			City put in a drainage culvert from that time we have had flood problems	
Kevin Evans	2823 Muirwood Ct, Bryan	9792206092	Residential	Renter	No	14 months	The only problem I see is the way the CIty has chosen to handle the situation.					The lack of concern for certain areas in this town is appalling. It is disturbing that the flooding of homes of the citizens and how it affects their lives is apparantly not as important to the City of Bryan as the new "Super Park" is. It seems to be a continuation of what has gone on here for as long as I can remember; crooked politics and motivation by self interest. It's really not surprising though, we are talking about an institution that held a private meeting to fire someone who wanted transparency for the residents. How about, "we" (the City of Bryan) do the right thing and start addressing the issues that truly and directly impact the citizens of this city then, move on to unneeded projects.
Carl Gough	3902 Park Meadow Lane, Bryan	9797742837	Residential	Owner	Yes	6yrs	The creek rising out of the creek banks				May 2016 rains brought flood waters to my back fence. Another 8” rise in water would have flooded my house. The city cannot allow anymore additional drainage upstream, where an 800 housing addition is being developed. The bridge on Copperfield wasclosed during this May 2016 event, which affected emergency vehicle access to Physicians Hospital.	
Dawna James	1100 Broadmoor, Bryan	2548655765	Residential	Owner	No	1 year	The creek rising out of the creek banks					
Katrina Ghiouli	4205 Cheyenne Cir, Bryan	9794220208	Residential	Owner	Yes	2 years	Runoff due to being downhill and neighborhood built with NO city drainage at all	12/27/15 4-6 inches above slab			Home had history of flood that was never disclosed when we purchased this property, full details are not available to exact dates of flood history, but there was evidence of past flooding with flood drill holes for drying throughout the home, water marks in home that were covered up by seller and pre-existing mold in hidden places due to flooding. We had 8k of damages that we came out of pocket to repair the damages done on 12/27/15 when our house flooded two weeks after we purchased the home. We have now also purchased flood insurance through FEMA, installed a sump pump, French drains, channel drains, degraded our yard and after 4k of outside modifications we are still battling flash flood runoff due to the lack of any sort of city drainage in the neighborhood. The drainage problem in this neighborhood should be surveyed, analyzed and modifications made.	There are many residents of Wheeler Ridge that have runoff problems from speaking with a few here and there. There is no city drainage at all in the neighborhood and the downhill houses suffer extremely.
Quinn Linford	1319 Garden Ln., Bryan	7022719894	Residential	Owner	No	2 years	Improper drainage on your lot or your neighbor's lot				Although no water has entered the main structure since we have owned the property, the house does show signs of previous flooding of up to 1 inch of water. The signs are especially present in rooms with exterior walls and carpet. Previous owners installed downspout extenders and exterior sump pump to mitigate problem. We have since re-graded a significant portion of the yard to prevent further flooding and we plan to install a french drain to redirect the water.	
Darrell Booker	1400 Lincoln Street, Bryan	9797788610	Residential	Owner	No	30 years	Flooding from the street over the curb and yard, Improper drainage on your lot or your neighbor's lot, the creek rising out of the creek banks					
Jim Floyd Jr.	1108 Clark Street, Bryan	9792182975	Residential	Owner	No	35 years	Flooding from the street over the curb and yard, the creek rising out of the creek banks	3 feet, 2015 and 3 feet 2017		All the lots 1100 block		Lincoln Street, Douglas Street, Frank

Citizen Flooding Survey

George E. Lewis Sr.	1201 Clark Street, Bryan	9792243027	Residential	Owner	No	28 years	Improper drainage on your lot or your neighbor's lot, Other	Leak from top of roof around plumbing			At top of house, flood water under house cause house to become unlevel, interior doors, exterior doors are not right. Neighborhood has been stressed due to the fact of Dr. Harrison altering the creek by putting things in it to block waterflow off its property course. It needs to be corrected ASAP. Thanks.	At the end of Clark Street, Lincoln Street, Frankfort Street, Castle Heights Park
Kimberly Mooring	4008 High Street, Bryan	9796769054	Residential	Owner		20+ years	Flooding from the street over the curb and yard, Improper drainage on your lot or your neighbor's lot, low driveway receiving water form the street, Flowerbed/landscaping filled against house/business above weep holes, the creek rising out of the creek banks				Didn't have these issues until new development has been added to area and concrete poured for sidewalks/drainage for new development on certain streets.	Several streets in Castle Heights Subdivision, there are several incomplete streets that have been developed; park area and around Castle Heights Baptist Church.
Tonja Mooring	3806 High Street, Bryan	9799976088	Residential			20 years	Flooding from the street over the curb and yard	9/2017 - 4 feet				Castle Heights Park, Castle Heights Church
Darrell Booker	4109 East Highway 21, Bryan	9797788618	Residential			10 years	Flooding from the street over the curb and yard, Improper drainage on your lot or your neighbor's lot, the creek rising out of the creek banks	Yes				
Dimple Wilson Suseberry	1404 Conroy Street, Bryan	9797210791	Residential		No	Family home	Flooding from the street over the curb and yard, Improper drainage on your lot or your neighbor's lot, low driveway receiving water form the street, the creek rising out of the creek banks					The creek bed, flooding park, bridge on Highway 21, Conroy Street, entrance from Highway 21, Castle Avenue curbs and yard water up to the steps.
Samson Wilson Jr.	1500 Conroy Street, Bryan	9793244154	Residential		Yes	18 years	Flooding from the street over the curb and yard, improper drainage on your lot or your neighbor's lot, low driveway receiving water from street, flowerbed/landscaping filled against house/business above weep holes, the creek rising out of the creek banks	Flood water running under the house		Water standing in yard	Heavy rain stands in yard	Behind my house water gets very high
Wilborn Wilson Jr.	1404 George Street, Bryan	9794121708	Residential	Owner	No	8/24/1985	Flooding from the street over the curb and yard, the creek rising out of the creek banks		June 2015, 1.5 feet and 2017, 1 foot	Over the curb and yard	Carter Creek and E. Highway 21, Lincoln, Clark, Gooseneck Drive	Shutdown E. Highway 21 water over road, year 2015
Howard Ray	1204 Water Oak Street, Bryan	9795759980	Residential	Owner	No	Since 1999	Flooding from the street over the curb and yard, Improper drainage on your lot or your neighbor's lot, the creek rising out of the creek banks	2002-2.5 feet		Yes	I have picture of flood water on my phone going from the street and drainage from creek	Cause the falling of my trees on my property and leveling of my house
John/Charlotte Standard	704 Chevy Chase, Bryan	9798221930	Residential	Owner	No	30 years	The creek rising out of the creek banks	Spring 1987 - The city inspector had approved a drainage line from patio surface drain into the sewer line instead of having builder whose plumber did the work causes rain water to back up through the sewer line into our bathroom under the commode and into adjoining 2 bedrooms. We had to pay for new drainage pipe to the street plus new carpet and commode.			Drainage ditch from Gordon Street overflows into our yard (west side) during heavy rain. The large (wide) ditch flows into Burton Creek on our yard. Burton Creek make a turn on our lot and the bank on our side is washing away	Much trash from under the bridge on Woodland Street near Gordon washes down and hangs on the overgrowth of plants. It cannot be reached from either side. Many branches that break off trees often are too large to continue with the flow of water. We call the city when this happens. There is always a collection of waste (trash-limbs) 50 yards or so downstream that stays there. A wooded area on the Woodland side prevents access Bad for snakes, diseases, etc. A sign No Dumping would help.
Cindy Boddie	702 Chevy Chase, Bryan	9797031751	Residential	Owner	No	7 years	Improper drainage on your lot or your neighbor's lot, the creek rising out of the creek banks, land erosion of creek				Creek flooding is causing flooding in yard area. Running water draining beside neighbor's house is coming through my backyard. Debris of all kinds in the creek, including sanitary napkins. Erosion of land on the other side of house, once fixed by city but the erosion is still happening. Concrete drainage pipe broken and in the creek.	
Mary Marsden	600 B Cache Cove, Bryan	2817954818	Residential		Yes	3 years					Never flooded to my knowledge but a danger	
Thaddeus Romansky	2801 Cherry Creek Circle, Bryan	9794921995	Residential	Owner	Yes	2 years	The creek rising out of the creek banks	5/26/16 - 3.5 feet	5/26/16 - 1.5 feet		It appears that flood waters hit our property from off the golf course and over the banks of Briar Creek. We also believe that the concrete debris in part of the creek (intended to mitigate erosion), unfortunately, slowed the water significantly causing it to overflow that banks.	
John & Lynn McKemie	3332 Fiddlers Green, Bryan	9797031292	Residential	Owner	No	2 years	The creek rising out of the creek banks				My neighborhood in Greenbriar was impacted by the flooding on Memorial Day weekend in 2016. I was unable to get to my house which was under construction due to the flooding at Briarcrest and Boonville Road. I then tried to go west and could not cross at Bullinger Creek Drive and Carter Creek as it was under water. I went further west and tried Old Reliance Road but it too was under water at Carter Creek. All 3 areas are choke points and need remediation to allow the water in Carter Creek to flow freely.	Debris in areas that do not allow for drainage
Park Hudson HOA - Laura Nelson	3920 Park Meadow Ln, Bryan	9797768786	Residential	Owner	Yes	Since 2008	The creek rising out of the creek banks				See PPT presentation provided with photos and dates by Laura Nelson and Lloyd and Mary Joyce	Park Village Subdivision (even number of Park Meadow Lane). Greenbelt area fills up and does not drain fast enough
Park Hudson HOA - Mary Joyce	3924 Park Meadow Ln, Bryan	9797796315	Residential	Owner	No	8 years	Flooding from the street over the curb and yard, the creek rising out of the creek banks				Park Village HOA - experience high water in recent years, no home volume, 6 couples committee 2016 - expressed concern to city staff, 800 home development upstream - worried about effect from this development. City be diligent in cleaning drainage ways. Copperfield bridge cleaned regularly	
Patrick Giammalva	213 Fairway, 404 Williamson	9794120251	Residential	Owner	No	5 years					Villa Maria and South College	Finfeather Lake
Johnny Ramirez Jr.	2803 Cherry Creek Circle, Bryan	9797774763	Residential	Owner	Yes	21 years	Flooding from the street over the curb and yard, improper drainage on your lot or your neighbor's lot, low driveway receiving water from the street, the creek rising out of the creek banks	5/26/2016				
John McBride	911 Harlem Lane, Bryan	9792299078	Vacant Lot	Owner	No	18 years	The creek rising out of the creek banks				A lot of flood water, erosion, debris, sluffing of banks. Appraisal district said that 20% of lot impacted by erosion	Flooding getting much worse since 1997 - since the removal of Mexican Tank at the railroad tracks.

Appendix I: Primary and Secondary Drainage Recommendations

Project Objective

The Bryan Storm Water Masterplan was prepared to assist the City in evaluating the existing conditions of selected storm water infrastructure and to develop a storm water capital improvement plan to address existing problems. The evaluation consisted of using various sources, such as storm water master plans/studies, Geographical Information System (GIS) data and documented flooding concerns to develop drainage capital improvement projects (CIPs). The results of the evaluation were used to develop an implementation plan for the City to prioritize improvements. A list of the various sources is included in Appendix A.

The developed drainage CIPs were organized into a Microsoft Access database where they can be stored and recalled. A site visit was done to complete the data collection for projects that were missing information. The site visit included visiting project areas throughout the city, gathering information from the site and the City staff as well as taking pictures for the database.

For cost estimating purposes, a 15% contingency was used to estimate the cost for surveying and engineering, and a 20% contingency was used to estimate engineering costs for projects requiring a study as well as design. All unit costs are in 2010 dollars. The cost for maintenance is not included in the cost analysis for each alternative. It is assumed that the City will perform regular maintenance, including mowing and removal of trash and debris. The cost estimates are approximate and based on conceptual proposed improvements.

The goal of this masterplan is to produce the following deliverables to the City of Bryan for use in City planning, watershed and floodplain management, and future storm water management initiatives:

- Provide a sustainable city-wide ranked storm water Capital Improvement Plan using a Microsoft Access database that identifies existing problems, solutions and recommended budgetary needs; and
- An interactive GIS color-coded map that is linked to the Access database and shows the locations of projects
- A summary report documenting the process and ranking methodology

City-Wide Storm Water Capital Improvement Projects

Existing flooding, erosion, maintenance, and water quality problems were identified based on the analyses of existing data. Preliminary improvements were proposed to alleviate these problems and grouped into larger projects, called capital improvement projects (CIPs). These CIPs are categorized based on geographic location according to watershed. There are a total of 122 drainage project areas identified in previous studies. These storm water capital improvement projects are prioritized according to a ranking system developed through coordination with City staff. Locations of the drainage CIPs are identified on Figure 2, and each Project area is summarized in a one page report developed using the Microsoft Access database. These reports are located in Appendix B.

CIP Ranking

The storm water capital improvement projects (CIPs) developed through the data assessment are prioritized according to a ranking system developed through coordination with City staff. The ranking system was used to assess the relative severity of the identified drainage problems. The CIP ranking will assist the City in distinguishing between projects of various priorities and will be useful for budgeting purposes. The system is also intended to be a "living" document with which future projects can be added and prioritized.

Criteria Weighting

FNI coordinated with City staff to determine weights for nine different ranking criteria: life safety, street flooding, infrastructure damage, structures flooding, frequency of flooding, maintenance, project cost, funding available, and right-of-way availability. FNI created a pair-wise comparison table, which allowed the City to weigh each criterion against the other. The City staff members were polled to determine which criterion was more important than another based on a scale of 1 to 3. A score of 3 means that one criterion is considered more important than another, a score of 2 means that the criteria are of the same importance, and a score of 1 means that the criterion is considered less important than another. The scores from each of the staff members present were averaged and added together to determine the weighted value assigned to each criterion, as shown in Table 3. For example, the City staff members were asked whether life safety is more important, equal to, or less important than structure flooding. According to Table 3, the City determined that life safety is considered more important than structure flooding; therefore, life safety received a score of 3 in that category. It should be noted that the scores are not whole numbers because they represent an average of the City responses during the pair wise evaluation exercise.

Table 3. Pair-wise Evaluation Criteria Ranking Results for the City of Bryan

		Public Safety					Economic Impact		Project Timing		
		1	2	3	4	5	6	7	8	9	
	Criteria	Life Safety	Street Flooding	Infrastructure Damage	Structure Flooding	Frequency of Flooding	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	**Weighting Sum**
Public Safety	Life Safety		3	2.5	2.25	2.75	2.75	2.75	3	3	22
	Street Flooding	1		1.25	1.5	1.75	2.25	1.25	2.25	2.5	13.75
	Infrastructure Damage	1.5	2.75		2.25	2.25	2.75	2.25	2.5	2.75	19
	Structure Flooding	1.75	2.5	1.75		2.75	2.25	2.25	2.5	2.5	18.25
	Frequency of Flooding	1.25	2.25	1.75	1.25		2.25	2.25	2.25	2.5	15.75
Economic Impact	Project Cost	1.25	1.75	1.25	1.75	1.75		1.5	2.25	2.5	14
	Maintenance	1.25	2.75	1.75	1.75	1.75	2.5		2.5	2	16.25
Project Timing	Funding Source	1	1.75	1.5	1.5	1.75	1.75	1.5		1.75	12.5
	Right-of-Way Availability	1	1.5	1.25	1.5	1.5	1.5	2	2.25		12.5

Based on this method, Table 4 shows the evaluation criteria and the appropriated weighted value in order from 1 to 9.

Table 4. Ranking Key

Rank	Evaluation Criteria	Weight
1	Life Safety	22
2	Infrastructure Damage	19
3	Structure Flooding	18.25
4	Maintenance	16.25
5	Frequency of Flooding	15.75
6	Project Cost	14
7	Street Flooding	13.75
8	Funding Source	12.5
9	Right-of-Way Availability	12.5

Criteria Descriptions

The nine ranking elements are described in detail below and organized into three categories: public safety, economic impact, and project timing.

Public Safety

1. Life Safety - During significant rainfall events, storm waters may overtop roadways or pedestrian routes. The depths of these flows are increasingly hazardous for pedestrians, bicyclists and motor vehicle operators. The value of life safety is determined by the depth of runoff in the road. Projects with a higher depth of storm water in the roadways will receive more points for this category.

Depth	Points
Over 24 inches	10
19 to 24 inches	9
13 to 18 inches	8
6 to 12 inches	7
Less than 6 inches	5

2. Street Flooding: During significant rainfall events, the flooding of a roadway effectively removes that segment from the surface transportation system. Based on the location of such flooding, and the traffic loading of the street, serious problems may result by interrupting driver's ability to move through the area, particularly to critical facilities.

Road Type	Points
Major Arterial and Highway	4
Minor Arterial	3
Collector	2
Local	0

- Should a roadway be considered as a primary route to a critical facility, 3 points are added to the scoring.
- Should a roadway segment subject to flooding not have an existing alternate route, 3 points are added to the scoring.
- However, the maximum score for the street flooding criteria is 10.

3. Infrastructure Damage: This category is used to account for the potential damage that may be caused to public infrastructure as a result of the situation to continue unabated. Because it is best to prevent significant damage to the infrastructure before safety becomes an issue and costs escalate dramatically, areas with a higher potential for damage will receive a higher point value for this category.

Damage Potential	Points
High	10
Moderate	7
Low	4
None	0

4. Structures Flooding: This category considers the number of structures (including roadways) which are subject to potential flooding or flood related damage. Projects with more structures at risk receive a higher point value.

Number of Flooded Structures	Points
3 or more	10
2	7
1	5

Number of Flooded Culverts/Roads	Points
3 or more	9
2	6
1	3

Frequency of Flooding: Although larger, more infrequent rainfall events can cause more damage during a single episode, the cumulative effect of repeated smaller events can be significant as well. Additionally, the more often flooding conditions are present, the greater the possibility of citizen complaint and personal injury. Therefore, situations which arise at lower flood intervals receiver higher point values in this category.

Storm Interval	Points
2-year Storm	10
5-year Storm	9
10-year Storm	7
25-year Storm	4
50-year Storm	2
100-year Storm	1

Economic Impact

5. Project Cost: It is important to recognize that each storm water capital project will vary in size of improvement, the type of project, and the overall cost. It is also important to the City to be able to provide funds for each identified project, and to obtain the most cost effectiveness for the funding provided. Because lower cost projects can be accomplished with less impact to the City budget, they receive more points in the category.

Project Cost	Points
Less than $100,000	10
$100,000 to $199,000	9
$200,000 to $349,999	8
$350,000 to $549,999	7
$550,000 to $999,999	6
$1,000,000 to $1,999,999	5
$2,000,000 to $2,999,999	4
$3,000,000 to $3,999,999	3
$4,000,000 to $4,999,999	2
$5,000,000 to $5,999,999	1
$6,000,000 or more	0

6. Maintenance: Projects may be identified as an on-going maintenance issue due to erosion, debris, repair or other situations. Projects that have the potential to reduce the long term maintenance costs to the city should be credited with this value, therefore project with higher numbers of associated work orders over the prior 5 year period are receive more points in this category.

Number of Work Orders	Points
More than 10	10
8 to 9	8
6 to 7	6
4 to 5	4
2 to 3	2
Less than 2	0

Project Timing

7. Funding Source: Capital improvement projects can be funded though other sources than City funds. Developer funding, grants through various agencies and donations can all be sources of external funding for a project. Projects with a higher level of external funding should be valued higher in this category to retain the most cost effective use of City funds.

External Funding Available	Points
75% to 100%	10
50% to 74%	9
40% to 49%	8
30% to 39%	6
20% to 29%	4
10% to 19%	2
Less than 10%	0

8. Right of Way Availability: The timing of a project can be impacted by the availability to gain rights of way needed for construction and future maintenance. In addition, the City is not allowed to spend public funds on private property issues. Project areas where the needed rights of way have already been obtained are therefore ranked higher in this category.

Level of ROW Acquired	Points
Full City ROW	10
Full City and TxDOT ROW	8
Partial City ROW	3
No ROW	0

The drainage improvement projects were ranked to assess the benefit of the project with respect to the other drainage improvements. Each project was scored in each of the nine criteria and then multiplied by the corresponding weight to develop a total score. The projects were ranked according to the total score, with 1440 being the maximum possible score and 0 being the lowest possible total score. These calculations are completed within the access database. The city-wide ranking of CIPs is included in Table 5 later in this section and Figure 2 presents the 122 identified projects.

The final deliverable is the electronic Access database and sustainable Capital Improvement Plan. The database creates the report for the overall ranked list of projects, Table 5, as well as a one page summary of each project, shown in Appendix B. The database is also linked to the GIS color-coded map, as shown in Figure 2. If a project is changed in the database, it will be changed in the GIS map as well.

The projects identified and ranking of the projects are a planning tool to aid City staff in annual budgeting and project implementation for their storm water infrastructure. It is meant to be a tool to prioritize existing projects as well as projects as they arise in the future. It should be noted that some aspects of the Capital Improvement Plan may need to be revisited annually. The ranking criteria for each project may have changed over the course of a year, and the City may want to update their criteria weights. These changes can be made within the current database, and the process is described in the next section.

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
1	SC11	Lynndale Acres Ph 2 Flooding: Old Hearne and McHaney Street	$643	8	6	10	10	7	6	10	0	10	1111
2	BU05	Willow Bend Drive Flooding	$2,320	10	4	10	10	2	4	10	0	10	1023
3	BR03	Villa Maria Road Overtopping	$431	8	9	4	10	10	7	4	0	10	1004
3	SC08	W 17th Street Crossing Trib A	$288	8	5	7	10	9	8	4	0	10	1004
5	BR05	Ettle Street Road Overtopping	$288	10	3	10	6	10	8	2	0	10	987
6	SC12	Malvern Street and Southside Drive Street Flooding	$30	8	6	10	6	7	10	2	0	10	965
7	SC01	23rd Street Drainage	$1,195	7	4	10	9	10	5	2	0	10	947
8	SC07	W MLK St Crossing Trib A	$403	7	8	7	10	9	7	0	0	10	945
9	BU14	Villa Maria Trib D Crossing	$306	10	10	4	8	7	8	0	0	8	902
10	CB02	Palasota Road Crossing Tributary 5	$230	10	6	7	3	9	8	2	0	10	901

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
11	CC10	MLK Road Overtopping - FNI	$460	9	3	10	3	9	7	2	0	10	881
12	BR02	Broadmoor Drive Road Overtopping	$517	8	2	4	10	10	7	2	0	10	875
13	BU30	Farm Patch Flooding	$59	5	3	7	10	7	10	2	0	10	873
14	BU04	Burton Drive Crossing	$217	9	0	4	10	7	8	4	0	10	868
15	BU25	Oakridge Drive and Barak Lane	$1,738	10	7	7	6	7	5	0	0	10	863
15	CC04	Boonville Road Overtopping - FNI	$518	8	7	4	10	7	7	0	0	10	863
17	CC13	Waco Road Overtopping - FNI	$259	8	2	4	10	9	8	0	0	10	841
18	SC03	Tennessee Avenue Crossing	$259	7	0	4	10	10	8	2	0	10	839
19	BU49	Hillside Drive Storm Sewer Improvements	$808	0	3	7	10	7	6	10	0	10	837
20	BU02	Avondale Crossing	$223	8	2	4	10	4	8	4	0	10	827
21	SC13	Harwood Drive Street Flooding	$50	5	0	4	7	7	10	8	0	10	819
22	BR25	Apple Creek Cr in Briarcrest Estates Erosion	$966	5	3	10	9	4	6	10	0	0	814

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
23	BU03	Esther Blvd Crossing	$217	8	0	4	10	7	8	2	0	10	813
24	SC05	Woodville Road Crossing WF Still Creek	$230	5	2	4	10	1	8	10	0	10	811
25	CB01	Palasota Road Crossing	$460	5	5	10	10	2	7	0	0	10	807
26	CC11	Dumas Road Overtopping - FNI	$230	10	0	7	8	4	8	0	0	10	799
27	TC01	Villa Maria Crossing	$431	10	10	4	3	7	7	0	0	8	797
28	BU41	Burton Creek Tributary D and E Channel Improvements	$1,553	10	3	7	7	4	5	6	0	3	790
29	BU15	Maloney Crossing	$320	10	0	4	8	7	8	0	0	10	789
30	BU11	Williamson Crossing	$251	7	3	4	10	2	8	4	0	10	788
31	CC12	Moss Road Overtopping	$403	10	0	7	8	4	7	0	0	10	785
32	CC03	Briarcrest Road Overtopping	$288	7	7	4	10	2	8	2	0	8	784
33	CC08	Old Reliance Road Overtopping	$460	9	3	4	3	7	7	4	0	10	768
34	HC01	Regional Detention	$308	7	9	7	3	2	8	2	0	10	767

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
35	TB03	SH 6 Frontage Road Overtopping at Thompsons Branch	$460	10	7	7	3	4	7	0	0	8	765
36	BU08	Duncan Street Crossing	$137	7	0	4	8	7	9	0	0	10	737
37	BR06	Ettle Street Road Overtopping	$431	7	7	4	3	10	7	0	0	8	736
38	BU09	Tract North of Carson Crossing	$344	10	0	4	8	7	8	2	0	3	734
39	CB03	Industrial Boulevard Crossing	$460	10	0	4	3	10	7	0	0	10	731
40	CC02	Green Valley Road Overtopping	$460	8	2	7	3	7	7	0	0	10	725
41	TB04	Mumford Road Overtopping	$460	10	2	7	3	4	7	0	0	10	722
42	BR07	SH 6 Freedom Boulevard Tributary Road Overtopping	$460	8	4	4	3	10	7	0	0	8	718
43	BU06	Broadmoor Street Crossing	$402	5	6	7	3	7	7	0	0	10	713
43	BU07	College Crossing	$357	5	6	7	3	7	7	0	0	10	713
45	BU13	Cavitt Crossing	$250	5	3	4	10	4	8	0	0	10	710

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
46	BU10	Carson Street Crossing	$206	5	2	4	8	7	8	0	0	10	707
47	BU51	826 and 827 Vine Street Property Flooding	$417	5	0	10	7	9	7	0	0	3	706
48	BU48	Briar Oaks Drive Storm Sewer Improvements	$241	5	2	7	3	7	8	2	0	10	705
49	CC16	Ursuline Ave Flooding	$25	5	2	4	5	7	10	6	0	3	690
50	BU01	Woodland Drive Crossing	$175	7	0	7	3	4	9	2	0	10	689
51	TB02	SH 6 Road Overtopping at Thompsons Branch - FNI	$518	7	10	4	3	4	7	0	0	8	684
52	TC03	Westwood Main Street Crossing SF Turkey Creek	$345	5	2	10	3	4	8	0	0	10	683
53	BR09	Assisted Living Road Overtopping	$288	7	0	4	3	10	8	0	0	10	679
54	CC09	Castle Heights Subdivision Flooding - FNI	$50	0	0	4	10	9	10	6	0	3	676
55	BU52	Truman Street between Franklin St and Truman Ave	$58	5	0	7	3	7	10	0	0	10	673

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
56	SC17	N Logan Ave and W 24th Street Drainage	$460	5	3	7	3	7	7	0	0	10	672
57	CB06	S Main Ave Flooding	$3,401	5	3	4	7	7	3	2	0	10	665
58	BU37	Kent and Oxford St Intersection Flooding	$210	7	0	4	3	9	8	0	0	10	664
59	BU50	S College Avenue Storm Sewer Improvements	$569	0	3	4	5	7	6	8	0	10	657
60	BR17	Briarcrest Bridge Flooding	$460	7	7	4	3	4	7	0	0	8	642
60	TB01	N Harvey Mitchell PW Road Overtopping	$460	7	7	4	3	4	7	0	0	8	642
62	BU12	College Crossing Trib D	$435	5	6	4	3	4	7	2	0	10	641
63	CB07	Suncrest Street Drainage	$35	5	0	4	5	4	10	2	0	10	637
64	BR08	Red River Drive Road Overtopping	$316	5	0	4	3	10	8	0	0	10	635
65	CB08	Richard St. and Mockingbird St Drainage	$35	5	0	4	3	4	10	4	0	10	634
66	CC14	Old Kurten Rd Overtopping	$345	7	0	4	3	7	8	0	0	10	632

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
67	CC18	Bravo Court Flooding	$25	5	2	4	5	7	10	2	0	3	626
68	BR01	SH 6 West Briar Creek Road Overtopping	$460	7	4	4	3	3	7	2	0	8	618
69	CC06	Pecan Ridge Subdivision Flooding - FNI	$50	0	0	4	10	1	10	10	0	3	614
70	SC16	Tabor Road Flooding	$345	5	3	4	0	7	7	2	0	10	593
71	SC14	McDade Property Flooding	$25	5	0	7	3	7	10	0	0	3	586
72	CB04	Commerce Street Property Flooding	$403	5	4	4	3	4	7	0	0	10	582
72	CB05	Lee St and Twin City Missions Property Flooding	$30	5	0	4	5	4	10	4	0	3	582
74	BU43	2508 and 2510 Willowbend Circle Flooding	$400	0	0	10	10	2	7	2	0	3	572
75	TC10	Hummingbird Lane Erosion	$144	0	3	10	5	4	9	2	0	0	544
76	BU27	Hillside Drive Flooding	$25	0	0	4	8	7	10	0	0	3	510
77	TC04	Leon Street Flooding	$40	0	3	0	5	4	10	2	0	10	493
78	TC02	London Bridge Crossing - FNI	$230	7	2	0	3	1	8	0	0	10	490

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
79	BU29	Sprucewood Street Flooding	$25	0	0	0	5	4	10	4	0	10	484
79	CC05	Oak Forest Estates Flooding	$50	0	0	4	10	1	10	2	0	3	484
81	BR18	E 26th Street from Dillard Street to S Coulter Drive	$25	0	0	4	0	7	10	2	0	10	483
81	BR22	River Forest and DeLee Street Cul-de-sac Flooding	$25	0	0	4	0	7	10	2	0	10	483
83	CC26	Pierce Street Storm Drain Improvements	$1,726	5	0	4	3	0	5	10	0	0	474
84	BR19	Briarcreek Court Flooding	$25	0	0	4	0	7	10	0	0	10	451
85	SC10	Shirley Lane Flooding	$35	0	0	1	5	4	10	6	0	3	448
86	BU28	Finfeather Lake Flooding	$25	0	0	0	5	1	10	4	0	10	437
87	CC17	Carters Creek Trib B Erosion	$776	0	0	4	5	7	6	2	0	3	432
88	TC05	W Villa Maria Erosion	$863	0	4	4	3	0	6	2	0	10	427
88	BR21	Freedom Blvd Culvert Flooding	$460	0	0	4	1	7	7	0	0	10	427
90	BU31	Trib 5 Sandra Dr to Holick Ln Erosion	$290	0	0	7	0	0	8	8	0	3	412

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
91	HC04	Kirkwood Drive Backyard Flooding	$30	0	2	0	0	7	10	0	0	10	403
92	CC22	Carters Creek Trib B Meadowbrook Drive Erosion	$776	0	0	4	0	0	6	10	0	3	360
93	SC02	23rd Street Drainage Maintenance	$20	0	6	0	0	0	10	0	0	10	347
94	BU32	Trib 5 Holick Ln to Broadmoor Dr Flooding	$2,588	0	0	0	7	4	8	0	0	3	340
95	BU22	Texas Ave to S. College Ave. along Trib D	$82	0	0	0	10	1	10	0	0	0	338
96	BR23	Briar Creek Tributary D Flooding	$25	0	0	4	0	7	10	0	0	0	326
97	BU23	Williamson to Duncan Channel Improvements	$82	0	0	7	0	1	10	2	0	0	322
98	TC06	Unnamed Trib Miana Ct Erosion	$311	0	0	4	0	0	8	0	0	10	313
98	TC08	S Traditions Dr Erosion	$207	0	0	4	0	0	8	0	0	10	313
100	BU40	Wayside Drive Erosion	$155	0	0	7	0	0	9	0	0	3	296

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
101	BU18	9th Street to Rosemary Channel Improvements	$864	0	0	7	0	0	6	2	0	3	288
102	TC07	N Traditions Dr Erosion	$690	0	0	4	0	0	6	0	0	10	285
103	BR13	Ettle Street Channel Maintenance	$10	0	0	0	0	4	10	2	0	3	274
104	BU45	Esther to Burton Channel Improvements	$1,553	0	0	7	0	0	5	2	0	0	236
104	BU39	Epy's Subdivision Flooding	$25	0	0	0	0	4	10	2	0	0	236
106	CC15	Trib B Erosion - FNI	$1,955	0	0	7	0	2	5	0	0	0	234
106	HC03	Copperfierld Subdivision Ph 2 Erosion Trib 4.1.1	$1,760	0	0	4	3	0	5	2	0	0	234
108	BU36	Trib C and Vine Street Erosion	$435	0	0	7	0	0	7	0	0	0	231
108	BU33	Spring Lane Residential Flooding	$25	0	0	7	0	0	7	0	0	0	231
110	BR20	Briar Creek Estates Ph 1 Channel Erosion	$828	0	0	4	0	0	6	4	0	0	225
111	BU42	605 Cache Street Flooding	$776	0	0	4	0	2	6	2	0	0	224

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
112	BU19	Rosemary to Tanglewood Drive Channel Improvements	$1,488	0	0	4	0	0	5	2	0	3	216
113	BU24	Burton Creek Channel Maintenance Program	$67	0	0	0	0	0	10	2	0	3	210
114	BU46	Burton to Villa Maria along Burton Creek Channel Improvements	$1,553	0	0	7	0	0	5	0	0	0	203
115	BU17	SH6 to 29th St Improvements	$140	0	0	4	0	0	9	0	0	0	202
116	BU44	Avondale to Esther Channel Improvements	$1,967	0	0	4	0	0	5	0	0	3	184
117	BU38	Trib 7 and Skrivanek Drive Flooding	$900	0	0	0	0	4	6	2	0	0	180
118	BU20	Woodland Drive to Avondale Ave Channel Improvements	$1,348	0	0	4	0	0	5	2	0	0	178
119	TC09	Traditions Golf Course Area Erosion	$1,840	0	0	4	0	0	5	0	0	0	146
120	BU21	Burton Creek to S. College Ave Channel Improvements	$144	0	0	0	0	0	9	0	0	0	126

Table 5. Summary of Results from CIP Ranking Analysis

Total Final Ranking	ID / Project Number	Project Name/Location	Project Cost in 2010 dollars ($1000)	Life Safety	Street Flooding	Infrastructure Damage:	Structures Flooding:	Frequency of Flooding:	Project Cost	Maintenance	Funding Source	Right-of-Way Availability	Total Score
121	BU34	Trib C Greenway to S College Erosion	$569	0	0	2	0	0	6	0	0	0	122
122	CC01	Carter Erosion-University to Briarcrest	$6,670	0	0	4	0	0	0	0	0	0	76

Hudson Creek Drainage Analysis
July 1999

By:
McClure Engineering
1722 Broadmoor, Suite 210
Bryan, Texas 77802

Recommendations:

Structural Improvements

- Extend Nottingham Drive from its present terminus in Copperfield Subdivision to FM 158, thereby providing an outlet from the subdivision that does not flood. Est. Cost = $600,000
- The crossing structure at FM 158 should be enlarged to 3- 10'x10' box culverts. Est Cost: $63,000
- The stream crossing structure at the extension of Copperfield Drive I the Park Hudson development should be 5-8'x 8' box culverts. ***Completed.***

Development Regulations

- Implement a drainage policy requiring regional detention along the West Fork of Hudson Creek
- Apply current drainage policies that require on-site detention to the remainder of the drainage basin.

Public Information

- Initiate a public education program to help residents understand the purpose of the drainage easements and inform them of planned improvements to the channels.
- Proceed with the submittal of floodplain mapping data to FEMA so that accurate floodplain maps can be made available for future development in the area.

Briar Creek
Flood Hazard Study
May 2001

By:
Mitchell & Morgan, LLP
511 University Drive East, Suite 204
College Station, Texas 77840

Recommendations:

Structural Improvements

- Increase the capacity of the detention ponds upstream of Villa Maria to be used as a regional detention facility.
- Est. Cost = $600,000 Benefit = Remove more than ½ of the structures (approx.16 structures) within the floodplain downstream.

Thompson's Branch
Flood Hazard Study
August 2002

By:
Mitchell & Morgan, LLP
511 University Drive East, Suite 204
College Station, Texas 77840

This flood hazard study was prepared specifically to update the 100- and 500-year regulatory floodplain maps as well as generate floodplain maps for the ultimate development conditions. There were no specific drainage improvement recommendations in an effort to reduce flooding within this report.

Carters Creek
Flood Hazard Study
& Letter of Map Revision (LOMR)

By:
Mitchell & Morgan, LLP
511 University Drive East, Suite 204
College Station, Texas 77840

This flood hazard study was prepared specifically to update the regulatory floodway and the 100- and 500-year regulatory floodplain maps. There were no specific drainage improvement recommendations in an effort to reduce flooding within this report.

Letter of Map Revision
Turkey Creek
April 2005

By:
CDM
12357-A Riata Trace Parkway
Suite 210
Austin, Texas 78727

The purpose of this study was to redefine the existing 100- and 500-year floodplains. Based upon the revised analysis, 62 of 63 structures impacted by the current FIRM 100-year floodplain boundary have been removed, 1 structure remains in the floodplain, and 3 additional structures fall within the revised 100-year floodplain boundary. There were no specific drainage improvement recommendations within this report.

Burton Creek Watershed
Floodplain and Floodway Analysis
September 2004

By
Klotz Associates, Inc.
1160 Dairy Ashford, Suite 500
Houston, Texas 77079

General Items

- Start a program of easement acquisition, to have the right to access and maintain all segments of the Burton Creek channel system.
- Perform an environmental permit needs review in the initial stages of major maintenance projects and improvements projects.
- Perform Phase 2 Environmental Site Assessments prior to obtaining any easements or rights-of-way

Maintenance Projects

- Repair the failed concrete lining downstream of 29th Street. The reairs need to include a drop structure and riprap downstream of the concrete lining to stabilize the channel and avoid future erosion leading to another failure of the concrete lining
- Install a concrete channel bottom liner in the section from 29th Street to Rosemary to protect the existing channel side slope concrete liners. It may be necessary to obtain an environmental permit from the U.S. Army Corps of Engineers for this work.
- Start a maintenance program to clear the channels of trees, brush, and other undesirable vegetation. After the clearing is done, establish a long-range maintenance program to maintain the improved conditions.

Improvements Projects

- Replace selected culverts with larger culverts or bridges. For major thoroughfares, raise the road profile to reduce the probability of the street being overtopped and becoming impassable during extreme storm events.
- Improve channels.

Floodplain Mapping

- Request revised floodplain and floodway mapping for existing conditions based on the updated hydrologic and hydraulic analysis. This can be in the form of a request to FEMA for a Letter of Map Revision (LOMR).
- As proposed culvert and channel improvements are developed, request a Conditional Letter of Map Revision (CLOMR).

Still Creek Watershed Study
January 2012

By:
Halff Associates Inc.
4000 Fossil Creek Blvd.
Fort Worth, Texas 76137

This flood hazard study was prepared specifically to perform a hyfrologic and hydraulic study of Still Creek and its tributaries and generate floodplain maps for this creek and its tributaries. There were no specific drainage improvement recommendations in an effort to reduce flooding within this report.

Still Creek Flood Protection Study
February 2012

By
Freese & Nichols, Inc.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109

Recommendations:

Structural Improvements

- Lynndale Acres –
  - Construct 2 regional detention ponds
    - East of Bonham Elementary School
    - Near intersection of Wilkes Street & Bonham Street
  - Modify culverts within Lynndale Acres to accommodate 100-year storm
  - Enclose drainage ditches in new storm drains along Old Hearne Road & Wilkes Street
- Miscellaneous channel, roadway, and culvert improvements as appropriate to accommodate the 100-year storm at the following road crossings:
  - Tennessee Avenue
  - Woodville Drive
  - Southside Drive
  - W. Martin Luther King Street
  - W 17th Street

Appendix J: Excerpt from Brazos County Hazard Mitigation – Mitigating Risk: Protecting the Brazos Valley from All Hazards 2017-2022 – Executive Summary, Section 6: Flood, and Section 13: Dam Failure

Brazos County Hazard Mitigation

Mitigating Risk: Protecting Brazos County from All Hazards

2017-2022

Department of Emergency Management
110 N. Main Street Suite 100
Bryan, Texas 77803

EXECUTIVE SUMMARY

PURPOSE AND PROCESS OF DEVELOPMENT

This update document, "Mitigating Risk: Protecting Brazos County from All Hazards, 2017 – 2022," was prepared by the jurisdictions within Brazos County. The jurisdictions participating in and the planning area of the Brazos County Hazard Mitigation Plan include Brazos County, the Cities of Bryan, College Station, Kurten, Wixon Valley and Texas A&M University. These will be refered to as the "Brazos County and participating entities" or the "planning area".

This plan is a five-year blueprint for the future, aimed at making communities in Brazos County, to enclude the planning area, disaster resistant by reducing or eliminating the long-term risk of loss of life and property from the full range of natural disasters. It meets the requirements of the Disaster Mitigation Act of 2000 (P.L. 106-390); Section 44 of the Code of Federal Regulations, Part 201.6 and Part 206; and State of Texas Division of Emergency Management standards. An open public process was established to provide multiple opportunities for all sectors in Brazos County and participating entities to be involved in the planning process and provide input during its drafting stage.

HAZARDS FACING THE PLANNING AREA

The plan identifies and assesses the potential impact of nine natural hazards that threaten Brazos County and participating entities. These include: dam failures; drought; excessive heat; fires; floods; hail; severe winter storms; thunderstorms; and tornadoes. Hazards were identified based on a review of historical records, national data sources, existing plans and reports, and discussions with local, regional, and national experts. The list of hazards that may threaten Brazos County and the participating entities are:

- Floods
- Droughts
- Fires
- Severe Winter Storms
- Tornadoes
- Hail
- Thunderstorms
- Dam failures
- Excessive Heat

MITIGATION VISION

A vision statement, 6 goals, and 21 objectives were developed to guide the jurisdictions in the planning area in reducing or eliminating the long-term risk of loss of life and property from the full range of natural disasters. The mitigation vision for Brazos County and participating entities incorporates:

- An informed citizenry aware of the risks they face and the measures that can be taken to protect their families, homes, workplaces, communities and livelihoods from the impact of disasters.
- Local governments and regional entities that are capable of hazard-mitigation planning and project implementation, and of leveraging state, federal, and private resources for investments in mitigation.
- Intergovernmental coordination and cooperation on mutual issues of concern related to floodplain management and hazard mitigation.
- A commitment to locate buildings outside hazardous areas and to promote building methods that result in structures able to withstand the natural hazards that threaten them.
- The integration of mitigation into routine budgetary decisions and planning for future growth and development in the planning area, making disaster resistance an integral part of the livability and sustainability of the county.

GOALS, OBJECTIVES AND ACTIONS

The overall goal of this plan is to reduce or eliminate the long-term risk of loss of life and property damage in Brazos County and participating entities from the full range of disasters. Individual goals are:

GOAL 1. Develop new, and upgrade existing capabilities for identifying the need for and implementing hazard mitigation activities.

GOAL 2. Generate support for and increase public awareness of the need for hazard mitigation.

GOAL 3. Increase awareness of public officials, community and business leaders of the need for hazard mitigation, and support actions to protect public health and safety.

GOAL 4. Promote resource-sharing and increase coordination and cooperation among governmental entities in conducting hazard-mitigation activities.

GOAL 5. Mitigate damage to and losses of new and existing real property.

GOAL 6. Promote sustainable growth.

Twenty-one objectives in support of these goals are presented in Section 3.

Mitigation Actions

This plan sets forth mitigation actions and action plans to be carried out by Brazos County and the participating entities to reduce the risks to these hazards facing the planning area. Each action statement includes a description of the action, estimated costs, benefits, the responsible organization for implementing the action, an implementation schedule, priority, and potential funding sources. Some actions are directed at reducing the risk from a single hazard, such as flooding. Others pertain to multiple hazards or all nine hazards. The hazards differ in important ways, such as in their predictability, length of warning time, speed of onset, magnitude, scope, duration of impact, and the possibilities of secondary impacts.

ORGANIZATION OF THE PLAN

The executive summary is at the beginning of the plan. Sections 1 and 2 outline the purpose of the plan and the process of development. Section 3 contains the vision statement and mitigation goals and objectives. Section 4 describes the geography, population, land use and development trends in the planning area.

The major natural hazards that the planning area faces and the property at risk are identified in Section 5. Background on each hazard, including why the hazard is a threat, a hazard profile, the location of hazardous areas, history of hazardous events, people and property at risk, and potential damages and losses, is presented in Sections 6 through 14.

Section 15 reports previously implemented mitigation actions, including those supported by federal and state agencies, and local programs relating to building and fire codes and floodplain management ordinances. Section 16 presents mitigation actions to be undertaken by each participating jurisdiction. Section 17 discusses plan maintenance procedures, including how the plan is to implemented, maintained and evaluated, and how the public will continue to be involved.

Appendix A defines acronyms used in this plan. Appendix B reports the results of a web-based hazard survey to elicit information from the public on issues of concern about hazard mitigation. Appendix C identifies members of the local hazard mitigation team who updated this plan. Appendix D identifies the critical facilities in the planning area. Appendix E will contain the resolutions adopted by jurisdictional authorities when the plan is approved and the resolutions are adopted.

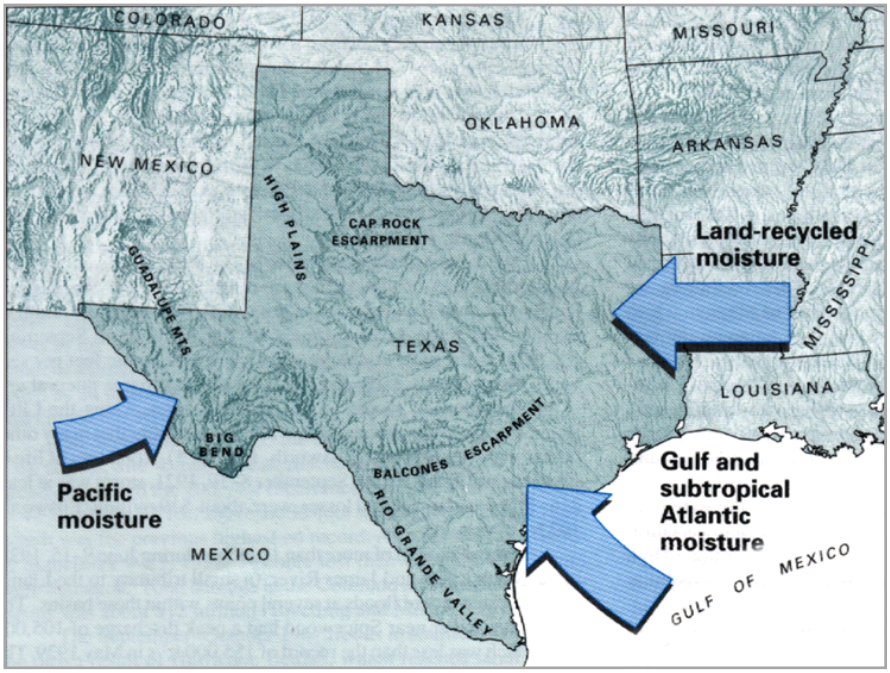
WHY FLOODS ARE A THREAT

Unique Geographic and Atmospheric Conditions

Texas, according to American Hazardscapes: The Regionalization of Hazards and Disasters published by the National Academy Press, consistently outranks other states in deaths and damage from floods. This is due to the location and size of the state. Texas is second in casualties and damages from hurricanes and tropical storms.

The state's vulnerability is the result of several factors: miles of Gulf of Mexico coastline; proximity to the Pacific Ocean off the west coast of Mexico; geographical location near the Rocky Mountains of Colorado and Arizona; the high-altitude jet stream; and nearness to the unique West Texas "dry line," a shifting, invisible atmospheric separation of dry desert air from the moist Gulf air. These factors create a breeding ground for the big storms of spring and fall that spawn tornadoes and suck up Gulf or Pacific moisture that feed the heavy rains that cause flash flooding. All these geographic factors cause Texas to experience extensive, annual storms. Figure 6-1 shows the state's vulnerability to damaging storms. Flooding takes many forms in the planning area.

Figure 6-1. Texas Sources of Moisture



Flash Flooding

Most flash flooding is caused by slow-moving thunderstorms, by thunderstorms repeatedly moving over the same area, or by heavy rains from hurricanes and tropical storms. Flash floods can occur within a few minutes or after hours of excessive rainfall. Often there is no warning that flash floods are coming.

Flash flooding can pose a deadly danger to residents of the planning area. A number of roads run through low-lying areas that are prone to sudden and frequent flooding during heavy rains. Motorists often attempt to drive through barricaded or flooded roadways. It takes only 18-to-24-inches of water moving across a roadway to carry away most vehicles. Floating cars easily get swept downstream, making rescues difficult and dangerous.

Riverine Flooding

Riverine flooding is natural and inevitable. It is the overbank flooding of rivers and streams, typically resulting from large-scale weather systems that generate prolonged rainfall over a wide geographic area. Some river floods occur seasonally when winter or spring rainfalls fill river basins with too much water, too quickly. Torrential rains from decaying hurricanes or tropical systems can also produce river flooding.

Urban Flooding

Urban flooding occurs as land is converted from fields or woodlands to roads, buildings and parking lots and when the natural land loses its ability to absorb rainfall. Urbanization changes the natural hydrologic systems of a basin, increasing runoff two to six times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while highway underpasses and underground parking garages can become death traps as they fill with water.

HAZARD PROFILE

Major flooding and flash flooding events can have a substantial severity of impact to the Brazos County and the participating entities. They can cause multiple deaths, completely shut down facilities for thirty days or more, and cause more than fifty percent of affected properties to be destroyed or suffer major damage.

The frequency of occurrence of flooding in the planning area is likely.

The extent of flooding in Brazos County and participating entities, can be water depths from between one and four feet deep in structures located in the identified flood hazard area.

Brazos County and participating entities have infrastructure and critical facilities that are vulnerable to floods. There are also residential structures that are vulnerable to flooding, and mitigation actions regarding those structures are addressed in Section 16 of this plan.

The annual probability of observing a 100-year flood is one-percent. The annual probability of observing a 500-year flood event is 0.2 percent.

Flooding occurs in seasonal patterns. Thunderstorms form when warm, moist air collides with cooler, drier air. Since these masses tend to come together during the transition from summer to winter, most thunderstorms and resulting flooding occur during the spring (April, May and June) and fall (October, November, and December).

HISTORY OF FLOODING

Flood events in the planning area reported to the National Weather Service are listed in Table 6-1.

Table 6-1. Reported Flood Events, January 1, 1994, to September 1, 2017

Type	Location	Date	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Flash flooding	Brazos	10/16/1994	0	0	$5.0M	$50K
Flash flooding/ flood	Brazos	12/15/1994	0	0	50K	5K
Flash flood	Bryan/ College Station	09/21/1995	0	0	5K	0
Flash flood	Countywide	02/20/1997	0	0	5K	0
Flash flood	North Portion	10/13/1997	0	0	5K	0
Flash flood	College Station	01/06/1998	0	0	5K	0
Flash flood	College Station	10/17/1998	0	0	5K	0
Flooding, riverine	County	10/17/1998	1	0	0	0
Flash flood	College Station	10/18/1998	0	0	2K	0
Flash flood	Countywide	10/18/1998	0	0	15K	0
Flooding, riverine	County	11/12/1998	0	0	0	0
Flash flood	Countywide	11/02/2000	0	0	1.0M	0
Flash flood	Countywide	11/03/2000	0	0	25K	0

Flash flood	Countywide	11/03/2000	0	0	25K	0
Flash flood	Countywide	11/03/2000	0	0	1.0M	0
Flash flood	Countywide	09/09/2001	0	0	50K	0
Flash flood	Bryan	07/14/2002	0	0	20K	0
Flash flood	Countywide	11/04/2002	0	0	95K	0
Flash flood	Countywide	02/20/2003	0	0	8K	0
Flash flood	Bryan	05/13/2004	0	0	250K	0
Flash flood	College Station	06/15/2004	0	0	55K	0
Flash flood	Bryan	06/30/2004	0	0	15K	0
Flash flood	Countywide	11/22/2004	0	0	0	0
Flash flood	Bryan	05/01/2007	0	0	130K	0
Flash flood	Countywide	12/15/2007	0	0	5K	0
Flash flood	Bryan	04/25/2009	0	0	1K	0
Flash flood	Bryan	06/09/2010	0	0	1K	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	06/09/2010	0	0	0	0
Flash flood	College Station	02/03/2012	0	0	100K	0
Flash flood	Bryan (Edge)	02/03/2012	0	0	2K	2K
Flash flood	Bryan	05/09/2013	0	0	10K	0
Flash flood	College Station	09/28/2013	0	0	0	0
Flash flood	Bryan	06/25/2014	0	0	0	0
Flash flood	College Station	07/17/2014	0	0	50K	0
Flash flood	Bryan	09/12/2014	0	0	3K	0
Flash flood	Bryan	05/25/2015	0	0	5K	0

Flash flood	Bryan	10/24/2015	0	0	0	0
Flash flood	College Station	12/27/2015	0	0	0	0
Flash flood	County Wide	05/26/2016	0	0	100K	0
Flood	County Wide	08/24/2017-08/28/2017	0	0	1.22M	0

LOCATION OF HAZARDOUS AREAS

Flood-hazard areas are determined using statistical analyses of records of riverflow, storm tides, and rainfall; information obtained through consultation with communities; floodplain topographic surveys; and hydrological and hydraulic analyses. FEMA's Flood Insurance Rate Maps (FIRMs) identify areas subject to flood hazard. These include Special Flood Hazard Areas, which are defined as areas that will be inundated by a flood event having a one-percent chance of being equaled or exceeded in any given year. The one-percent-annual-chance flood is also referred to as the base flood or 100-year flood. Moderate flood-hazard areas are also shown on the FIRM, and are the areas between the limits of the base flood and the two-tenths of a percent-annual-chance (or 500-year) flood.

The location of flood hazard areas for Brazos County and participating entities are shown in Figure 6-2. Flooding is primarily located along the Brazos River on the west side of the county and along the Navasota River on the east side of the county. Depths of flood waters can range from one to four feet deep along the Brazos River and one to three feet deep along the Navasota River.

The City of Bryan experiences flooding in many locations through out the City. In particular localized flooding is prevalent in areas with old drainage infrastructure (culverts, storm sewer, ditches, etc.) which are sensitive to heavy intensity, short duration storms.. Flood water in these areas can reach between one and three feet deep. There is a mitigation action item in Section 16 that addresses the identification of these areas through a 2D Modeling effort the results of which are available in GIS. Additionally the City of Bryan has homes that were constructed at elevations below the 100 year base flood elevation which were constructed prior to those elevations being determined by FEMA maps. Mitigation action items include purchase or elevate properties subject to Repetitive Loss or Severe Repetitive Loss properties, replace culverts and storm sewers from Storm Water Masterplan and perform detailed studies of flood areas to determine best solution.

The location of flood hazard areas in the City of College Station includes flooding up to three feet deep along Old Wellborn Road, which impacts structures located there as well as Old Wellborn Road itself. There is a mitigation action in Section 16 that addresses the structures located on Old Wellborn Road. The City of College Station also experiences flood waters several feet deep along Bee Creek and Wolf Pen Creek.

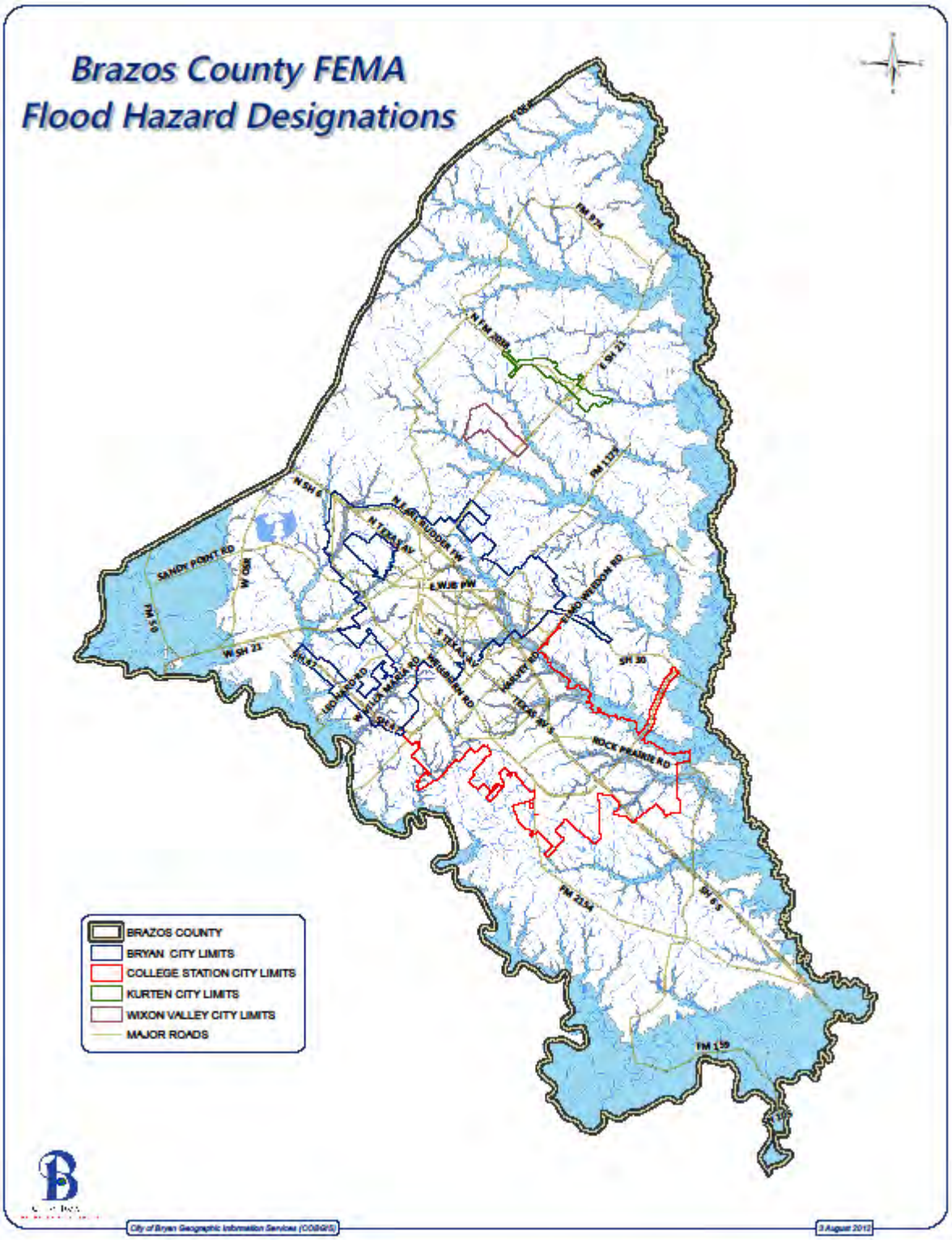
The City of Kurten experiences ponding of water between one and two feet deep along North Oakland Lane and South Oakland Lane, in addition to ponding of water up to one foot deep along Sagebrush Drive.

The location of flood hazard areas in Wixon Valley includes shallow ponding of water between one and two feet deep along FM 2776 and along Dilly Shaw Tap Road.

Texas A&M University has flooding along the northern portion of the campus where a golf course is located. Ponding of water can be expected up to one foot deep in this location.

Figure 6-2 on the following pages depicts the flood zones throughout the planning area, where there is potential for damage to property and loss of life.

Figure 6-2. Riverine Flooding Potential for the Planning Area



NFIP PROGRAM PARTICIPATION

Flood insurance offered through the National Flood Insurance Program (NFIP) is the best way for home and business owners to protect themselves financially against the ravages of flooding. There are currently over 600 flood insurance policies in force in Brazos County and the participating entities.

According to FEMA, jurisdictions participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

Brazos County and the cities of Bryan and College Station are currently the only jurisdictions within the county that participate in the NFIP.

These jurisdictions maintain their continued NFIP compliance in several ways, including:

- Requiring all new development in the identified flood hazard area to be permitted
- Requiring revisions to existing structures in the identified flood hazard area to be permitted
- Requiring Elevation Certificates to be submitted as part of the permitting process
- Persons looking to purchase flood prone property are being advised of the flood hazard area through credited hazard disclosure measures
- Continued preservation of open space in the floodplain
- Acquisition of existing structures from the floodplain
- Keeping track of building improvements and repairs to structures located in the identified flood hazard area
- Continued enforcement of stream dumping regulations
- The cities of Bryan and College Station both participate in the NFIP's Community Rating System (CRS). This voluntary incentive program recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Additional activities are verified annually and community success is translated into ratings which equal policy holder discounts.

For more information regarding the floodplain management ordinance of each community, see Section 6.

Table 6-2. National Flood Insurance Program, Policies and Losses for the Planning Area

Community	Policies in Effect	Total Coverage in Thousands	Total Losses	Dollars Paid, Historical	Policies in Effect
Brazos County	73	$12,697	6	$48,768	73
Bryan	334	$41,521	98	$588,684	334
College Station	284	$47,233	107	$412,631	284

People and Property at Risk

To assess flood risk, flood areas were modeled for 100-year and 500-year events. Flood depth was estimated at the pixel level for affected areas, along with proportion of the area affected within the census block. HAZUS-MH inventory and damage functions were then utilized to estimate exposure. Table 6-3 shows the estimated buildings and people at risk to flooding.

Because detailed information was not available to calculate potential losses due to flood, it is assumed that in a worst-case-scenario event, all exposed areas would be impacted and the exposed values would equal the potential losses.

Table 6-3. Potential Wet Exposure for 100-Year Flood (Riverine Flooding)

County	Potential Residential Building Exposure at Risk		Potential Commercial Building Exposure at Risk		People at Risk
	Number	Value ($1,000)	Number	Value ($1,000)	
Brazos	16,274	$2,283,987	981	$552,663	66,772

Potential Damages and Losses

To estimate annualized losses due to flood, the exposed values were multiplied by the probability of the occurrence of a 100-year flood event (1 percent) to calculate the estimated annualized losses. Annualized losses by county are shown in Table 6-4. Potential impacts to critical facilities and infrastructure are provided in Table 6-5. Repetitive losses are provided in Table 6-6.

Table 6-4. Potential Annualized Losses (Riverine Flooding)

County	Total Exposure of Residential and Commercial Buildings ($1000)	Annualized Losses for Residential Buildings at Risk ($1000)	Annualized Losses for Commercial Buildings at Risk ($1000)	Total Annualized Expected Property Losses	Annualized Percent Loss Ratio
Brazos	3,355,947	29,946	5441	35387	0.01000

Table 6-5. Critical Facilities and Infrastructure Potentially Damaged, Brazos County

County	Critical Facilities and Infrastructure		
	Total Number	Number Inside the 100-year Floodplain	Percentage Susceptible to Flooding
Brazos	298	129	43.29

REPETITIVE LOSSES

Brazos County has one (1) structure on FEMA's Repetitive Loss (RL) list and no Severe Repetitive Loss (SRL) structures.

The City of Bryan has seventeen (17) structures on FEMA's RL list and one (1) structure on the SRL list.

The City of College Station has six (6) structures on FEMA's RL list and one (1) structure on the SRL list.

Out of these structures twenty-four are in the cities of Bryan and College Station, one is in rural Brazos County, and one is unknown. Twenty-two structures are residential, two are commercial, and the remaining two are unknown at this time. They are primarily constructed of brick and mortar on concrete slab foundations.

None of the other jurisdictions within this plan have either RL or SRL structures listed by FEMA.

SECTION 13: DAM FAILURE

WHY DAM FAILURE IS A THREAT

Dams are water storage, control, or diversion barriers that impound water upstream in reservoirs. Dams provide many benefits and are an important part of our public works infrastructure. They are built for a variety of reasons, including maintenance of lake levels, flood control, power production, and water supply.

Although dams have many benefits, the risk that a dam could fail still exists. Dams can pose a risk to communities if not designed, operated and maintained properly. Dam failure is a collapse or breach in the structure. While most dams have storage volumes small enough that failures have little or no repercussions, dams with large storage amounts can cause significant flooding downstream. Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which cause most failures;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal problems, or maintain gates, valves, and other operational components;
- Improper design, such as use of improper construction materials;
- Failure of upstream dams in the same drainage basin;
- Landslides into reservoirs, which cause surges that result in overtopping;
- High winds, which can cause significant wave action and result in substantial erosion;
- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, leading to structural failure.

The nation's infrastructure of dams is aging. Old age and neglect can intensify vulnerability to these same influences. Furthermore, the terrorist attacks of September 11, 2001, have brought an increased focus on infrastructure protection nationwide, including the safety of dams.

Dam failures may result in the quick release of all the water in the lake. In the event of a dam failure, the energy of the water stored behind the dam is capable of causing rapid and unexpected flooding downstream, resulting in loss of life and great property damage downstream of the dam.

HAZARD PROFILE

The frequency of occurrence of a major dam failure in the planning area is a highly unlikely event. If a major dam should fail, however, the severity of impact could be substantial. It could

cause multiple deaths, completely shut down facilities for thirty days or more, and cause more than fifty percent of affected properties to be destroyed or severely damaged.

The extent of a major dam failure in our planning area is that several thousand gallons of water could be released at a sudden and unexpected rate. Over 2,000 people could be affected, 700 buildings could be flooded and several million dollars in damages could occur.

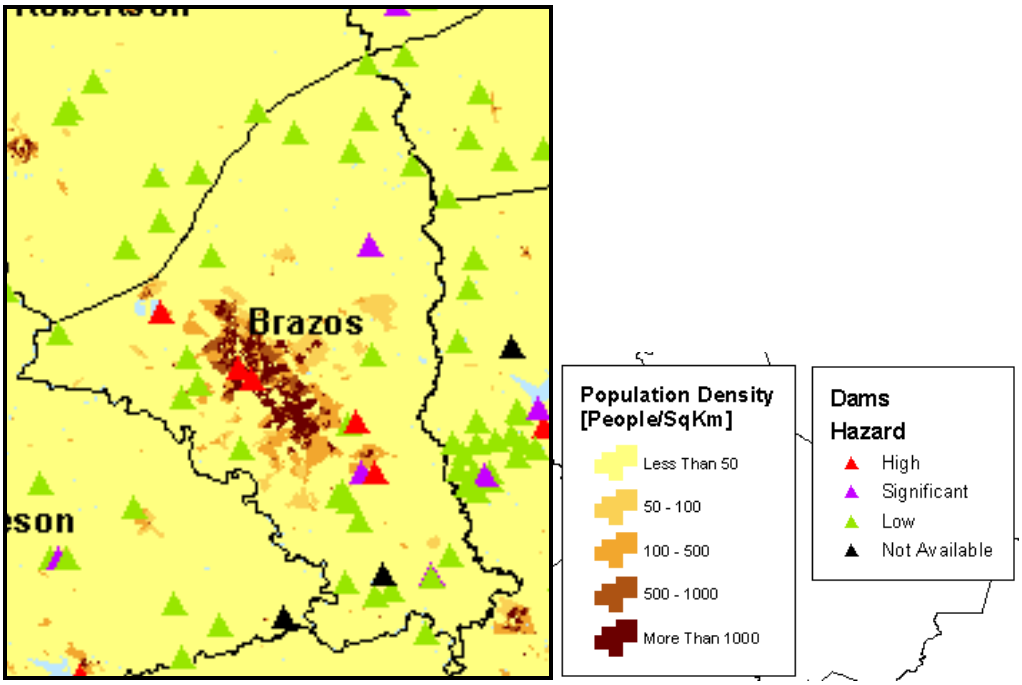
Flooding-related dam failure would most likely occur in months when floods are most likely -- during the spring (April, May and June) and fall (October, November, and December). Warning time for dam failure, or the potential speed of onset, varies with the causes but is estimated to be three to six hours.

There are about 80,000 dams in the United States today. Catastrophic dam failures have occurred frequently throughout the past century. Between 1918 and 1958, 33 major dam failures in the United States caused 1,680 deaths—an average of 42 deaths a year. From 1959 to 1965, nine major dams failed worldwide.

LOCATION OF HAZARDOUS AREAS

Figure 13-1 shows the location of dams in planning area. Detailed maps of the dam failure inundation areas are not currently available for all dams. It is assumed that dam breaks happens most likely at the time of maximum capacity of the lake and that the location of the released water would inundate a downstream quarter-circle buffer proportional to the maximum capacity of the dam to represent the maximum impact area.

Figure 13-1. Location of Dams in Brazos County



PEOPLE AND PROPERTY AT RISK

High-hazard-potential dams are those at which failure or misoperation would probably cause loss of human life. Significant-hazard-potential dams are those at which failure or misoperation probably would not result in loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or other significant damage. Significant-hazard-potential dams often are located in predominantly rural or agricultural areas but could be located in populated areas having significant infrastructure. Low-hazard-potential dams are those at which failure or misoperation probably would not result in loss of human life but would cause limited economic and/or environmental losses. Losses would be limited mainly to the owner's property.

Table 13-1. Dam Failure Hazard-Potential Classifications, National Inventory of Dams

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, and Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Some local damages
High	Probable. One or more expected	Yes (but not necessary for this classification)

Significant and low hazard dams pose no threat to the communities participating in this plan, and thus, will not be profiled further. High hazard dams, which do pose a threat to human life and property damage in Brazos County and participating entities, are profiled in this plan. There are currently five (5) high hazard dams in the planning area.

Table 13-2. Summary Status of Dams in Brazos County

County	High	Significant	Low	Undetermined	Total
Brazos	5	3	23	0	31

The five (5) high hazard dams in our planning area are listed in Table 13-3.

Table 134-3. High Hazard Dams in Brazos County

Dam	Hazard
Bryan Utilities Lake Dam	High
Carter Lake Dam	High
Country Club Lake Dam	High
Fin-Feather Lake Dam	High
Thousand Oaks Dam No. 11	High

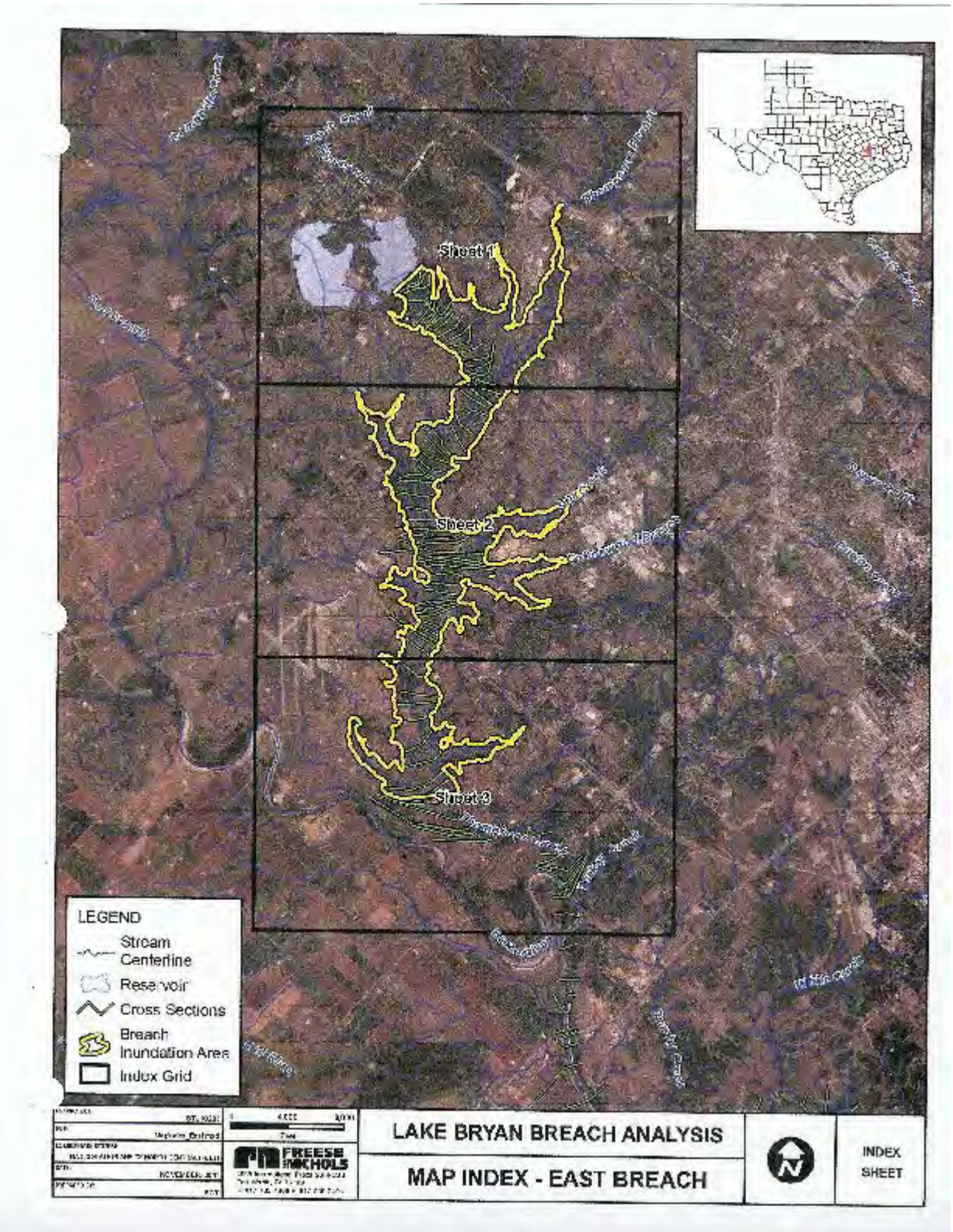
Bryan Utilities Lake Dam

An Emergency Action Plan (EAP) was created for the Bryan Utilities Lake Dam. The EAP contains information on who will be notified in the case of a dam failure. An inundation map is provided on the following page. The number of people and structures impacted by a dam failure is currently not known and not addressed in the EAP. A mitigation action addressing this deficiency is listed in Section 17.

- # of people impacted — Unknown, answer is not in the EAP
- # of house/ structures vulnerable — Unknown, answer is not in the EAP
- How much water there will be — 13,647 feet of water
- How far the water will go — 24 miles downstream
- Rural or city — rural

No critical facilities or infrastructure in the planning area, or the participating jurisdictions, would be impacted by a dam failure on Bryan Utilities Lake Dam. A map showing the inundation area for Bryan Utilities Lake Dam is shown on the following page.

Map showing the inundation area of Bryan Utilities Lake Dam.



Carter Lake Dam

Description:

The Owner of Carter Lake Dam TX01862 is the Carter Lake Home Owners Corporation and is part of the unnamed tributary of Carter Creek Location: 6 miles southeast of Bryan, TX

Property & Number of people effected:

Gessner Engineering of College Station performed a breach inundation study for Carter Lake Dam for this Emergency Action Plan in November of 2010. The results of that study are included in map form behind Tab 3. The downstream structures that could be affected by a breach of the dam include the four houses adjacent to the spillway as well as five lots in the Williams Creek development, 3 miles downstream. Approximately 27 people will be affected.

Water Capacity:

Its Length is approximately 1425 feet; its height is approximately 32 feet. The embankment crest is approximately 26 feet wide. Normal storage volume is 481 acre-feet. At capacity it is estimated that the volume is 600 acre-feet.

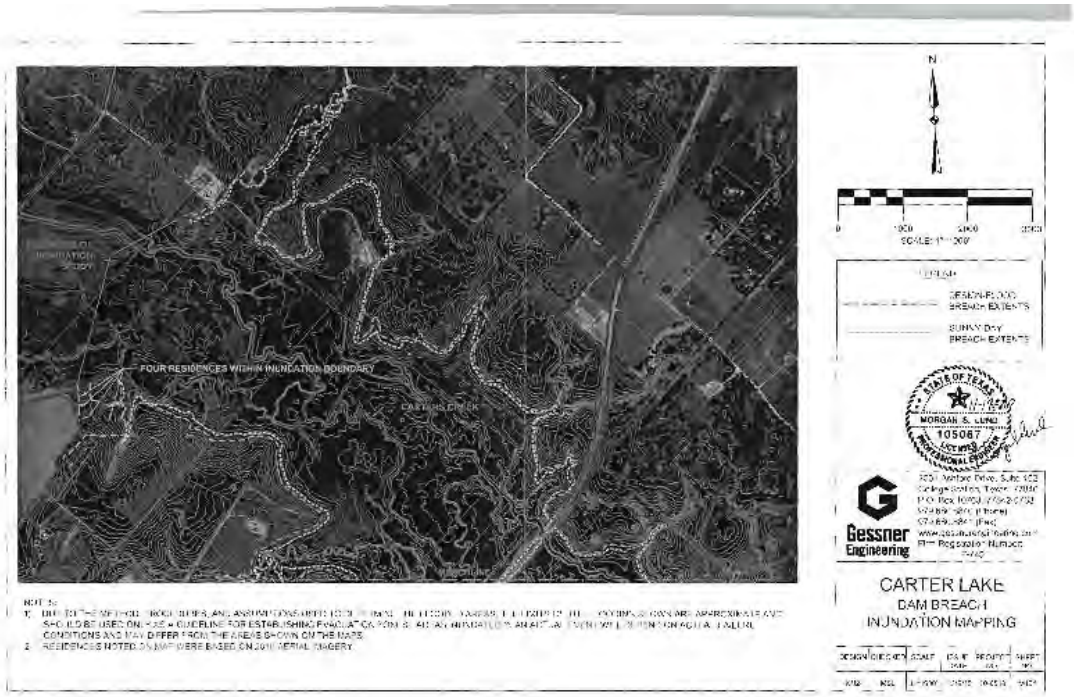
Inundation Effect:

The downstream structures that could be affected by a breach of the dam include the four houses adjacent to the spillway as well as five lots in the Williams Creek development, 3 miles downstream. If Carter Lake Dam fails, a flood wave will move east down through the low-lying area along Carter Creek toward William D. Fitch Road and beyond. A map showing the inundation areas is located on the following page.

Critical Facilities:

There are no critical facilities or infrastructure in the inundation area in accordance with the EAP on file for Carter Lake Dam.

Map showing the inundation area of Carter Lake Dam.

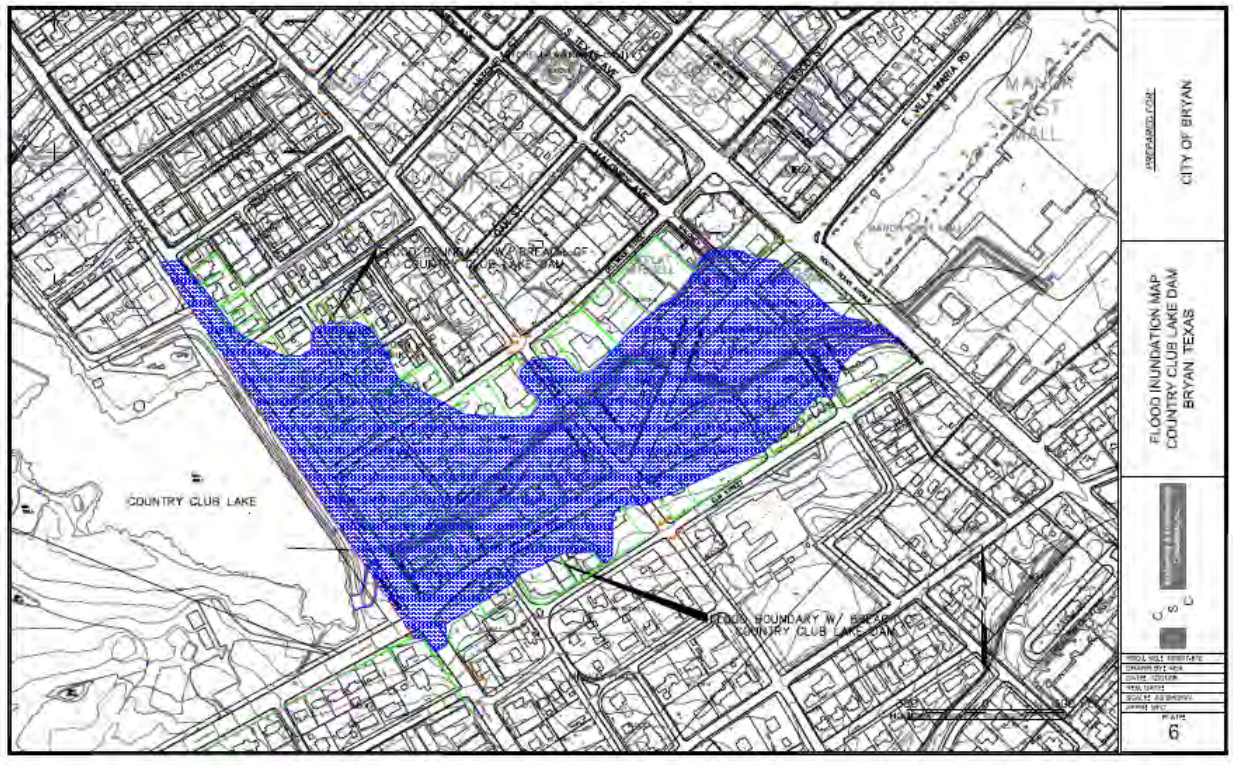


Country Club Lake Dam

An Emergency Action Plan (EAP) was created for the County Club Lake Dam. The EAP contains information on who will be notified in the case of a dam failure. A location map of the lake and downstream inundation map is provided below. The number of people and structures impacted by a dam failure is currently not known and not addressed in the EAP. A mitigation action addressing this deficiency is listed in Section 17.

- # of people impacted 279
- # of house/ structures vulnerable 93
- How much water there will be One foot inundation
- How far the water will go S. College west to S. Texas Ave. two city blocks
- Rural or city city – urban

Map showing the location of Country Club Lake and inundation map included below.



Finfeather Lake Dam

An Emergency Action Plan (EAP) was created for the Fin Feather Lake Dam. The EAP contains information on who will be notified in the case of a dam failure. An inundation map is provided on the following page. The number of people and structures impacted by a dam failure is

currently not known and not addressed in the EAP. A mitigation action addressing this deficiency is listed in Section 17.

- # of people impacted — Unknown, EAP does not answer
- # of house/ structures vulnerable — Unknown, EAP does not answer
- How much water there will be — 50.8 – 97.8 million gal.
- How far the water will go — 2.8 stream miles
- Rural or city — city - urban

Map showing the inundation area of Finfeather Lake Dam.

The methods, procedures, and assumptions used to develop the limits of the flooding shown are approximate and should only be used as a guideline for establishing evacuation zones. Actual areas inundated will depend on actual failure conditions and may differ from areas shown on the maps.

WARNING: This record contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons without a "need to know", as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other action. For U.S. government agencies, public disclosure is governed by 5 U.S.C. 552 and 49 CFR parts 15 and 1520.

Thousand Oaks Dam # 11

Description:

The Owner of Thousand Oaks Dam is Animate Habitat Ltd. (AH). Thousand Oaks Dam is located approximately 1 mile southeast of the intersection of State Highway 6 and State Highway 40 in College Station in Brazos County, Texas. Thousand Oaks Dam is designated by the National Inventory of Dams ID number TX06880. The Latitude and longitude of the dam are 30°32'40.14"1N; and 96°13'53.19'W, respectively. Thousand Oaks Dam flows into Alum Creek. A vicinity map for the dam and surrounding area is found on the following page.

Property & Number of people effected:

There are two property owners that own property in the floodplain below Thousand Oaks Dam. There are no structures that are occupied in the inundation area.

Water Capacity:

Its Length is approximately 890 feet; its height is approximately 25 feet. The embankment crest is approximately 70 feet wide. At capacity it is estimated that it covers 1.43 acres with a volume of 35.76 acre-feet.

Inundation Effect:

The projected inundation area is assumed to be limited to the floodplain area along Alum Creek. This area is vacant ranch land consisting of wooded areas mixed with open pasture land. Inundation timing and duration is highly dependent on the rate of dam failure.

Critical Facilities:

There are no critical facilities or infrastructure in the inundation area in accordance with the EAP on file for Thousand Oaks Dam # 11.

Map showing the location of Thousand Oaks Dam # 11.

POTENTIAL DAMAGES AND LOSSES

Table 13-5 shows the risk to people and buildings of failure of high-hazard dams in the planning area. HAZUS-MH inventory was used to estimate potential exposure, losses, and affected population due to dam failure. It was assumed that dam break happens most likely at the time of maximum capacity and that a downstream quarter-circle buffer proportional to the maximum capacity of dams represents the maximum impact area. There have been no previous occurrences of dam failure at high hazard dams in the planning area. Dam inundation maps are not currently available Thousand Oaks Dam #11.

Table 13-5. Exposure of People and Buildings to Failure of High-Hazard Dams in Brazos County

County	Affected		
	Exposure		Number of People at Risk
	Number of Buildings	Value ($1,000)	
Brazos	695	232,506	2,008

Appendix L: Unified Stormwater Design Guidelines – August 2012

Unified Stormwater Design Guidelines

City of Bryan

City of College Station

AUGUST, 2012

Unified
Stormwater
Design Guidelines

City of Bryan

City of College Station

AUGUST 2012

Sentences and/or paragraphs that are double underlined indicate revisions that were made from the 2009 manual.

Acknowledgements

Appreciation is expressed to participants in the Bryan / College Station Drainage Design Guidelines Form for their assistance during numerous work meetings and discussions, and to a working committee including engineering staff of both Cities. In addition, appreciation is extended to William Lowery, P.E. of the Texas Engineering Extension Service, Texas A&M University System, for his work in facilitating meetings and discussions and in preparation of the final document.

Unified Stormwater Design Guidelines

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Section I
Introduction

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION I

INTRODUCTION

A. Purpose

The standards and criteria in this document are promulgated to implement the intent of the stormwater management ordinances adopted respectively by the City of Bryan and the City of College Station for use in their respective jurisdictions. The term **"Guidelines"** is used throughout this document in reference to itself. The objective is to encourage uniformity of results through the use of unified criteria and sound practices in the planning, analysis, design, and construction of drainage facilities.

B. Source of Authority

These Guidelines are regulatory in nature, deriving their authority from the stormwater management ordinances and floodplain management ordinances adopted from time to time by the City Council of each of the two cities.

C. Definitions

Unless specifically defined in these Guidelines and/or in the Glossary, Appendix F, words or phrases used in these Guidelines shall be interpreted so as to give them the meaning they have in common usage and to give these Guidelines their most reasonable application. Responsibility for final interpretation of the meaning of language used herein rests with the City Engineer of each of the respective Cities.

D. Considerations

Managed Stormflow

One of the basic purposes of these stormwater Guidelines is to assure that newly developing land areas are planned and designed in a manner that safeguards life, property, and public infrastructure from damage due to ill-managed storm flow.

Guidelines Apply

Inasmuch as platting must provide for right of way and easements that assure efficient conveyance of storm flow within streets, storm drains, and prepared swales or channels, these guidelines are applicable to all such platting proposals. Likewise platting must demonstrate suitable spatial relationships between proposed building sites and floodplain areas designated by the Federal Emergency Management Administration (FEMA). For these reasons, anyone interested in building real property or public or service infrastructure of any kind in either Bryan or College Station is obligated to demonstrate to the City that they are in substantial compliance with these Guidelines. Such compliance will be one of the measures by which the adequacy of any proposed land plan, preliminary plat, final plat, or site plan will be evaluated.

Section II
Policies

Unified
Stormwater
Design Guidelilnes

City of College Station
City of Bryan

August 2012

SECTION II

POLICIES

A. Stormwater Principles

Drainage System

For purposes of regulation, the drainage system shall be divided into geographical and functional groupings. The drainage system consists of all natural and man-made features that collect or receive concentrated stormwater flow. Examples are swales or channels (natural or man-made), streets, storm sewers, minor streams and major streams.

Primary and Secondary

Functional division is separation of the drainage system into its primary and secondary components. The Primary System consists of major streams that convey collected stormwater through and out of the two cities, including primary tributaries thereof. The Primary System is made up of the watercourses that are part of the FEMA-designated floodplain management network, the geographic limits of which may be amended from time to time by the City. The Secondary System consists of all minor drainage ways, streets, storm sewers, and swales that collect stormwater and convey it to the Primary System.

Storm Duration

From a hydrologic standpoint, the Secondary System is sensitive to short duration, high intensity rainfall events. Flood effects occur suddenly and dissipate quickly, usually within a period of a few hours. By contrast the Primary System is sensitive to longer duration, moderate intensity rainfall events. Flood events occur over a longer period, with a slower rise to the fall from peak flows and flood elevations. This fundamental difference between the Primary and Secondary Systems forms the basis for strategies to manage stormwater and its effects within each.

Unique Characteristics

Geographical division involves separating the various streams and land areas into broad drainage areas having unique characteristics in terms of land cover, pattern of development, governmental jurisdiction, proposed land uses, and system interconnection. Recognition of these differences allows for logical formulation of policies and standards tailored to specifics rather than generalities.

Known Problems

Because the basic reason for regulating stormwater runoff and conveyance is to promote public safety, it must be emphasized that where persistent, known drainage problems exist, criteria more stringent than stated in these Guidelines may be necessary.

B. Framework of Stormwater Management Terms

A great variety of terms are used in the science and administration of managing urban stormwater. To foster clarity and expediency in use of these Guidelines, a limited series of terms has been specially defined. The focus is on the definitions of drainage areas, land proposed for development, and the purposes of detention. The diagram in Figure II-1 offers a graphical representation supporting this

framework of terms. The principal terms coined below are in bold print in this Section and are capitalized throughout these Guidelines. The Glossary in Appendix F provides specific definitions of these and other key terms.

1. Watersheds

Every land area in the Bryan-College Station region is in a "**watershed**" of some description, each of which is associated with some kind of watercourse. For managing storm runoff in these areas it is useful to divide these areas according to the watercourses that drain them.

Named Streams

For purposes of these Guidelines "**watersheds"** are all of the land areas contributing storm runoff to each of the principal watercourses making up the primary system. The primary system is divided into logical parts that are referred to as the "**Named Regulatory Watercourses"** listed in Table B-1, Appendix B. Reference maps of the principal watersheds are also included in Appendix B.

A hypothetical "Principal Named Watercourse" and the hypothetical watershed ("Watershed A") it drains are sketched in Figure II-1.

2. Basins

Tributaries

For purposes of these Guidelines a "**basin**" is defined as the land area drained by a tributary of a "Principle Named Watercourse". Each "Principal Named Watercourse" has several tributaries (some possibly having localized names) that serve to help drain the **watershed**. Each **watershed** is made up of several **basins,** and all areas in a **watershed** are considered to be part of one of its **basins.**

Specific Limits

The specific geographic limits of any **basin** are a function of topographic features that can only be determined through engineering study. Such limits must be determined when dictated by the characteristics of a proposed land development project as determined by the City Engineer or his/her designee during project review processes.

Figure II-1 illustrates the **basins** of a hypothetical **watershed**. In this sketch the "Principal Named Watercourse" has six tributaries, so the **watershed** is considered to have six **basins**. **Watershed** "A" has six identified **basins,** basins 1, 2, … 6.

3. Land Development Projects

a Land Areas

Enhanced Consistency

Land development projects occur in many shapes and sizes in a variety of locations. These Guidelines apply to all proposed projects but their application is a function of numerous variables. To enhance consistency in determining how these Guidelines apply to particular situations, the following land area terms will be used.

Project Area

Project Area: The entire land holding associated with any proposed land development project will be considered the **"Project Area"**. This is to include the largest acreage of any combination of: the entire ownership, the entire parent tract, and/or the entire purchase option acreage, if any. This is true for all contiguously owned tract(s) or lots regardless of whether platted or not platted. It is also irrespective of whether construction (buildings or infrastructure) is planned on portions of the land near term and/or at some future time, however well or poorly defined.

2-Phase Project

In Figure II-1 hypothetical Project B is a two-phase project. Stormwater analysis and design for Phase 1 of Project B must consider Phase 2 to be part of the **project area**, even if Phase 2 facilities and/or buildings are planned for future construction. In addition, it must consider any "**Above-Project Area(s)"** and "**Pathway Area(s)**" as described below.

Above-Project Areas

Above-Project Areas: These are any land areas that contribute storm runoff onto or through the **project area**. In Figure II-1 schematic projects A, C, and E all have **"above-project areas"** since upland areas contribute storm runoff to the **project areas**. Schematic projects "B" and "F" may or may not receive runoff from limited upland areas. Schematic Project "D", in Basin 1, borders the **basin** divide and receives no runoff from upland areas, so it has no **above-project area**.

Pathway Areas

Pathway Areas: As described in Paragraph C2 of this Section, "designated conveyance pathways", however simple or complex, must be identified for every land development project. Conveyance pathways downstream of a **project area** may carry runoff from land that is not part of the **project area** or the **above-project area**. Areas discharging to a "conveyance pathway" downstream of the **project area** are considered "**Pathway Areas"**.

Two Basins

In Figure II-1 Projects "A", "B", and "D" each include **pathway areas** along the "conveyance pathway" that would extend from the **project area** to the tributary, then to **Watercourse A**. Project "F" straddles the divide between basins, so it will have two "conveyance pathways" and two sets of **pathway areas**, one in each of the two **basins**. The extent of analysis, design, and improvement for the conveyance pathway and the land areas it drains varies as stipulated elsewhere in these Guidelines.

Drainage Study Area

Drainage Study Area: Every project will be considered as having a **"Drainage Study Area"** that is the **project area** at a minimum. As applicable, it may also include **above-project area(s)**, and/or **pathway area(s)**. To be considered complete, a "drainage study" must address all three components of a **drainage study area,** as well as the conveyance pathway itself to limits as determined under provisions of Paragraph D2 of this section. If such areas do not exist for a particular project, it shall be so stated in the drainage study report.

Design Drainage Area

Design Drainage Area: Every **drainage study area** will include any number of **"Design Drainage Areas"** that must be analyzed to determine the design storm flow for the purpose of sizing and placing stormwater management facilities of various types. This can vary widely, from a small area draining to a curb inlet, to many acres served by a channel and culvert.

b. Purposes of Detention

Two Purposes

Detention is a useful stormwater management technique. As fully addressed in Paragraph C3 of this Section, it can be used for managing flood control over a broad area such as an entire **basin** or **watershed**. It can also be used to manage property-to-property conveyance of stormwater. Whether detention is required by these Guidelines is partially a function of how a **project area** is situated in a **watershed**. This gives rise to three types of detention as a function of the purpose.

Not Design Type

"Type" in this context does not relate to design characteristics of facilities used to accomplish detention objectives.

Flood Control

Type 1 Detention (Flood Control): The purpose of this type of detention is to manage runoff from a **watershed** or **basin**. A **project area** located near the bottom of a **watershed** will generally not require detention for this purpose. Schematic Project "E" in Figure II-1 illustrates this condition.

Conveyance Mgmt.

Type 2 Detention (Conveyance Management): The purpose of this type of detention is to manage the delivery of runoff from a property to neighboring (generally adjoining) properties. This may be necessary regardless of how a **project area** is situated along the length of a principal watercourse. In Figure II-1 schematic project "D" illustrates this condition because it may be low enough in the **watershed** not to warrant **Type 1 Detention**.

Dual Purpose

Type 3 Detention (Dual Purpose): Detention in this category is considered to have a dual purpose. It is important for both flood control and managing property-to-property conveyance. Schematic projects "A", "B", and "F" illustrate this condition. All three projects must drain to or through adjoining properties to reach a tributary, so detention may be required to satisfy conveyance criteria. In addition, because they are situated in the upper areas of a **watershed**, managing the peak discharge from them is likely to contribute to flood

control objectives for the **watershed** as a whole or for the **basin** in which each is located.

No Detention

In Figure II-1 schematic "Project C" illustrates a situation where detention may not be warranted. If low enough in the **watershed**, **Type 1 Detention** may be unnecessary, possibly even detrimental, to flood control objectives. Moreover, because it can drain directly into the principal watercourse, there may be no need for **Type 2 Detention**.

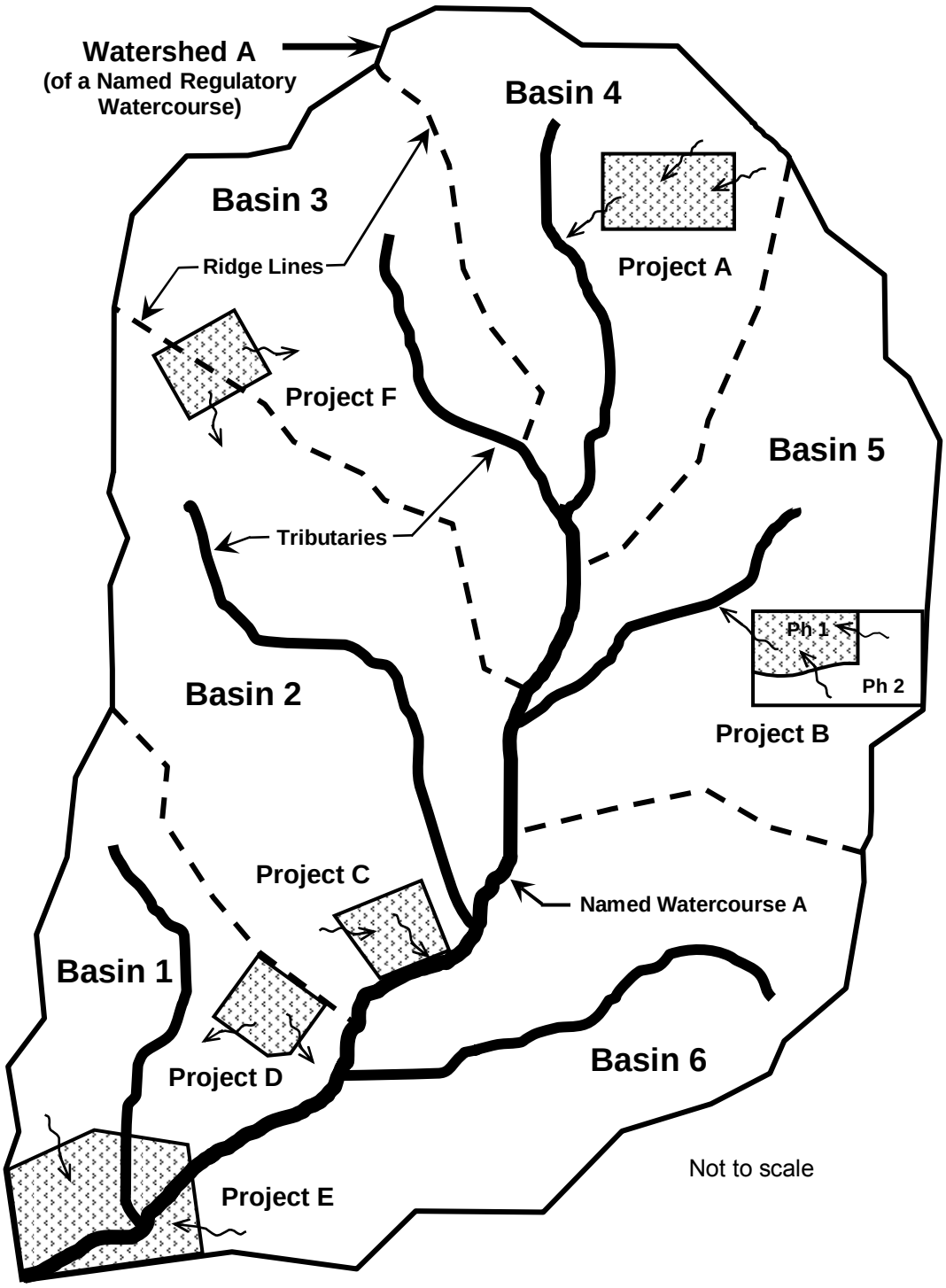

Figure II-1: Watershed – Basin – Projects Diagram

C. Watershed Management

1. Primary Drainage System

a. Nature of Problems in Primary System

Floodplains

Stormwater problems in the primary drainage system result from floodwaters rising out of the banks of natural streams and inundating adjacent natural floodplains. Symptomatic problems are flooding of building structures, overflow of bridges and culverts hampering traffic access, and damage to public and private infrastructure (utilities, roads, etc).

Problem Causes

Problems in the primary system can be caused by the following:

- Inadequate capacity of crossing structures and failure to allow for overflow.
- Placing the finish elevation of the lowest floor of a structure situated adjacent to the Primary System below the existing or ultimate 100 year flood elevation.
- Inadequate or out-dated engineering studies that form the basis of the regulatory flood elevations.
- Failure to allow for increased discharge from, and resulting flood elevations in, upstream areas.
- Failure to control and limit increased stormwater discharge to downstream areas.
- Improper or ineffective alterations to natural channels that have the effect of “transferring” flood problems to upstream or downstream areas.

Resulting Hazards

The results are creation of hazards to life and damage to public and private properties. Remedial measures usually involve large capital improvements to channelize streams, create large detention facilities, or build larger crossing structures for roadways.

Hydrologic Studies

As a first step to dealing with these problems, the Cities adopted comprehensive hydrologic and hydraulic engineering studies for most of the primary system and tributaries thereof. These identify the flood discharge and flood elevations within the primary system, for existing and ultimate development conditions. Ultimate development conditions reflect the drainage situation as expected if the development within the City follows that projected in the City’s adopted comprehensive land use plan. In theory, the existing and ultimate flood conditions are known. Duly adopted flood studies will govern actions and treatments (whether public projects or associated with land development projects) that affect the primary system and its tributaries, consistent with state and federal regulatory requirements.

Minimize Flooding

The policies of the Cities are to encourage the efficient conveyance of stormwater through and out of the Cities within the primary system. The lowest floor of all structures adjacent to the primary system shall be kept at a level above the ultimate 100-year flood level, and no structure will be allowed within the existing 100-year flood path defined as the "floodway." In order to eliminate sporadic and uncoordinated site improvements, modification of the floodway shall be restricted to projects engineered and treated in conformance with a comprehensive master plan established for regulatory channel reaches.

Encroachments

Unless stipulated otherwise in a City ordinance or other design guidelines, minor encroachments in the floodway fringe will be allowed for individual sites and developments, provided they are clearly part of a "Drainage Development Permit" approved by the City. Crossing roadway structures are allowable to include encroachments, provided they are designed to accommodate the range of ultimate design flows through them (or through and over them) to eliminate formation of hazards and damage to private property or public infrastructure.

Regulations

To implement this policy, stormwater management ordinances and design guidelines have been adopted by each City. Requirements vary along each channel reach to recognize the differences related to development conditions, expected increases in flood elevations, and the potential for damages.

b. Recognized Watersheds and Channel Reaches

Watershed Maps

Figures B-1 through B-21 in Appendix B present maps of the drainage watersheds within and adjacent to the Cities. Watersheds are divided into "reaches" to recognize the relationships of geography, land uses, political jurisdiction, and proposed development relative to their effects on existing and ultimate storm flow and flood elevations. Within each watershed, the named regulatory streams are designated as part of the primary system, and individual reaches of each are, in some cases, identified for regulatory purposes.

Watershed Landmarks

Watershed identification is schematic in the figures. A land area is defined as being part of a given watershed if stormwater that falls upon it travels overland by natural or man-made pathways, and enters the main channel of the primary system of that watershed. The primary system and channel reaches are established by physical landmarks such as stream confluences and crossing structures.

Floor Elevations

The elevation of the lowest habitable floor of a structure adjacent to a watercourse of the primary system shall be at least one foot above the base flood elevation associated with the ultimate development condition. However, Table B-2 in Appendix B lists channel reaches where the minimum elevation of the lowest habitable floor of any structure shall be above the base flood elevation by more than one foot. In those cases the minimum floor elevation shall be that shown in Table B-2.

2. Secondary Drainage System

Typical Problems

Stormwater problems in the secondary system tend to be localized and scattered throughout both Cities. Typically they result from inadequate provision for streets, storm sewers, and collection channels. Examples include: excessive ponding in streets at low points, excessive storm flow through principal street intersections, overflow of streets, undersized drainage easements, facilities requiring excessive maintenance, and restriction of street uses due to excessive storm flow.

Problem Causes

Causes of problems in the secondary drainage system are listed as follows:

- Inadequate capacity for design flows.
- Inadequate allowance for increases in storm flow due to future development.
- No provision for containing and controlling (within designated easements or right of way) the discharge from the 100 year rainfall event under ultimate development conditions.
- Failure to control discharge from new developments that exceeds the capacity of the receiving secondary system, existing or proposed.

Damage or Nuisances

The results are creation of nuisance problems and situations where damage to public and private property can occur. Remedial measures may be very difficult to achieve, and may range from expensive public improvement projects to situations where remedies are infeasible from a practical standpoint.

Drainage By Design

The policy of both Cities is to avoid formation of these problems through efforts at the design and development stage. Central to this strategy are the performance standards for drainage design contained in these Guidelines, including the “conveyance pathway” concept for containing the base flood discharge.

Performance Criteria

Based on this policy, performance criteria are set for design rainfall events. The emphasis at the performance level is to mitigate the nuisance aspect of storm drainage. An example of a performance standard would be: “design the street and attendant drainage system to carry the discharge from a ten-year rainfall event leaving an area approximately the width of one lane at the center free of any water flow”. These Guidelines contain similar performance standards for various parts of the secondary and primary systems.

Conveyance Pathways

The secondary system is to be evaluated and designed for the stormwater conditions that will result for storms up to the magnitude of the 100-year rainfall event based on ultimate development within the applicable basin. From the location where storm flow is first introduced into a public easement or right of way near the upper end of any basin, a “conveyance pathway” shall be identified and provided to a

discharge point at a main channel of the primary system. The designated "conveyance pathway" must follow or provide clearly identifiable watercourses. Needs for easements or ROW for conveyance pathways are to be assessed per the provisions of Paragraphs E and F of this Section. The purpose of providing for the 100-year storm level is to prevent the creation of situations hazardous to life, or harmful to public and private property. Accordingly, a major emphasis is on deliberately confining storm flow to designated conveyance pathways.

Watershed Diversion

Generally stormwater emitting from land drained by one named regulatory watercourse of the primary system shall not be diverted to drain into a different named regulatory watercourse of the primary system.

3. Detention / Mitigation

Detention Purposes

Detention is an important mitigation measure. It can be used effectively for either or both of two fundamental purposes. As a tool for watershed management, it can be deployed with other features to minimize potential flooding along major watercourse(s). It can also be used to manage how stormflow is discharged from a property to adjacent properties. Thus, it can be an integral part of stormflow conveyance in route to the primary system or to a tributary thereof. Both are legitimate reasons for using detention facilities and any one detention facility might work toward both purposes, depending on its location in a watershed. The functional purposes for detention are further defined in foregoing Paragraph B3-b of this Section.

a. Detention Requirements

Right Uses

For optimum results detention facilities must be deployed for the right reasons at the right locations. It is the intent of these Guidelines to stipulate the conditions under which detention must be used and why. These Guidelines are not intended to preclude the use of detention at locations where qualified engineers may deem it to be beneficial. Nevertheless, where detention is required by these Guidelines designed facilities must meet the criteria stipulated herein.

Peak Flow Regulated

Where detention facilities are required, peak stormflow rates from a project area resulting from the two (2), ten (10), twenty-five (25), and one hundred (100) year storm frequency events shall not be increased at any point of discharge. Regulation of peak flows to allowable levels, as determined by the provisions of these Guidelines, shall be achieved by storage facilities on, or away from, a project area, or by participation in an approved Regional Stormwater Management Program.

b. Detention Facilities May Be Optional

Detention Limited

At the discretion of the City Engineer, land development activity is not subject to the stormwater detention requirements of these Guidelines if one or more of the four conditions listed in Sub-paragraphs 3-b(1) through 3-b(4) before are satisfied, and an engineer registered in the State of Texas submits a signed, sealed, and dated letter addressed to the City Engineer, stating the following without qualification:

> "*I have conducted a topographic review and field investigation of the existing and proposed flow patterns for stormwater runoff from* (name of subdivision or site project*) to the main stem of* (name of creek)*. At build-out conditions allowable by zoning, restrictive covenant, or plat note, the stormwater flows from the subject subdivision or site project will not cause any increase in flooding conditions to the interior of existing building structures, including basement areas, for storms of magnitude up through the 100-year event*":

(1). Adjacent to Primary System

Any development adjacent to the Primary System may demonstrate that detention is not beneficial to the system with an engineering timing analysis. The analysis should include all upstream development broken into basins of size similar to the development being studied and carried downstream until the development represents less than 2% of the total drainage basin.

(2). One Existing Lot
The proposed development project involves one single existing* legal lot that is limited to detached single-family land use by zoning, restrictive covenant, or plat note.

(3). Small Lot
The size of an existing* platted lot is equal to or less than one (1) acre for commercial use, or two (2) acres for detached single family use.

(4). Draining to Designated Streams
At locations included in the drainage watersheds of certain streams stipulated as not requiring detention in Table B-2 in Appendix B, provided Type 2 Detention is not needed for managing property-to-property stormflow.

* Existing platted lot as used above shall be defined as legal lots of record prior to January 2007.

4. Water Quality

Concurrent Objectives

The intent of these Guidelines is to cause development of stormwater management facilities that effectively collect and convey stormflow without causing water damage impacts on life and property. A concurrent objective is to achieve facilities that minimize any adverse

affect(s) on the quality of water conveyed into natural waterways that traverse and/or drain the Cities.

Water Quality Matters It is important that water quality considerations be integral to all aspects of planning, designing, and constructing any facilities regulated by these Guidelines. When design alternatives are at option, the preferred design will be that offering better water quality characteristics for near-term and long-term conditions, as well as during construction, provided the public safety objectives of these Guidelines are not jeopardized.

Tradeoffs Where tradeoffs are faced between public safety and enhanced water quality in any design, greater favor shall usually be afforded to public safety by the designer. However, consistent with applicable State and Federal regulatory requirements, the City Engineer, or his/her designee, may opt to require greater attention to water quality. All information necessary to such decisions shall be the responsibility of property owners (or applicants) proposing the affective land development project(s).

5. Master Drainage Plans

Plan Consistency All land development projects and site re-development projects subject to the provisions of these guidelines must demonstrate that plans for managing the stormflow expected to emit from the project(s) are consistent with the City's Master Drainage Plan, or with any applicable publicly approved Watershed management master plan.

D. Extent of Design

1. Threshold for Engineered Design

Limited Exemptions For purposes of these Guidelines, some land development projects may be exempted from requirements for drainage plans designed by a licensed engineer and approved by the Cities. However, in designated FEMA floodplain areas no construction of any kind, including clearing, grubbing or earthwork, may begin without fully approved engineering studies. Likewise, this provision shall not be construed to obviate any requirements of the Texas Professional Engineering Practices Act regarding engineering of facilities to be constructed for public use.

Possible Exemptions Developments of the general nature listed below may be exempted from designs conforming with provisions of these Guidelines after appropriate review and approval by the City Engineer or his/her designee.

- A small lot (existing prior to 2007) less than one acre in size that does not receive stormflow from adjacent or nearby land areas.

- A platted lot (existing prior to 2007) set aside for construction of one detached single family residential unit.
- Any platted lot (existing prior to 2007) less than one acre in size for which adequate stormwater management provisions can be administered through building permit requirements.
- Where, in the judgment of the City Engineer, development of a proposed project on a platted lot will have no appreciable down-steam effect**.**

2. Study Limits

Analysis Limits

Engineering for assessment of conditions resulting from a stormwater project shall include the **project area**, **above-project area(s)**, and **pathway area(s)** as necessary, and must extend upstream and/or downstream along designated **conveyance pathways** to a point where the applicant (or his engineer) can demonstrate to the City Engineer's satisfaction that there are no appreciable drainage effects caused by the proposed project. Downstream or upstream of these points the minimum responsibility of the project engineer is to merely document the location of the "conveyance pathway" to limits otherwise specified in these Guidelines.

3. Special / Alternate Designs

a. City Engineer Approval

Equivalent Safe Design

The City Engineer may, upon request, approve an alternate design or construction methodology that differs from the requirements in these Guidelines if the City Engineer determines that:

(1). The alternate design or construction methodology is equivalent or superior to the design that would result from using these Guidelines, and

(2). The alternate design or construction methodology is sufficient to ensure public health and safety.

b. Substantiation of Alternate Designs

Responsibility

It shall be the responsibility of the owner's/developer's (applicant's) engineer to substantiate that any proposed alternate design or construction methodology deviating from these Guidelines meets or exceeds designs or construction methodologies promulgated by these Guidelines.

4. Applicable Ordinance Requirements

Design Reviews Nothing herein shall be construed to conflict with or supersede design review criteria otherwise established in applicable ordinances of the City of Bryan or the City of College Station.

E. Public Facilities

1. Principles For Public / Private Facilities

Public/Private Mix Stormwater management involves some combination of private and public facilities occurring on (or across) land, and in easements or ROW, in a mix of public and private holding (or ownership). The two-fold intent of these Guidelines is to regulate all such facilities as necessary to achieve specific objectives, while minimizing regulation where it is not fundamental to meeting those objectives.

Rural To Urban Development activities either change the character (or use) of a previously developed site(s), or generally move land from rural to urban conditions. In the later case, storm runoff is necessarily directed into various types of concentrated flow that typically did not previously exist. This can tend to change both how and where flow is delivered to immediately adjacent properties or facilities. Because the new facilities are commonly situated in easements or ROW proposed to be conveyed to a public entity, the process may create a measure of public responsibility where none had previously existed.

Discharge Options It is the responsibility of the owner/developer of any development project to properly provide for storm discharge from the project area. Where street or drainage ROW(s) or drainage easement(s) are to be dedicated to the public, and discharge is to drain across neighboring property(ies) before reaching a Named Regulatory Watercourse (or a recognized drainage way serving as a tributary thereof), it shall be the responsibility of the project owner/developer to accomplish one of the two following scenarios, or some combination thereof.

a. First Scenario: Establish Drainage Easement(s)

Receiving Easements Drainage easements must be established across down stream properties as necessary along identified conveyance pathways. Such easements must be aligned and sized to safely accommodate the design discharge(s) from the project area, and must extend to a Named Regulatory Watercourse (or a tributary thereof). The easement(s) may be conveyed to a private party or to a public entity at the discretion of the City Engineer or her/his designee.

b. Second Scenario: Pre-Development Release

Designed Release(s) Drainage facilities must be situated and designed so that discharge(s) are delivered to down stream properties with substantially the same

flow characteristics (rate of flow, concentration, velocity, etc.) that existed in pre-development conditions. In addition, discharges are to be released at substantially the same locations that existed in pre-development conditions. Usually, all work necessary to accomplish this must be within the geographic limits of the project area.

2. Maintenance Considerations

A Design Function

All stormwater management projects subject to the provisions of these Guidelines that are to be dedicated to the public shall be designed with adequate provisions for maintenance of the designed facilities, regardless of their nature. Maintainability and access are important design objectives. These two factors must be an integral part of the design considerations for all stormwater facilities. The same principles must apply to the easements and/or right of way within which such facilities are to be placed.

Importance

Where, in the opinion of the City Engineer, design alternatives meet detention, flood level, and water quality criteria promulgated by these Guidelines and other regulatory requirements in essentially an equal manner, the option(s) offering lesser demand for maintenance work will be preferred. Likewise option(s) offering improved access will be preferred.

Justification Data

All information necessary to making such decisions shall be the responsibility of property owners proposing the land development project(s). Changes in proposed designs may be required in order to meet these objectives.

3. Easements and Right of Way

Drainage ROW

Where any part of a project area is traversed by a channel or stream, whether man-made or natural, an easement or drainage right of way (ROW) is to be provided for the watercourse. Likewise ROW is to be provided for drainage ways newly formed by runoff concentration within the project area of subdivision projects. In all cases ROW is required unless easements are specifically approved by the City Engineer. ROW will generally be required unless stormflow is conveyed via underground conduit, in which case easements will be considered.

Uses Limited

The purpose of easements or right of way (ROW) is to provide the necessary space for stormwater flow and for maintenance of drainage facilities. Any uses of such areas that are inconsistent with these purposes are prohibited. Prohibited uses include, but are not limited to, construction of fences or other obstructions, placement of building structures, or any uses that alter the required shape, configuration, or surface treatment needed for stormwater management functions.

a. Size Parameters

Approvals Needed

Decisions about the necessary alignment and extent of ROW and easements shall be subject to approval by the City Engineer or his/her designee, and shall be based, in part, on drainage information provided by the applicant. Criteria for this determination shall be based on the anticipated amount and spread of stormwater flow, the possibility of increased flow at some time in the future, any concurrent uses to be associated with the designated areas, the space required for the appropriate maintenance equipment and personnel, and the access necessary to conduct maintenance activities.

ROW For Channels

Where a land development project is traversed by a constructed swale, a constructed channel, a natural channel, or a stream, drainage ROW conforming substantially to the limits of such watercourse (plus additional width to accommodate flow from a 100-year frequency event) must be provided. Additional width may be required for maintenance purposes.

Conduit Easements

Where stormwater is to be conveyed in buried conduits, drainage facilities may be situated in drainage or utility easements provided flow from a 100-year frequency event will be wholly contained within the easement.

b. Minimum Standards

The following minimum standards shall be used in determining the size and placement of drainage easements and ROW.

(1). The minimum width of any drainage easement shall be 15 feet.

(2). For buried conduit storm sewer, the minimum width for any drainage easement (or ROW) that is not congruent with any other pubic ROW or easement shall be 15 feet, and the centerline of the storm sewer shall not be closer than five (5) feet to either side of the easement. In addition, the easement or ROW (inclusive of the conduit capacity) must adequately convey the 100-year storm flow.

(3). For purposes of maintenance access for improved open channels, the minimum ROW width shall be the design top width of the channel plus an additional 20 feet (five feet along one side and 15 feet along the other side). However, where the design top width of the channel exceeds 30 feet, 15 feet of additional ROW shall be provided on both sides of the design channel width. Where special designs approved under the provisions of Section II, Paragraph C3 of these Guidelines will obviate the need for easements of these widths, smaller or narrower easements will be considered by the City. However, in no case shall adequate provisions for maintenance be seriously compromised.

(4). If access to a drainage easement or ROW is not available from public ROW, then an access easement having a width of 15 feet or more

shall be provided from a public ROW to the easement or ROW containing drainage facilities.

(5). The width of all easements and ROW shall be sufficient to include areas that will be part of the designated conveyance pathways of the secondary system.

(6). The widths of all ROW for the primary system shall be sufficient to cover the designated floodway for the existing base flood as defined by the latest FEMA regulations.

F. Private Facilities

1. Detention Systems

Guidelines Apply

All stormwater detention facilities required by these Guidelines shall be sized, designed, and constructed in conformance with the criteria stipulated herein and elsewhere in City ordinances or regulations, whether to be retained as private facilities or dedicated to the public within an easement or ROW.

2. Conveyance Systems

Figure II-2

The four conditions described in this sub-paragraph are illustrated in Figure II-2.

a. Discharges Received By Private Land or Facilities

From Private

Stormwater conveyance features that will receive discharge only from private land or facilities at ultimate development conditions may be established as private conveyance systems at the discretion of the City Engineer or her/his designee. Design of such facilities in accordance with provisions of these Guidelines is generally at the discretion of the Registered Professional Engineer in charge of the work.

From Public

Where stormflow is proposed to discharge from existing or proposed public ROW(s) or easement(s) to private land or facilities it is the responsibility of the owner/developer (or applicant) to assure that the project discharge is compatible with the down stream land and conveyance features. This responsibility must be met as outlined in Paragraph E1-a /or Paragraph E1-b of this Section, or via some combination of the two concepts.

b. Discharges Leaving Private Land or Facilities

To Private

In situations were conveyance facilities that are to be permanently held in private ownership will discharge to conveyance facilities that are likewise to be permanently held in private ownership, the design is generally at the discretion of the Registered Professional Engineer in

charge of the work. At the discretion of the City Engineer or his/her designee, exceptions to this may apply for watershed management purposes.

To Public

Where private lands or facilities will discharge to publicly held lands or facilities, whether in fee simple or in easement(s) or ROW(s), the design, configuration, and construction of the upland facilities shall be in conformance with these Guidelines to the extent required by the City Engineer or her/his designee. Likewise, if private land or facilities are to discharge into floodplain areas or tributaries of a Named Regulatory Watercourse without first traversing public easements or ROW or publicly held land, they are subject to application of these Guidelines at the discretion of the City Engineer or his/her designee.

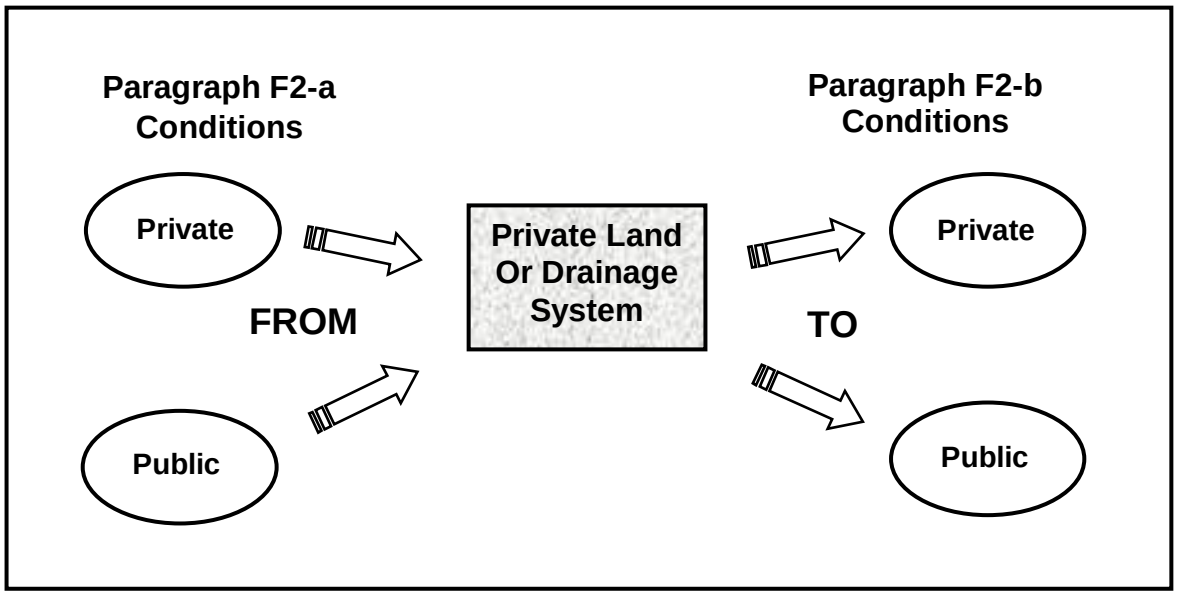

Figure II-2: Public / Private Conveyance Systems Diagram (Paragraph F2)

Section III
Stormwater Administration

Unified Stormwater Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION III

ADMINISTRATION

A. Permitting Process

The review process for any drainage plan must be in compliance with requirements of the City of Bryan or the City of College Station as applicable. The following general four-step process is recommended. Depending on the size and hydrologic complexity of the proposed development project, the City may waive one or more steps.

1. Step One

This is a Stormwater Planning Conference with the engineering staff of the City. This may be satisfied in conjunction with a "pre-development conference" or other discussions about any number of other regulatory matters that may affect a particular site or proposed subdivision project.

2. Step Two

A Preliminary Drainage Plan may be required by the City Engineer or her/his designee following the Stormwater Planning Conference. This step has the benefit of formally documenting the questions and decisions reached during the Stormwater Planning Conference. Its review will allow exploration of all drainage issues that may have bearing on a particular project area and will fully identify the drainage study area (those areas requiring some level of identification and/or analysis). This will facilitate expeditious handling of subsequent steps.

3. Step Three

This is submittal of a Drainage Report that fully documents the plan and facilities for managing stormflow of a land development project. At the City's option this may take the form of an Abbreviated Drainage Plan for smaller projects. In either case this is required for all grading permits, site plans, and subdivision development. The City will provide written notice of review findings pertaining to these reports or plans. This step is completed only when the City has approved the Drainage Report and when engineering plans and specifications for stormwater facilities are "released for construction" by the City.

4. Step Four

The fourth step is filing of a development permit application through which a grading or other construction permit(s) may be issued. The application must be completed by the applicant, and approved by the City, prior to clearing and grading operations on any part of a project area.

B. Stormwater Planning Conference (Step 1)

1. Stormwater Management Concept

Early Discussions

In order to help guide preparation of a plan consistent with City guidelines and minimize work efforts and review time, the design concept for managing storm flow within and from any proposed land development project shall be discussed with the City prior to the development of any specific design, or preparation of construction plans of any kind for drainage facilities. The hydrologic analysis method(s) to be used must be determined and approved as a result of the discussions. The parties representing the proposed development shall obtain all resources, plans, and references necessary to discuss the items outlined in this section. The conference shall address the following information relative to the proposed development.

a. General Location Map

(1). Roadways within and adjacent to the development

(2). Primary and Secondary watercourses and all drainage facilities in the vicinity of a proposed project.

(3). Names, location, and general configuration of surrounding land developments.

b. Project Area Description

(1). Acreage of property(ies)

(2). Location and size of all project phases, if any.

(3). Type of land cover (both existing and proposed)

(4). Name of owner and type of development

(5). Current zoning status and proposed change, if any

(6). Any existing natural or man-made topographic features that have the effect of storing or detaining stormwater.

c. Above-Project Areas

(1). Approximate identification of any upland areas that are expected to contribute storm flow to the **project area** (proposed land development project).

(2). Existing and foreseeable future runoff characteristics of all **above-project areas**.

d. Conveyance Pathway Areas

(1) General identification of downstream conveyance pathways for delivery of runoff from the **project area** to a Primary System watercourse

(2) Identification of land areas that generally drain to the **conveyance pathway** downstream of the **project area** and the existing runoff characteristics of those areas**.**

e. Regulatory Watershed Description

(1). Identification of the **Regulatory Watershed(s)** (and Reach thereof) in which the proposed project is located.

(2). General existing land use characteristics of the **Regulatory Watershed**.

(3). References to any available earlier drainage studies that addressed any part or all of the land proposed for development

(4). Applicable Flood Insurance Maps

f. Drainage Basin Description

Thorough Planning

The report should clearly describe the **Basin**(s) of the **Regulatory Watershed** of which the development project is a part. Drainage patterns on both the **project area** and any applicable **above-project area(s)** must be clearly identified, along with all anticipated impacts on existing and ultimate development. Likewise, the conveyance pathway(s) must be identified along with **pathway areas** (all areas drained by the conveyance pathway).

(1). General Facility Design

a). The report must identify typical drainage patterns and proposed concepts for managing storm flow generated by the proposed project. This shall include sketch delineation of pathways for conveying stormflow within the **drainage study area** and to the Primary Drainage System.

b). Considerations for handling runoff from **above-project areas**, and to conveyance **pathway areas** must be discussed.

c). The potential need for tables, charts, figures, or drawings to be in the report must be identified.

(2). Specific Details

a). Existing and potential drainage and erosion problems and possible solutions at specific design points must be explored. This is applicable for the entire **drainage study area**, not only the **project area**.

b). The potential need for detention/retention storage must be explored, along with the any proposed outlet design concept.

c). Aspects of the design important to reasonable maintenance access must be identified.

d). Areas to be set aside as drainage easements and/or right of way are to be identified in a general manner.

e). Needs for bridges or culverts for roadway crossing watercourse(s), including any possible need for skewed crossings or watercourse turns at crossings, must be fully identified.

f). All required permits must be identified. This includes those required from the US Army Corps of Engineers, the Federal Emergency Management Agency (FEMA), the Texas Natural Resource Conservation Commission (TNRCC), the Texas Commission on Environmental Quality (TCEQ), TxDOT, or any other State or Federal agency.

e. References

A preliminary list of all criteria, master plans, and technical information applicable to the proposed project must be provided.

2. Preliminary Drainage Plan (Report) (Step 2)

Report is Key

Upon completion of the Stormwater Planning Conference (or the pre-development conference) the City Engineer or her/his designee may require the submission of a Preliminary Drainage Report for the purposes of substantiating any assumptions and/or clearing up any questions identified via the conference. A Preliminary Drainage Report (with Drawings) shall be prepared to generally meet the most salient requirements for the Drainage Report but can be in lesser detail. When a Preliminary Drainage Report is required by the City Engineer (or his/her designee) it shall be submitted and approved prior to substantial preparation of construction plans.

C. Drainage Report Requirements (Step 3)

1. Purpose of Report

Find Needs

The purpose of the Drainage Report is to identify and define conceptual solutions to the problems which may occur as a result of the proposed development, on **project areas, on above-project areas,** and along conveyance areas. The Drainage Report must include drawings as necessary to fully and clearly describe the information required by these Guidelines. All reports shall be printed on 8-1/2" x 11" paper, bound together, and submitted in two hard copies and one electronic copy (pdf format). The report shall include a cover letter presenting the proposed design for review, and shall be prepared by a Registered Professional Engineer licensed in Texas. The report shall contain a sheet authenticating its technical accuracy as follows:

Work Certification

"This report (plan) for the drainage design of (name of development) was prepared by me (or under my supervision) in accordance with provisions of the Bryan/College Station Unified Drainage Design Guidelines

for the owners of the property. All licenses and permits required by any and all state and federal regulatory agencies for the proposed drainage improvements have been issued."

_____

Licensed Professional Engineer

State of Texas No._____

(Affix Seal)

2. Abbreviated Drainage Plan

a. Suitability

In certain situations, consistent with the policies and practices of each City, the owner/developer (or applicant) may provide an Abbreviated Drainage Plan in satisfaction of these Guidelines. This is applicable only to small site plan projects on platted lots, not involving the development of stormwater detention facilities, private or public. Although not precluding involvement of an engineer, the scope of such site projects generally does not involve hydrologic or hydraulic engineering analysis or the design of stormwater management facilities. Subdivision land development projects are specifically excluded from this type of submittal. As a function of the size, location, and hydrologic complexity of a project, the City Engineer or his/her designee may require submittal of an engineered drainage report.

b. Submittal Requirements

An Abbreviated Drainage Report is generally a very simple presentation of how stormwater is to be managed on a small project. At a minimum such a plan must include the information listed below. It must be accompanied by a letter of transmittal requesting approval, and all proposed site features must be subject to inspection via building permit processes.

- A site plan drawn to a standard engineering or architectural scale showing vertical dimensional controls and proposed site grading,
- Finish floor elevations of structures and illustration of how stormwater is to be routed around and away from them,
- Illustration of any flumes, walls, berms, and/or landscaping features proposed for the purpose of managing runoff,
- Documentation of how erosion and sedimentation will be prevented as a permanent part of the project,
- Description of how runoff is to be routed away from the property,

- Measures employed to preclude any negative affects on downstream properties, and
- Measures to preclude any negative effects on public or private watercourses to which runoff will be directed.

3. Drainage Report Contents

Report Or Summary

The Drainage Report may be submitted in one of two formats. It may be written in a traditional prose format complete with an executive summary at the beginning, or it may be submitted as a Technical Design Summary. In either format, the report shall be in accordance with the following outline and contain the applicable information stipulated below. The executive summary attendant to a traditional report shall include, at a minimum, the same information as required in Part 1 of a Technical Design Summary, and shall be presented in the same format.

a. General Location and Description of Project Area

(1). Location

a). Streets and roadways within and adjacent to the Project Area (proposed land development project)

b). Named Regulatory Watercourses and facilities

c). Names of existing or approved developments or plats surrounding the proposed Project Area whether adjoining it, or separated from it by a street (or highway) or watercourse.

d). Names and location(s) of master plan(s), preliminary plat(s), and/or site plan(s) for adjoining properties that may be in pending status with either City as of the date of the report, to the extent such information is available from local jurisdictions.

(2) Description of Project Area Property

a). Total acreage of Project Area

b). Acreage of Project Area proposed for near term and any future phased improvements

c). Name of property owner(s) and land developer(s) and applicant (s)

d). Land cover characteristics

e). Primary and secondary system watercourses within or adjacent to the property

f). General description of proposed project

b. Drainage Watershed (s) and Study Area(s)

(1) Regulatory Watershed Description

a). Reference to Named Regulatory Watercourse planning studies such as flood hazard delineation reports and flood insurance rate maps.

b). General existing land use characteristics of the Regulatory Watershed and the applicable Reach(s) thereof.

(2). Drainage Basin(s) (sub-Watershed) Description

a). Identification of drainage flow patterns from above-project areas

b). Impact of proposed development on existing and proposed conveyance pathways to Named Regulatory Watercourse(s)

c). Description of historic drainage patterns in areas proposed for development

d). Description of existing natural or man-made topographic features that have the effect of storing or detaining stormwater within the Project Area.

(3). Drainage Study Area

a). Clear delineation of all of the Project Area (the proposed land development project), all Above-Project Areas contributing, or proposed to contribute, stormflow to the Project Area, and all Conveyance Pathway Areas.

b). Existing drainage conditions and flow patterns for all of the proposed Project Area, and for all Above-Project Areas.

(4). Drainage Plan

a). Proposed drainage conditions and flow patterns for all of the proposed Project Area and for all Above-Project Areas contributing stormflow to the Project Area must be shown.

b). General review of the Conveyance Pathway(s) and identification of any points along it (them) were capacity limitations are known or suspected to exist.

c). General location and size of any proposed detention/retention facilities.

d). Identification of the location and type of all collection and conveyance facilities proposed to serve the Project Area.

c. Drainage Design Criteria

(1). The range of design storm flows anticipated at critical points throughout the proposed drainage system must be shown, in addition to how flow will be accommodated at each point. All assumptions and hydrologic parameters must be shown.

(2). Stormwater Management Criteria Reference(s) and Site Constraints

a). Identification of earlier drainage studies for or including the Project Area or any portion of Above-Project Areas that influence, or are influenced by, the selected drainage design.

b). Demonstration of how conditions in any Above-Project Area(s) will affect drainage design for the Project Area.

c). Explanation of how existing and proposed topographic constraints such as streets, structures, and layout of proposed facilities (including building pads if applicable) will impact plans for managing storm flow.

(3). Hydrological Parameters

a). Documentation for determination of design rainfall

b). Identification of runoff calculation method

c). Identification of detention discharge and storage calculation method, if any

d). Identification of design storm recurrence intervals

(4). Conveyance System Hydraulic Parameters

a). Identification of capacity of various existing and proposed conveyance systems, citing any design or study references used

b). Identification of detention/retention outlet type, if any

c). Identification and explanation of any drainage facility design criteria not presented in these Guidelines.

(5). Any criteria, methods, or design techniques that deviate from these Guidelines must be identified and fully justified.

d. Drainage System Design

(1). General Concept

a). Identification of anticipated and proposed drainage patterns and the proposed stormflow management concept(s).

b). Documentation of compliance with all requirements for managing Above-Project Area runoff in terms of discharge and capacity.

c). Documentation of compliance with requirements for analysis and design of conveyance pathways as determined necessary during the pre-development conference or other meetings with the City Engineer or her/his designee.

d). Explanation of the content of tables, charts, figures, or drawings presented in the report

(2). Specific Details

a). Descriptions of drainage problems and proposed solutions at specific design points

b). Description of detention storage design and outlet design including measures for minimizing erosion at discharge points

c). Identification of access ways for maintenance of all proposed stormflow management features, whether to be privately held or conveyed via platting to the City.

e. Conclusions

(1). Statements of compliance with the Bryan/College Station Unified Drainage Design Guidelines.

(2). Effectiveness of drainage design to control flooding or damage due to design stormflows, including minimization of erosion along conveyance pathways serving the project.

(3). Explanation of the effectiveness of existing and proposed drainage improvements for controlling discharges of the 2-year, 10-year, 25-year, and 100-year storms, assuming ultimate development conditions within the Drainage Study Area of the proposed land development project.

f. References

Reference all criteria, master plans, and technical information applicable to the proposed land development project must be referenced.

g. Appendices (where applicable)

(1). Hydrologic Computations

a). Land use assumptions regarding adjacent properties

b). Minor and major storm runoff at specific design points

c). Runoff computations at specific design points for both existing and ultimate development of all Design Drainage Areas.

d). Hydrographs at critical design points

(2). Hydraulic Computations

a). Culvert capacities

b). Storm sewer capacity

c). Street capacity

d). Storm inlet capacity including inlet control rating at connection to storm sewer

e). Open channel design

f). Detention area/volume capacity and outlet capacity calculations

(3). Municipal Approvals and Permits

This appendix to a drainage report is for the purpose of documenting any approvals or permits issued by either City as applicable. Examples include (but are not limited to) zoning, final or preliminary plats, clearing and grading permits, or building permits. The status of all pending requests is to be documented as well as any issued approvals or permits. Presentation of this information may take the form of a simple list that includes the pertinent identifying data such as case codes, property identification, applicant, and application/action dates. Alternatively, photocopies of application and/or approval documents may be included. Specific requirements for this information should be addressed during the stormwater planning conference.

(4). Non-Municipal Permits

a). Issued or pending permits regarding FEMA-designated Regulatory Watercourses.

b). Issued or pending permits required by the US Corps of Engineers

c). Issued or pending permits regarding water quality or endangered species in stormwater management or land development activities, whether required by units of State or Federal Government.

d). Easements or statements of technical reviews required to satisfy other governmental units including TxDOT, Brazos County, and the Texas A& M University System.

4. Drainage Report Drawings

a. Sheet # 1 – General Location Map

(1). Depict drainage flows entering and leaving the Project Area

(2). Identify construction along drainage ways, including all areas where natural ground cover is to be removed or significantly disturbed

(3). Illustrate general drainage flow within entire Drainage Study Area

(4). Draw at a scale of between 1’ = 500’ and 1” = 2000’

b. Sheet #2 – Floodplain Information

(1). Copies of existing 100-year floodplain maps showing the location and approximate boundaries of the land development project.

c. Sheet #3 – Drainage Plan Maps(s) Showing:

(1). Complete Drainage Study Area boundary including: Above-Project Areas and how stormwater flows from them to the Project Area, Conveyance Pathways draining the Project Area, and Pathway Areas.

(2). Entire Project Area, including depiction of areas proposed for near term construction activity, at a standard engineering scale providing complete legibility and on drawings not exceeding 24 inches by 36 inches in size.

(3). Existing and proposed contours at maximum intervals of two feet

(4). Property lines and easements with purposes noted

(5). Existing and proposed streets and highways including ROW lines

(6). Existing drainage facilities, roadside ditches, drainage ways, gutter flow directions, and culverts. All pertinent information such as material, size, shape, slope, and location shall also be included.

(7). Boundaries of all Design Drainage Areas.

(8). Proposed type of street flow (roadside ditch and/or gutter flow) and flow directions.

(9). Plan and profile of proposed storm sewers and open drainage ways, including inlets, manholes, culverts, junction structures, and other appurtenances.

(10). Clear indication of changes in pipe size in storm sewer system

(11). Proposed outfall point(s) for runoff from areas proposed for construction and facilities to convey flows along proposed Conveyance Pathways to outfall points in the system of Named Regulatory Watercourses.

(12). Routing and accumulation of stormflow at various critical points for the minor storm runoff

(13). Path(s) chosen for computation of time-of-concentration

(14). Location of detention/retention storage facilities and outlet works

(15). Location and elevations of all documented floodplains affecting the properties proposed for land development.

(16). Location and elevations of all existing and proposed utilities affected by or affecting the drainage design.

(17). Routing of any drainage that must flow through the development project from Above-Project Areas.

(18). Finished floor elevations of existing structures in flood plains adjacent to Primary or Secondary watercourses.

(19). Existing 100-year water surface elevations for each lot or building site in flood plains adjacent to Primary or Secondary watercourses.

(20). Notation about any off-project features influencing the proposed land development

D. Construction Drawings and Specifications

1. Compliance With Drainage Report

Plans Fulfill Report

Where drainage improvements are to be constructed they must be in accordance with the approved Drainage Report. Construction plans and specifications must demonstrate how and where the stormwater management concepts of the Drainage Report will be implemented. Plans on sheets no larger than 24 inches by 36 inches, together with any specifications not consistent with B-CS Technical Specifications, shall be submitted for review and approval prior to construction. Plans (plan and profile sheets) and specifications for the drainage improvements will include all of the following information as applicable.

a. Storm Sewer Systems

- Line sizes, alignments, flow line elevations
- Junction boxes, man holes
- Inlets and outlets

b. Culverts

- Size, alignment, flow line elevations
- End treatments
- Inlet and outlet protection

c. Open Watercourses

- Channel alignment, section, and flow line elevations
- Sizes and flow lines of ditches and swales
- Surface treatments

d. Detention Facilities

- Pond size, placement, grading and elevations
- Pond outlets, and outfall treatments
- Pilot channel alignment, grade, and section (when used)
- Landscaping

e. Related Structures / Facilities

- Erosion control features
- Provisions for maintenance access
- ROW and/or easements, both public and private as applicable

f. Flood Information

- Finished floor elevations of buildings adjacent to stormwater facilities
- 100-year water surface elevations

g. Approvals

- Engineer's certification
- Action by the respective City to "release for construction" as evidenced by titles and signatures of required City officials

2. Compliance With Design Guidelines (Step 4)

Thorough Plans

The information presented by the drawings and specifications shall be in accordance with sound engineering principles, the design parameters herein, and requirements for subdivision design stipulated by the City of Bryan or City of College Station, as applicable. Construction documents shall include geometric, dimensional, structural, foundation, bedding, hydraulic, geotechnical, ecological, landscaping, erosion control, project limits, and other details as needed to construct the project. The approved Drainage Report shall be included as part of the construction documents for all facilities affected by the drainage plan.

E. Record Drawings

1. Required Plans

Before Acceptance

Plans documenting all constructed public drainage facilities and private detention/retention ponds ("Record Drawings") shall be submitted to the city upon completion of the construction work. These documents (on 24" by 36" three-mil mylar) must be received and deemed consistent with all applicable regulations by the City before the improvements will be accepted. The construction drawings are acceptable as Record Drawings provided construction has not significantly deviated from them.

2. Engineering Attestation

Accuracy Of Plans

A registered professional engineer licensed to practice in Texas must attest that the "Record Drawings" provided in satisfaction of the forgoing paragraph are a reasonably accurate representation of the location and characteristics of public storm drainage facilities and all detention facilities (private or public) as actually constructed. The center line alignment within plus or minus six (6) inches, and size of buried conveyance conduit shall be shown. Information about the size, elevation, and conveyance attributes of detention outlet structures and spillways shall be shown. The storage capacity and perimeter elevations of public and private detention ponds shall be shown. Attestation shall be via the following statement affixed with signature and seal to each sheet of the Record Drawings:

"I hereby attest that I am familiar with the approved drainage plan and associated construction drawings and furthermore, attest that the drainage facilities have been constructed within dimensional tolerances prescribed by the Bryan & College Station Unified Stormwater Design Guidelines and in accordance with the approved construction plans or amendments thereto approved by the City of

_____ *."*
(Bryan or College Station)

_____
Licensed Professional Engineer

*State of Texas No.*_____

(affix seal)

3. Construction Attestation

Full Construction

Each plan and profile sheet of materials presented as Record Drawings shall bear a certification from the general contractor as follows:

"I certify that the subdivision improvements shown on this sheet were actually built, and that said improvements are substantially as shown hereon. I further certify, to the best of my knowledge, that the materials of construction and sizes of manufactured items, if any, are stated correctly hereon"

_____
General Contractor

Section IV
Related Permitting

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION IV

RELATED PERMITING

A. FEMA-Designated Floodplains

1. Regulatory Floodplains

Named Watercourses

Based on long experience with helping offset the costs suffered by flood victims, The Federal Emergency Management Administration (FEMA) has developed a flood insurance program centered on the concept of floodplain management. Based on a series of engineering studies FEMA has mapped flood-prone areas along principal watercourses and their tributaries in urban areas nationwide. Termed "Flood Insurance Rate Maps", these indicate areas where citizens may obtain flood insurance at favorable rates due to FEMA subsidies. For purposes of these Guidelines the FEMA-designated watercourses and their tributaries are designated as the "Named Regulatory Watercourses" of the Cities. The pertinent watercourses are identified in Table B-1, Appendix B.

Floodplains

The Cities administer FEMA regulation of the floodplains of the Named Regulatory Watercourses as necessary to ensure the availability of affordable flood insurance to area citizens.

2. Regulations

Minimize Flooding

FEMA has established certain criteria that must be met by the Cities along specific watercourses. The purpose is to minimizing flooding, so use of "flood fringe" areas is purposely limited. Complex criteria affect both mapped areas and, in some instances, areas that are not yet fully mapped based on engineering studies. Where a land development project or construction of any kind will have the effect of limiting the cross sectional area of a FEMA-designated watercourse, engineering studies are necessary to determine the hydraulic effects, and to assess whether flood stage water surface elevations will be affected outside of allowable criteria. Where the upper reaches of a FEMA-designated watercourse are not adequately mapped, engineering studies will be necessary to do so.

3. Managing Encroachment

Watersheds

Development of lands along FEMA-designated watercourses may involve the proposed use of "flood fringe" areas, overbank areas not usually involved with conveyance of stormwater during low flow conditions. Use of such areas is considered "encroachment" into regulated floodplains, and is therefore, limited. Encroachments generally have the affect of restricting the cross sectional area of a watercourse, so the objective is to avoid causing water surface elevations at flood stage to rise above certain predetermined levels as necessary to the characteristics of each watercourse.

4. Procedures

Other Sections

The possible need for engaging FEMA in review and approval of flood studies or crossings of FEMA-designated watercourses must be identified at the Stormwater Planning Conference outlined in Section III of these Guidelines. Different levels of FEMA approval are required as a function of the proposed activity and its potential impact on flood-prone areas. The approval appropriate to a project must be obtained and documented to the City Engineer's satisfaction before authorization will be given to start construction.

Encroachments

The rationale for determining the extent of allowable encroachment and specific limitations are stipulated in Sections V and VI of these Guidelines. Both general criteria and criteria applicable to specific watercourses are included. Associated information is included in the Appendix.

B. Stormwater Quality

Permits If Needed

There are a number of national and state regulations that have bearing on the quality of stormwater emitted from land development projects in the Cities. These are principally focused on efforts to minimize the amount of sediments and pollutants carried into streams and waterways by storm runoff. Specific permitting requirements that may, from time to time, be required under any of the legislative provisions listed below must be met by owners/developers (or applicants) of land development projects. Proof that required permits have been issued by the appropriate authority must be provided before construction will be authorized by the City.

- Section 10 US Harbors and Rivers Act as administered by the US Army Corps of Engineers (USACE).
- Section 404 of the US Clean Water Act as administered cooperatively by the US Environmental Protection Agency (EPA) and the USACE.
- Section 401 of the US Clean Water Act as administered by the EPA.
- Section 402 of the US Clean Water Act as administered by the EPA in cooperation with the Texas Commission on Environmental Quality (TCEQ).
- Texas Administrative Code (30 TAC, Chapter 319) as administered by the TCEQ pursuant to the Texas Pollutant Discharge Elimination Program in cooperation with the EPA's Section 402 regulation of small MS4s.

Sections Apply

More specific information about these regulatory requirements is included in the appropriate sections of these Guidelines. Section 402 provisions about Stormwater Pollution Prevention Plans (SW3Ps) are addressed in Section VII, Erosion and Sedimentation. Section VIII,

Water Quality, provides more information about all of the regulatory citations listed above. Appendix E outlines several Best Management Practices (BMPs) that might be used in minimizing the pollutants discharged from a land development project through storm runoff.

C. Governmental Entities In Bryan-College Station Region

Planning Required

If a land development project of any size or complexity might possibly involve one or more of the entities listed in this Paragraph (Section III, Paragraph C), that potential must be made known as early as possible in the development review process. Ideally the needed coordination and approvals will be fully discussed during the Stormwater Planning Conference outlined in Section III of these Guidelines. At the very least, such coordination must be identified as an open matter at that time and fully addressed in the project Drainage Report.

1. Brazos County

Approvals Required

Certain land development projects may directly or indirectly involve Brazos County Government. This may include site construction projects as well as subdivisions, and includes the creation of public drainage easements or ROW. Approvals by the office of the County Engineer must be substantiated in the form of letters or any documentation acceptable to the County Engineer and the City Engineer, or their respective designees.

Site Projects

Any site development project that is wholly or partially in the corporate limits of the City is subject to these Guidelines. Where a project will discharge stormwater directly or indirectly into roadway areas administered by Brazos County, it will be necessary for the project owner/developer (or applicant) to secure the necessary approvals by the office of the County Engineer, or his/her designee. Likewise, if stormwater is to be discharged into a drainage way of any character that is maintained or administered by the office of the County Engineer, approvals must be obtained. Approvals must be substantiated before site drainage plans will be approved by the City.

Subdivisions

Subdivisions are commonly proposed within the corporate limits or the Extra Territorial Jurisdiction (ETJ) of the City, and may be partially in both. Also, a subdivision project area may be partially in a City's ETJ and extend outside of the ETJ. Under any of these conditions stormwater facilities may be planned to discharge into roadside ditches or watercourses that are under the jurisdiction of Brazos County. In such circumstances County roadway facilities may be affected within or adjacent to the project area, or downstream thereof. For this reason the project owner/developer (or applicant) must secure the necessary approvals by the office of the County Engineer, or his/her designee. City approval of plats is subject to this approval after full coordination between the offices of the City Engineer and the County Engineer.

2. Texas Department of Transportation (TxDOT)

TxDOT Facilities

Any land development project that is adjacent to or astride a highway route administered by TxDOT must be fully coordinated with the office of the TxDOT Area Engineer or his/her designee. All ROW and drainage easements under TxDOT jurisdiction must be fully identified, as well as any stormwater discharge(s) received from TxDOT facilities. Likewise any proposed discharges to TxDOT facilities or easements must be identified in detail.

Documented Action

Evidence of adequate coordination with TxDOT must be provided to the City Engineer or her/his designee. Documentation of the necessary coordination must be to the mutual satisfaction of the offices of the TxDOT Area Engineer and the City Engineer. Approval of site construction projects and final plats is subject to satisfaction of this requirement by the project owner/developer (or applicant).

3. Brazos River Authority

State Agency

The Brazos River Authority is a State agency charged with overall management of the water resources of the entire Brazos River Watershed stretching from far west Texas to the Gulf of Mexico. The Agency's focus is on water treatment and sewage treatment services for communities along the river's route. Its mission includes development and management of several water and flood control reservoirs.

Limited Role

During recent years the Agency has been given a broader role in support of the TCEQ's water quality mission. This largely parallels the Agency's other activities so it is focused on effluent point sources like sewage treatment and industrial processing enterprises. The Agency has no known role in reviewing or permitting stormwater facilities proposed in land development projects in the Bryan-College Station Region. The one possible exception would be in situations where permanent water impoundment is proposed directly on tributaries to the Brazos River. The Agency should be contacted as early as possible if impoundment is proposed in order to determine the extent of permitting that might be required, if any. Any associated permitting requirements must be met by the project owner/developer (or applicant). Documentation thereof must be provided to the office of the City Engineer before design plans will be accepted for construction.

4. Texas A&M University System

Land Owner

The TAMU System (TAMUS) has no authority over land development activities outside of its own land ownership. However, it must be accorded all of the rights and most (if not all) of the responsibilities ascribed to property owners by Texas surface water law. Stormwater discharges by the TAMUS into facilities under jurisdiction of the City will be directly coordinated between the TAMUS and the City.

Documented Action

Stormwater discharges to or through land owned by the TAMUS must be coordinated with the System Facilities Office located in College Station. Where a land development project proposes to discharge stormwater onto or though TAMUS properties it will be the responsibility of the owner/developer (applicant) to handle that coordination with the TAMUS and to substantiate the results to the City Engineer or his/her designee. The coordination must be documented to the satisfaction of the City Engineer or her/his designee before site or subdivision development projects can be approved.

Section V
Hydrology

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

August 2012

A. Introduction

Analysis Methods

The two types of hydrologic analyses most often required are the computation of the peak discharge at a specific location and the computation of a hydrograph at a specific location. Two methods are recommended for computation of peak discharges and two methods are recommended for computation of hydrographs. The application of these methods is a function of the purpose of the hydrologic examination and the size of the Design Drainage Areas being examined as outlined in these Guidelines. Other methods of proven use may be submitted to the City for approval. It is highly recommended that approval be obtained before significant hydrologic work is accomplished for a project.

B. Stormwater Runoff Calculation Methods

1. The Rational Formula

a. Variables

The formula shall be expressed as:

$$Q = ciA$$

Where the variables are defined below.

"Q" is the discharge in exact units of acre-inches per hour and accepted to be equivalent to units of cubic feet per second (cfs). This value is taken as the peak or highest discharge expected at a designated design point.

"c" is a coefficient, having no units, that represents the average runoff characteristics of the land cover within the drainage area delineated for a designated design point.

"i" is the rainfall intensity in units of inches per hour (in/hr.).

"A" is the area of land in acres that contributes stormwater runoff that passes through or at a designated design point.

(1). Intensity-Duration-Frequency Relationship

Rainfall intensity (**i**) is defined as the average rate of rainfall in inches per hour. It can be determined for storms of various return frequencies as commonly represented by several intensity-duration-frequency (IDF) curves in graphical form. Duration ranges from ten minutes to 24 hours, and is assumed to be the time of concentration. Rainfall intensities may be determined from (IDF) curves or from the equations

presented in Table C-1, Appendix C. These equations approximate the IDF curves within a reasonable margin of error. For the Rational Method, the critical rainfall intensity is that having a duration equal to the time of concentration of the design drainage area. Determination of time of concentration (t_c) is discussed in Paragraph B1-a(3) below.

2). Runoff Coefficients

a). Tables C-2 and C-3 in Appendix C shall be used to select the runoff coefficient "**c**" for the appropriate land cover and land use. Linear interpolation shall be used to choose specific values within the ranges given.

b). For areas that consist of different types of land cover or land use, a weighted average runoff coefficient shall be computed using the following equation.

$$c = \frac{c_1 A_1 + c_2 A_2 + \ldots c_x A_x}{A}$$

Where:

$A = A_1 + A_2 + \ldots = A_x$ the total drainage area,

$c_1, c_2, \ldots c_x$ are the runoff coefficients for sub-areas,

$A_1, A_2, \ldots A_x$ are the areas of land cover or land use that correspond to the runoff coefficient **$c_1, c_2, \ldots$ and c_x** respectively, and

c is the runoff coefficient for use in the formula for the Rational Method.

c). The runoff coefficient "**c**" shall be determined using the "land use" when using the rational formula to compute the peak discharges within or from specific sites and developments.

d). Referring to Tables C-2 and C-3 in Appendix C, the runoff coefficient "**c**" may be determined from the "land use" when using the rational formula to compute the peak discharge from more than one site or development.

(3). Time of Concentration

<u>a) Principles</u> --Time of Concentration (t_c) is the theoretical time required for a drop of rain to travel from the most hydraulically remote point in a Design Drainage Area to a point where storm flow is to be determined (the point of calculation). Assuming rainfall is uniform over time and uniform on the watershed, the time of concentration is the first moment when the entire Design Drainage Area is contributing to the runoff at the point of calculation, because during that time all other parts of the Design Drainage Area will also be contributing flow to that point. This is fundamental to estimating total flow at the point of

calculation based on the assumption of uniform rainfall over time, as accomplished using the Rational Method.

Hydrograph Peak

When used within computations using shaped unit hydrographs, the time of concentration is used (usually indirectly) to determine the timing of the peak of the hydrograph in relation to the beginning of the storm event.

Watershed Factors

The length of time will depend on several characteristics of the Design Drainage Area. Slope, ground cover, degree of concentration, and the antecedent moisture content of the soil are principle among these. When such characteristics are not entirely uniform it is necessary to assess the composite effects of differing characteristics found in parts of the Design Drainage Area. Because hydraulic equations are rarely linear in nature, the averaging of characteristics, such as slope, can readily create inaccuracies. Likewise, multiple variations in characteristics of the Design Drainage Area can cause compounding of inaccuracies, thus generating unreliable results.

Segment Analyses

In order to ensure accurate results, each segment having different characteristics must be calculated independently, and the resulting times then added to obtain the overall time of concentration ($\mathbf{T_c}$). The time of concentration should be determined for each segment of significantly differing slope, surface roughness, and/or cross sectional area. Values of velocity (**v**) for determining (t_c) for each segment are given in Table C-4 in Appendix C. The time needed for runoff to flow through each of these segments is known as Travel Time ($\mathbf{T_t}$).

Flow Characteristics

To expedite these calculations, formulas have been developed to estimate travel time by factoring out certain variables from the basic hydraulic equations. Some are assumed to be effective for the initial sheet flow state where the runoff is spread very thinly over a relatively wide area. Some equations are applied to a condition known as 'shallow concentrated flow' in which the runoff is not in a uniform sheet, but is concentrated in an irregular manner not allowing determination of flow cross sections. Where flow is channelized in a reasonably uniform manner allowing use of cross section information, Manning's Equation is normally used to determine velocity, and thus time of travel.

b). Analysis Criteria -- For purposes of consistency, these Guidelines provide a single set of equations for the estimation of Time of Concentration. These equations and related criteria are adapted directly from the TR-55 manual published in 1986 by the Soils Conservation Service (now the Natural Resources Conservation Service). Other accepted methods may be submitted and considered as special designs.

Initial Sheet Flow: For initial flow areas, which are both uniform and planar, Manning's Kinematic equation (shown below as published by Overton and Meadows, 1976) should be used. Its use is based on the

four assumptions listed below. In no case should a length exceeding 300 feet be considered.

- Shallow uniform steady flow
- Constant rainfall intensity
- Rain duration of 24 hours
- Infiltration does not impact travel time

$$T_t = \frac{0.007(nL)^{0.8}}{(P_i)^{0.5} s^{0.4}}$$

Where:

T_t = Travel time (hours)

n = Mannings' roughness coefficient for sheet flow (Table C-5, Appendix C).

L = Overland flow distance (feet)

P_i = Recurrence interval for the 24-hour rainfall depth (inches) in the **i^{th}** year (Table C-6, Appendix C)

S = Slope of land (feet per foot)

Shallow Concentrated Flow: For reaches where the flow is no longer uniform and planar, and a flow cross section cannot be determined, the equation for shallow concentrated flow should be used. This equation estimates flow velocity, which can be translated into travel time.

$$T = \frac{D}{60V}$$

Where:

T = Travel time (minutes)

D = Flow distance (feet), and

V = Average velocity of runoff (feet per second)

Channel Flow: Where a flow cross section can be determined, Manning's Equation should be used with appropriate factors for the segment being analyzed.

In any case the time of concentration need not be taken as being less than 10 minutes.

b. Assumptions and Limitations

(1). The Rational Formula shall only be used to estimate peak discharges at specific designated design points.

(2). The contributing area **"A"** of runoff shall not exceed 50 acres.

2. Natural Resource Conservation Service (formerly SCS) Methods

a. Hydrology Principles

"SCS" No. 55

Technical Release No. 55 – Urban Hydrology For Small Watersheds forms the basis for examination of watersheds considered large as regulated by these Guidelines. These "SCS" methods are empirically derived relationships that use precipitation, land cover, and physical characteristics of Design Drainage Areas to calculate runoff amounts, peak discharges, and hydrographs. Of the various methods available, the following two are adopted for use:

(1). Chart Method – used to determine the peak stormwater discharges and the effect of development on those peak discharges at a designated design location.

(2). Tabular Method – used to determine a hydrograph of stormwater discharges at a designated design location.

b. Variables

(1). 24 Hour rainfall depths for the Bryan-College Station area (Table C-6 in Appendix C) shall be used to select the rainfall depth for selected storm return periods. This value shall be used for the variable "P" as input to all equations, graphs, and tables as applicable. A Type III rainfall distribution developed in 1990 shall be used to determine incremental totals.

(2). Hydrologic Land Cover Parameters (SCS Curve Numbers)

a) The engineer shall determine the land cover parameters based on soil type from the county soils maps and natural vegetation only. All development shall be input as impervious percentage per Table C-7.

(3). Determination of Peak Discharges – The TR-55 Chart Method

a). Calculations must include the appropriate factors and modifications for the shape and slope of the Design Drainage Area, and urbanization (percent of impervious area and percent of hydraulic length modified).

b). Where a Design Drainage Area consists of several types of land cover and/or land use, a composite percent of impervious area shall be determined using the same methodology outlined in Paragraph B1-a-(2)-b) of this Section.

(4). Determination of Time of Concentration

One of two methods shall be used, the "Lag Method" or the "Upland Method". Details on the use of both are available in "TR-55".

c. Assumptions and Limitations

(1). The accepted methods from Technical Release No. 55 are for use in determining stormwater discharges and hydrographs in the Secondary Drainage System only.

(2). Application of these methods shall be in strict conformance with the instructions and recommendations given in Technical Release No.55 and the latest updates and revisions issued by the Natural Resource Conservation Service (formerly SCS), except as superseded or altered by the requirements of this section.

(3). The Design Drainage Area for application of these methods shall not exceed 2000 acres.

3. Hydrograph Methodology

a. Methods

Hydrographs

Two methods of determining a hydrograph are accepted for use. These are the Tabular Method of NRCS (formerly SCS) Technical Release No. 55, and the NRCS (formerly SCS) Dimensionless Unit Hydrograph method. The principal aspects of each are outlined below.

(1). Tabular Method of NRCS (SCS) Technical Release No. 55 --The hydrograph is computed by an empirical method that relates drainage area, land use, and time of concentration.

(2). NRCS (SCS) Dimensionless Unit Hydrograph – The hydrograph is computed using basin area, land cover, lag, and precipitation as modifiers to a dimensionless unit hydrograph.

(3). Combining Hydrographs – In larger Design Drainage Areas covering large Basins or entire Watersheds it may be necessary to combine hydrographs in order to accurately depict the runoff with one hydrograph where two or more sub-areas intersect and combine flows. If this occurs, the drainage report shall explain the location of these intersections, and provide the necessary input files in conjunction with the report.

b. Assumptions and Limitations

(1). Tabular Method of NRCS (SCS) Technical Release No.55

a). This method shall be applied according to the instructions and limitations outlined in NRCS (SCS) Technical Release No. 55, and revisions issued by the Natural Resource Conservation Service.

b). This method shall only apply to analysis of the Secondary Drainage System.

(2). NRCS (SCS) Dimensionless Unit Hydrograph Method

a). This method is used in the hydrologic analysis for the adopted Flood Studies of the Cities.

b). The method shall be used to compute hydrographs at locations in the primary system where the adopted Flood Study does not determine a hydrograph.

c). The method shall be applied using the Generalized Computer Program, HEC-HMS, Flood Hydrograph Package developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers. At the discretion of the City Engineer the HEC-1 Program may be used.

d). Data from the adopted Flood Study shall be used with only the modifications necessary to account for the desired location of the hydrograph. This will typically involve deletion of data for areas outside of (or downstream of) the study location, and modification of the most downstream drainage area and/or routing reach.

c. Computer Analysis and Simulation

(1). A comprehensive hydrologic model of several of the Primary Systems has been adopted by the Cities. Most of the models are applied using Generalized Computer Program, HEC-1, Flood Hydrograph Package of the U.S. Army Corps of Engineers.

(2). The model uses the following methods available in HEC-HMS:

a). Precipitation is computed using the 24 hour rainfall depths (see Table C-6 in Appendix C) distributed according to the Natural Resource Conservation Service Type III Distribution.

b). Basin Hydrographs are computed using the NRSC (SCS) Dimensionless Unit Hydrograph Method.

c). Routing of hydrographs is computed by Normal Depth Storage and Outflow (“Channel Routing”).

(3). Amendment of the adopted FEMA flood study will be processed by the City as conditions in the drainage basins change based on revised flood study data submitted to the City for review.

Range of Analyses

The model consists of analyses of the 10-year, 25-year, 50-year, and 100-year storms for two Design Drainage Area conditions: ”Existing” and “Ultimate”. The “Existing” condition analysis reflects the land uses and channel conditions in the Design Drainage Area as they exist at the time of analysis. The “Ultimate” condition analysis reflects the fully developed conditions defined by the adopted Comprehensive Land Use Plan guiding development within the City, coupled with the existing channel and floodplain conditions at the time of the study. No allowance is to be made for proposed channelization in determining the “Ultimate” condition flood discharges or elevations.

C. Applications

1. The Rational Method

Limited Use

The Rational Formula shall be limited to use in determining the peak discharge from small areas of overland or sheet flow, and concentrated flows in street gutters, storm sewer, and man-made channels. It shall not be used for determining peak discharge from any Design Drainage Area exceeding 50 acres in size nor for determining or estimating storage or discharge requirements for design of detention facilities. Likewise it shall not be used to estimate stormwater discharges of the primary system. Its use is strictly limited to small Design Drainage Areas discharging to the secondary drainage system.

2. Natural Resource Conservation Service (NRCS) Methods

Primary Use

Methods promulgated by the NRCS (formerly the Soil Conservation Service – SCS) have a variety of applications. Those detailed in Technical Release No. 55 are for use in determining stormwater discharges and hydrographs in the Secondary Drainage System only and for Design Drainage Areas not exceeding 2000 acres. For purposes of these Guidelines these methods are applicable to Design Drainage Areas of 50 to 2000 acres. In the event a Design Drainage Area exceeding 2000 acres is to be analyzed, the methodology must receive specific approval of the City engineer.

3. Dimensionless Unit Hydrograph Method

This method must be used where analysis and design of the primary drainage system is involved.

4. Detention Facilities

Storm flow hydrographs for use in designing detention facilities shall be determined using one of the methodologies defined in Paragraph B3 of this Section. The applications and limitations therein stated shall apply.

Section VI
Hydraulic Design

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION VI

HYDRAULIC DESIGN

A. Street Drainage

1. Design Principles

Street Purposes

The primary purpose of streets is transportation: to offer effective mobility for all users, and to ensure that each land parcel has reasonable access. Stormwater collection and conveyance is an important, but secondary purpose. Consequently, designs for handling storm flow should minimize interference with transportation uses. In general, the more important the street (in terms of functional classification) the more important it is that stormwater design not interfere with transportation uses. Conversely, moderate interference with transportation uses is more acceptable on lower class streets.

Flow Parameters

The design flow of water in streets shall be related to the extent and frequency of interference with traffic as related to street functional class and the chance of flood damage to surrounding properties. Interference with traffic is regulated by design limits of the spread of water into traffic lanes. Flooding of surrounding properties is regulated by limiting the depth of flow at the curb and by containment of the 100-year design storm flow within the street right of way.

2. Performance Standards and Limitations

a. Velocity of Flow

(1). The maximum velocity of street flow shall not exceed 10 feet/second. At “T” street intersections flow velocity must be checked on the stem of the “T” to ensure that flow will not traverse the crown and opposing curb of the crossing street and enter onto private property.

(2). A minimum velocity shall be maintained to ensure cleansing flushes at low flows by keeping the minimum gutter slope to six tenths of one percent (0.006 ft/ft).

b. Allowable Depth of Flow

Top of Curb

The depth of flow shall be limited to the top of curb for a design storm having a return period of ten years.

Within ROW

Design flows for storms with an average return period up to and including 100 years shall be confined within the limits of the street right-of-way until discharged into a drainage easement or drainage ROW that is part of the designated Conveyance Pathway system, or directly into a main channel of the primary drainage system. The capacity of the storm drain system shall be increased beyond other design criteria in these Guidelines as necessary to ensure this objective. Design computations shall demonstrate satisfaction of this criterion.

c. Grades and Cross-slopes

Street grades and cross-slopes shall be consistent with B-CS Technical Specifications.

d. Allowable Water Spread

(1). Local Streets – The design storm flow in local streets shall be limited to the top of crown or the top of curb, whichever is less. Stormwater shall be removed from the streets by inlets or openings into adjacent drainage systems. These shall be placed at low points and as frequently as necessary to avoid exceeding water spread and depth criteria. The design storm shall have a return period of ten years.

(2). Collector Streets – Design storm flow in collector streets shall be limited so that one 12-foot wide area (one traffic lane width) at the center of the street will remain clear of water. Stormwater shall be removed from the street by inlets or openings into adjacent drainage systems. These shall be placed at low points and as frequently as necessary to avoid exceeding water spread and depth criteria. The design storm shall have a return period of ten years.

(3). Arterial and Parkway Streets – Design storm flow in arterial and parkway streets (any street having a raised median regardless of classification) shall be limited so that one (1) twelve-foot traffic lane each direction at the center of the street (or one on each side of a raised median) will remain clear of water. Stormwater shall be removed from the street by inlets or openings into adjacent drainage systems. These shall be placed at low points and as frequently as necessary to avoid exceeding water spread and depth criteria. The design storm shall have a return period of twenty-five years.

(4). Intersections – Inlet placement and storm sewer size shall ensure that design storm flows are intercepted ("dried up") along street legs entering the intersection in advance of the curb returns connecting the streets based on the criteria provided below. In no case shall inlets be placed in the curved portion of curbs connecting intersecting streets. Where storm flow is allowed to pass through an intersection, valley gutter design must provide for smooth, uninterrupted traffic flow as stipulated by B-CS Technical Specifications.

Intersection Pair	Intercept	Valley Gutter Criteria
Arterial – Arterial	All legs	No valley gutters
Arterial – Collector	All legs	No valley gutters
Arterial – Local	All legs	No valley gutters
Collector – Collector	All legs	No valley gutters
Collector – Local	Local legs	Valley gutters can parallel Collector
Local – Local	Two legs preferred	Valley gutters acceptable

(5). Mid block Cross Drainage – Where storm drainage is collected on one side of a street and must be conveyed to the other side, it shall be accomplished via underground conduit unless the roadway is functionally classified as a local street. Where storm flow is to cross such a local street the preferred conveyance is via underground conduit, however, at the discretion of the City Engineer, very low design flow may be conveyed in a valley gutter that satisfies B-CS Technical specifications.

3. Design Procedure

a. Straight Crowns

Flows in streets which have a straight crown will be calculated using the following equation for triangular channels:

$$Q = 0.56 \frac{z}{n} S^{0.5} Y^{2.67}$$

where,

Q = gutter discharge (cubic feet per second)

z = reciprocal of the crown slope (ft/ft)

S = street or gutter slope (ft/ft)

n = Manning's roughness coefficient

Y = depth of flow (ft)

When flows over concrete or asphalt pavement are being calculated, the valve of "**n**" shall be taken as 0.018.

b. Parabolic Crowns

Flows in streets which have a parabolic crown become complicated and difficult to precisely solve for each design case. Design equations must be used to determine gutter flow when street design is to include parabolic crown sections. If parabolic crowns are planned, the concept is to be discussed during the Stormwater Planning Conference with the City Engineer or her/his designee.

B. Storm Drain Inlets

1. Principles

The purpose of a storm drain inlet is to intercept street or surface runoff and direct it into another component of the drainage system, usually an underground conduit. Inlets are typically of the curb opening type for streets and grate type for area drainage. Curb inlets

occur at low points or on grade, and can have a throat that is either depressed or flush with the gutter invert grade. Grate inlets can only occur in low points and may or may not be depressed.

2. Street Inlet Criteria

Recessed Inlets

Inlets along arterial or major collector streets shall be recessed (horizontally displaced) away from the line of the curb so that any depression at the mouth of the inlet occurs wholly within the limits of the gutter, with no irregularity of elevation extending into the travel lane. A diagram of a recessed inlet is illustrated in Figure C-1, Appendix C.

Inlets on minor collector streets shall be recessed away from the line of the curb when a depression of four (4) inches or greater is used at the mouth of the inlet.

Optional Design

Inlets along streets classified as “local” may or may not be recessed.

Inlet Length

Curb opening inlets shall have a minimum length of five (5) feet, and construction details shall conform to the B-CS Technical Specifications.

3. Types of Inlets

Standard Inlets

Standard inlets are classified into two groups: inlets in sumps (Type A) and inlets on grade (Type B). These are further subdivided as follows:

Inlets in Sumps

- Curb openings (with or without gutter depression) Type A-1
- Grate inlet; Type A -2

Inlets on Grade

- Curb openings with gutter depression Type B-1
- Curb openings without gutter depression Type B-2

Combination Inlets

A combination inlet is a side-by-side placement of a standard curb inlet and a grate inlet. The upstream inlet may be a standard curb inlet or simply part of an inlet. The benefit is that the curb opening tends to intercept debris that might otherwise clog the grate inlet. Such arrangements typically offer very little additional capacity over standard depressed inlets. In order to determine the capacity of a combination inlet on grade, it is recommended that the capacity of each (standard and grate) be calculated and the greater capacity be assumed for the pair for design purposes.

4. Inlet Location

Limit Conflicts

Inlet locations shall conform to the requirements of paragraph A of this section of these Guidelines, and shall be located as feasible to limit

conflicts (caused by the inlet itself or associated stormwater) with vehicle, bicycle, or pedestrian traffic.

Limit Cross-Flow

Inlets shall be located along streets to prevent concentrated stormwater flow from crossing traffic lanes, except as outlined in paragraph A of this section. Typical locations for these conditions are at transitions to super elevated sections, at the ends of long traffic islands, or at the ends of medians in super elevated sections.

Meet Standards

Specific configuration and exact location of inlets shall be consistent with requirements of the B-CS Technical Specifications but shall not be in conflict with provisions of Paragraph A2-d of this Section.

5. Inlet Sizing

a. Inlets in Sumps

Minimize Ponding

These inlets are placed at low points to relieve ponding of surface water. For purposes of design, inlets having a gutter depression greater than five (5) inches on streets with less than a one percent (1%) grade may be considered as inlets in sumps.

Maximum Depth

Under no circumstances shall inlets at low points in streets allow water to pond to a depth exceeding 24 inches above the gutter flow line for up to 100-year frequency design storms based on project buildout and ultimate development conditions. Where computations show that this would be exceeded, provision must be made for an overflow outlet designed to handle the excess flows. This can take the form of a flume draining the street or a swale in an adjacent drainage easement, provided neither present an obstruction to non-motorized travel. Alternatively, the inlet system and receiving facilities shall be oversized as necessary.

(1). Curb Openings Inlets (Type A-1) that are not submerged are considered to function as a rectangular weir with a discharge coefficient of **3.0**. The capacity of a curb opening inlet is found by the following equation:

$$Q = 3.0Ly^{1.5}$$

where:

Q = capacity in cubic feet per second (cfs)

L = length of the opening which water enters into the inlet

y = total depth of water or head on the inlet

Clogging Factor

Because of the tendency for curb opening inlets in sumps to collect debris, their calculated capacity shall be reduced by ten percent (10%) to compensate for potential clogging.

(2). Grate Inlets (Type A-2) are considered to function as an orifice with a discharge coefficient of 0.60. The capacity of a grate inlet is based on the following equation:

$$Q = 4.82 A_g y^{0.5}$$

where:

Q = capacity in cubic feet per second

$\mathbf{A_g}$ = clear opening area in square feet

y = total depth of water or head on the inlet in feet.

Clogging Factor

Because of the tendency for grate inlets to collect debris, their calculated capacity shall be reduced by twenty-five percent (25%) to compensate for potential clogging, except where used as a controlling device in a detention facility.

b. Inlets on Grade

(1). Curb Inlets (without gutter depression) Type B-1

The capacity of such inlets is based on the weir equation, reduced to account for street grade and cross-flow effects. The head, "**y**", shall be taken as the depth of flow at the upstream end of the opening determined via criteria stipulated in Paragraphs A2 and A3 of this Section. Equation 1 in Table C-8 (Appendix C) shall be used to determine the capacities of these inlets on grade, with the value for "**a**" set equal to zero.

(2). Curb Opening Inlets (with gutter depression) Type B-2

The same guidelines and criteria apply as for those inlets without a gutter depression, except the value "**a**" shall be taken as the gutter depression. The gutter depression is defined as the difference in elevation from the normal gutter grade line to the pavement grade at the throat or entry of the inlet (see Figure C-2 in Appendix C).

(3). The equations in Table C-8 in Appendix C are to be used to determine the necessary size of curb inlets on grade. The applicable determinates and variables are defined in the table and the purpose of each equation is described.

C. Storm Drainage Systems

1. Principles

Conduit System

Storm Drain systems are conduits for the collection and conveyance of surface water to desired points of discharge. Design is accomplished by application of the Manning equation either directly, or through charts and nomographs derived from the equation. The following general conditions apply to the design.

Accept Design Flow The system must be designed to accommodate all intercepted flow for the design storm at each inlet and opening that allows stormwater into the system. Preferably the system shall operate "flowing full" and within the theoretical limits of open channel flow for the required design flows.

Future Runoff Design and construction shall take into account any stormflow from future subdivision areas contributing to the system. No existing system shall have flows added (or directed to it) that will exceed its theoretical design capacity.

100-Year Runoff The system shall be evaluated with associated drainage systems for the flow conditions that will result from a 100-year frequency rainfall event under ultimate development conditions over the Design Drainage Area. Design shall be revised as required to prevent formation of any conditions that could be considered hazardous to life, property, or public infrastructure, or that could create conditions inconsistent with the requirements of other sections of these Guidelines.

2. Initial Design Considerations

a. Minimum and Maximum Velocities

Minimum velocities are necessary to prevent excessive deposits of sediment that could lead to clogging. The minimum design velocity for conduits flowing full shall be 2.5 feet per second.

Maximum velocities are necessary to prevent excessive erosion of the inverts. The maximum design velocity for conduits flowing full shall be 15 feet per second.

b. Roughness Coefficients, "n"

Selection of a roughness coefficient should reflect the average condition present during the life of the conduit. Factors to consider are erosion of the interior surface, displacement of joints, and introduction of foreign material and deposits. The following values shall be used for the materials listed:

Reinforced Concrete: 0.013

Ductile Iron or steel (Smooth): 0.010

Corrugated Metal: 0.024

Smooth lined High Density Poly-Ethylene (HDPE): 0.012

Non-lined High Density Poly-Ethylene (HDPE): 0.020

c. Location of Manholes and Junction Boxes

(1). Junction boxes shall be provided at all changes in conduit size and grade, and where changes in alignment are made at pipe joints

Manhole access shall be provided as part of the design of all junction boxes unless otherwise approved by the City Engineer.

(2). Manholes shall be provided at intervals not to exceed 300 feet for conduits 54 inches in diameter or smaller. For conduits exceeding 54 inches in diameter, the interval between openings shall not exceed 500 feet.

d. Minimum and Maximum Grades

(1). The minimum grade for conduits shall be that necessary to produce the minimum acceptable velocity per Paragraph C2-a.

(2). In order to prevent formation of a hydraulic jump conditions at the terminus of a conduit, the maximum grade along the outfall shall be less than the calculated grade that would result in supercritical flow, except where approved energy dissipation measures are used.

e. Minimum Pipe Diameter

18-Inch Usual

In most instances conduit that will become an integral part of the public storm sewer system shall have a diameter of 18 inches or greater. For design purposes, conduits having a diameter of 24 inches or less shall be assumed to have a twenty-five percent (25%) reduction of cross-sectional area to compensate for potential partial blockage.

Limited 12-Inch

At the discretion of the City Engineer, short laterals connecting inlets to a main line, and the last run of conduit at the uppermost end of a main line, may be twelve (12) inches in diameter. In no case shall a run of twelve-inch conduit serve more than one inlet or exceed a length of 30 feet.

f. Other Considerations

(1). Designs shall attempt to increase the velocity in the downstream direction.

(2). Pipe sizes shall increase in the downstream direction, regardless of additional capacity developed by increased grade, and pipe soffit (inside top) elevations shall be aligned.

(3). An elevation drop is to be provided at all inlets, manholes, and junction boxes equal to the change in pipe diameter or a minimum of one tenth of a foot.

(4). Pipe shall be placed on the design friction slope as much as practical.

3. Hydraulic Design Requirements

a. Flow Assumptions and Manning's Equations

Design shall be by application of the Continuity equation and Manning's Equation as follows:

$$Q = AV$$

$$Q = \frac{1.49}{n} AR^{0.67} S_f^{\ 0.5}$$

where :

Q = flow in cubic feet per second

A = cross sectional area in square feet

V = velocity of flow in feet/sec

n = roughness coefficient of conduit

R = hydraulic radius = **A/WP** in feet.

WP = wetted perimeter in feet $\mathbf{S_f}$ = friction slope of conduit in feet/foot

Capacity of a given size conduit is based on an assumption that it is "flowing full". Thus, **R** is equivalent to the cross sectional area divided by the inner circumference, while a value for **n** and $\mathbf{S_f}$ must be chosen.

b. Head Losses and Friction Losses

Head losses computed at junctions, inlets, and manholes shall be determined using the following equation:

$$h_j = k_j \left(\frac{V_2^2 - V_1^2}{2g} \right)$$

where:

$\mathbf{h_j}$ = head loss in feet at structures

$\mathbf{V_1}$ = velocity at upstream entrance of structure (feet per second)

$\mathbf{V_2}$ = velocity at downstream exit of structure (feet per second)

$\mathbf{k_j}$ = structure coefficient of loss (Table C-9, Appendix C)

g = 32.2 feet per second per second

Head losses due to friction for open channel flow conditions are found by the following equation:

$$h_f = S_f L$$

where:

$\mathbf{h_f}$ = head loss due to friction in feet

S_f = friction slope (normally equal to the slope of the conduit, **S_o**), in feet per foot

L = length of conduit in feet

c. Computation of Hydraulic Grade Line

All designs shall verify the elevation of the hydraulic grade line by calculation along the length of the system for two conditions. For the 10 year design storm the theoretical hydraulic grade line shall be verified as being at least one half foot (0.5 feet) below the inlet opening elevation, the gutter elevation, or the ground surface which ever is lowest. The hydraulic grade line shall also be calculated for the 100-year frequency storm assuming ultimate development conditions in the Design Drainage Area, and must be kept within the limits specified in all other sections of these Guidelines.

d. Allowance for Surcharging

Design of the system and evaluation of hydraulic grade lines shall take into account the tail water elevation at the outlet or final discharge point. Discharge at free outfalls shall assume a starting water surface elevation at the soffit of the conduit. For outlets that might operate in a submerged or partially submerged condition, the starting water surface elevation shall be taken as the water surface elevation of the receiving facility at that location or the conduit soffit, whichever is highest.

4. Use of WINSTORM Program

Use of the WinStorm computer program is acceptable for calculating the capacity of inlets and storm drain systems. The program is available at no cost through TxDOT's web site. If WinStorm is used as a design aid for a project, the complete report the program can generate shall be submitted as part of the drainage report. In addition, both an analysis layout and an electronic medium (diskette or CD) of the analysis shall be provided.

D. Open Channels

1. Principles

Analysis of open channels is necessary to determine the depth and velocity of a given flow for an established cross-section. Typical uses are to determine the tail water and/or the back water condition(s) at a culvert structure, flood elevation for selected discharge of natural streams and watercourses, and discharge capacities for existing or proposed designed channels.

Design Objectives

Design of open channels involves the selection of a cross-section, surface treatment, and alignment to accommodate some series of design discharges. A successful channel design can take one of two basic forms. It can replicate the features and characteristics commonly found in natural streams, or it can provide the characteristics of traditional constructed channels. In either case the design objective is to provide stable structural components that will not develop excessive sediment deposits or erosive cuts, that will maintain a stable cross-section, that will minimize the need for maintenance, and that will not be damaged by entry of uncontrolled surface flows.

Natural Designs

Leaving streams in their natural state offers numerous advantages, so this practice is preferred. Designs that replicate the characteristics of natural streams are encouraged, provided they meet the objectives of the provisions in these Guidelines. Such a design approach may be required at the discretion of the City Engineer. Where plant growth and hydro-environments can be created or maintained to accomplish stabilized channels they are encouraged. Such designs must ensure that long term maintenance costs are not likely to be greater than would be expected from the use of traditional channel lining treatments.

2. Determination of Water Surface Profiles

a. Methods of Analysis

(1). Manning's Equation

The equation is expressed as follows:

$$Q = \frac{1.49}{n} A R^{0.67} S^{0.5}$$

where:

Q = the discharge in cubic feet per second

n = Manning's Roughness Coefficient

A = cross-sectional area representing the depth of flow in feet

R = hydraulic radius = **A/WP** in feet.

WP = wetted perimeter of channel section for area "**A**" in feet

S = slope of channel bed in feet/foot

The equation is applied to a single cross-section and assumes a uniform channel cross-section and slope as well as steady, uniform flow in the channel. Consequently, its use shall be limited to designed channels and suitable natural channels in the secondary drainage system.

(2). Standard – Step Procedure

This procedure shall be used in analyzing natural or man-made channels of the primary drainage system. It may also be applied to open channels in the secondary drainage system.

Bernoulli's Equation

The procedure involves application of Bernoulli's Equation to a series of stream cross-sections using the continuity equation, the velocity head, and Manning's Equation as inputs. A detailed description is beyond the scope of these Guidelines.

HEC-RAS Software

The method shall be applied using the HEC-RAS software endorsed by the Hydraulic Engineering Center of the U.S. Army Corps of Engineers, or other computer analysis programs employing the same methodology. The application shall be according to the recommendations contained in the user's manual for the program.

b. Primary Design Parameters

(1). Channel Section

Cross-section(s) should be representative of the channel reach being studied.

(2). Manning's Roughness Coefficients ("**n**" values)

Section of values for "n" shall fall within the range of values and descriptions given in Table C-10 in Appendix C.

(3). Channel Slope

The slope of the channel shall be taken as the average slope along the reach being studied.

c. Determination of Flow Character

In order to prevent formation of areas of supercritical flow and hydraulic jumps except where planned, flow must be kept within the limits of sub-critical flow. To do this, design flow depth must be greater than critical depth. For non-rectangular channels, the critical depth can be found through application of trial depths and the following relationship:

$$\frac{Q^2}{g} = \frac{A_c^3}{T_c}$$

where:

Q = discharge in cubic feet per second

g = 32.2 feet per second per second

$\mathbf{A_c}$ = cross-sectional area of flow at critical depth in square feet

$\mathbf{T_c}$ = top width of critical flow in feet.

For non-uniform cross sections, a rating curve of critical depth versus discharge shall be constructed.

Once the discharge **Q**, area **A**, and depth **d** are determined, the slope necessary to produce these conditions in a channel can be computed from Manning's Equation.

3. Design of Open Channels

Traditional Designs

The criteria outlined in this section are intended to guide the development of traditional designed/constructed open channels. Roadside ditches shall be designed as open channels per the Guidelines in Paragraph D4 of this Section. Alternate channel designs will be considered by the City Engineer provided they are shown to meet the intent of these Guidelines.

Natural Designs Encouraged

Designs intended to replicate the characteristics of natural streams are encouraged but must be shown to satisfy the essential purposes of the provisions of this paragraph. Example features that might be considered for such designs are among those outlined in Appendix E.

a. Physical Considerations

(1). Cross-Section Geometry

The minimum standards acceptable for use in traditional lined channel design are in the B-CS Technical Design Specifications. The maximum side slope shall be four horizontal to one vertical (4:1).

(2). Minimum and Maximum Grades

The minimum longitudinal slope shall be 0.006 foot per foot (0.6 percent) for earthen or vegetative lined channels to prevent formation of standing water. The maximum allowable grade shall be a function of allowable flow velocity as related to channel lining materials stipulated in Table C-11 (Appendix C). If the proposed maximum grade will exceed 70 percent of the calculated critical slope values for the required range of design flows, special channel linings and energy dissipation features must be used to compensate for the high velocities and hydraulic jumps associated with supercritical flow. Designs for supercritical flow are limited to straight sections having a minimum grade that is at least 130 percent of the critical slope values calculated for the required range of design flows.

(3). Bends and Horizontal Curves

The maximum allowable deflection angle for bends in designed channels shall be 45 degrees. The outside of horizontal curves shall provide additional channel bank height and surface treatment as necessary to fully contain the design flow and prevent erosion and overtopping.

(4). Erosion Protection Measures

Measures required for protection of earthen channels are described in Section VII of these Guidelines (see Paragraph C3).

(5). Berms

If earthen berms are proposed as permanent features for stormwater management they shall meet a structural compaction of 98 percent Standard Proctor. Berm side slopes shall be a maximum of three horizontal to one vertical (3:1) if to be privately maintained and four horizontal to one vertical (4:1) if to be publicly maintained. As a function of height, berms shall have a minimum top width as follows:

- Height 2 feet or less — 3 feet top width
- Height between 2 and 6 feet — 5 feet top width
- Height exceeding 6 feet — 10 feet top width

b. Flow Considerations

(1). Design Flows

a). Channel capacity shall be determined to accommodate the discharge from a 25-year storm assuming buildout conditions for all of the Project Area of a land development project that can be foreseen to discharge to the channel, plus the 100-year storm flow from existing conditions on all other land areas served by the channel.

b). Channels shall be designed to flow supercritical for the range of discharges resulting from the 5-year, 10-year, 25-year, and 100-year design storms on the Design Drainage Area.

c). When a low-flow flume is to be constructed in an open channel, an invert section of concrete or other materials acceptable to the City Engineer must be designed to carry 33 percent of the peak design discharge of a 5-year storm for the channel as stipulated in the previous sub-paragraph.

(2). Velocity Limitations

a). Velocity of flow shall not be less than two and one half (2.5) feet per second for the 25 year design storm.

b). Maximum velocities for the design flow shall be less than the values given in Table C-11 in Appendix C for the type of surface treatment(s) specified.

(3). Freeboard Requirements

Channels shall be designed with a minimum freeboard equal to one foot above the 25 year design depth of flow.

c. Outfall Junctures

Junctures Important

Where part of a storm drainage system discharges into another part of the system, on-going long-term maintenance difficulties can result, particularly where the receiving facility is an open channel. The complexity and importance of these junctures warrants careful design attention.

Juncture Categories

Junctures can be grouped into three categories: discharge from an under ground storm sewer conduit into the secondary or primary drainage system; discharge of an open flume into the secondary or primary drainage system; and the confluence of two channels (secondary/secondary or secondary/primary).

Public System

The following guidelines apply to points of discharge into the public stormwater conveyance system, whether from a private or public drainage facility.

(1). Storm Sewer Outfall Points

Acute Connections

Where storm sewer lines are to discharge directly into culverts or channels they must do so at an acute angle (preferably not exceeding 45 degrees) so that flow is generally in the same direction as the flow of the receiving facility. Where discharge is into a culvert, the connection should match the soffit elevation of the two facilities as closely as practical. Connection details and grouting shall be in conformance with the B-CS Technical Specifications.

Match Inverts

Where discharge is directly into a designed or natural watercourse, the discharge invert elevation should match that of the receiving facility as closely as practical. Alternatively, special channel treatment designs may be proposed so that the outfall discharge will not inhibit or obstruct flow in the receiving channel. In either case, the design must work to manage the velocity of the outfall discharge to prevent scour of the bottom or sides of the receiving channel.

(2). Flume Outfall Points

No Erosion, Scour

Flumes that convey stormflow into a natural or designed watercourse shall be designed to prevent storm flow from interfering with the integrity of the bottom or sides of the receiving facility. This will necessarily involve managing discharge velocity to avoid scour, as well as possible treatment of portions of the receiving water course. No such connection shall inhibit or obstruct conveyance of the design storm flow of the receiving water course.

(3). Points of Channel Confluence

Control Turbulence

Channel confluences should be at 45 degrees or less, and the design should bring flows together as nearly as possible at the same velocity in order to minimize turbulence. The design must include treatments to ensure adequate erosion control consistent with provisions in Section VII of these Guidelines.

4. Roadside Ditches

Where the use of roadside ditches is approved by the City Engineer, the design shall be governed by provisions for open channel flow as set out in the forgoing paragraphs of this Section, unless superseded by higher or more explicit standards as outlined below.

a. Hydraulic Design of Ditches

(1). Ditches must completely contain the flow from the design 25-year storm with a water surface elevation six (6) inches below the top of the ditch.

(2). The maximum 25 year design depth of flow shall be limited to three (3) feet.

b. Ditch Geometry

(1). Culverts must be at least 18 inches in diameter.

(2). The top of the ditch bank must be separated laterally from the roadway shoulder (edge of base course) by at least two (2) feet.

(3). Ditch sections shall have a minimum depth of one and one half (1.5) feet.

(4). Side slopes shall be no steeper than four horizontally to one vertical (4:1).

c. Ditch Construction

(1). Culverts and grading shall be constructed in compliance with B-CS Technical Specifications.

(2). All ditches must be completely vegetated in accordance with B-CS Technical Specifications.

(3). All computations and design drawings shall demonstrate satisfaction of design provisions of these Guidelines.

5. Modification of Natural Watercourses

a. FEMA and "Non-FEMA" Systems

Both the Primary and Secondary Systems include natural watercourses of various sizes and capacities. The great majority of these watercourses form the FEMA-designated Floodplains as defined in paragraph G of this Section. Most of the remaining natural watercourses are generally upstream extensions of those forming the FEMA-designated system. For purposes of these Guidelines natural watercourses shall be considered to be in one of two categories: as part of the Named Regulatory Watercourses defined in Section II (the "FEMA-Designated Flood Plain System"), or as "Non-FEMA" watercourses.

b. FEMA-Designated Flood Plain System

Watercourses making up the FEMA-Designated Flood Plain System must be in compliance with the requirements of paragraph G of this section, in addition to provisions of this paragraph (D-5) and its subparagraphs.

c. Principles

(1). Modifications shall be defined as physical changes in a watercourse's vertical and/or horizontal alignment, cross-section geometry, surface characteristics, or over-bank areas. Movement or addition of earthen materials, grubbing, and wholesale removal of vegetation is considered modification activity, but trimming of vegetation is considered maintenance and is not governed by these Guidelines.

(2). At a minimum, all modifications to natural watercourses shall meet the requirements governing design or improvement of open channels stipulated elsewhere in these Guidelines.

(3). Changes to natural watercourses must be consistent with an approved master plan for modification of a complete reach of the Primary System if such a master plan exists. If no plan exists, one may be required at the discretion of the City Engineer. Changes to short parts of a natural watercourse must demonstrate compatibility with similar modifications along the length of that reach, whether existing or planned.

(4). On any site that is a single platted lot, minor encroachments, consisting of fill and earthwork changes in existing defined floodway fringe areas may be allowed at the discretion of the City Engineer. Any encroachments shall meet all requirements listed in the following sub-paragraphs.

d. Determination of Floodway and Floodplain Areas

(1). For streams forming the primary drainage system, a comprehensive hydraulic model, referred to as the City's Flood Study, has been adopted. This study shall be used as the principal source defining floodway and floodplain areas for streams and channels making up the primary system.

(2). Along streams and channels lacking an existing study, floodway and floodplain areas shall be determined by extending the adopted Flood Study using the standard step procedure. Where new flood discharges must be determined, they shall be computed using the methods outlined in Section V of these Guidelines.

(3). Land development projects proposing to use land filling or berms or structural features to raise existing floodplain areas above flood levels are considered encroachments into floodplain areas. Because this will raise the base flood elevations (BFE) in the vicinity of the proposed work the extent of encroachment must be limited so that the BFE is not raised by more than one foot. These geographic limits will define the

resulting "floodway" for that Watercourse, or tributary thereof. This effect is illustrated in Figure C-3, Appendix C.

(4). The floodway shall be determined using an encroachment method based on proportionate conveyance reduction (as a function of hydraulic cross sectional areas) from both sides of the channel over-bank. However, the limits of encroachment shall not extend into the designated channel area. The engineering studies necessary to identify "floodways" rests with the owner/developer (or the applicant) of the proposed project at the discretion of the City Engineer or his/her designee.

e. Design Considerations

(1). Analysis for System Impacts

Modified Channels

When existing channels are straightened, improved in cross-section, and/or lined, their hydraulic efficiency increases. Such action results in reduced travel times and reduced times of concentration. It can also result in loss of over bank storage capacity. These factors cause higher flood discharges and higher flood elevations downstream of the area of improvement. Any changes to channels within the Primary System shall be accompanied by a revised analysis of the hydrologic model (both current condition and ultimate condition) of the adopted Flood Study. The changes will be reflected in the routing reaches and lag factors for affected channel reaches and s.

Downstream Effects

Downstream impacts shall be reviewed to prevent damage to existing property and structures. Key items shall include the effect of higher discharges at bridges and culverts, and the changes in flood elevations. Channel improvements shall not cause increases in flood discharges that will exceed the capacity of downstream crossing structures, and shall not raise ultimate 100-year flood elevations.

(2). Transition Sections

Smooth Transitions

Modification of any channel section shall include designs to affect smooth transitions with the existing channel features, both upstream and downstream. These transitions should be gradual to prevent the formation of excessive energy losses and turbulence, or the creation of inappropriate velocities in upstream or downstream sections of the channel. Any proposals for abrupt changes in section, profile, or alignment must be accompanied by engineering studies demonstrating that planned energy dissipation measures will preserve the long term integrity of channel elements. Energy dissipation measures must be acceptable to the City Engineer.

E. Detention Facilities

1. Principles

Controlled Discharge

The purpose of a detention facility is to store excess stormwater runoff and discharge it at a predetermined controlled rate. Typically, this is done so that discharge rates from a development site will be limited to those that existed prior to any land development activities. This is accomplished for a range of design storms.

Facility Types

As a function of how they are designed to operate, detention facilities can be grouped into three categories. One type is effectively a permanent pond. That is, it retains a significant water pool on a year-round basis, but acts to detain stormflow, metering water release until some predetermined pool level is reached. This might be termed a "pool-type" (retention) facility. Another type might be termed a "wetland-type" facility. This type retains storm flow and meters its release, but is not intended to drain fully dry. Rather, an aquatic ecosystem is specifically designed into part or all of the facility so that it is sustained by the storm flow that passes through the facility. The third type is designed to drain fully dry between storm events, a "dry-type" facility.

Detention Philosophy

These Guidelines are largely oriented toward development of "dry-type" facilities. However, where topographic, water, and other physical characteristics make it feasible to design viable "wetland-type" facilities, they are encouraged. Successful "wetland-type" or "pool-type" facilities can be difficult to establish and are highly dependent on an expert multi-discipline design team for their success. Use of a "wetland-type" or "pool-type" facility will be considered a special design, and must be approved by the City Engineer on a case-by-case basis. The City Engineer must be informed early during the planning of a project. In addition, the design must be handled by qualified professionals, experienced in establishing self-sustaining wetland environments. The stormwater detention function shall not be compromised by such special designs.

Drained Areas

Detention facilities may be site-specific, or may be designed for a specific land development project comprised of multiple lots, streets, utilities, and other infrastructure elements. In any case, their primary purpose is to protect immediate downstream properties and drainage system from excessive stormflow. One detention facility, or a system of facilities, may be necessary to meet stormwater management objectives for an entire Project Area. A site-specific example would be using a detention facility in a large parking area to avoid overwhelming adjacent streets and storm sewers of the secondary system. Common methods include use of depressions in parking lots and/or landscaped areas that drain dry between rainfall events.

Regional Detention Detention facilities also may be regional in scope, receiving stormwater from many land development Project Areas and/or sites. In such situations a limiting capacity is often that of the drainage system that traverses an exiting developed area.

Multi-Purpose Areas A regional facility requires a large land area for the required storage and, thus, is usually designed for multiple uses compatible with its stormwater purpose. For best results, these are permanent storage ("pool-type") facilities designed to hold water between rainfall events, and may be combined with green-space and recreation areas.

"Regional" Limited Detention facilities will only be considered "Regional" at the discretion of the City Engineer.

2. Design Parameters

a. Design Storm

Secondary System Any detention facilities to be located in the Secondary Drainage System that are site-specific, or will serve a specific development project, shall use a maximum design storm based on specific detention requirements stipulated in these Guidelines. The following sequence of design storms shall be used until the maximum design storm is reached: 2-year, 10-year, 25-year, 50-year, and 100-year. Full consideration must be given to the receiving facilities of the secondary system relative to performance standards and Conveyance Pathway requirements. In addition, the 100-year design storm shall be evaluated to check emergency overflow requirements of the detention facility and the effects of resulting flows on downstream drainage systems.

Primary System Where detention facilities are required to be located in the primary drainage system, either on-line (astride the main channel) or as an adjacent flood relief feature, they shall use a maximum design storm having an average return period of 100 years or greater as determined by the City Engineer.

b. Delineation of Drainage Area

Each detention facility shall serve a Design Drainage Area that contributes (or will contribute) runoff to the facility. The Design Drainage Area and the runoff computations shall be determined for existing pre-development conditions and for expected post-development conditions.

c. Pre-development and Post-development Hydrographs

A pre-development hydrograph representing the Design Drainage Area and land cover conditions existing prior to the proposed development shall be determined. Likewise, a post-development hydrograph shall be determined representing the Design Drainage Area and land cover

conditions proposed to exist after buildout of the Project Area that contributes runoff to the detention facility.

Hydrographs shall be determined using the appropriate methods from Section V (Hydrology) of these Guidelines.

d. Determination of Storage Volume

Pre/Post Flows

Storage volume shall be adequate to ensure that the peak discharges from the detention facility determined via the post-development hydrographs will be limited to values equal to, or less than, the peak discharges determined by the pre-development hydrographs for the design storms.

Existing Storage

Any land features, such as low areas or ponds, having the effect of storing or detaining stormwater during pre-development conditions shall not be ignored in determining the required post-development storage volume. If such features are to be altered or eliminated, then the required storage volume must be increased to account for their pre-development detention characteristics. The existence and effects of such features shall be disclosed during the design review process.

Storage Routing

All detention facilities shall have the necessary storage volume determined from storage routing analysis procedures.

e. Storage Routing Analysis

The basis of this method is the continuity equation modified to yield the following:

$$(I_1 + I_2) + \left(\frac{2S_1}{dt} - O_1\right) = \left(\frac{2S_2}{dt} + O_2\right)$$

where:

I = the inflow over time period t,

O = the outflow over time period t,

S = the storage volume,

dt = the designated time period, and

subscripts 1 and **2** represent the beginning and end of time period respectively.

The use of this procedure is based the following assumptions:

- The inflow hydrograph is known.
- The starting conditions of storage volume and outflow are known at the beginning of the routing.
- The discharge rate at the outlet structure(s) is only a function of the head available.

- The relationship between depth and storage are known.
- The time period "**dt**" shall be taken as less than or equal to 1/5 $\mathbf{t_c}$ (time of concentration).

f. Outlet Structures

(1). Design of outlet structures shall consider the conditions for all required design storms. The structure shall limit the peak discharge to be equal to, or less than, the peak discharge that existed under pre-development conditions for all design storms.

(2). Except for facilities designed to have a permanent storage component, outlet structures shall be designed to allow the facility to be drained dry by gravity.

(3). An emergency overflow outlet shall be provided with a capacity to carry the peak discharge from a 100-year frequency storm for buildout conditions over the entire Design Drainage Area. This discharge must be limited and directed in a manner that will: prevent damage to adjacent properties or public infrastructure; avoid damaging the structural integrity of any element of the detention facility; and present no hazardous conditions. In addition, the discharge shall be evaluated for its effect on the downstream receiving drainage system, and shall not exceed its capacity to control and contain the storm discharge assuming ultimate conditions.

(4). Analysis and design of outlet works shall use the methods promulgated by these Guidelines, namely those dealing with drainage inlets, drainage conduit, open channel flow, and culverts. In addition the B-CS Technical Specifications shall apply.

3. Physical Characteristics for Dry-Type Facilities

a. Side and Bottom Slopes

(1). Side slopes shall not exceed 4:1 for vegetative cover and 2:1 for non-vegetative cover.

(2). Bottom slopes must be a minimum of 5 percent (5%) for a vegetative cover and 0.5% for a flume section or steeper and directed to the low flow outlet.

(3). A low-flow invert section of concrete or other materials acceptable to the City Engineer shall be provided for all facilities proposed to have a bottom with vegetative cover. To minimize the need for these sections, designs are encouraged to locate the inflow and outflow points as close to each other as practical.

b. Emergency Overflow Requirement

(1). All detention facilities shall be fitted with an emergency overflow feature that discharges into a recognized drainage facility acceptable to the City Engineer.

(2). The geometry of an emergency overflow structure shall be that of a rectangular or trapezoidal weir.

(3). The surface treatment of the structure and its discharge path to a recognized drainage facility shall give due regard to maintenance. Velocities shall be limited to be consistent with the proposed surface treatments to prevent erosion, prevent undercutting of structural components, and avoid other maintenance difficulties.

(4) The elevation of the weir crest shall not be less than the water surface elevation resulting from the design 100-year storm, assuming a fully operating discharge structure. See diagram presented in Figure C-4 in Appendix C.

(5). The entire perimeter of the facility shall have at least one half (0.5) foot of freeboard above the water surface elevation generated by the 100-year storm assuming buildout conditions of the Design Drainage Area, a completely clogged discharge structure, and a fully functioning spillway.

c. Storage Depth

In parking areas the maximum design storage depth, based on site buildout conditions, shall not exceed six (6) inches.

d. Retention (Permanent Storage) Facilities

All facilities located astride natural streams or water courses that are designed with a permanent storage component shall meet all design and construction criteria for dams and reservoirs as required by the Texas Commission on Environmental Quality (TCEQ).

e. Allowance For Sedimentation

The design storage capacity of detention facilities shall be increased by ten percent (10%) to allow for sedimentation.

F. Culverts and Bridges

1. Principles

Transportation Purpose

The purpose of a culvert or bridge is to allow a transportation facility to cross a drainage way. Consequently, its primary function is to satisfy transportation purposes. Designs to accomplish this end necessarily involve satisfying both hydrologic and transportation parameters.

Design Objectives

Hydrologic parameters are established to achieve important design objectives: safety of transportation users; safety of surrounding properties; long term integrity of constructed facilities; minimum maintenance costs; and integrity of the natural environment.

Parameters Vary

Not all parameters are universally applicable to drainage way crossings. Because transportation facilities (roadways) vary in their function and importance, related hydrologic parameters are varied accordingly. Conversely, parameters relating to the integrity and maintenance of constructed facilities, and those relating to potential flooding of adjacent properties cannot vary.

2. General Parameters

100-Year Discharge

The design storm discharge shall be based on the ultimate development conditions that are projected to exist in the Watershed or served by the watercourse to be crossed. In addition to satisfying parameters for passing the design discharge, the 100-year storm flow must be accommodated. Arterial and major collector roadways are not to be toped by flow from the 100-year design storm. Certain minor roadways may be toped according to criteria set out in Paragraph F3-c below.

Minimize Erosion and Siltation

Structures shall include design features that can receive the discharge of street or storm drain flow in a manner that will prevent erosion or scour of adjacent embankments or the floor or walls of the channel. Typically, a concrete apron or other suitable surfacing shall be provided to receive the discharge. Multiple barrel culvert crossings shall be designed such that a single barrel has a “lower flow-line” where the proposed 2 year design flow velocity will match or exceed the channel during a 2 year storm event. Similarly, bridge crossings shall have a “low-flow channel” designed to meet the same velocity design. This design intent is to ensure that the smaller, more frequent storms passing through crossings do not lose velocity and energy causing siltation deposits which commonly become performance and maintenance problems.

Flood Hazard Areas

Structures within established areas of special flood hazard as defined by the flood plain management ordinance(s) of the City shall meet all the requirements for those areas as a minimum. These Guidelines supersede provisions for such areas only to the extent that more stringent requirements are promulgated.

3. Design Limitations and Performance Criteria

a. Determination of Design Discharges

(1). For structures over Named Regulatory Watercourses or their direct tributaries, the design discharges shall be determined from the adopted Flood Study of the City per Section II of these Guidelines.

(2). For structures over watercourses making up the secondary system, the design discharges shall be determined using the appropriate methods outlined in Section V of these Guidelines.

b. Maximum Operating Headwater

(1). For all discharges up to and including the 100-year frequency storm culverts shall be designed to limit upstream headwater to elevations that will not endanger their structural integrity or cause flooding to adjacent structures or properties.

(2). At bridge crossings the water surface elevation of the 100-year storm flow shall not be higher than one (1.0) foot below the lowest bridge support stringers.

(3). For culvert crossings the upstream headwater elevation for the design discharge shall be at least one (1.0) foot below the lowest top of curb at the crossing.

c. Allowable Over-Road Flow

Over Minor Roads

Where a roadway classified as a local street or minor collector will be toped by flow from a 100-year frequency storm due to allowable lesser design storms for a culvert, the excessive storm flow may be conveyed over the roadway provided the following criteria are met.

(1). Roadway and storm drainage features must be designed so that all over-road storm flow is conveyed across the road and routed to the downstream watercourse without endangering adjacent properties or structures.

(2). The maximum depth of over-road flow shall be two (2.0) feet, measured from the roadway crown at the lowest point in the roadway profile.

(3). Considered together, the velocity and depth of over-road flow provide an indication of the potential detriment to the structural integrity of the roadway. Therefore, the product of the velocity of the overflow discharge (in feet per second) and the maximum depth of flow (in feet) as described in the foregoing paragraph shall be less than six (6), a dimensionless number. The overflow velocity shall be determined from the continuity equation as follows.

$$V = \frac{Q_{over}}{A}$$

where:

V = velocity in the overflow discharge, feet per second.

$\mathbf{Q_{over}}$ = maximum discharge over roadway, cubic feet per second.

A = area of the overflow section described by the headwater elevation and roadway profile at the crown.

d. Maximum Discharge Velocities

The velocity of discharge through a structure shall be limited based on channel conditions immediately downstream of the structure. Reference is made to Table C-11 in Appendix C. For discharges from the five-year design storm, downstream conditions will be evaluated to the point where normal flow characteristics are re-established in the receiving channel, but not less than a distance that is four (4) times the difference between the width of the downstream flow and the width of the structure opening. This does not apply for discharges from less frequent storms.

4. Physical Configuration

a. Alignment Criteria

Match Flow Lines

Bridges and culverts beneath roadways should provide flow lines that match, as closely as possible, the alignment of the watercourse they are to serve. At the same time, it is desirable for watercourses to cross roadways in a perpendicular manner. Where both of these design objectives can not be reasonably satisfied, the amount of skew in crossing a roadway should be minimized. In addition, the hydraulic demands resulting from introducing any artificial turns in a watercourse must be fully accommodated by the design.

Driveway Culverts

Where driveways must cross roadside ditches, culverts shall be placed in public right-of-way, generally parallel to the street, and aligned with the flow line of the ditch.

Straight Structures

Changes in bridge or culvert alignment shall not occur within the right-of-way of the roadways they cross.

b. Right-of-Way / Easements

ROW At Roadways

At roadway crossings right of way must be provided to fully contain all bridge and culvert features, including headwalls, end-walls, wing-walls, and any support structures. This can be in any combination of right-of-way for the roadway and/or the watercourse.

100-Year Easements

Where culverts are designed to convey flow less than that generated by the 100-year design storm, areas inundated by backwater conditions shall be wholly contained in right-of-way or drainage easements.

Pass 100-Year

Bridges are to be designed to pass the flow from the design 100-year storm and, therefore, are not to create a design backwater condition requiring easements or right-of-way. If storm flow exceeding the 100-year design is to be routed around a bridge opening and over the roadway approaches, right-of-way must be provided for the path of the routed flow.

c. Culvert Ends

The following guidelines shall be used in designing culvert end treatments. Figure C-5 (Appendix C) shows a schematic diagram illustrating terms commonly used to describe a typical culvert structure.

(1) Concrete headwalls and end-walls shall be provided to be functionally monolithic with the culvert conduit and must generally be parallel with the alignment of the crossing roadway. Related wing walls shall generally be oriented according to the flow characteristics of the crossing watercourse. In no case shall headwalls or wing walls restrict the clear opening of the structure.

(2) Flared wing-walls shall be used where both of the following conditions apply:

- Approach velocities exceed six (6) feet per second for the design discharge
- The approach channel is irregular and not well defined.

(3) Wing-walls parallel to the flow line of a watercourse may be used where all of the following conditions are met:

- Approach velocities are less than six (6) feet per second for the design discharge, and
- The channel is well defined and regular in cross section, and
- Downstream channel surface protection is not necessary.

(4) The maximum side slopes for all grading in the vicinity of culvert headwalls shall be six horizontal to one vertical (6:1), unless 4:1 or flatter is approved via a design exception approved by the City Engineer.

5. Bridge and Culvert Hydraulic Design

a. Analysis Methodology

Bridge Hydraulics

The following items shall be addressed as part of the engineering design and analysis of crossing structures. Bridges shall be analyzed for hydraulic conditions using the HEC-RAS Water Surface Profiles computer program applied using the guidelines and recommendations of the U.S. Army Corps of Engineers. Unless other parameters can be substantiated to the satisfaction of the City Engineer, the following nine shall apply:

- A combination of TP40 and Hydro 35 Precipitation Data as provide in Table C-6, Appendix C.
- 10, 25, 50, 100, and 500 year rainfall runs.
- Lag Times for the unit hydrograph should be computed using the NRCS (SCS) lag equation.

- Rational Formula should be used for the peak Q from Design Drainage Area less than 50 acres in size.
- Balanced triangular hydrograph for the PH record in HEC-1 should be used for draining between 50 and 200 acres, and lag times less than 30 minutes.
- NRCS (SCS) Type III, 24-hour duration storm should be used for drainage s larger than 200 acres or lag times exceeding 30 minutes.
- Modified-PULS for Channel Routings and PULS may be used for steep slopes.
- Losses should be computed using the NRCS (SCS) curve number method.
- The NRCS (SCS) unit hydrograph technique is encouraged where no data is available to estimate other parameters.

Culvert Hydraulics

Culverts may be analyzed using the same method as for bridges. Additionally, they may be analyzed using accepted charts and nomographs for the type of structure and material proposed for use. TxDOT's Hydraulic Manual contains a complete treatment of culvert analysis and design, including nomographs. The latest version of TxDOT's Hydraulic Manual shall be considered the standard for analysis of culverts by these Guidelines.

b. Culvert Operations

The rate of flow through a culvert barrel is limited by several direct factors such as slope, length, and surface roughness. Where conditions at the culvert entrance (inlet) prevent optimum flow based solely on these factors, the culvert is considered to operate under "inlet control". When the flow permitted through the barrel is less than the flow allowed at the upstream entrance, the culvert is considered to operate under "outlet control" (sometimes referred to as "barrel control"). For each design discharge the type of control shall be determined.

c. Headwater and Tail Water Elevations

(1). Tail water elevations shall be determined using one of the methods described in the portion of this Section guiding open channel design (see paragraph D2-a).

(2). Headwater elevations shall be determined by adding the total head losses through the structure to the tail water elevation, for the given discharge.

d. Head Losses

The total head losses, **H**, on a structure is the sum of all losses due to exit, friction, and entrance conditions for the given discharge.

(1). Entrance losses are caused by the narrowing of flow from the normal channel width to the structure opening (predominant for bridges), or to the shape or condition of the actual inlet or opening (predominant for culverts). Channel losses of this type must be computed using a standard step procedure as outlined in the part of this Section dealing with open channels. Entry losses shall be computed using the following equation:

$$H_e = k_e \left[\frac{V_2^{\,2}}{2g} - \frac{V_1^{\,2}}{2g} \right]$$

where:

H_e = entrance head loss, feet

V_2 = velocity of flow in culvert, feet per second

V_1 = velocity of flow in approach channel, feet per second

g = 32.2 feet per second per second

k_e= entry loss coefficient from Table C-12, Appendix C.

(2). Exit losses are caused by the expansion of flow from the structure opening to the normal downstream channel width. The same equation for entrance losses applies to those for exit losses except **k_e** may be taken as **1.0** and **V_1** shall be defined as the velocity of flow in the downstream receiving channel after full expansion.

(3). Friction losses are those that occur within the structure itself. These can range from open channel flow losses, and pressure flow losses, to losses caused by physical obstructions within the structure (bridge piers for example). All friction losses shall be accounted for in the analysis and design of crossing structures.

e. Erosion and Scour Protection

(1). All culverts determined to be functioning under inlet control for the design discharge shall have an energy dissipation structure at the outlet of the culvert or meet the requirements of Paragraph 5e-(2) below.

(2). The velocity of the design stormflow in the structure shall not exceed the requirements for the downstream channel condition stipulated in Table C-11, Appendix C.

G. Floodplains

1. Principles

Floodplain Definition

A "floodplain" is generally land areas along and near a waterway that are inundated during large and relatively infrequent storm events. The runoff from smaller, more frequent storm events is generally contained within the main channel of the waterway and has little to no effect on adjacent "over-bank" land areas.

Width Varies

Fundamentally, every watercourse has attendant floodplain areas that can be situated along one or both sides of the main channel, depending on topographic features. Along smaller streams or channels there may be little distinguishable difference between the main flow area and the floodplain. However, on larger streams or channels floodplain areas may be very broad and shallow, and may provide for very little conveyance of stormwater.

Public Policy

Due to rather infrequent flooding of over-bank areas and other factors, property owners often have interest in establishing urban land development in flood-prone areas, particularly in broad shallow floodplain areas. Consequently, public policy, by all levels of government, has established mechanisms designed to mitigate the negative effects of using floodplain areas. One of the purposes of these Guidelines is to facilitate those policies in the Bryan-College Station area.

2. Identification of Floodplains

Identified Floodplains

Floodplains are principally associated with the primary drainage system. The primary system and its tributaries make up the Named Regulatory Watercourses listed in Table B-1 (Appendix B) of these Guidelines. The over-bank areas of these waterways are considered to be the "identified" floodplains, even though the specific geographic limits of some reaches of each watercourse system are not dimensionally defined in hydrologic and/or topographic terms.

Floodplain Limits

As land development occurs along the Watercourses identified in Table B-1 (Appendix B) of these Guidelines, and along upstream extensions thereof, it will be necessary to fully define the geographic limits of the attendant floodplains. This will allow application of these Guidelines to those areas in a precise manner, thus defining hydraulic engineering needs, land development parameters, and private/public interests.

3. Regulations

FEMA Flood Studies

A series of several FEMA-approved hydrologic studies have been conducted to determine the floodplain areas along the majority of the reaches of the Named Regulatory Watercourses listed in Table B-1

(Appendix B). These are the FEMA-designated watercourses in the Bryan-College Station area. Taken together, the flood studies conducted for these Watercourses represent the "Flood Study" of the City.

Areas Not Defined

In some instances the floodplain areas along upper reaches of a Watercourse are undefined even though the floodplain clearly extends beyond areas shown on FEMA maps. In other instances floodplain areas may be ill-defined due to topographic or other constraints.

Define Limits

Land development or building projects proposed on properties astride of, or adjacent to, the Watercourses listed in Table B-1 (Appendix B) may require flood studies in order to precisely identify the elevation and geographic limits of potential floods, and thus the mitigation measures necessary for the project(s). If a proposed development will involve more than 50 lots or five (5) acres at buildout, a comprehensive flood study may be required at the discretion of the City Engineer.

Special Use Areas

In land areas set aside for parks or other recreational or green space uses, or proposed for such uses, special regulations by the City may require adjustments in how these Guidelines are applied. Any deviation from provisions of these Guidelines in such areas will be at the discretion of the City Engineer or his/her designee.

4. Procedures

If Study Needed

When a comprehensive flood study is needed for a land development or building project, a number of procedures are required. The hydrologic analyses criteria and methods stipulated in Section V (Hydrology) of these Guidelines and those stipulated in Paragraph D5 of this Section will apply. For minor streams or channels that are tributaries to the Named Regulatory Watercourses, existing and ultimate flood elevations shall be established by extending the adopted Flood Study as described in foregoing Paragraph D5-d.

Plot Limits

Water surface elevations based on the configuration and limitations of the existing channel shall be determined for the ultimate development conditions planned by the City for the Watershed involved. The resulting geographic limits of projected flooding will be plotted by the engineer conducting the study.

Channel Changes

When existing channels are straightened, improved in cross-section and/or lined, existing floodplain and floodway areas are likely to be altered. Redefinition shall follow the methodology for floodway determination outlined in Paragraph G2 of this Section.

Limited Effects

Proposed changes in channel section or alignment shall not increase the existing or ultimate flood elevations (established by the adopted Flood Study) within, or upstream or downstream of, the area of modification, more than allowed by these Guidelines. Any changes shall be made part of the adopted Flood Study and submitted to the required authorities for approval prior to construction work in floodway or floodplain areas.

Section VII
Erosion & Sedimentation

Unified Stormwater Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION VII

EROSION & SEDIMENTATION

A. Principles

1. Temporary and Lasting Measures

Measures to mitigate the effects of erosion and resulting sedimentation are divided into two categories: temporary (non-permanent) and permanent.

a. Non-Permanent Measures

Non-permanent (temporary) measures are designed to manage soil materials in a manner that will minimize their migration away from any land development or site improvement project during clearing, grubbing, grading, excavation, filling, and construction activities. This includes capturing sediments eroded by stormwater that traverses areas where established vegetation has been disturbed or removed, or that impacts loose materials, including stockpiles. The emphasis is on preventing sediment from being transported and deposited, by wind, water, or actions of man, onto adjacent properties, or into the primary or secondary drainage systems.

b. Permanent Measures

Permanent measures are designed to prevent erosion and resulting sedimentation from occurring over time, whether within earthen channels, in various facilities constructed for purposes of managing storm flow, or across unpaved land areas. Properly conceived, designed, and constructed, permanent measures can also promote the proper management of storm flow.

2. Erosion Reference

A general guide and reference service for erosion and sediment control methods and protection is published by the National Resource Conservation Service (formerly Soil Conservation Service). The publication entitled “Erosion and Sediment Control Guidelines for Developing Areas in Texas” is adopted as the definitive reference for purposes of these Guidelines, and can be obtained at the address listed below. The agency can also be reached through its web site at: www.NRCS.USDA.gov.

U.S. Natural Resource Conservation Service
P.O. Box 6567
Fort Worth, TX 76115

3. Scope of Actions

Measures to prevent the movement of sediment by erosion or action of man shall be implemented at all areas undergoing development or construction. Positive steps shall be taken by those conducting such work to accomplish the following:

a. Prevention

Prevent the transport of sediment from all work areas onto adjacent properties or into any part of the primary or secondary drainage systems.

b. Clean Up

Promptly remove all sediment resulting from their activities if it enters onto adjacent properties or into any part of the primary or secondary drainage systems.

B. Non-Permanent Erosion Control Measures

Methods

Non-permanent methods to control or contain sediment materials generally fall into two categories: sediment basins and barriers. One or more methods shall be used on areas where construction activity of any kind results in earthen soils that are not covered by vegetation or impervious surfaces prior to final completion of a project.

Regulations

Non-permanent erosion control measures as required by the latest regulations of the Texas Commission on Environmental Quality (formerly the Texas Natural Resource Conservation Commission) shall be used on all applicable land development or site projects approved for construction in the City. Compliance with such regulations during project construction shall be a requirement for continued operation of construction activities. Construction plans for grading, excavation, and street and utility construction in subdivision projects must include stormwater pollution prevention plans (SW3Ps).

C. Permanent Erosion Control Measures

The following actions shall be incorporated into the design and construction of permanent land development or permanent improvements to properties.

1. Land Grading

a. Excavation

The cut face of earth excavation that will be in publicly maintained areas and is to be vegetated shall not be steeper than four horizontal to one vertical (4:1). Such excavated areas that will be vegetated and remain privately owned shall not be steeper than three horizontal to one vertical (3:1). Cut slopes that will not be vegetated shall be protected by approved surface treatments to protect them from erosion.

b. Earthen Fills

Permanent exposed faces of fills shall be no steeper than three horizontal to one vertical (3:1) and shall be vegetated or otherwise surfaced to protect them from erosion.

c. Runoff Management

Provisions are to be made to safely convey surface water to storm drains or suitable natural water courses and to prevent surface runoff from damaging cut faces and fill slopes.

d. Adjoining Properties and Facilities

Near Property Lines

Excavations shall not be made so close to property lines as to endanger adjoining property without protecting such property from erosion, sliding, settling, or cracking. No fill is to be placed where it will slide or wash onto adjacent or down stream properties, including structures.

Near Channels/Streams

No fill shall it be placed adjacent to the bank of a channel or natural stream in a manner that will allow it to migrate into the channel or stream, cause bank failure, or reduce the capacity of the channel or stream in any way.

2. Unpaved Areas and Swales

a. Stripped Areas

All areas that are graded and stripped of natural vegetative cover shall receive at least a finish layer of topsoil at least six (6) inches in depth and be seeded or covered with sod according to approved plans. The result shall be reestablishment of a protective vegetative cover capable of resisting the erosive effects of surface flow.

b. Swale Treatments

Earthen swales that will not be lined with hard surfaces shall be formed allowing for a finish layer of topsoil at least six (6) inches in depth and one inch of vegetation below the design invert elevations,

and shall be seeded or covered with sod according to approved plans.

3. Channels

a. Banks and Inverts

Earthen channel banks and inverts shall be treated with vegetative materials according to the requirements of the B-CS Stormwater Construction Standards.

b. Surface Treatments

Design velocities shall be less than the recommended maximum velocity acceptable for the proposed surface treatment as outlined in Table C-11, Appendix C. Where multiple surface treatments are to be situated in a length of channel in close enough proximity to have interactive effects, the limiting velocity shall be the minimum recommended value among those representing the proposed surface treatment types.

c. Supercritical Flow

Channels designed to function with supercritical flow shall be fitted with lining and energy dissipation features adequate to handle the resulting velocities and hydraulic jumps.

d. Channel Protection

The integrity of channel linings and cross sections shall be protected at all locations where stormwater enters a channel from other stormwater facilities. See “Outfall Junctures” in Section VI, Paragraph D3-c of these Guidelines.

4. Energy Dissipation

Energy dissipation features are required at any point where stormflow design velocities are expected to exceed the surface erosion characteristics of the receiving facility, or empirical criteria established elsewhere in these Guidelines.

a. Allowable Velocities

Design velocities shall be less than the recommended maximum velocity acceptable for the proposed surface treatment as outlined in Table C-11, Appendix C.

b. Examples Designs

Acceptable configurations for energy dissipation structures at outfall structures and channels are reflected in B-CS Technical Specifications, but other special designs will be considered.

Designs suitable to specific situations are encouraged. Reinforcing steel shall be designed to resist the anticipated hydraulic, hydrostatic, dead, and live loads for the structures.

c. Natural Dissipation Features

Energy dissipation features designed to replicate those occurring due to interaction between stormflow and the stream bed along natural streams are encouraged. Plunge pools in series, stilling "basins", surfaces, and vegetative materials are examples of elements that might be used in combination to achieve such designs.

5. Best Practices

Managing erosion and sediment must be an integral part of designing effective stormwater management and conveyance systems for urban areas. Design techniques are subject to ongoing development and assessment, particularly from the standpoint of environmental quality. Consequently, if special designs call for deviation from the empirical criteria (and the traditional design approach) promulgated by these Guidelines, the following reference is recommended:

> Storm Water Phase II Menu of Best Management Practices, published by the US Environmental Protection Agency (EPA).

Section VIII
Water Quality

Unified
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Design Guidelines

City of College Station
City of Bryan

August 2012

SECTION VIII

WATER QUALITY

A. Principles

Polluted Runoff

It is well understood that stormwater runoff in urban and suburban environments tends to carry an assortment of sedimentation and pollutants into the streams and waterways that drain a region. The nature of those materials depends on numerous variables. Among them are the type and intensity of land use in the areas drained, the characteristics of rainfall flushing those areas, the urban development parameters used, and the effects of natural or specially deployed features that work to enhance or aggravate the quality of storm runoff.

Design Effects

Based on scientific information derived and promulgated at the State and National levels, it is clear that hard surfaces that quickly drain areas tend to do nothing to enhance the quality of stormwater runoff. Likewise, stormflow across exposed earthen areas tends to carry undesirable sediment loads. Conversely, runoff that first travels through or over turf, wetland, or sedimentation features tends to transport smaller quantities of undesirable materials. For this reason one of the objectives of these Guidelines is to encourage the use of innovative facilities that minimize adverse affect(s) on water quality, provided the primary objective of protecting life and property is not compromised.

Known Problems

Where persistent, known drainage problems exist, the primary focus must necessarily be on promoting public safety and minimizing flooding of property. In such areas improving the quality of storm runoff will be a carefully considered in light of public safety objectives.

B. Imbedded Objective

Foster Water Quality

One of the objectives of these Guidelines is to foster improvement of the quality of stormwater runoff in the Bryan – College Station region. Part of the intent is to cause water draining from newly developing areas to carry smaller amounts of pollutant loads than would occur under former guidelines.

Design Encouraged

Water quality objectives are clearly delineated in policy statements in Section II, and in the sedimentation control guidance outlined in Section VII. They are also imbedded in Section VI in two areas of hydraulic design. Special designs aimed at improving stormwater quality are encouraged for detention facilities and at points where traditional facilities outfall to streams and waterways. In some instances such designs may be less expensive to construct than traditional stormwater features.

Early Teams

Special water quality designs must be coordinated with the City Engineer or his/her designee as early as possible in design processes, preferably during the stormwater planning conference described in Section III. Emphasis is placed on use of qualified specialists for

deriving designs intended to reduce pollutant loads. This is important because long term maintenance needs and cost may not be exacerbated by such designs.

SW3P Required

As stipulated in Section VII of these Guidelines, non-permanent erosion and sedimentation control measures are required during construction projects. The latest requirements of the TCEQ must be satisfied.

C. Regulatory Context

The quality of storm runoff into streams and waterways is regulated by law in several ways both at the National and State levels.

1. National Regulations

a. Section 10 Rivers and Harbors Act

Navigable Waters

Section 10 of the Rivers and Harbors Act of 1899 places jurisdiction over certain waters squarely in the hands of the Federal Government. The US Army Corps of Engineers (USACE) operates a regulatory program under the authority of this and subsequent law. This deals with the "navigable waters of the United States". "Navigable waters" are those that are subject to the ebb and flow of the tide shoreward to the mean high water mark and/or are presently used, or have been used in the past or may be susceptible to use, to transport interstate or foreign commerce. The Brazos River and its tributaries (with some limitations) are included in this definition.

Basic Provisions

The Corps of Engineers regulates all work and structures in, or affecting, the course, condition, or capacity of navigable waters of the United States. Example activities and structures include dredging, filling, excavation, bulkheads, revetments, riprap, and pilings. This has obvious application to roadway crossings, on line or adjacent detention facilities, and most types of earthwork along the banks of applicable watercourses.

b. Section 404 Clean Water Act

Waters 0f The US

Administered jointly by the USACE and the Environmental Protection Agency (EPA), Section 404 has the objective of restoring and maintaining the chemical, physical, and biological integrity of the "waters of the United States". This deals with the surface water tributary system. It includes the smallest of streams, any lake, pond, or other water body on those streams, and adjacent wetlands. Under this Act the US Army Corps of Engineers has certain regulatory powers.

Basic Provisions

The Corps of Engineers' Wetland Delineation Manual provides guidelines for determining whether wetland areas are regulated by

Section 404. Placement of dredged or excavated materials into waters of the US is regulated. This includes the addition of material associated with mechanized land clearing, ditching, channelization, side-casting, temporary stockpiling, and other ground-disturbing activities, especially if materials have the effect of replacing water or wetland environments, or changing the bottom elevation of waters of the US.

c. Section 401 Clean Water Act

Point Sources

Dating from 1977, Section 401 established permitting requirements for allowing discharges of effluent into navigable waters of the US. The focus was on permitting for construction of plants or facilities that would discharge potentially polluted water, primarily from point sources, as from food processing, industrial processes, or waste treatment. Later legislation began applying water quality regulation to stormwater runoff.

d. Section 402 Clean Water Act

Stormwater Quality

In 1987 the US Congress amended Section 402 of the Clean Water Act regarding administration of the National Pollutant Discharge Elimination System (NPDES). As to the quality of stormwater discharge, a comprehensive two-phased permitting framework was initiated for dealing with "municipal separate storm sewer systems". "Separate" is important because it differentiates between systems that collect and discharge only storm runoff from those that may include effluents from such sources as sewage treatment or industrial processes. Fundamentally, it requires municipalities to initiate comprehensive programs for minimizing pollutant loads discharged into streams and waterways.

Phases I & II

Phase I regulates large and medium "municipal separate storm sewer systems" (MSSSS or MS4). Municipalities having a population in excess of 100,000 are known as "Phase I MS4s". These have been required to implement some system of practices designed to improve the quality of stormwater discharges. Under Phase II rules issued by the EPA in 1999, smaller MS4s must also be in compliance with NPDES requirements. Smaller MS4s are defined as municipalities having less than a population of 100,000 and located in "urbanized areas" as defined by the US Census. These are knows as "Phase II MS4s". Both Bryan and College Station are in this category.

2. State Of Texas Regulations

In 1998 administration of the National Pollutant Discharge Elimination System (NPDES) was partially delegated by the Environmental Protection Agency, via a memorandum of understanding, to the State of Texas. However, the EPA retains its enforcement authority.

a. Texas Administrative Code (30 TAC, Chapter 319)

Texas Waters

The Texas Commission on Environmental Quality (TCEQ) is the State agency responsible for the quality of "Waters of the State", including stormwater quality. Since 1998 stormwater quality has been regulated pursuant to the Texas Pollutant Discharge Elimination Program administered by TCEQ. Prior to that, individual permits were issued to larger MS4s by the EPA, but since 2002 the TCEQ has issued renewal permits and addressed various issues for those MS4s. The TCEQ has responsibility for administering Phase II permitting. This will include designating small MS4s, developing a template general permit, providing suitable BMPs for use by municipal entities, and administering the permitting process.

Requirements

Under Phase II requirements, small MS4s are required to reduce the discharge of pollutants to the maximum extent practicable. MS4s are to accomplish this by developing and implementing a Stormwater Management Program (SWMP) for their jurisdiction. Each local SWMP is to deploy acceptable BMPs that use the six minimum control measures listed in Paragraph C1-d above. The intent is to provide general permitting to MS4s that deploy an acceptable SWMP, thereby avoiding the need for an individual permit from the TCEQ.

b. Permitting Requirements

Although Phase II requirements for small MS4s have been established by the EPA, the TCEQ remains in the rule-making phase.

Pursuant to the Texas Pollutant Discharge Elimination System (TPDES) permit issued by the Texas Commission on Environmental Quality (TCEQ) to the City of Bryan and the City of College Station for the Municipal Separate Storm Sewer System (MS4), the Cities are implementing these guidelines. The purpose of these guidelines is to satisfy the requirements promulgated in the TPDES permit regarding the implementing of a program to reduce the discharge of pollutants into the Cities MS4.

Construction site activities shall be conducted in a manner as to meet the minimum requirements mandated in the TPDES General Permit No. TXRI50000. The General Permit is required by the TCEQ for any construction activities.

Less than 1 acre disturbance 1 to 5 acres disturbance

Greater than 5 acres disturbance

List of Best Management Practices **not** approved by the City of Bryan or the City of College Station are as follows:

- Oil / Grit Separators
- Traditional Sand bags for inlet protection (environmental control socks are preferred)

BEST MANAGEMENT PRACTICES – STORMWATER QUALITY CONTROLS

	Construction Stages / Sequencing	Non-Structural	Structural
1	Pre-construction / Survey clearing / limited ground disturbance	• Establishment of Trees to protect (if desired) • Limited equipment (no tracked equipment)– no significant ground vegetation disturbance	
2	Install Detention Facilities – rough graded to capture runoff	• Install waste receptacles on site • Temporary Sanitary Facilities (port-a-potties) • Designate concrete / equipment washout area • Install Temporary Construction Access • Install storm sewer inlet protection (existing inlets)	• Silt Retention Devices (ex. Silt fence, check dams) • Sedimentation Traps / ponds / baffles • Rough grade detention ponds • Outlet structure installed • Slope protection measures
3	Full Clearing and Grading	• Dust Control (wetting disturbed areas) (daily) • Street Sweeping (daily)	• Maintain Silt Retention Devices • Rough Grade property to drain to ponds • Slope protection measures
4	Utility Infrastructure & Drainage System	• New Storm inlet protection • Proper directing of rainwater pumping from construction ditches	• storm sewers / inlets • Detention Pond • Onsite Utilities installed
5	Site Development (buildings)	• Utilize washout areas • Maintain trash and sanitary facilities • Installation of roof gutters directed to storm system • Dust Control (wetting disturbed areas) (daily) • Street Sweeping (daily)	• Install paving on site (minimize erosion) – done before building foundations
6	Site Stabilization	• Maintenance Bond (1 year) provided to cover public infrastructure and final site stabilization	• Full grass / landscape coverage and establishment • Removal of silt retention devices upon grass establishment

c. Compliance

Compliance with the above General Permits is required. The City of Bryan and the City of College Station have the authority to enforce compliance with the General Permit including the SWPPP prepared for each development. Copies of Notice of Intent, Construction Site Notices, Notice of Change and Notice of Termination along with the SWPPP shall be submitted to the City Engineer's office.

Section IX
Appendices

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

A. Authority
B. Region's Watersheds
C. Computational Information
D. Technical Design Summary
E. Best Practice
F. Glossary
G. General References

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Appendix A
Authority

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

APPENDIX A – AUTHORITY

These Uniform Stormwater Design Guidelines regulate the design philosophies and criteria that are to be used in assessing the need for and design of stormwater management facilities planned and engineered for land development projects within the jurisdictions of the City of Bryan and the City of College Station. Important purposes are: 1) to offer the citizens of the both cities a single set of requirements that clearly define what must be done to satisfy the broad policies of each city, and, 2) to achieve greater uniformity of resulting stormwater facilities. To those ends, these Guidelines work to implement stormwater management ordinances adopted respectively by the City of Bryan and the City of College Station for use in their respective jurisdictions.

These Guidelines derive their authority from the stormwater management ordinances and floodplain management ordinances adopted from time to time by the City Council of each of the two cities. The respective ordinances are referenced below.

City of Bryan:

Stormwater Management Ordinance, adopted via Ordinance No. 669, September 28, 1987, as amended:
Ordinance No. 849 – October 27, 1992 (effective November 26, 1992)
Ordinance No. 1156 – January 26, 1999

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Codified Municipal Ordinance: Chapter 10 – Flood Prevention and Protection

City of College Station:

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Codified Municipal Ordinance: Chapter 13 – Flood Hazard Projection

Appendix B
Region's Watersheds

Unified
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City of College Station
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Table B-1

Detention Requirements by Watershed and Watershed Reach

Reference Section II, Paragraph B, page 2 of 18

Watershed Name	Channel Reach		Detention For Flood Control
	From	To	
Alum Creek	Carter Creek	SH 6	Not Required
	SH 6	Upstream	Required
Bee Creek	Carter Creek	Texas Avenue	Not Required
	Texas Avenue	Southwest Parkway, Welsh, Deacon	Evaluate
	Southwest Parkway, Welsh, Deacon	Upstream	Required
Briar Creek	Carter Creek	Quail Hollow, SH 6	Not Required
	Quail Hollow, SH 6	E. Villa Maria	Evaluate
	E. Villa Maria	Upstream	Required
Brushy Creek	Wickson Creek	Cole Lane	Not Required
	Cole Lane	Elmo Weedon Road	Evaluate
	Elmo Weedon Road	Upstream	Required
Burton Creek	Carter Creek	E. 29th Street	Not Required
	E. 29th Street	E. Villa Maria	Evaluate
	E. Villa Maria	Upstream	Required
Carters Creek	Navasota River	Upstream	Evaluate
Cottonwood Branch	*Thompson's Creek*	FM 2818	Evaluate
	FM 2818	Upstream	Required
Hudson Creek	Carter Creek	Boonville Road	Not Required
	Boonville Road	Miramont	Evaluate
	Miramont	Upstream	Required
Lick Creek	Navasota River	Greens Prairie Road	Not Required
	Greens Prairie Road	SH 6	Evaluate
	SH 6	Upstream	Evaluate
Little Wikson Creek	Wickson Creek	Dilly Shaw Tap Road	Evaluate
	Dilly Shaw Tap Road	Upstream	Required
Peach Creek	Navasota River	Peach Creek Road	Not Required
	Peach Creek Road	Upstream 14,000 feet	Evaluate
	14,000 ft. above Peach Creek	Upstream	Required
Spring Creek	Lick Creek	SH 6	Evaluate
	SH 6	Upstream	Required

Table B-1 (continued)

Detention Requirements by Watershed and Watershed Reach

Reference Section II, Paragraph B1, page 2 of 18

Watershed Name	Channel Reach		Detention For Flood Control
	From	To	
Steep Hollow Branch	Wickson Creek	Green Branch Loop, Easterling Drive	Evaluate
	Green Branch Loop, Easterling Drive	Upstream	Required
Still Creek	Thompsons Creek	FM 2818	Evaluate
	FM 2818	Upstream	Required
Thompsons Branch	Thompsons Creek	N. Texas Avenue	Evaluate
	N. Texas Avenue	Upstream	Required
Thompsons Creek	Brazos River	SH 21	Not Required
	SH 21	Thompsons Branch	Evaluate
	Thompsons Branch	Upstream	Required
Turkey Creek	Brazos River	SH 47	Not Required
	SH 47	W. Villa Maria Drive	Evaluate
	W. Villa Maria Drive	Upstream	Required
White Creek	Brazos River	Unnamed Road off White Creek Road	Not Required
	Unnamed Road off White Creek Road	FM 2818	Evaluate
	FM 2818	Upstream	Required
Wolf Pen Creek	Carter Creek	Dartmouth Street	Not Required
	Dartmouth Street	George Bush Drive at Texas Avenue	Evaluate
	George Bush Drive at Texas Avenue	Upstream	Required

Table B-2
Minimum Floor Elevations Along Selected Named Regulatory Watercourses

Reference Section II, Paragraph C1-b, page 8 of 18

Regulatory Watercourse	Channel Reach		Elevation Above Base Flood
	Fro m	To	
Bee Creek (Main Watercourse)	Bee Creek Trib. B	Texas Ave.	3 feet
Bee Creek Trib. "A"	Walsh Ave.	Main Bee Creek below* East Bypass	2 feet
Bee Creek Trib. "B"	South Fork Trib. "B' above Welsh Ave.	FM 2818	4 feet
	FM 2818 at Rio Grand	Main Bee Creek	2 feet
	North Fork Trib. "B" at FM 2818 and at Southwest Parkway	South Fork Trib. "B" near Welsh Ave.	2 feet
	South Fork Trib. "B" at Wellborn Road	Bee Creek Trib. "B"	2 feet
Lick Creek	Graham Road	Alum Creek confluence	3 feet
South Fork of Lick Creek	First trib. above CS city limits	Main Lick Creek	3 feet
Spring Creek	Confluence of North and South Forks	Main Lick Creek	3 feet
North Fork of Spring Creek	Upper limits	Confluence with South Fork	3 feet
South Fork of Spring Creek	Upper limits	Confluence with North Fork	3 feet

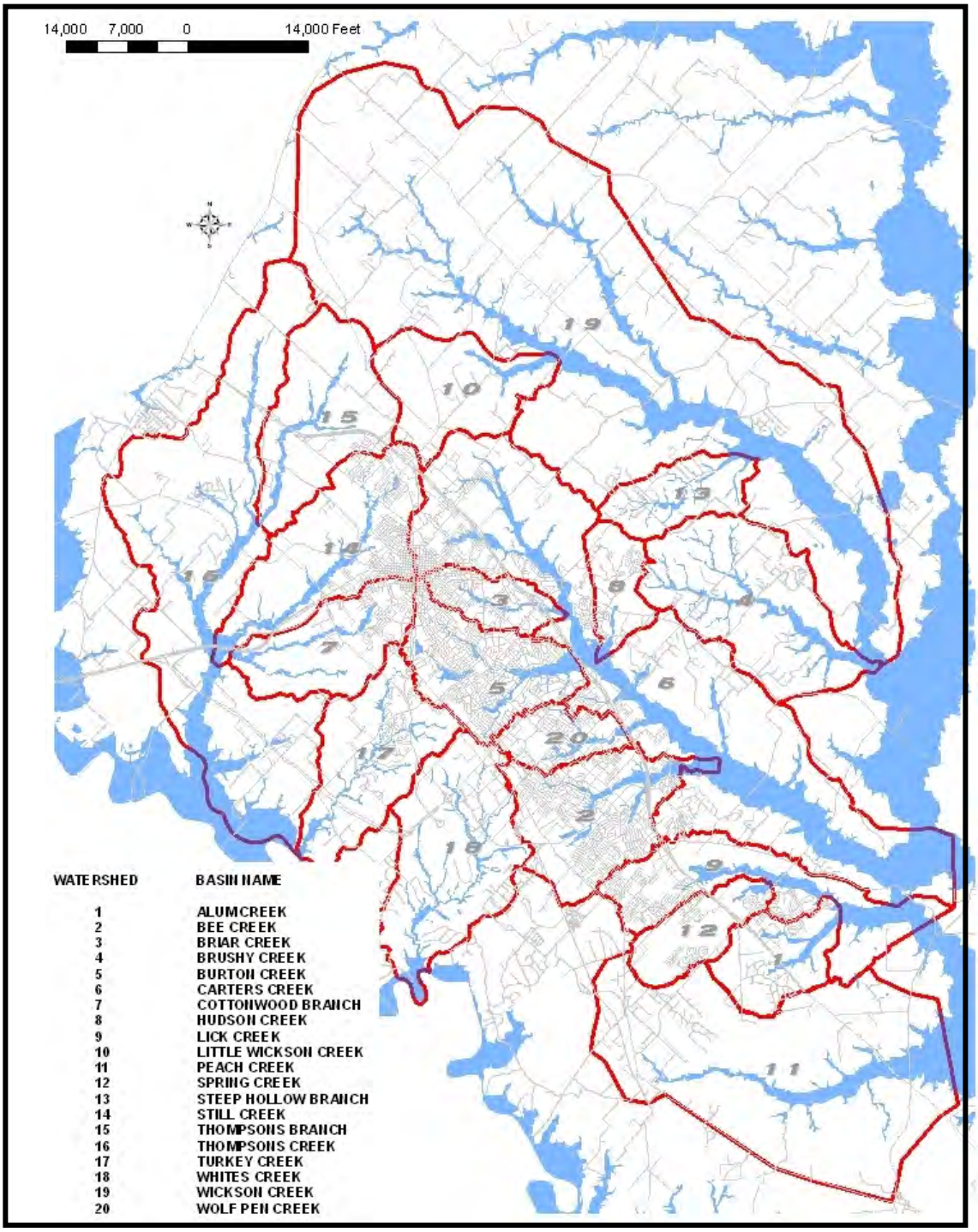


Figure B-1: Watersheds of Bryan / College Station Region

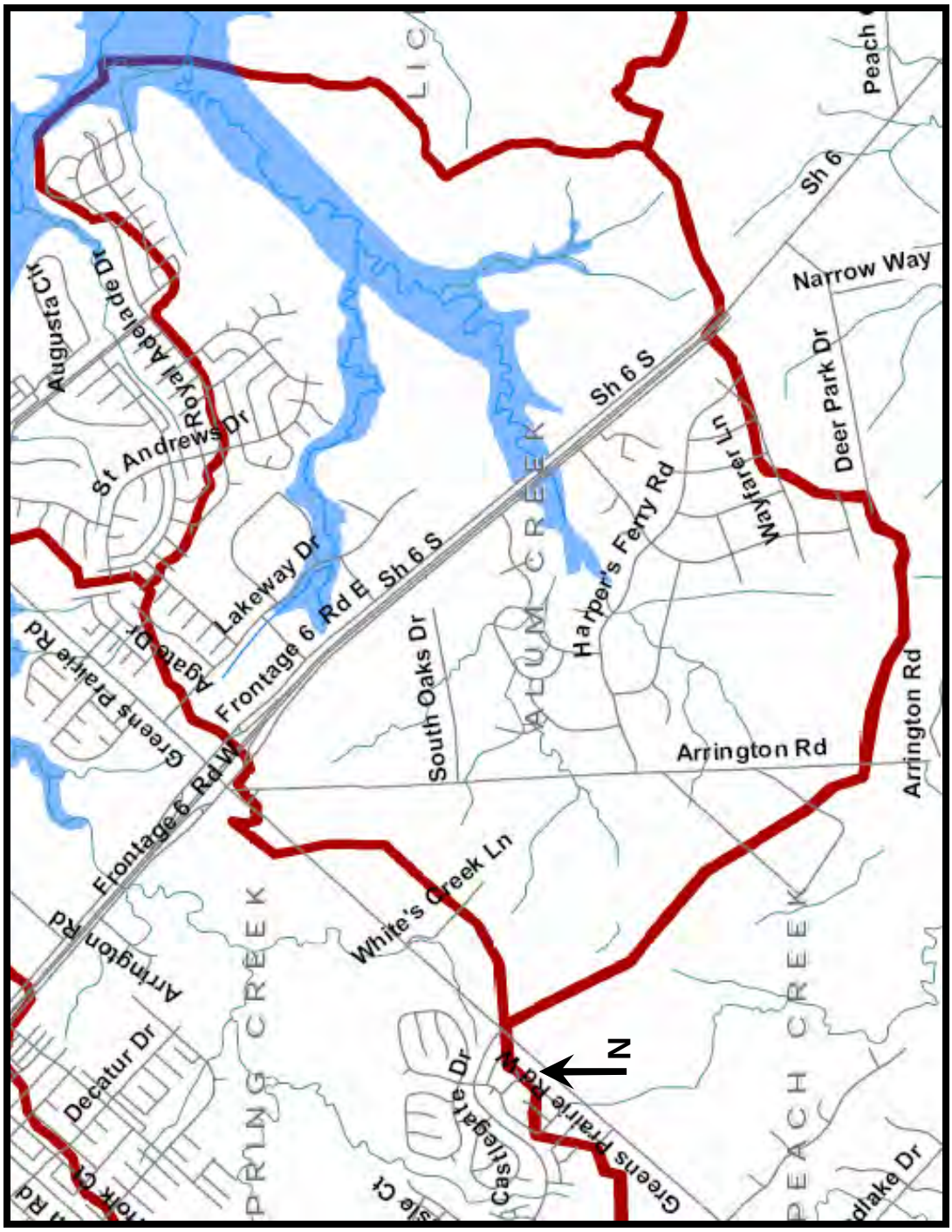


Figure B-2: Alum Creek Watershed Area

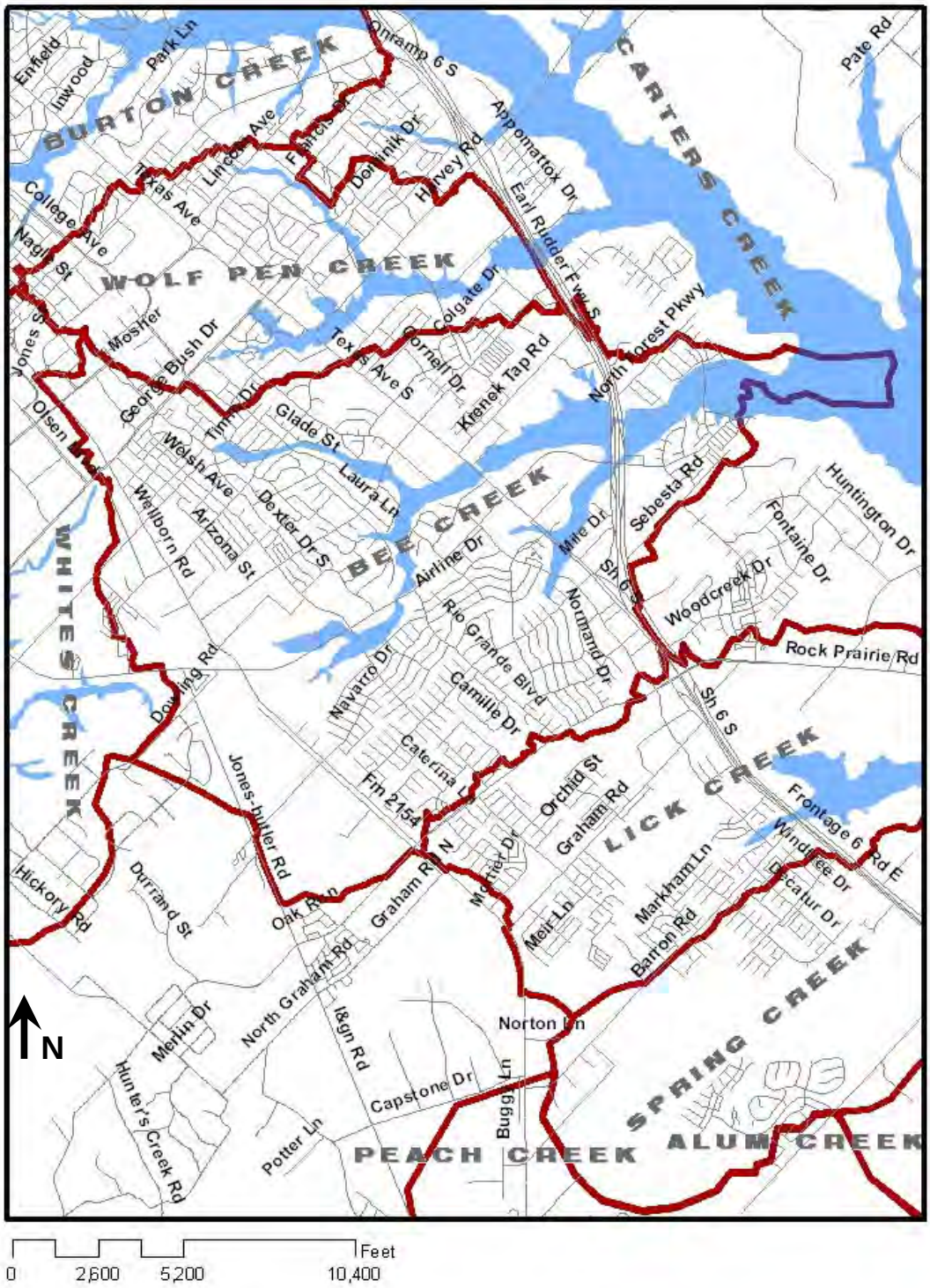


Figure B-3: Bee Creek Watershed Area

Figure B-4: Briar Creek Watershed Area

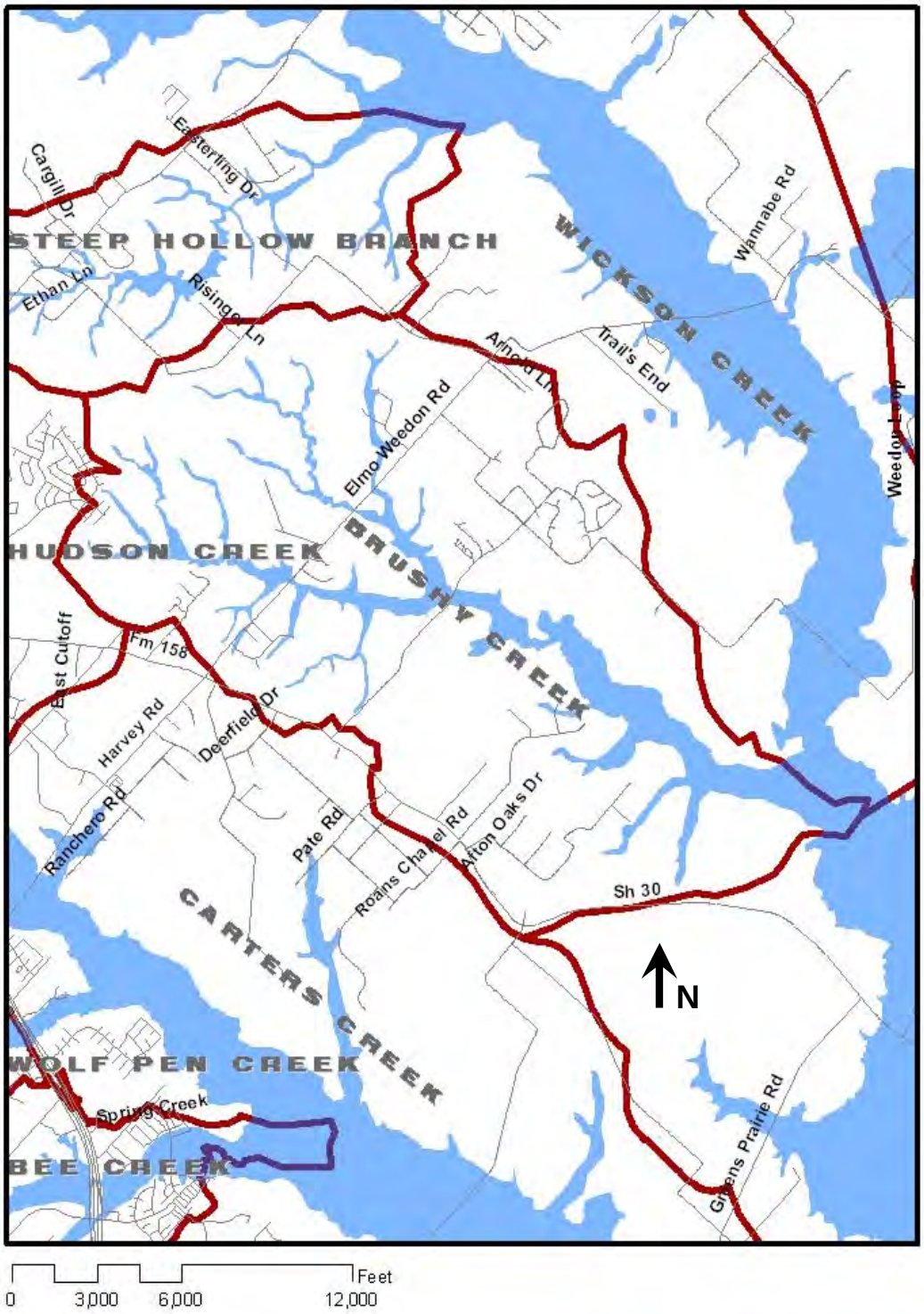


Figure B-5: Brushy Creek Watershed Area

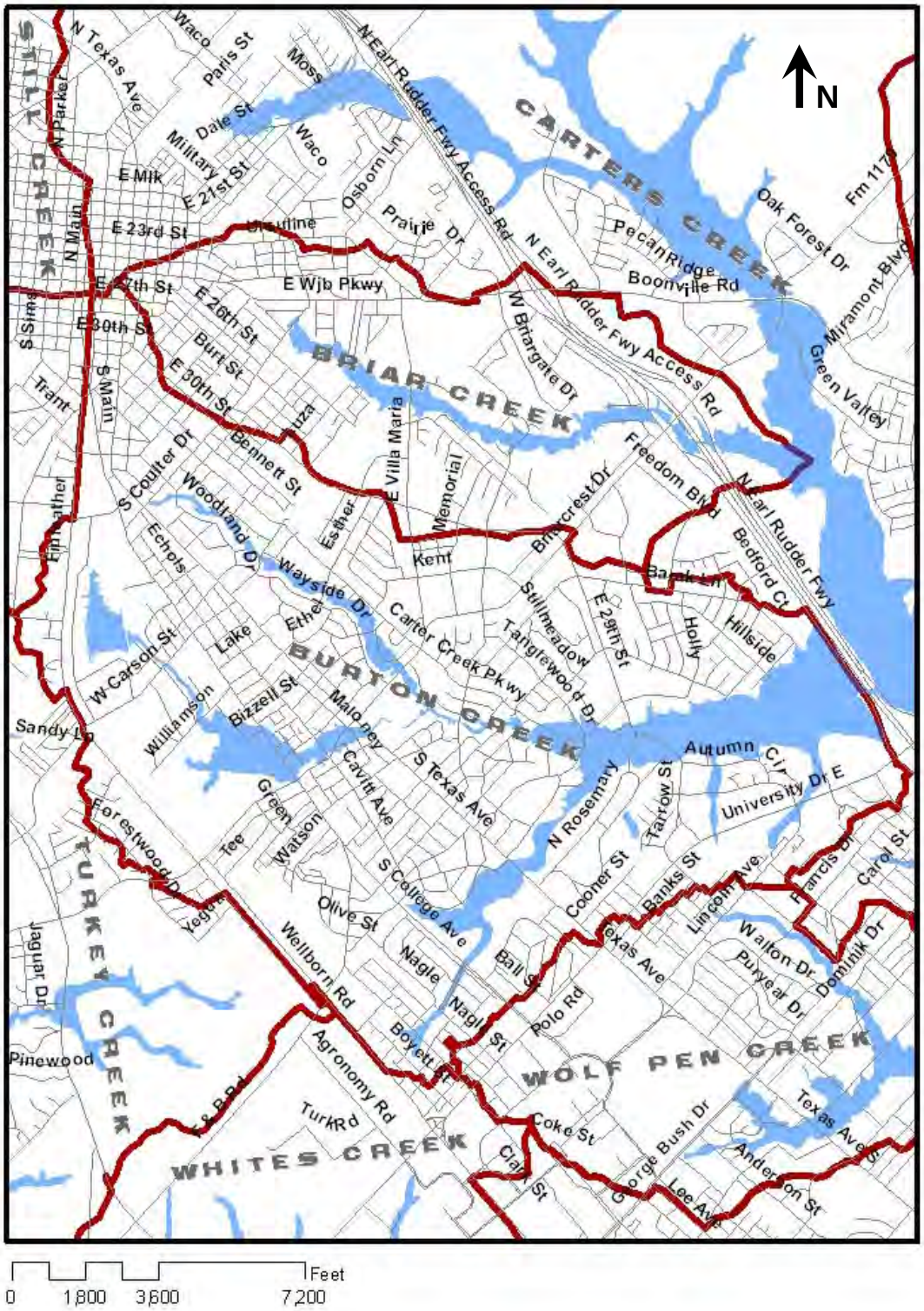


Figure B-6: Burton Creek Watershed Area

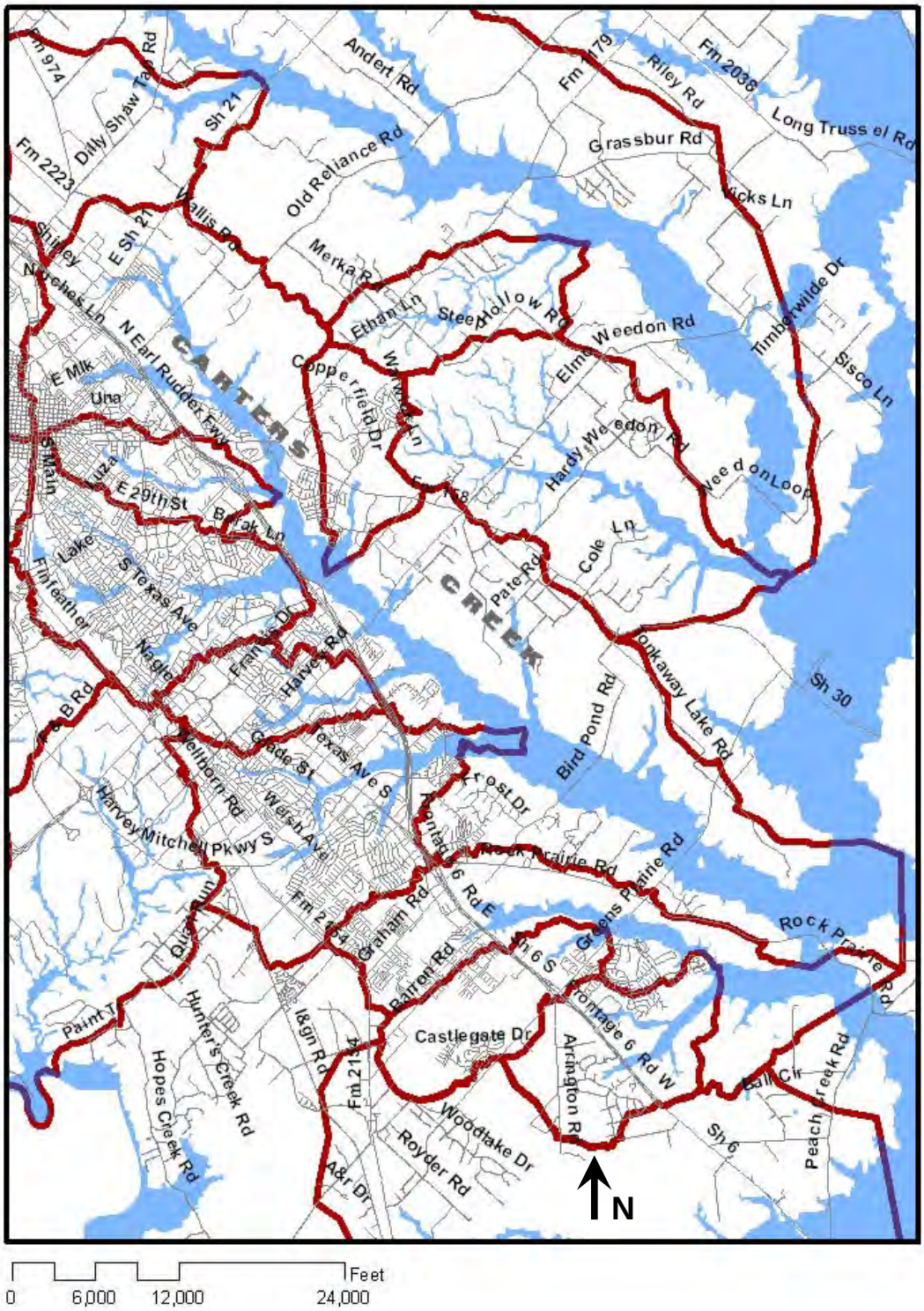


Figure B-7: Carters Creek Watershed Area

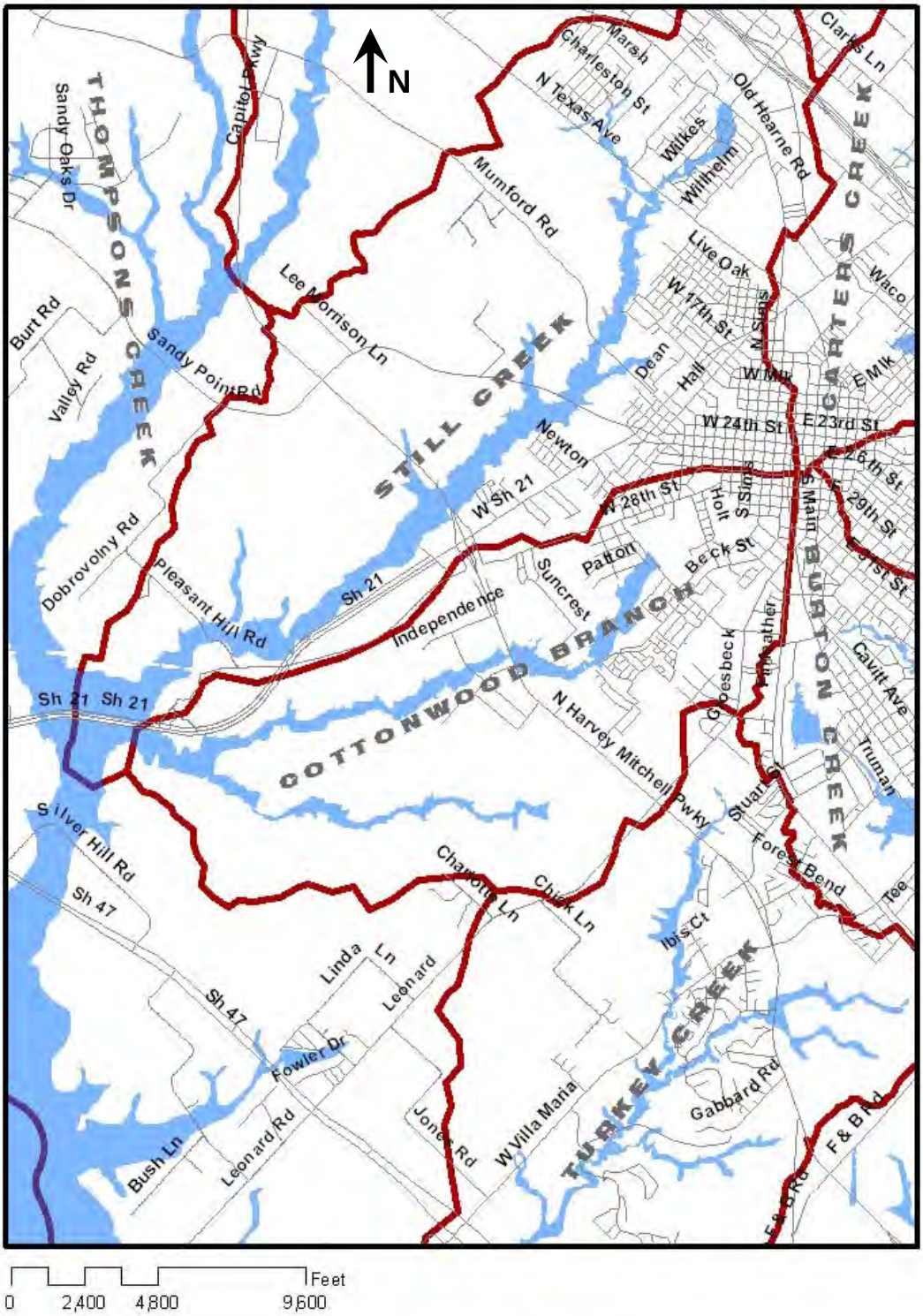


Figure B-8: Conttonwood Branch Watershed Area

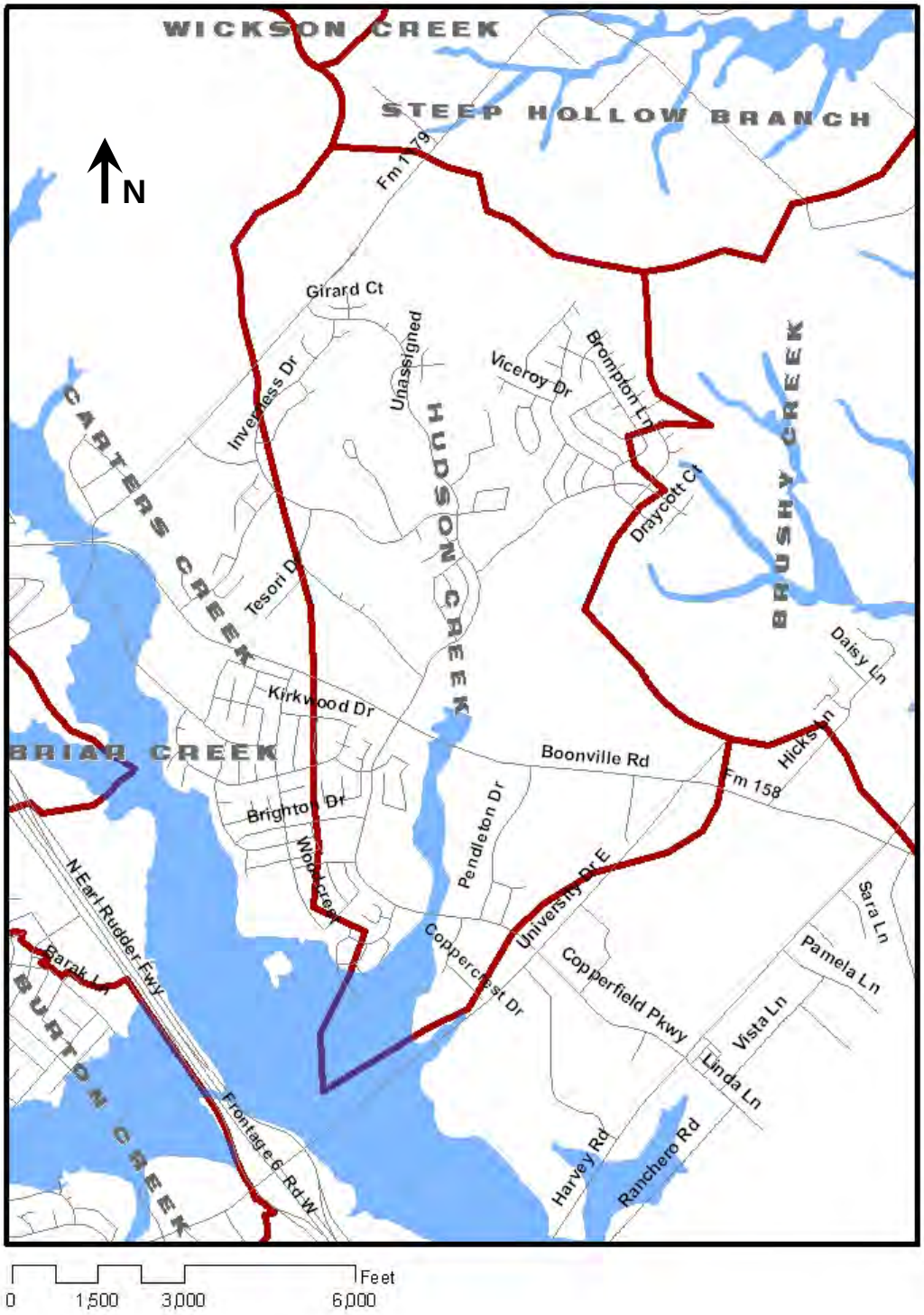


Figure B-9: Hudson Creek Watershed Area

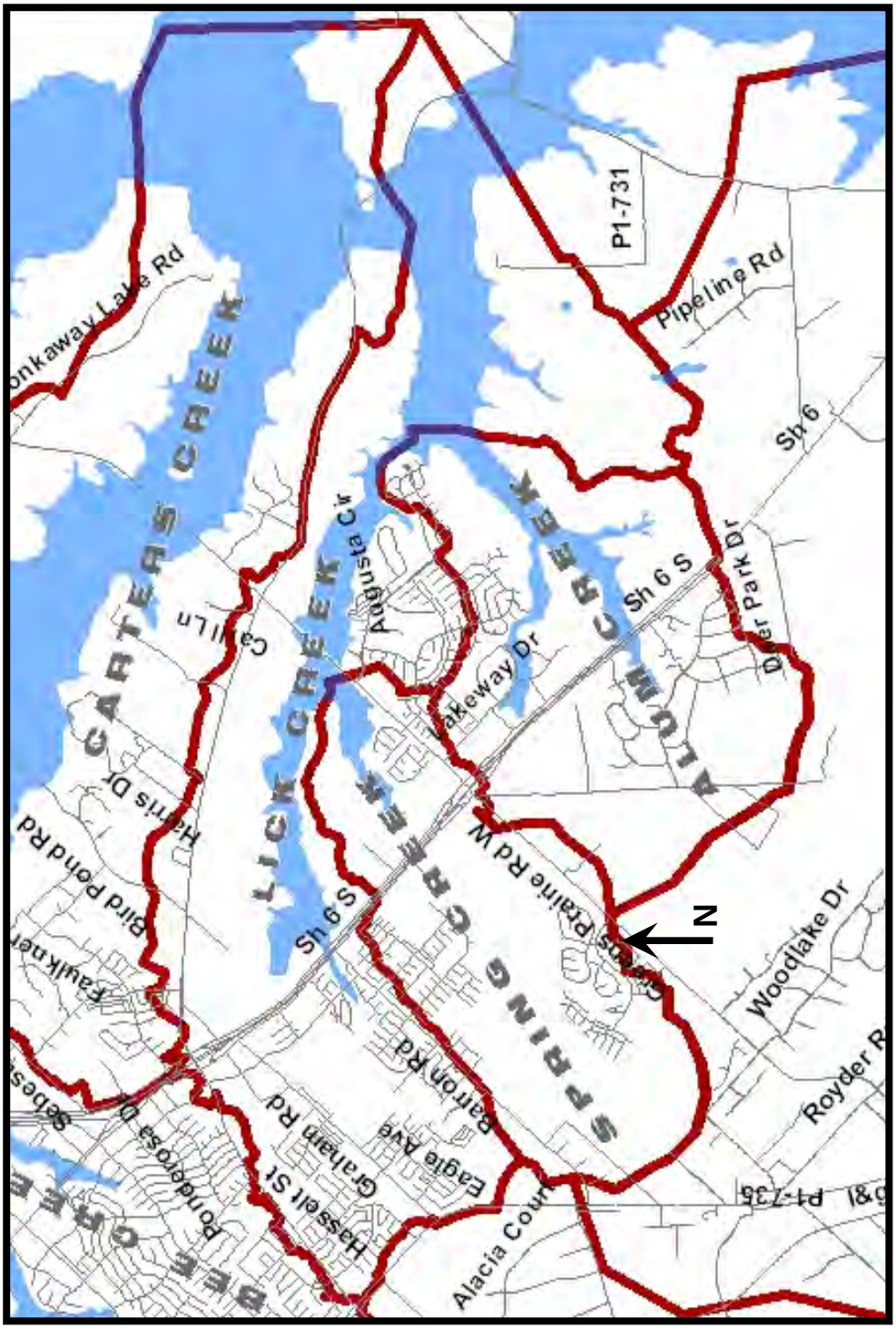


Figure B-10: Lick Creek Watershed Area

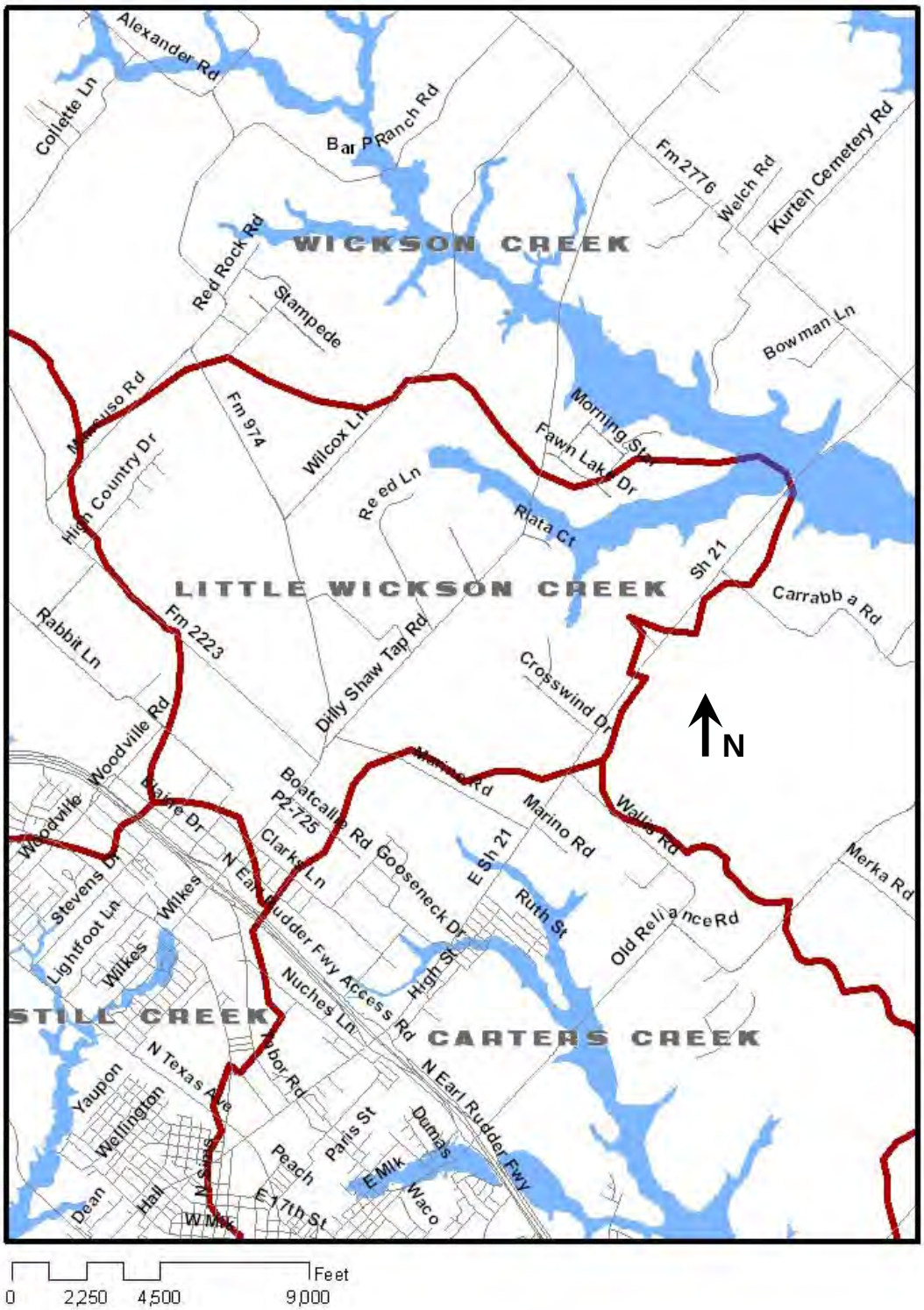


Figure B-11: Little Wickson Creek Watershed Area

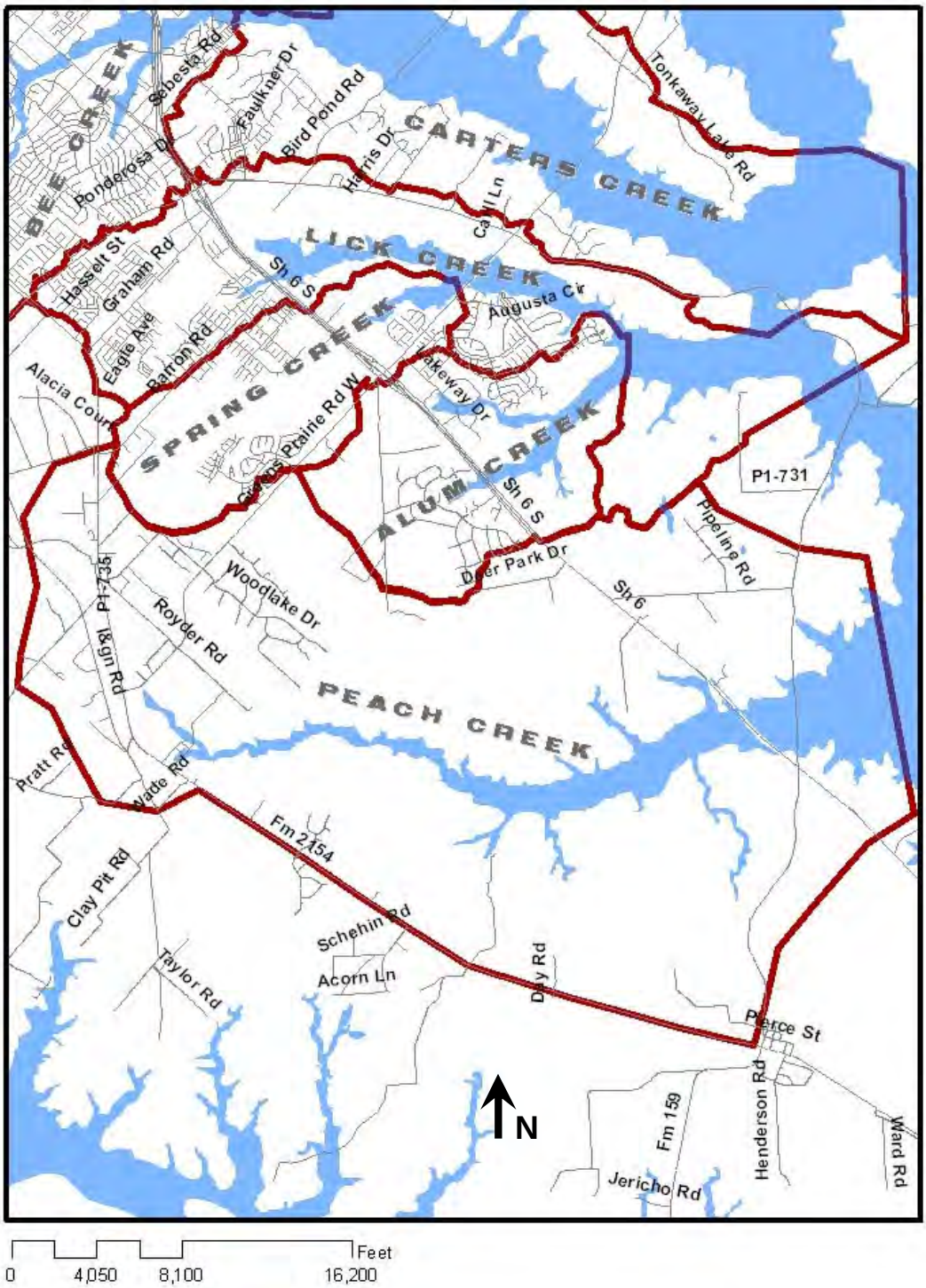


Figure B-12: Peach Creek Watershed Area

Figure B-13: Spring Creek Watershed Area

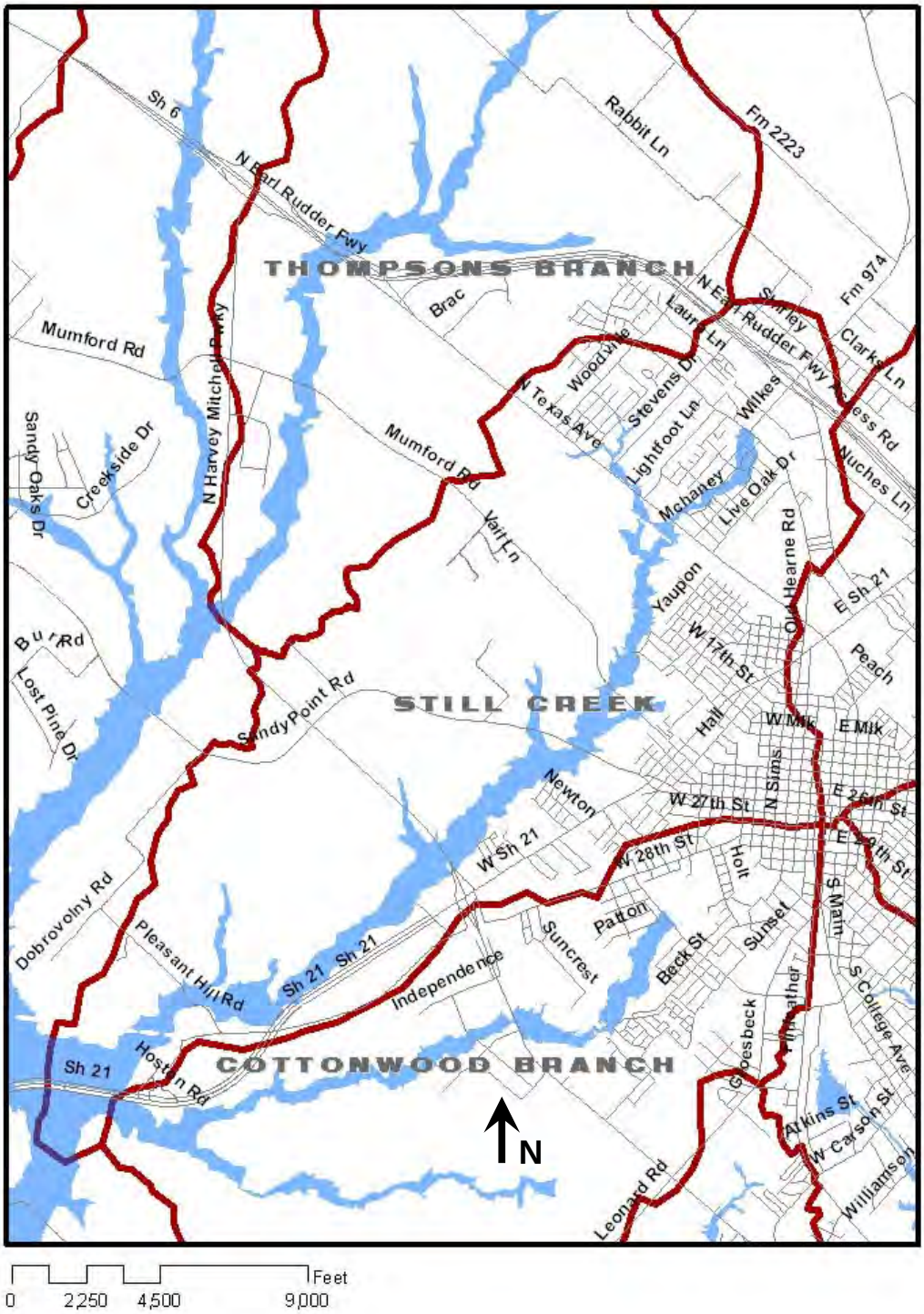


Figure B-14: Still Creek Watershed Area

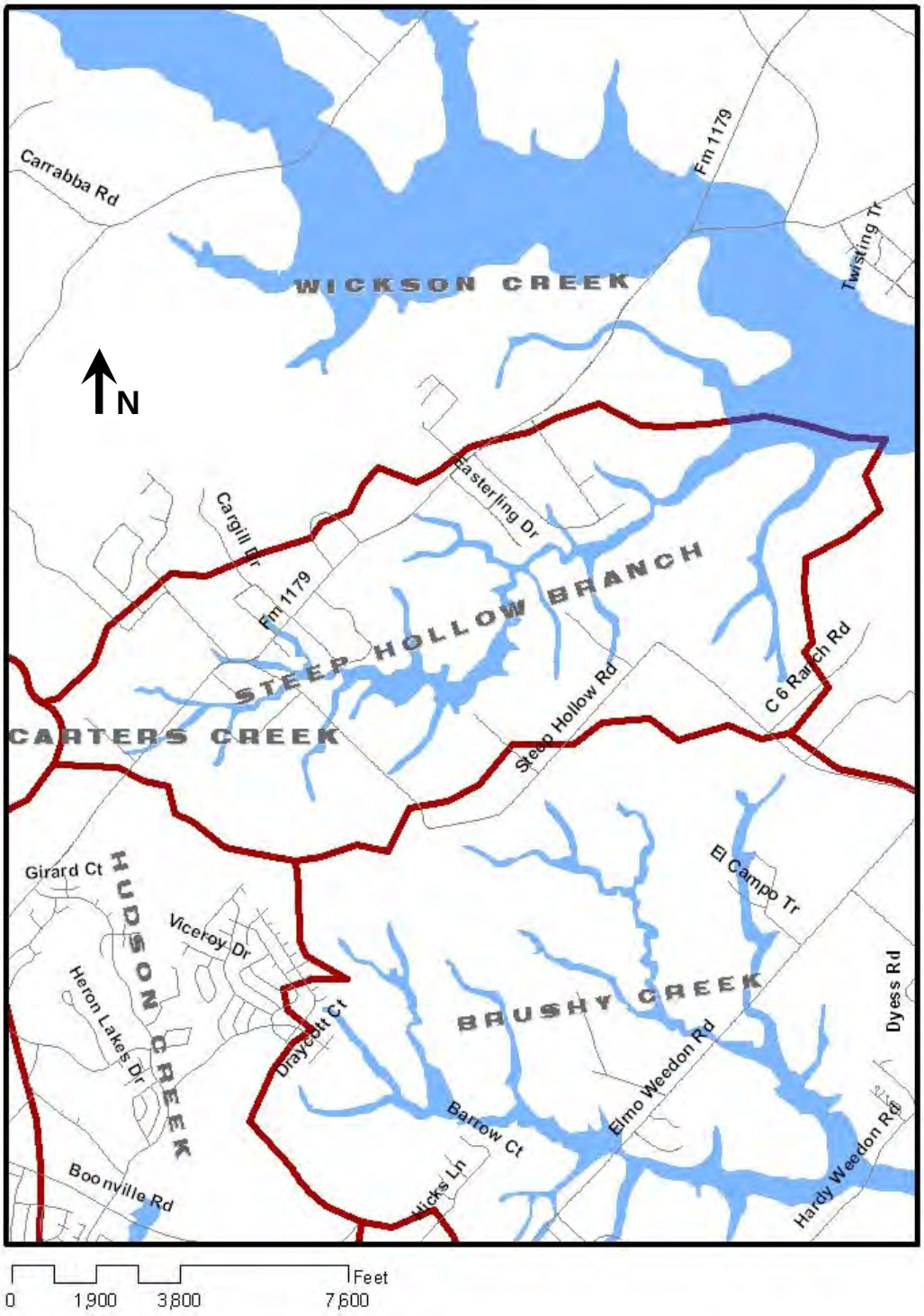


Figure B-15: Steep Hollow Branch Watershed Area

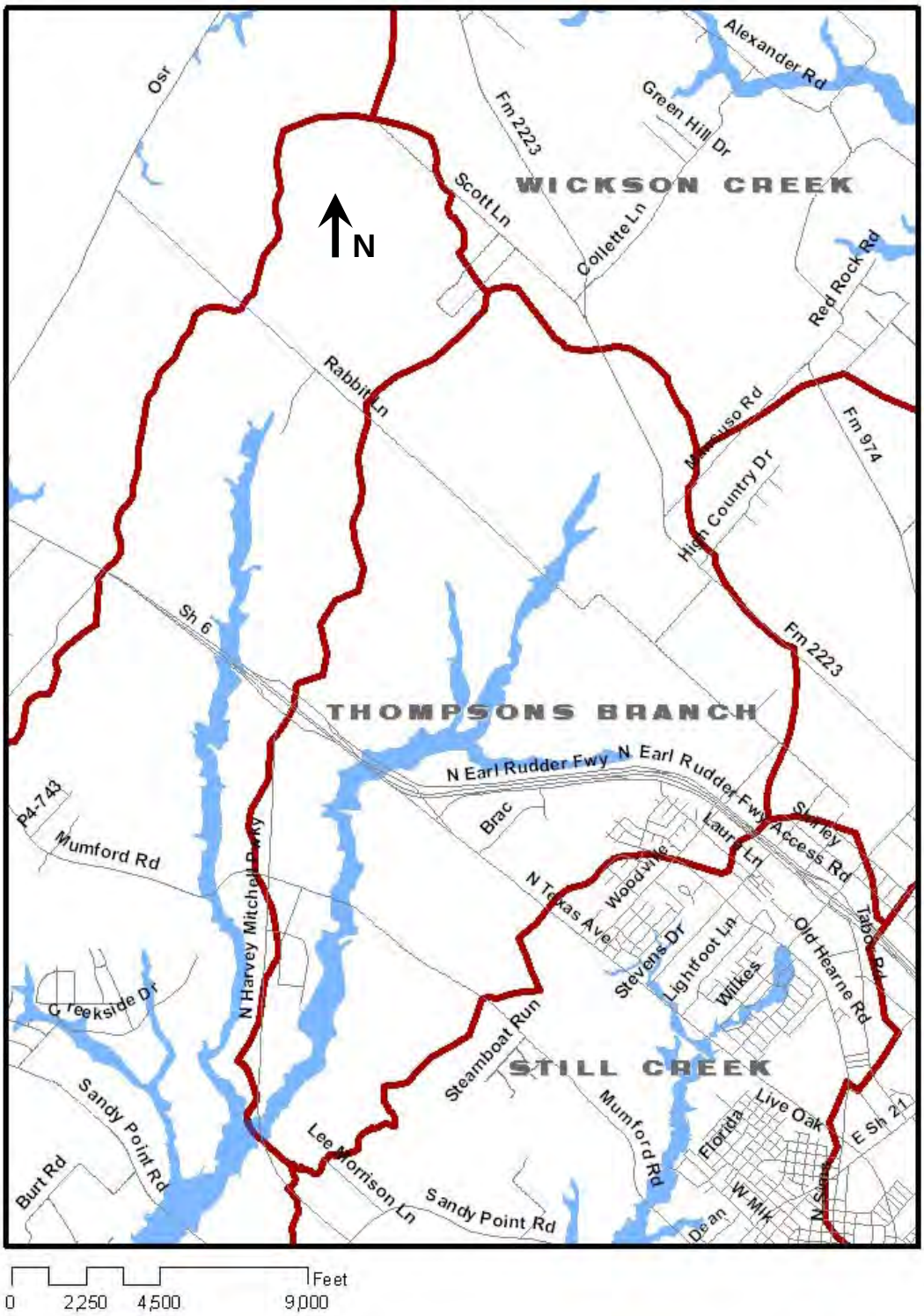


Figure B-16: Thompsons Branch Watershed Area

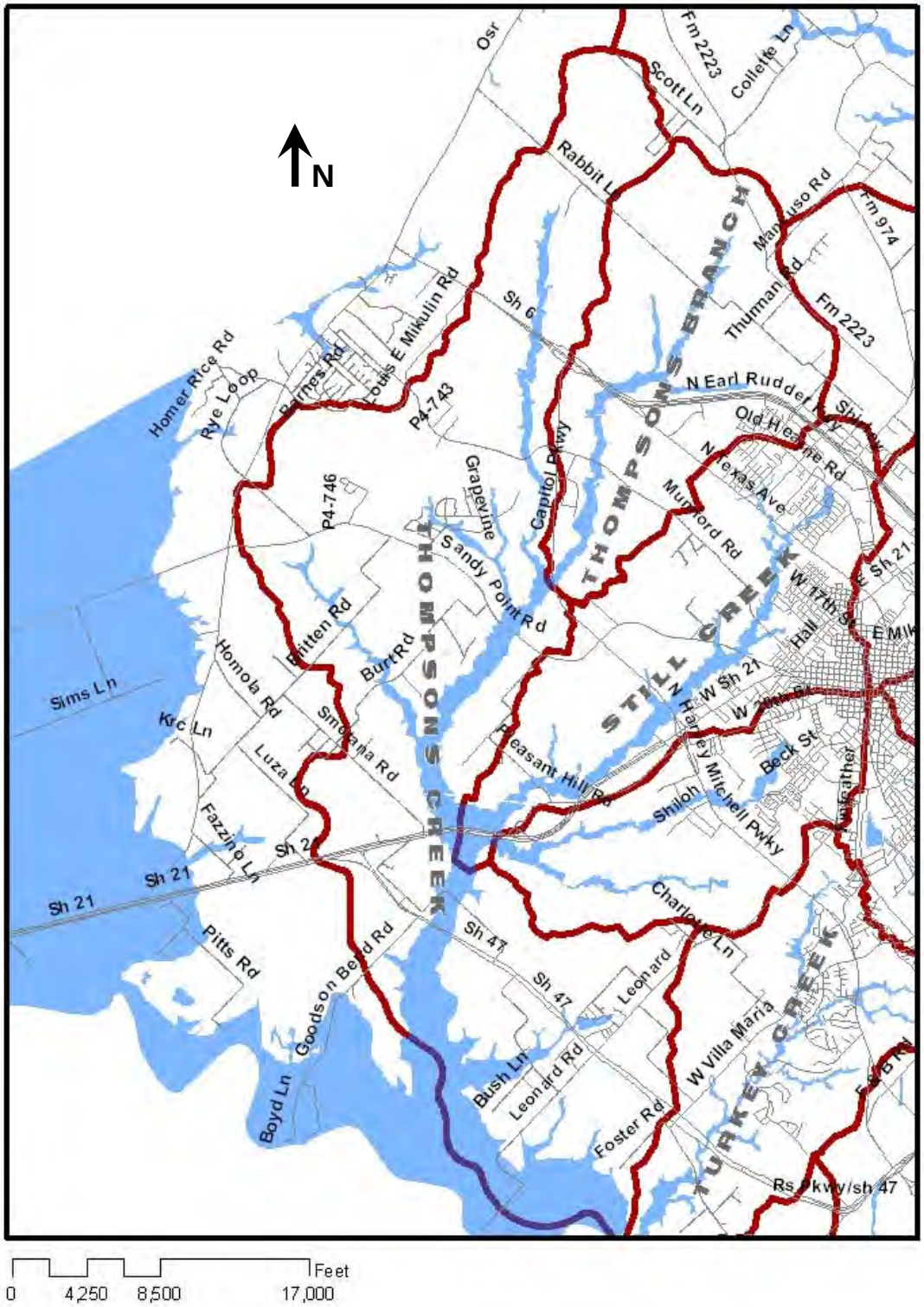


Figure B-17: Thompsons Creek Watershed Area

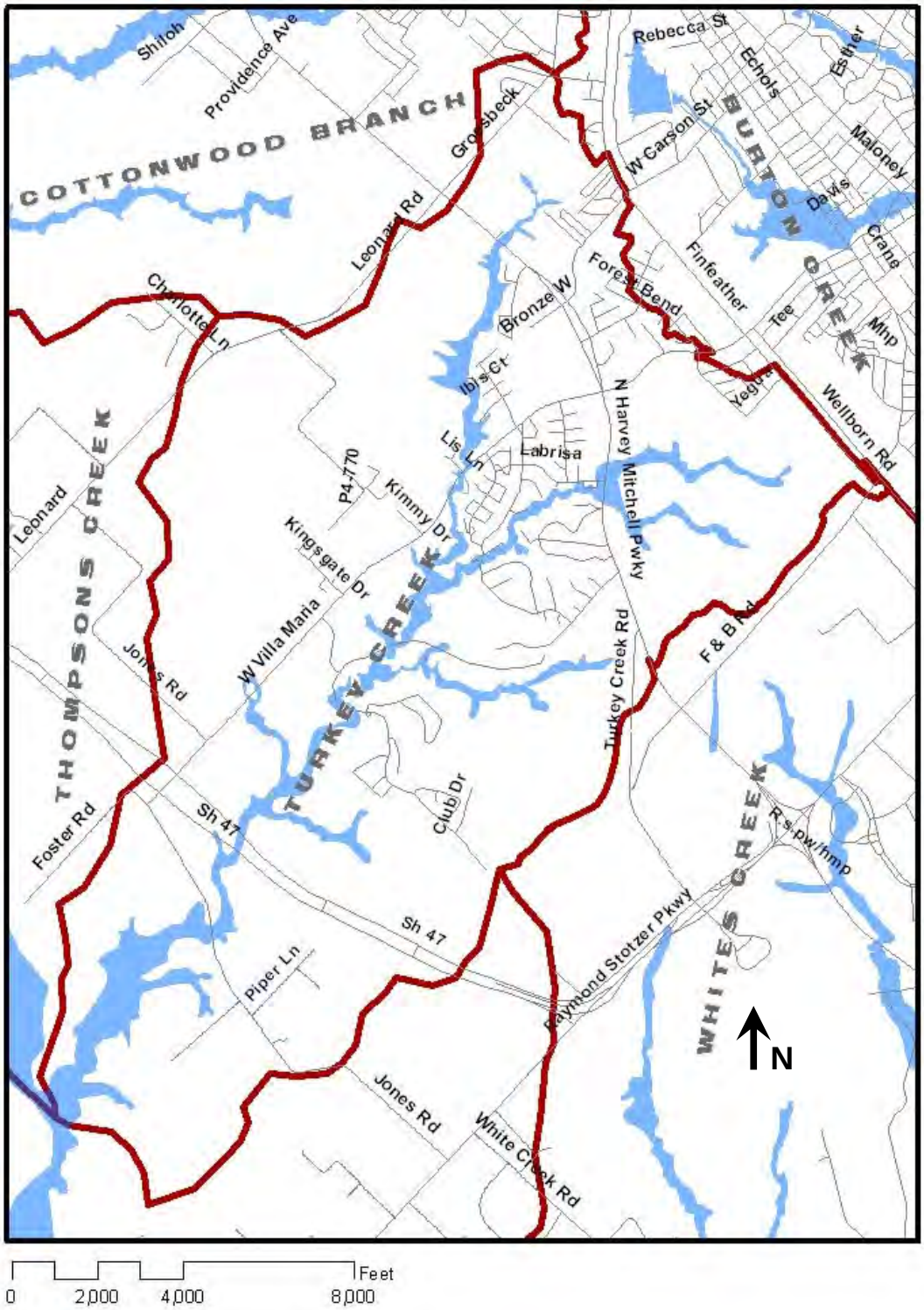


Figure B-18: Turkey Creek Watershed Area

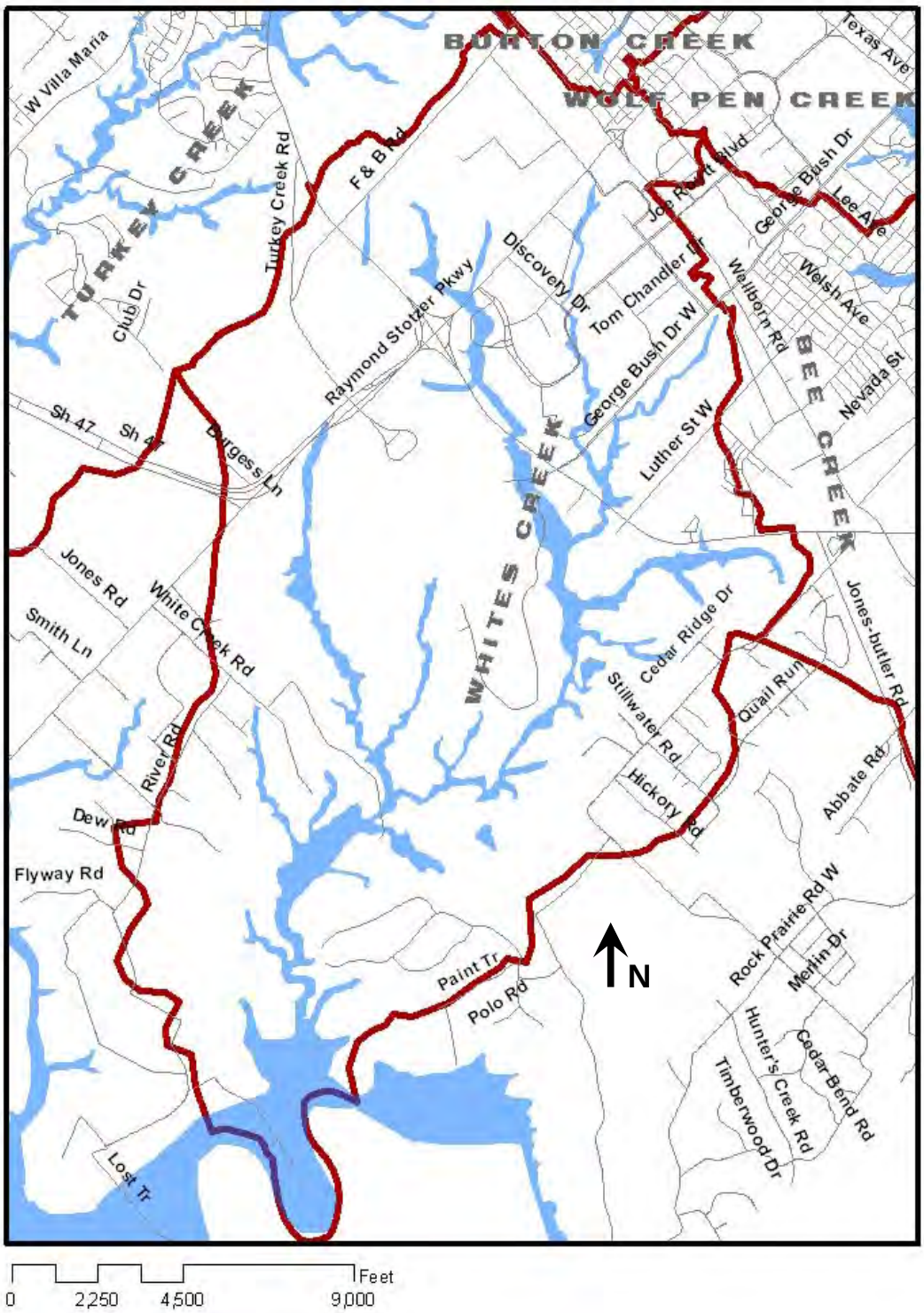


Figure B-19: Whites Creek Watershed Area

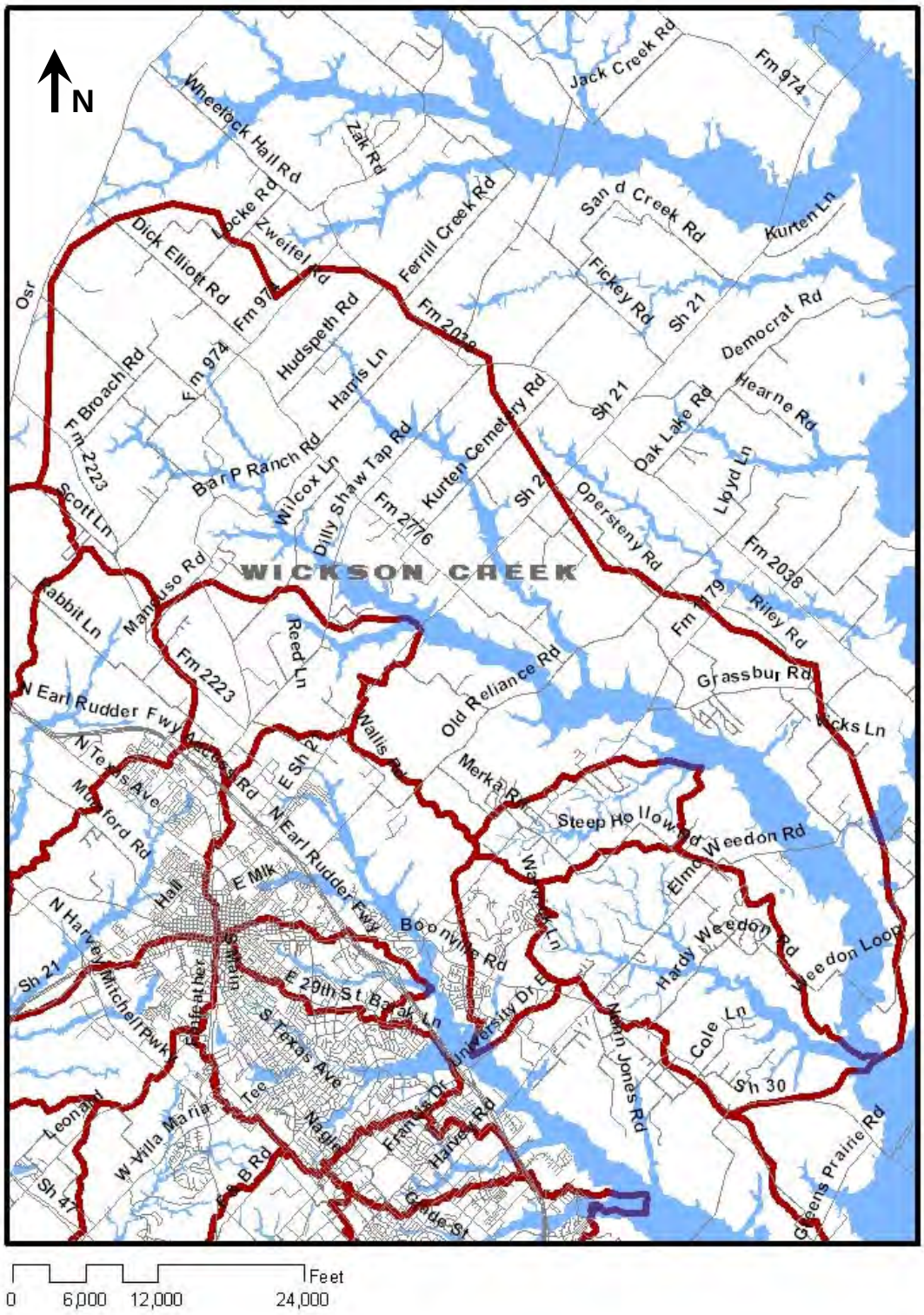


Figure B-20: Wickson Creek Watershed Area

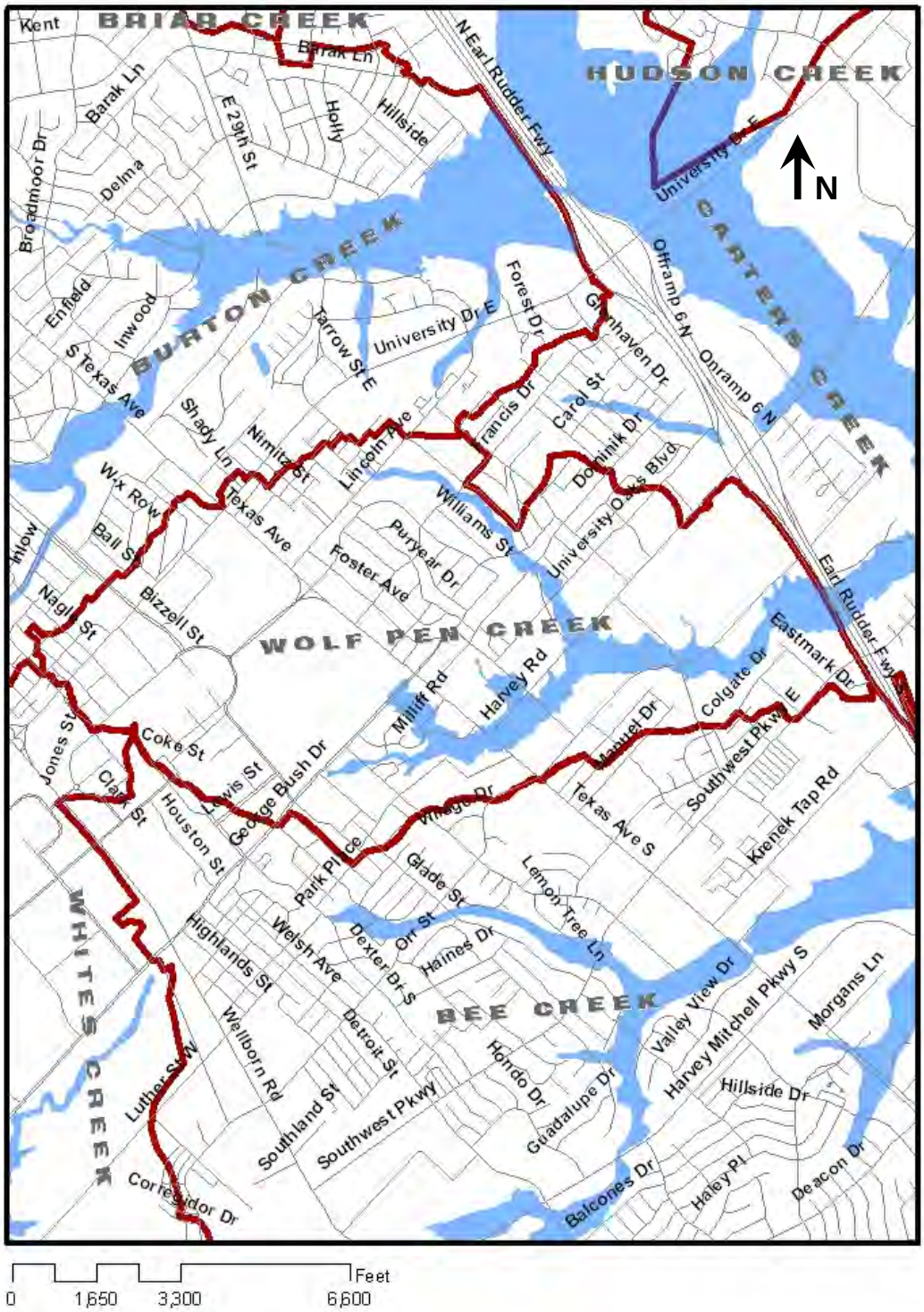


Figure B-21: Wolf Pen Creek Watershed Area

Appendix C
Computational Information

Unified Stormwater Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

Hydrology Computational Information

This portion of Appendix C provides tables and figures in support of the methodologies stipulated in Section V of these Guidelines dealing with the application of hydrologic principles. It includes the following Tables and Figures:

- Table C-1: Equations for Calculating Rainfall Intensities
- Table C-2: Runoff Coefficients (c) by Land Use Type
- Table C-3: Runoff Coefficients (c) by Surface Type
- Table C-4: Runoff Velocities (v) for Determining Time of Concentration (t_c)
- Table C-5: Manning's Roughness Coefficients for Sheet Flow (n)
- Table C-6: Depth-Duration-Interval Data (TP-40 and Hydro 35)
- Table C-7: Curve Numbers (SCS) and Percent Impervious Area

Table C-1
Equations for Calculating Rainfall Intensities

Reference Section V, Paragraph B1-a, page 2 of 8)

Storm Frequency	Intensity (i) (inches per hour)
2-Year	$65/(t_c + 8.0)^{0.806}$
5-Year	$76/(t_c + 8.5)^{0.785}$
10-Year	$80/(t_c + 8.5)^{0.763}$
25-Year	$89/(t_c + 8.5)^{0.754}$
50-Year	$98/(t_c + 8.5)^{0.745}$
100-Year	$96/(t_c + 8.0)^{0.730}$

Source: TxDOT Hydraulic Manual, 1986.

Table C-2

Runoff Coefficients (c) By Land Use Type

Reference Section V, Paragraph B1-a, page 2 of 8.

Land Use Description	Slope	Range of Values	
		From	To
Park and Open Space	Flat (0 to 2%)	0.25	0.41
	Average (2 to 7%)	0.33	0.49
	Steep (>7%)	0.73	0.53
Single Family Residential			
Lot size 5,000 to 7,000 sq. ft.	Flat (0 to 2%)	0.50	0.69
	Average (2 to 7%)	0.54	0.74
	Steep (>7%)	0.56	0.76
Lot size 7,000 to 10000 sq. ft.	Flat (0 to 2%)	0.44	0.62
	Average (2 to 7%)	0.49	0.68
	Steep (>7%)	0.52	0.71
Lot size 10,000 to 20,000 sq. ft.	Flat (0 to 2%)	0.38	0,56
	Average (2 to 7%)	0.44	0.63
	Steep (>7%)	0.47	0.66
Estate Lots (> 20,000 sq. ft.)	Flat (0 to 2%)	0.32	0.48
	Average (2 to 7%)	0.38	0.56
	Steep (>7%)	0.42	0.60
Multiple Family Residential			
Low Density (3 stories or less)	All	0.65	0.74
Medium Density (6 stories or less)	All	0.68	0.76
High Density (more than 6 stories)	All	0.71	0.80
Commercial			
Limited & General Office Sites	All	0.75	0.84
Shopping Center Sites	All	0.79	0.88
Neighborhood Business Districts	All	0.79	0.88
Office Parks	All	0.80	0.88
Central Business District	All	0.87	0.96
Industrial			
Limited (service station, restaurant)	All	0.79	0.88
General (auto sales, rental storage)	All	0.79	0.88
Heavy (parking lots, warehousing)	All	0.87	0.96

Source: City of Temple Drainage Criteria Manual

Table C-3

Runoff Coefficients (c) By Surface Type

Reference Section V, Paragraph B1-a, page 2 of 8

Surface Description	Slope	Range of Values	
		From	To
Undeveloped			
Cultivated Land	Flat (0 to 2%)	0.31	0.47
	Average (2 to 7%)	0.35	0.51
	Steep (>7%)	0.39	0.54
Pasture / Unimproved	Flat (0 to 2%)	0.25	0.41
	Average (2 to 7%)	0.33	0.49
	Steep (>7%)	0.37	0.53
Wooded	Flat (0 to 2%)	0.22	0.39
	Average (2 to 7%)	0.31	0.47
	Steep (>7%)	0.35	0.52
Floodplains	Flat (0 to 2%)	0.40	0.60
Developed Areas			
Roof Areas	All	0.92	0.97
Asphaltic Areas	All	0.90	0.95
Concrete	All	0.92	0.97
Compacted Crushed Limestone Base	All	0.80	0.90
Grass Areas (lawns, parks, etc.)			
Poor Condition	Flat (0 to 2%)	0.32	0.44
(< 50% vegetative cover)	Average (2 to 7%)	0.37	0.49
	Steep (>7%)	0.40	0.52
Fair Condition	Flat (0 to 2%)	0.25	0.37
(50 to 75% vegetative cover)	Average (2 to 7%)	0.33	0.45
	Steep (>7%)	0.37	0.49
Good Condition	Flat (0 to 2%)	0.21	0.32
(>75% vegetative cover)	Average (2 to 7%)	0.29	0.42
	Steep (>7%)	0.34	0.47

Sources: Rossmiller, R.L. "The Rational Formula Revisited"; City of Austin Drainage Criteria Manual; City of Temple Drainage Criteria Manual. Revised by B/CS Drainage Design Guidelines Forum, March, 2005.

Table C-4

Runoff Velocities (v) for Determining Time of Concentration (t_c)[1]

Reference Section V, Paragraph B1-a, page 3 of 8.

Reach Description	Slope of Reach			
	0 to 3 %	4 to 7%	8 to 11%	>12%
	v *	v *	v*	v*
Overland or Sheet Flow				
Natural Woodlands	0 – 1.5	1.5 – 2.5	2.5 – 3.25	>3.25
Natural Grasslands	0 – 2.5	2.5 – 3.5	3.5 – 4.25	>4.25
Landscaped Areas	0 – 3.0	3.0 – 4.5	4.5 – 5.5	>5.5
Pavements	0 – 8.5	8.5 – 13.5	13.5 – 17.0	>17.0
Concentrated Flow				
Natural Channels	0 – 2.0	2.0 – 4.0	4.0 – 7.0	>7.0
Street or Gutter Flow	Use procedure in Section VI, Paragraphs A & B			
Storm Sewer	Use procedure in Section VI, Paragraph C			
Open Channels (designed)	Use procedure in Section VI, Paragraph D			
*Note: "v " in feet per second				

[1] From the "Hydraulic Design Manual" of the Texas Department of Transportation, 2002

Table C-5

Manning's Roughness Coefficients for Sheet Flow (n)

Reference Section V, Paragraph B1-a, page 4 of 8

Description of Surface	Roughness Coefficient (n)
Smooth surfaces (concrete, asphalt, gravel or bare soil)	0.011
Cultivated Soils	
Fallow (no residue)	0.050
Residue Cover (less than 20%)	0.060
Residue Cover (greater than 20%)	0.170
Grass	
Short grass prairie	0.150
Dense grass prairie	0.240
Bermuda grass	0.410
Range (natural)	0.130
Woods	
Light underbrush	0.400
Dense underbrush	0.800

Source: After U.S. Department of Agriculture (1986).

Table C-6
Depth-Duration-Interval Data (TP-40 and Hydro 35)

Reference Section V, Paragraph B2-b, page 5 of 8

Storm Duration	Rainfall Depth for Duration and Storm Recurrence Interval (inches)						
	2-year	5-year	10-year	25-year	50-year	100-year	USGS 500-year
5-min	0.53	0.60	0.66	0.75	0.82	0.89	-
15-min	1.15	1,33	1.46	1.66	1.82	1.98	3.0
30-min	1.68	2.00	2.24	2.59	2.87	3.14	3.6
60-min	2.20	2.68	3.02	3.52	3.91	4.30	5.8
2-hr	2.60	3.36	3.94	4.57	5.10	5.60	8.3
3-hr	2.86	3.70	4.41	5.14	5.65	6.30	9.0
6-hr	3.33	4.41	5.29	6.20	6.95	7.90	11.0
12-hr	3.80	5.25	6.28	7.42	8.45	9.50	12.5
24-hr	4.50	6.20	7.40	8.40	9.80	11.00	14.0

Source: Combination of Soil Conservation Service TP 40 and Hydro 35

Table C-7
Curve Numbers (SCS) and Percent Impervious Area[1]

Reference Section V, Paragraph B2-b, page 5 of 8

Soil Type	Pasture	Wooded	Row Crops
A	**49**	**36**	**67**
B	69	60	78
C	79	76	85
D	84	79	89

For more complete information see TR-55, Table 2-2a

Category	Percent Impervious
Land Uses	
Low Density Residential	38
Medium Density Residential	52
High Density Residential	65
Business/Commercial	85
Industrial	72

[1] Values shall be calculated for watersheds in all cases.

Hydraulic Computational Information

This portion of Appendix C provides tables and figures in support of the methodologies stipulated in Section VI of these Guidelines dealing with the application of hydraulic design principles. It includes the following Tables and Figures:

- Table C-8: Equations for Sizing Inlets on Grade
- Table C-9: Coefficient of Loss, K_j
- Table C-10: Manning's Roughness Coefficients, n
- Table C-11: Maximum Design Velocities, V
- Table C-12: Values of Entrance Loss Coefficients, K_e

Table C-8
Equations for Sizing Inlets On Grade

Reference Section VI, Paragraph B5-b, page 6 of 32

Ref. No.	Equation	Use
1	$L_x = K_c Q^{0.42} S^{0.3} \left(\frac{1}{nS_x}\right)^{0.6}$	Calculating length of curb inlet (without gutter depression) required for total interception of gutter flow.
2	$E = 1 - \left[1 - \frac{L_i}{L_T}\right]^{1.8}$	Calculating efficiency of curb inlet shorter than required length.
3	$E_o = \frac{Q_w}{Q} = 1 - \left[1 - \frac{W}{T}\right]^{2.67}$	Calculating E_o, the ratio of the frontal flow to total gutter flow for a straight roadway cross slope; used in equation 4.
4	$S_e = S_x + \frac{a}{W} E_o$	Calculating S_e to substitute for S_x in Equation 1 to determine length of curb inlet (with gutter depression) for total interception of gutter flow.
NA	**Where symbols are as follows:** E_o = Ratio of frontal flow to total gutter flow Q_w = Flow in width W, cfs Q = Total gutter flow, cfs W = Width of depressed gutter, feet T = Total spread of water in gutter, feet K_c = 0.6 (in English measure) L_x = length of curb inlet required, feet S = longitudinal slope, (ft/ft) n = Manning's roughness coefficient S_x = cross slope of road surface, (ft/ft) E = Efficiency of inlet or percentage of interception L_i = Curb-opening length, ft L_T = Curb-opening length required for 100% interception, ft S_e = equivalent cross slope, (ft/ft) a = gutter depression depth, ft	
Note:	The length of a recessed inlet is to be determined in the same manner as inlets having a depressed gutter section, because a depressed section is to be provided at the throat of the inlet but behind the curb line (Fig. C-1).	

Table C-9

Coefficient of Loss, K_j*

Reference Section VI, Paragraph C3-b, page 9 of 32

Design Condition	K_j *
Inlet on Main Line	0.50
Inlet on Main Line with Branch Lateral	0.25
Junction or Manhole on Main Line with 45 degree Branch Lateral	0.05
Junction or Manhole on Main Line with 90 degree Branch Lateral	0.25
Inlet or Manhole at Beginning of Line	1.25
Conduit on Curve for 90 degree	
Curve Radius = Diameter	0.05
Curve Radius = (2 to 8)	0.04
Curve Radius = (7 to 8)	0.25
** Where bends other than 90 Degree are used, then 90 Degree bend coefficient can be used with the following percentage factor applied:	60° Bend – 85% 45° Bend – 70% 22.5^o Bend – 40%

* From City of Austin Drainage Criteria Manual

Table C-10
Manning's Roughness Coefficients (n)[1]

Reference Section VI, Paragraph D2-b, page 12 of 32

Design Conditions	Coefficients Min.	Max.
Natural Stream Channels		
Minor Streams With Fairly Regular Section, and:		
1. Some grass and weeds, little or no brush	0.030	0.035
2. Dense weeds, flow depth materially exceeds weed height	0.035	0.050
3. Some weeds, light brush on banks	0.035	0.050
4. Some weeds, heavy brush on banks	0.035	0.050
5. Some weeds, dense willows on banks	0.050	0.070
6. Trees in channels & branches submerged at high stage, increase all values above by:	0.010	0.020
Minor Streams With Irregular Section (pools, slight channel meander): use 1 to 5 above, and increase values by:	0.010	0.020
Flood Plain (adjacent to natural streams)		
Pasture: no brush, short grass	0.030	0.035
Pasture: no brush, tall grass	0.035	0.050
Heavy weeds, scattered brush	0.050	0.070
Wooded: Varies depending on undergrowth, height of foliage on trees, etc. The area of "n" = 0.10 and greater indicated extremely heavily wooded condition.	0.075	0.120
Lined Channels		
Metal corrugated	0.021	0.024
Neat concrete lined	0.012	0.018
Concrete	0.012	0.018
Concrete rubble	0.017	0.030
Grass Covered Small Channels, Shallow Depth		
No rank growth	0.035	0.045
Rank growth	0.040	0.050
Unlined Channels		
Earth, straight and uniform	0.017	0.025
Dredged	0.025	0.033
Winding and sluggish	0.022	0.030
Stony beds, weeds on bank	0.025	0.040
Earth bottom, rubble sides	0.028	0.035

[1] From "Hydraulic Design Manual" of Texas Depart of Transportation, 2002

Table C-11
Maximum Design Velocities (V) [1]

Reference: Section VI, Paragraph D3-a, page 13 of 32

Surface Treatment	Max. Design Velocity
Grass: seeded with erosion matt	4.5 ft./sec.
Grass: established sod	6.0 ft./sec.
Rubble: placed rock or concrete	10.0 ft./sec.
Impermeable: (concrete, Gunite, etc.)	15.0 ft./sec.
Gutter Flow (Sec.6, A.2.a)	10.0 ft./sec.
Channel (25-year)	Min. 2.5 ft./sec. - Max (below)
Conduit (10-year)	Min. 2.5 ft./sec. – Max. 15.0 ft./sec.
*Note: Velocities in excess of 12 feet per second shall require additional methods such as baffles, stilling basins, and/or drop structures to reduce velocities to levels stipulated.	

[1]From "Erosion and Sediment Control Guidelines for Developing Areas inTexas" by the US Soil Conservation Service.

Table C-12
Values of Entrance Loss Coefficients, K_e[1]

Reference Section VI, Paragraph F5-d, page 28 of 32

Type of Structure and Entrance Design	Value of K_e
Box, Reinforced Concrete (Submerged Entrance)	
Parallel Wing walls	0.5
Flared Wing walls	0.4
Box, Reinforced Concrete (Free Surface Flow)	
Parallel Wing walls	0.5
Flared Wing walls	0.15
Pipe, Concrete	
Projecting from fill, socket end	0.2
Projecting from fill, square cut end	0.5
With headwall or headwall and wing walls	
Socket end of pipe	0.2
Square cut end	0.5
End-section conforming to fill slope	0.5
Pipe or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall & wing walls (square edge)	0.5
End-section conforming to fill slope	0.5

[1]From City of Austin Drainage Criteria Manual

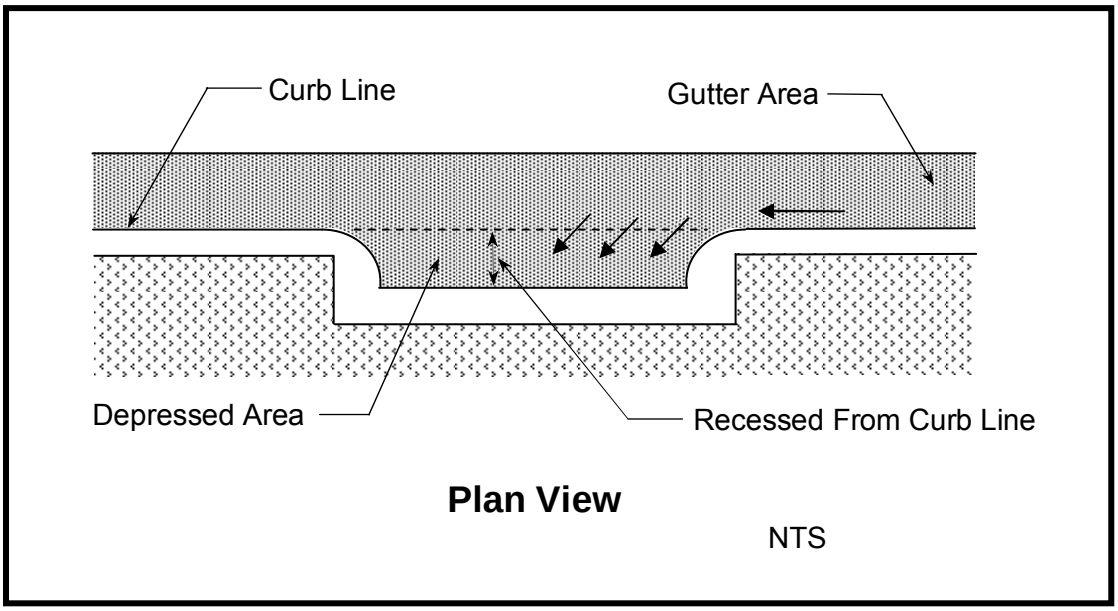


Figure C-1: Recessed Curb Inlet Diagram

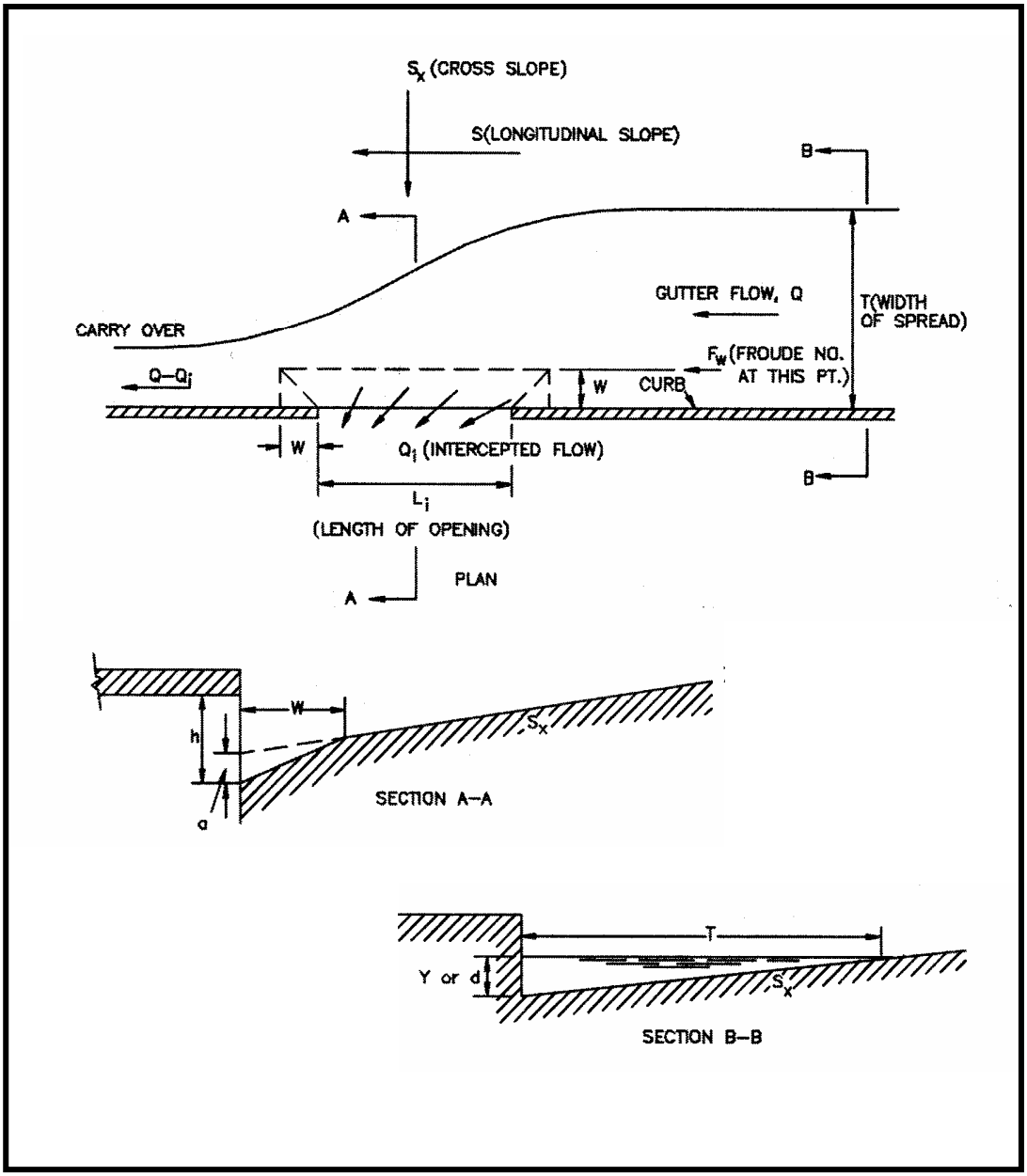


Figure C-2: Non-Recessed Curb Inlet Diagram

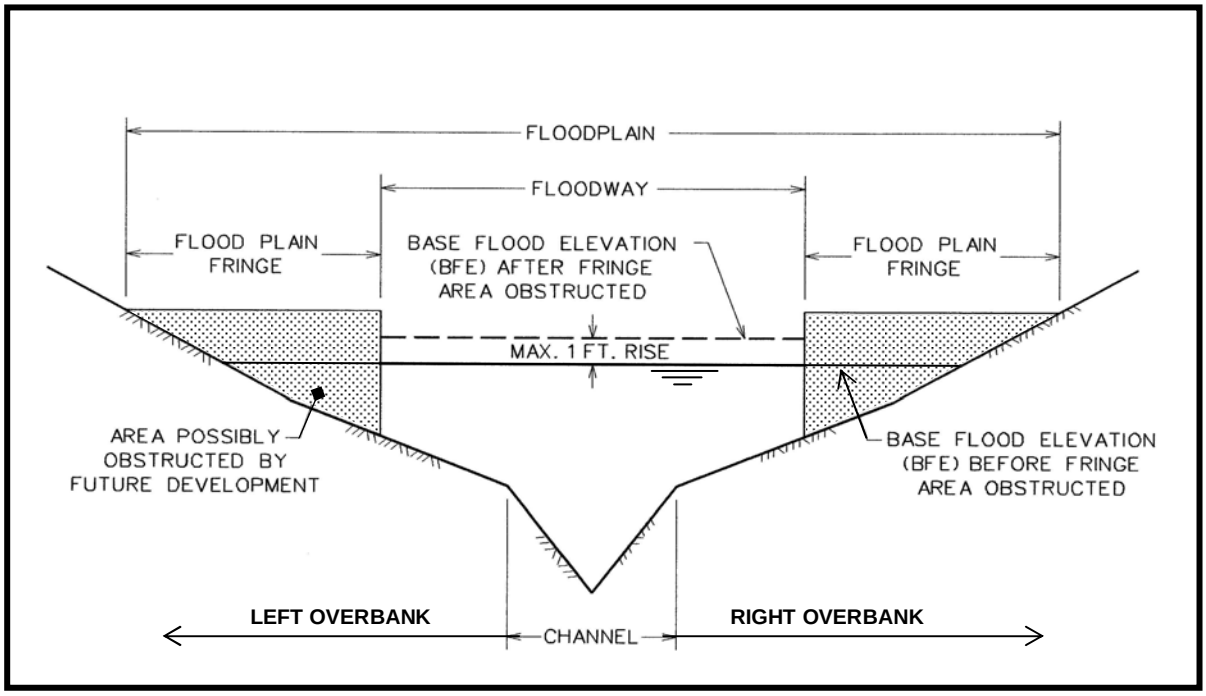


Figure C-3: Floodplain – Floodway Diagram

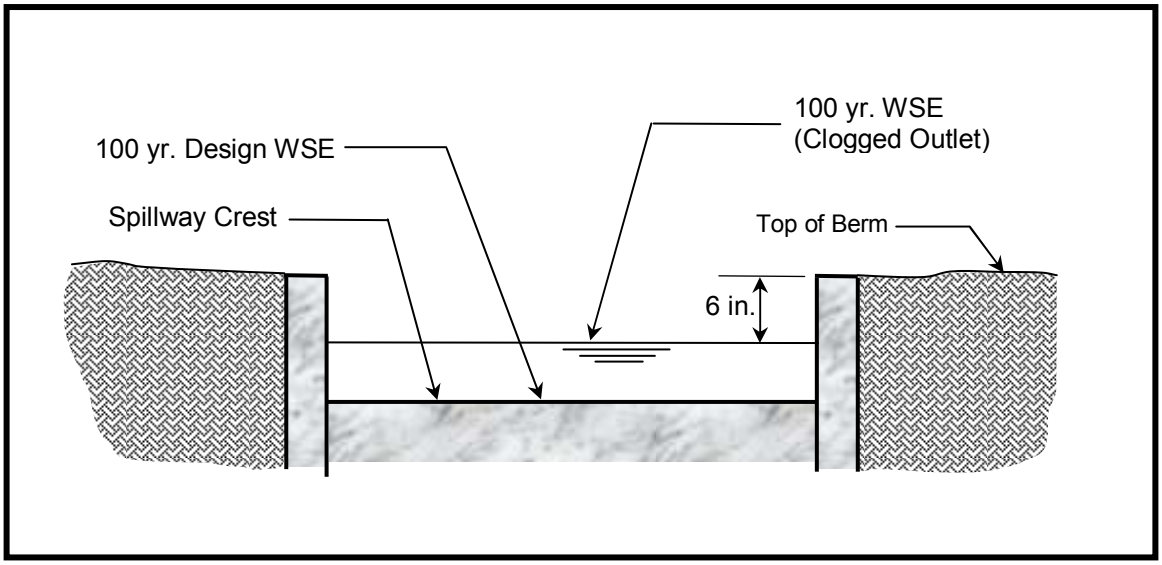
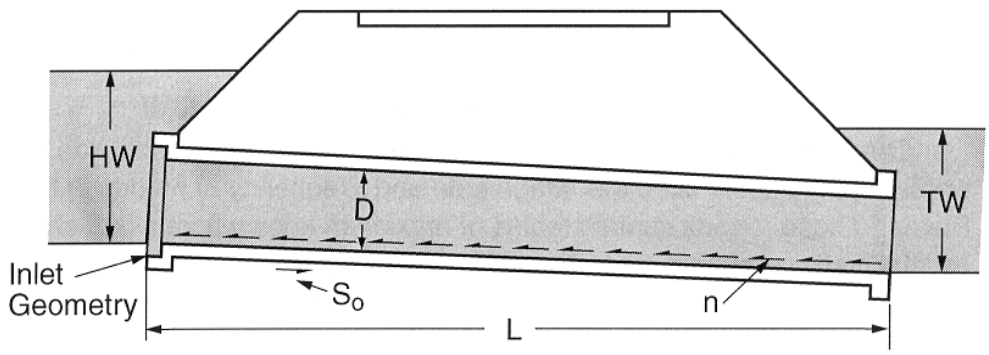


Figure C-4: Diagram of Detention Spillway Section



Where:

D = inside diameter for circular pipe (ft.)
HW = headwater depth at culvert entrance (ft.)
L = length of culvert (ft.)
n = Manning's surface roughness (dimensionless)
S_o = slope of the culvert pipe (ft./ft.)
TW = tailwater depth at the culvert outlet (ft.)
K_e = Entrance Loss (dimensionless)

Figure C-5: Factors Influencing Culvert Discharge

Appendix D
Technical Design Summary

Unified Stormwater Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

SECTION IX

APPENDIX D – TECHNICAL DESIGN SUMMARY

The Cities of Bryan and College Station both require storm drainage design to follow these Unified Stormwater Design Guidelines. Paragraph C2 of Section III (Administration) requires submittal of a drainage report in support of the drainage plan (stormwater management plan) proposed in connection with land development projects, both site projects and subdivisions. That report may be submitted as a traditional prose report, complete with applicable maps, graphs, tables and drawings, or it may take the form of a "Technical Design Summary". The format and content for such a summary report shall be in substantial conformance with the description in this Appendix to those Guidelines. In either format the report must answer the questions (affirmative or negative) and provide, at minimum, the information prescribed in the "Technical Design Summary" in this Appendix.

The Stormwater Management Technical Design Summary Report shall include several parts as listed below. The information called for in each part must be provided as applicable. In addition to the requirements for the Executive Summary, this Appendix includes several pages detailing the requirements for a Technical Design Summary Report as forms to be completed. These are provided so that they may be copied and completed or scanned and digitized. In addition, electronic versions of the report forms may be obtained from the City. Requirements for the means (medium) of submittal are the same as for a conventional report as detailed in Section III of these Guidelines.

Note: Part 1 – Executive Summary must accompany any drainage report required to be provided in connection with any land development project, regardless of the format chosen for said report.

Note: Parts 2 through 6 are to be provided via the forms provided in this Appendix. Brief statements should be included in the forms as requested, but additional information should be attached as necessary.

Part 1 – Executive Summary Report

Part 2 – Project Administration

Part 3 – Project Characteristics

Part 4 – Drainage Concept and Design Parameters

Part 5 – Plans and Specifications

Part 6 – Conclusions and Attestation

STORMWATER MANAGEMENT TECHNICAL DESIGN SUMMARY REPORT

Part 1 – Executive Summary

This is to be a brief prose report that must address each of the seven areas listed below. Ideally it will include one or more paragraphs about each item.

1. Name, address, and contact information of the engineer submitting the report, and of the land owner and developer (or applicant if not the owner or developer). The date of submittal should also be included.
2. Identification of the size and general nature of the proposed project, including any proposed project phases. This paragraph should also include reference to

applications that are in process with either City: plat(s), site plans, zoning requests, or clearing/grading permits, as well as reference to any application numbers or codes assigned by the City to such request.

3. The location of the project should be described. This should identify the Named Regulatory Watershed(s) in which it is located, how the entire project area is situated therein, whether the property straddles a watershed or basin divide, the approximate acreage in each basin, and whether its position in the Watershed dictates use of detention design. The approximate proportion of the property in the city limits and within the ETJ is to be identified, including whether the property straddles city jurisdictional lines. If any portion of the property is in floodplains as described in Flood Insurance Rate Maps published by FEMA that should be disclosed.

4. The hydrologic characteristics of the property are to be described in broad terms: existing land cover; how and where stormwater drains to and from neighboring properties; ponds or wetland areas that tend to detain or store stormwater; existing creeks, channels, and swales crossing or serving the property; all existing drainage easements (or ROW) on the property, or on neighboring properties if they service runoff to or from the property.

5. The general plan for managing stormwater in the entire project area must be outlined to include the approximate size, and extent of use, of any of the following features: storm drains coupled with streets; detention / retention facilities; buried conveyance conduit independent of streets; swales or channels; bridges or culverts; outfalls to principal watercourses or their tributaries; and treatment(s) of existing watercourses. Also, any plans for reclaiming land within floodplain areas must be outlined.

6. Coordination and permitting of stormwater matters must be addressed. This is to include any specialized coordination that has occurred or is planned with other entities (local, state, or federal). This may include agencies such as Brazos County government, the Brazos River Authority, the Texas A&M University System, the Texas Department of Transportation, the Texas Commission for Environmental Quality, the US Army Corps of Engineers, the US Environmental Protection Agency, et al. Mention must be made of any permits, agreements, or understandings that pertain to the project.

7. Reference is to be made to the full drainage report (or the Technical Design Summary Report) which the executive summary represents. The principal elements of the main report (and its length), including any maps, drawings or construction documents, should be itemized. An example statement might be:

> **"**One _____-page drainage report dated _____, one set of construction drawings (_____sheets) dated _____, and a _____-page specifications document dated _____ comprise the drainage report for this project.**"**

Part 2 – Project Administration	Start (Page 2.1)

Engineering and Design Professionals Information	
Engineering Firm Name and Address:	Jurisdiction City: _____ Bryan _____ College Station Date of Submittal:
Lead Engineer's Name and Contact Info.(phone, e-mail, fax):	Other:
Supporting Engineering / Consulting Firm(s):	Other contacts:

Developer / Owner / Applicant Information	
Developer / Applicant Name and Address:	Phone and e-mail:
Property Owner(s) if not Developer / Applicant (& address):	Phone and e-mail:

Project Identification	
Development Name:	
Is subject property a site project, a single-phase subdivision, or part of a multi-phase subdivision? _____ If multi-phase, subject property is phase _____ of _____.	
Legal description of subject property (phase) or **Project Area:** (see Section II, Paragraph B-3a)	
If subject property (phase) is second or later phase of a project, describe general status of all earlier phases. For most recent earlier phase Include submittal and review dates.	
General Location of **Project Area,** or subject property (phase):	
In City Limits? Bryan: _____ acres. College Station: _____ acres.	Extraterritorial Jurisdiction (acreage): Bryan: _____ College Station: _____ Acreage Outside ETJ: _____

Part 2 – Project Administration	Continued (page 2.2)

Project Identification (continued)

Roadways abutting or within **Project Area** or subject property:	Abutting tracts, platted land, or built developments:
Named Regulatory Watercourse(s) & Watershed(s):	Tributary Basin(s):

Plat Information For Project or Subject Property (or Phase)

Preliminary Plat File #: _____ Name:	Final Plat File #: _____ Date:_____ Status and Vol/Pg:

If two plats, second name: File #: _____
Status: Date: _____

Zoning Information For Project or Subject Property (or Phase)

Zoning Type: Existing or Proposed? Case Code: _____
Case Date _____ Status:

Zoning Type: Existing or Proposed? Case Code: _____
Case Date _____ Status:

Stormwater Management Planning For Project or Subject Property (or Phase)

Planning Conference(s) & Date(s):	Participants:

Preliminary Report Required? _____ Submittal Date _____ Review Date _____

Review Comments Addressed? Yes ____ No ____ In Writing? _____ When? _____

Compliance With Preliminary Drainage Report. Briefly describe (or attach documentation explaining) any deviation(s) from provisions of Preliminary Drainage Report, if any.

Part 2 – Project Administration	Continued (page 2.3)

Coordination For Project or Subject Property (or Phase)

Note: For any Coordination of stormwater matters indicated below, attach documentation describing and substantiating any agreements, understandings, contracts, or approvals.

Coordination With Other Departments of **Jurisdiction City** (Bryan or College Station)	Dept.	Contact:	Date:	Subject:

Coordination With **Non-jurisdiction City** Needed? Yes ____ No ____	Summarize need(s) & actions taken (include contacts & dates):
Coordination with Brazos County Needed? Yes ____ No ____	Summarize need(s) & actions taken (include contacts & dates):
Coordination with TxDOT Needed? Yes _____ No ____	Summarize need(s) & actions taken (include contacts & dates):
Coordination with TAMUS Needed? Yes ____ No ____	Summarize need(s) & actions taken (include contacts & dates):

Permits For Project or Subject Property (or Phase)

As to stormwater management, are permits required for the proposed work from any of the entities listed below? If so, summarize status of efforts toward that objective in spaces below.

Entity	**Permitted or Approved ?**	**Status of Actions** (include dates)
US Army Crops of Engineers No _____ Yes ___		
US Environmental Protection Agency No ____ Yes ___		
Texas Commission on Environmental Quality No _____ Yes ____		
Brazos River Authority No _____ Yes ___		

Part 3 – Property Characteristics	Start (Page 3.1)

Nature and Scope of Proposed Work

Existing: Land proposed for development currently used, including extent of impervious cover?

Site Development Project (select all applicable)	_____ Redevelopment of one platted lot, or two or more adjoining platted lots. _____ Building on a single platted lot of undeveloped land. _____ Building on two or more platted adjoining lots of undeveloped land. _____ Building on a single lot, or adjoining lots, where proposed plat will not form a new street (but may include ROW dedication to existing streets). _____ Other (explain):
Subdivision Development Project	_____ Construction of streets and utilities to serve one or more platted lots. _____ Construction of streets and utilities to serve one or more proposed lots on lands represented by pending plats.
Describe Nature and Size of Proposed Project	Site projects: building use(s), approximate floor space, impervious cover ratio. Subdivisions: number of lots by general type of use, linear feet of streets and drainage easements or ROW.

Is any work planned on land that is not platted or on land for which platting is not pending? _____ No _____ Yes	If yes, explain:

FEMA Floodplains

Is any part of subject property abutting a Named Regulatory Watercourse (Section II, Paragraph B1) or a tributary thereof?	No _____ Yes _____
Is any part of subject property in floodplain area of a FEMA-regulated watercourse?	No _____ Yes _____ Rate Map _____
Encroachment(s) into Floodplain areas planned? No _____ Yes _____	Encroachment purpose(s): _____ Building site(s) _____ Road crossing(s) _____ Utility crossing(s) _____ Other (explain):

If floodplain areas not shown on Rate Maps, has work been done toward amending the FEMA-approved Flood Study to define allowable encroachments in proposed areas? Explain.

Part 3 – Property Characteristics	Continued (Page 3.2)
Hydrologic Attributes of Subject Property (or Phase)	
Has an earlier hydrologic analysis been done for larger area including subject property?	
Yes ____	Reference the study (& date) here, and attach copy if not already in City files.
	Is the stormwater management plan for the property in substantial conformance with the earlier study? Yes _____ No _____ If not, explain how it differs.
No ____	If subject property **is not** part of multi-phase project, describe stormwater management plan for the property in Part 4.
	If property **is** part of multi-phase project, provide overview of stormwater management plan for **Project Area** here. In Part 4 describe how plan for subject property will comply therewith.
Do existing topographic features on subject property store or detain runoff? _____ No _____ Yes Describe them (include approximate size, volume, outfall, model, etc).	
Any known drainage or flooding problems in areas near subject property? _____ No _____ Yes Identify:	
Based on location of study property in a watershed, is **Type 1 Detention** (flood control) needed? (see Table B-1 in Appendix B) _____ Detention is required. _____ Need must be evaluated. _____ Detention not required.	
If the need for **Type 1 Detention** must be evaluated:	What decision has been reached? By whom?
	How was determination made?

Part 3 – Property Characteristics	Continued (Page 3.3)

Hydrologic Attributes of Subject Property (or Phase) (continued)

Does subject property straddle a Watershed or Basin divide? _____ No _____ Yes If yes, describe splits below. In Part 4 describe design concept for handling this.

Watershed or Basin	Larger acreage	Lesser acreage

Above-Project Areas(Section II, Paragraph B3-a)

Does Project Area (project or phase) receive runoff from upland areas? ____ No ____ Yes
Size(s) of area(s) in acres: 1) _____ 2) _____ 3) _____ 4) _____

Flow Characteristics (each instance) (overland sheet, shallow concentrated, recognizable concentrated section(s), small creek (non-regulatory), regulatory Watercourse or tributary);

Flow determination: Outline hydrologic methods and assumptions:

Does storm runoff drain from public easements or ROW onto or across subject property?
_____ No _____ Yes If yes, describe facilities in easement or ROW:

Are changes in runoff characteristics subject to change in future? Explain

Conveyance Pathways (Section II, Paragraph C2)

Must runoff from study property drain across lower properties before reaching a Regulatory Watercourse or tributary? _____ No _____ Yes

Describe length and characteristics of each conveyance pathway(s). Include ownership of property(ies).

Part 3 – Property Characteristics	Continued (Page 3.4)

Hydrologic Attributes of Subject Property (or Phase) (continued)		
Conveyance Pathways (continued)		
	Do drainage easements exist for any part of pathway(s)? ____ No ____ Yes	If yes, for what part of length? _____% Created by? ____ plat, or _____instrument. If instrument(s), describe their provisions.
Pathway Areas	Where runoff must cross lower properties, describe characteristics of abutting lower property(ies). (Existing watercourses? Easement or Consent aquired?)	
Nearby Drainage Facilities	Describe any built or improved drainage facilities existing near the property (culverts, bridges, lined channels, buried conduit, swales, detention ponds, etc).	
	Do any of these have hydrologic or hydraulic influence on proposed stormwater design? _____ No _____ Yes If yes, explain:	

Part 4 – Drainage Concept and Design Parameters	Start (Page 4.1)
Stormwater Management Concept	
Discharge(s) From Upland Area(s)	
If runoff is to be received from upland areas, what design drainage features will be used to accommodate it and insure it is not blocked by future development? Describe for each area, flow section, or discharge point.	
Discharge(s) To Lower Property(ies) (Section II, Paragraph E1)	
Does project include drainage features (existing or future) proposed to become public via platting? _____ No _____ Yes Separate Instrument? _____No _____Yes	
Per Guidelines reference above, how will runoff be discharged to neighboring property(ies)?	_____ Establishing Easements (Scenario 1) _____ Pre-development Release (Scenario 2) _____ Combination of the two Scenarios
Scenario 1: If easements are proposed, describe where needed, and provide status of actions on each. (Attached Exhibit #_____)	
Scenario 2: Provide general description of how release(s) will be managed to pre-development conditions (detention, sheet flow, partially concentrated, etc.). (Attached Exhibit #_____)	
Combination: If combination is proposed, explain how discharge will differ from pre-development conditions at the property line for each area (or point) of release.	
If Scenario 2, or Combination are to be used, has proposed design been coordinated with owner(s) of receiving property(ies)? _____ No _____ Yes Explain and provide documentation.	

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.2)

Stormwater Management Concept (continued)

Within Project Area Of Multi-Phase Project

Will project result in shifting runoff between Basins or between Watersheds? _____ No _____ Yes	Identify gaining Basins or Watersheds and acres shifting: What design and mitigation is used to compensate for increased runoff from gaining basin or watershed?
How will runoff from **Project Area** be mitigated to pre-development conditions? Select any or all of 1, 2, and/or 3, and explain below.	1. _____ With facility(ies) involving other development projects. 2. _____ Establishing features to serve overall Project Area. 3. _____ On phase (or site) project basis within Project Area.

1. Shared facility (type & location of facility; design drainage area served; relationship to size of Project Area): (Attached Exhibit #_____)

2. For Overall Project Area (type & location of facilities): (Attached Exhibit #_____)

3. By phase (or site) project: Describe planned mitigation measures for phases (or sites) in subsequent questions of this Part.

Are Special Designs Planned? Yes ___ No ___	
	Are aquatic echosystems proposed? _____ No _____ Yes In which phase(s) or project(s)?
	Are other Best Management Practices for reducing stormwater pollutants proposed? _____ No _____ Yes Summarize type of BMP and extent of use:
	If design of any runoff-handling facilities deviate from provisions of B-CS Technical Specifications, check type facility(ies) and explain in later questions. _____ Detention elements _____ Conduit elements _____ Channel features _____ Swales _____ Ditches _____ Inlets _____ Valley gutters ____ Outfalls _____ Culvert features _____ Bridges _____Other

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.3)

Stormwater Management Concept (continued)

Within Project Area Of Multi-Phase Project (continued)

Will Project Area include bridge(s) or culvert(s)? _____ No _____ Yes Identify type and general size and In which phase(s).

If detention/retention serves (will serve) overall Project Area, describe how it relates to subject phase or site project (physical location, conveyance pathway(s), construction sequence):

Within Or Serving Subject Property (Phase, or Site)

If property part of larger Project Area, is design in substantial conformance with earlier analysis and report for larger area? _____ Yes _____ No, then summarize the difference(s):

Identify whether each of the types of drainage features listed below are included, extent of use, and general characteristics.

Are roadside ditches used? ___ Yes ___ No

Typical shape?		Surfaces?
Steepest side slopes:	Usual front slopes:	Usual back slopes:
Flow line slopes: least_____ typical_____ greatest_____		Typical distance from travelway: (Attached Exhibit #_____)

Are longitudinal culvert ends in compliance with B-CS Standard Specifications? _____ Yes _____ No, then explain:

Are streets with curb and gutter used? ___ Yes ___ No

At intersections or otherwise, do valley gutters cross arterial or collector streets? _____ No _____ Yes If yes explain:

Are valley gutters proposed to cross any street away from an intersection? ____ No ____ Yes Explain: (number of locations?)

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.4)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Are streets with curb and gutter used? (continued)	Gutter line slopes: Least _____ Usual _____ Greatest _____		
	Are inlets recessed on arterial and collector streets? _____ Yes _____ No If "no", identify where and why.		
	Will inlets capture 10-year design stormflow to prevent flooding of intersections (arterial with arterial or collector)? _____ Yes _____ No If no, explain where and why not.		
	Will inlet size and placement prevent exceeding allowable water spread for 10-year design storm throughout site (or phase)? _____ Yes _____ No If no, explain.		
	Sag curves: Are inlets placed at low points? _____ Yes _____ No Are inlets and conduit sized to prevent 100-year stormflow from ponding at greater than 24 inches? _____ Yes _____ No Explain "no" answers.		
	Will 100-yr stormflow be contained in combination of ROW and buried conduit on whole length of all streets? _____ Yes _____ No If no, describe where and why.		
	Do designs for curb, gutter, and inlets comply with B-CS Technical Specifications? _____ Yes _____ No If not, describe difference(s) and attach justification.		
Is storm drain system used? Yes ___ No ___	Are any 12-inch laterals used? _____ No _____ Yes Identify length(s) and where used.		
	Pipe runs between system access points (feet):	Typical _____ Longest _____	
	Are junction boxes used at each bend? _____ Yes _____ No If not, explain where and why.		
	Are downstream soffits at or below upstream soffits? Yes _____ No _____ If not, explain where and why:		Least amount that hydraulic grade line is below gutter line (system-wide):

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.5)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Storm drain system (continued) (on separate sheet provide same info. for more instances)	Outfall(s)	Describe watercourse(s), or system(s) receiving system discharge(s) below (include design discharge velocity, and angle between converging flow lines).	
		1) Watercourse (or system), velocity, and angle?	
		2) Watercourse (or system), velocity, and angle?	
		3) Watercourse (or system), velocity, and angle?	
		For each outfall above, what measures are taken to prevent erosion or scour of receiving and all facilities at juncture? 1) 2) 3)	
Are swales used to drain streets? ____ No ____ Yes		Are swale(s) situated along property lines between properties? _____ No _____ Yes Number of instances: _____ For each instance answer the following questions.	
		Surface treatments (including low-flow flumes if any):	
		Flow line slopes (minimum and maximum):	
		Outfall characteristics for each (velocity, convergent angle, & end treatment).	
		Will 100-year design storm runoff be contained within easement(s) or platted drainage ROW in all instances? _____ Yes _____ No If "no" explain:	

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.6)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Roadside Ditches	Are roadside ditches used? _____ No _____ Yes If so, provide the following: Is 25-year flow contained with 6 inches of freeboard throughout ? ____ Yes ____ No Are top of banks separated from road shoulders 2 feet or more? ____ Yes ____ No Are all ditch sections trapezoidal and at least 1.5 feet deep? ____ Yes ____ No	
	For any "no" answers provide location(s) and explain:	
Are swale/conduit combinations used in lieu of open channels? ____ No ____ Yes (on separate sheet provide same information for any additional instances)	If conduit is beneath a swale, provide the following information (each instance).	
	Instance 1 Describe general location, approximate length:	
	Is 100-year design flow contained in conduit/swale combination? ____ Yes ____ No If "no" explain:	
	Space for 100-year storm flow? ROW _____ Easement _____ Width _____	
	Swale Surface type, minimum and maximum slopes:	Conduit Type and size, minimum and maximum slopes, design storm:
	Inlets Describe how conduit is loaded (from streets/storm drains, inlets by type):	
	Access Describe how maintenance access is provided (to swale, into conduit):	
	Instance 2 Describe general location, approximate length:	
	Is 100-year design flow contained in conduit/swale combination? ____ Yes ____ No If "no" explain:	
	Space for 100-year storm flow? ROW _____ Easement _____ Width _____	
	Swale Surface type, minimum and maximum slopes:	Conduit Type and size, minimum and maximum slopes, design storm:
	Inlets Describe how conduit is loaded (from streets/storm drains, inlets by type):	
	Access Describe how maintenance access is provided (to swale, into conduit):	

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.7)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Will swales without buried conduit receive runoff from public ROW or easements? ____ No ____ Yes. Explain	If "yes" provide the following information for each instance:
	Instance 1 Describe general location, approximate length, surfacing:
	Is 100-year design flow contained in swale? ____ Yes ____ No Is swale wholly within drainage ROW? _____ Yes _____ No Explain "no" answers:
	Access Describe how maintenance access is provide:
	Instance 2 Describe general location, approximate length, surfacing:
	Is 100-year design flow contained in swale? ____ Yes ____ No Is swale wholly within drainage ROW? _____ Yes _____ No Explain "no" answers:
	Access Describe how maintenance access is provided:
	Instance 3, 4, etc. If swales are used in more than two instances, attach sheet providing all above information for each instance.
Channel improvements proposed? ____ No ____ Yes Explain	**"New" channels:** Will any area(s) of concentrated flow be channelized (deepened, widened, or straightened) or otherwise altered? ____ No ____ Yes If only slightly shaped, see "Swales" in this Part. If creating side banks, provide information below.
	Will design replicate natural channel? ____ Yes _____ No If "no", for each instance describe section shape & area, flow line slope (min. & max.), surfaces, and 100-year design flow, and amount of freeboard: Instance 1: Instance 2: Instance 3:

Part 4 – Drainage Concept and Design Parameters		Continued (Page 4.8)
Stormwater Management Concept (continued)		
Within Or Serving Subject Property (Phase, or Site) (continued)		
	Channel Improvements (continued)	**Existing channels (small creeks):** Are these used? _____ No _____ Yes If "yes" provide the information below.
		Will small creeks and their floodplains remain undisturbed? ____ Yes ____ No How many disturbance instances? _____ Identify each planned location:
		For each location, describe length and general type of proposed improvement (including floodplain changes):
		For each location, describe section shape & area, flow line slope (min. & max.), surfaces, and 100-year design flow.
		Watercourses (and tributaries): Aside from fringe changes, are Regulatory Watercourses proposed to be altered? _____ No _____ Yes Explain below.
		Submit full report describing proposed changes to Regulatory Watercourses. Address existing and proposed section size and shape, surfaces, alignment, flow line changes, length affected, and capacity, and provide full documentation of analysis procedures and data. Is full report submitted? _____ Yes _____ No If "no" explain:
		All Proposed Channel Work: For all proposed channel work, provide information requested in next three boxes.
		If design is to replicate natural channel, identify location and length here, and describe design in Special Design section of this Part of Report.
		Will 100-year flow be contained with one foot of freeboard? ____ Yes ____ No If not, identify location and explain:
		Are ROW / easements sized to contain channel and required maintenance space? ____ Yes ____ No If not, identify location(s) and explain:

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.9)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Are Detention Facilities Proposed? ____ No ____ Yes

How many facilities for subject property project? _____ For each provide info. below.

For each dry-type facilitiy:	Facility 1		Facility 2	
Acres served & design volume + 10%				
100-yr volume: free flow & plugged				
Design discharge (10 yr & 25 yr)				
Spillway crest at 100-yr WSE?	_____ yes	____ no	_____ yes	____ no
Berms 6 inches above plugged WSE?	_____ yes	____ no	_____ yes	____ no

Explain any "no" answers:

For each facility what is 25-yr design Q, and design of outlet structure?
Facility 1:
Facility 2:

Do outlets and spillways discharge into a public facility in easement or ROW?
Facility 1: ____ Yes ____ No Facility 2: ____ Yes ____ No
If "no" explain:

For each, what is velocity of 25-yr design discharge at outlet? & at spillway?
Facility 1: _____ & _____ Facility 2: _____ & _____
Are energy dissipation measures used? _____ No ____ Yes Describe type and location:

For each, is spillway surface treatment other than concrete? Yes or no, and describe:
Facility 1:
Facility 2:

For each, what measures are taken to prevent erosion or scour at receiving facility?
Facility 1:
Facility 2:

If berms are used give heights, slopes and surface treatments of sides.
Facility 1:
Facility 2:

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.10)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Detention Facilities (continued)

Do structures comply with B-CS Specifications? Yes or no, and explain if "no":

Facility 1;

Facility 2:

For additional facilities provide all same information on a separate sheet.

Are parking areas to be used for detention? _____ No _____ Yes What is maximum depth due to required design storm?

Are culverts used at private crossings? Yes ___ No ___

Roadside Ditches: Will culverts serve access driveways at roadside ditches?
____ No ____ Yes If "yes", provide information in next two boxes.

Will 25-yr. flow pass without flowing over driveway in all cases? _____ Yes ____ No
Without causing flowing or standing water on public roadway? _____ Yes ____ No
Designs & materials comply with B-CS Technical Specifications? _____ Yes ____ No
Explain any "no" answers:

Are culverts parallel to public roadway alignment? _____ Yes _____ No Explain:

Creeks at Private Drives: Do private driveways, drives, or streets cross drainage ways that serve Above-Project areas or are in public easements/ ROW?
_____ No _____ Yes If "yes" provide information below.

How many instances? _____ Describe location and provide information below.

Location 1:

Location 2:

Location 3:

For each location enter value for:	1	2	3
Design year passing without toping travelway?			
Water depth on travelway at 25-year flow?			
Water depth on travelway at 100-year flow?			

For more instances describe location and same information on separate sheet.

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.11)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Are culverts used at public roadway crossings? _____ No _____ Yes
(for more instances of any type describe location and same information on separate sheet)

Named Regulatory Watercourses (& Tributaries): Are culverts proposed on these facilities? _____ No _____ Yes, then provide full report documenting assumptions, criteria, analysis, computer programs, and study findings that support proposed design(s). Is report provided? _____ Yes ____ No If "no", explain:

Arterial or Major Collector Streets: Will culverts serve these types of roadways? _____ No _____ Yes How many instances? _____ For each identify the location and provide the information below.

Instance 1:

Instance 2:

Instance 3:

Yes or No for the 100-year design flow:	1	2	3
Headwater WSE 1 foot below lowest curb top?			
Spread of headwater within ROW or easement?			
Is velocity limited per conditions (Table C-11)?			

Explain any "no" answer(s):

Minor Collector or Local Streets: Will culverts serve these types of streets? _____ No _____ Yes How many instances? _____ for each identify the location and provide the information below:

Instance 1:

Instance 2:

Instance 3:

For each instance enter value, or "yes" / "no" for:	1	2	3
Design yr. headwater WSE 1 ft. below curb top?			
100-yr. max. depth at street crown 2 feet or less?			
Product of velocity (fps) & depth at crown (ft) = ?			
Is velocity limited per conditions (Table C-11)?			
Limit of down stream analysis (feet)?			

Explain any "no" answers:

Part 4 – Drainage Concept and Design Parameters			Continued (Page 4.12)
Stormwater Management Concept (continued)			
Within Or Serving Subject Property (Phase, or Site) (continued)			
	Culverts (continued)	**All Proposed Culverts:** For all proposed culvert facilities (except driveway/roadside ditch intersects) provide information requested in next eight boxes.	
		Do culverts and travelways intersect at 90 degrees? ____ Yes ____ No If not, identify location(s) and intersect angle(s), and justify the design(s):	
		Does drainage way alignment change within or near limits of culvert and surfaced approaches thereto? ____ No ____ Yes If "yes" identify location(s), describe change(s), and justification:	
		Are flumes or conduit to discharge into culvert barrel(s)? _____ No ____ Yes If yes, identify location(s) and provide justification:	
		Are flumes or conduit to discharge into or near surfaced approaches to culvert ends? _____ No ____ Yes If "yes" identify location(s), describe outfall design treatment(s):	
		Is scour/erosion protection provided to ensure long term stability of culvert structural components, and surfacing at culvert ends? _____ Yes ____ No If "no" Identify locations and provide justification(s):	
		Will 100-yr flow and spread of backwater be fully contained in street ROW, and/or drainage easements/ ROW? ____ Yes ____ No if not, why not?	
		Do appreciable hydraulic effects of any culvert extend downstream or upstream to neighboring land(s) not encompassed in subject property? _____ No _____ Yes If "yes" describe location(s) and mitigation measures:	
		Are all culvert designs and materials in compliance with B-CS Tech. Specifications? _____ Yes ____ No If not, explain in Special Design Section of this Part.	

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.13)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Bridge(s)	Is a bridge included in plans for subject property project? ____ No ____ Yes If "yes" provide the following information.	
	Name(s) and functional classification of the roadway(s)?	
	What drainage way(s) is to be crossed?	
	A full report supporting all aspects of the proposed bridge(s) (structural, geotechnical, hydrologic, and hydraulic factors) must accompany this summary report. Is the report provided? ____ Yes ____ No If "no" explain:	
Water Quality	Is a Stormwater Pollution Prevention Plan (SW3P) established for project construction? ____ No ____ Yes	Provide a general description of planned techniques:

Special Designs – Non-Traditional Methods

Are any non-traditional methods (aquatic echosystems, wetland-type detention, natural stream replication, BMPs for water quality, etc.) proposed for any aspect of subject property project?
____ No ____ Yes If "yes" list general type and location below.

Provide full report about the proposed special design(s) including rationale for use and expected benefits. Report must substantiate that stormwater management objectives will not be compromised, and that maintenance cost will not exceed those of traditional design solution(s). Is report provided? _____ Yes _____ No If "no" explain:

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.14)

Stormwater Management Concept (continued)

Within Or Serving Subject Property (Phase, or Site) (continued)

Special Designs – Deviation From B-CS Technical Specifications

If any design(s) or material(s) of traditional runoff-handling facilities deviate from provisions of B-CS Technical Specifications, check type facility(ies) and explain by specific detail element.
_____ Detention elements _____ Drain system elements _____ Channel features
_____ Culvert features _____ Swales _____ Ditches _____ Inlets ____Outfalls
_____ Valley gutters _____ Bridges (explain in bridge report)

In table below briefly identify specific element, justification for deviation(s).

Specific Detail Element	Justification for Deviation (attach additional sheets if needed)
1)	
2)	
3)	
4)	
5)	

Have elements been coordinated with the City Engineer or her/his designee? For each item above provide "yes" or "no", action date, and staff name:
1)
2)
3)
4)
5)

Design Parameters

Hydrology

Is a map(s) showing all Design Drainage Areas provided? _____ Yes _____ No

Briefly summarize the range of applications made of the Rational Formula:

What is the size and location of largest Design Drainage Area to which the Rational Formula has been applied? _____ acres Location (or identifier):

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.15)

Design Parameters (continued)

Hydrology (continued)

In making determinations for time of concentration, was segment analysis used?
____ No ____ Yes In approximately what percent of Design Drainage Areas? _____ %

As to intensity-duration-frequency and rain depth criteria for determining runoff flows, were any criteria other than those provided in these Guidelines used? _____ No ____Yes If "yes" identify type of data, source(s), and where applied:

For each of the stormwater management features listed below identify the storm return frequencies (year) analyzed (or checked), and that used as the basis for design.

Feature	Analysis Year(s)	Design Year
Storm drain system for arterial and collector streets		
Storm drain system for local streets		
Open channels		
Swale/buried conduit combination in lieu of channel		
Swales		
Roadside ditches and culverts serving them		
Detention facilities: spillway crest and its outfall		
Detention facilities: outlet and conveyance structure(s)		
Detention facilities: volume when outlet plugged		
Culverts serving private drives or streets		
Culverts serving public roadways		
Bridges: provide in bridge report.		

Hydraulics

What is the range of design flow velocities as outlined below?

Design flow velocities;	Gutters	Conduit	Culverts	Swales	Channels
Highest (feet per second)					
Lowest (feet per second)					

Streets and Storm Drain Systems Provide the summary information outlined below:

Roughness coefficients used: For street gutters: _____

For conduit type(s) _____ _____ Coefficients: _____ _____

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.16)
Design Parameters (continued)	
Hydraulics (continued)	
Street and Storm Drain Systems (continued)	
For the following, are assumptions other than allowable per Guidelines? Inlet coefficients? ____ No ____ Yes Head and friction losses ____ No ____ Yes Explain any "yes" answer:	
In conduit is velocity generally increased in the downstream direction? ____ Yes ____ No Are elevation drops provided at inlets, manholes, and junction boxes? ____ Yes ____ No Explain any "no" answers:	
Are hydraulic grade lines calculated and shown for design storm? ____ Yes ____ No For 100-year flow conditions? ____ Yes ____ No Explain any "no" answers:	
What tailwater conditions were assumed at outfall point(s) of the storm drain system? Identify each location and explain:	
Open Channels If a HEC analysis is utilized, does it follow Sec VI.F.5.a? ____ Yes ____ No	
Outside of straight sections, is flow regime within limits of sub-critical flow? ____ Yes ____ No If "no" list locations and explain:	
Culverts If plan sheets do not provide the following for each culvert, describe it here.	
For each design discharge, will operation be outlet (barrel) control or inlet control?	
Entrance, friction and exit losses:	
Bridges Provide all in bridge report	

Part 4 – Drainage Concept and Design Parameters	Continued (Page 4.17)

Design Parameters (continued)

Computer Software

What computer software has been used in the analysis and assessment of stormwater management needs and/or the development of facility designs proposed for subject property project? List them below, being sure to identify the software name and version, the date of the version, any applicable patches and the publisher

Part 5 – Plans and Specifications

Requirements for submittal of construction drawings and specifications do not differ due to use of a Technical Design Summary Report. See Section III, Paragraph C3.

Part 6 – Conclusions and Attestation

Conclusions

Add any concluding information here:

Attestation

Provide attestation to the accuracy and completeness of the foregoing 6 Parts of this Technical Design Summary Drainage Report by signing and sealing below.

"This report (plan) for the drainage design of the development named in Part B was prepared by me (or under my supervision) in accordance with provisions of the Bryan/College Station Unified Drainage Design Guidelines for the owners of the property. All licenses and permits required by any and all state and federal regulatory agencies for the proposed drainage improvements have been issued or fall under applicable general permits."

(Affix Seal)

_____

Licensed Professional Engineer

*State of Texas PE No.*_____

Appendix E
Best Management Practices

Unified Stormwater Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

As defined in Section VIII of these Guidelines, improving stormwater quality is a worthy objective. At key points, the Guidelines encourage special designs aimed at improving the quality of stormwater discharged into the region's major streams and waterways. Specific details for such designs are not stipulated. Rather, applications are left to the creativity of qualified engineers and environmental specialists who serve the development community.

This Appendix is provided in order to facilitate and foster design solutions that will help improve water quality. The effectiveness of the techniques outlined herein is very dependent on proper application and implementation, and is in no way assured. Likewise their use does not assure achieving public safety objectives, and can work against those objectives if improperly conceived or deployed.

Special designs may propose using any of the examples outlined herein or other techniques that may have been implemented in other jurisdictions. It is highly recommended that any special design concepts be carefully coordinated with the City Engineer or his/her designee as early as possible in design processes. It shall be the designers' responsibility to substantiate that the special design does not compromise public safety objectives or aggravate long term maintenance requirements.

"Best Management Practices"

In their publication "National Menu of Best Management Practices For Storm Water Phase II", the US Environmental Protection Agency (EPA) has advanced a number of concepts for managing urban stormwater runoff in a manner that will enhance water quality. The techniques are intended to provide guidance to regulated small MS4s. This Appendix provides a brief introduction to several of those techniques. They are offered only as examples. There is no requirement to use them, nor are they specifically recommended over other potential design solutions. Likewise, designers should not limit their thinking to only these examples.

All of the techniques offered by the EPA have been used at various locations and have been scientifically evaluated for their general effectiveness. The specific chemical or physical effectiveness of the techniques is beyond the scope of these Guidelines, as are their advantages and disadvantage in terms of initial cost, comparative costs, or maintenance ramifications. Nevertheless, these later issues must be addressed in technical reports substantiating special design proposals. The designers' attention is directed to the aforementioned publication for the information necessary to implement these and other techniques.

Retention / Irrigation Basins

Retention refers to the idea of capturing stormwater and retaining it, as opposed to simply collecting it and metering its release at some pre-determined flow rate. As suggested by the title, the concept of this technique is to collect runoff into a holding pond and then draw from it to irrigate landscaped areas. The intent is to replicate natural situations where the majority of rainfall is infiltrated into the soil or underlying groundwater, and pollutants are captured by soils. In addition, particles settle while the water is pooled.

Extended Detention Basins

A traditional detention facility captures storm flow and releases it at a pre-determined rate, one associated with pre-development conditions, with no particular consideration for water quality objectives. An "extended detention basin" functions in a similar way but is designed to release the collected water at a much slower rate, one that causes the water to remain pooled much longer, usually on the order of 24 hours. This allows time for suspended solids to settle, and can derive other water quality benefits. Such a facility should serve no more than 100 acres, and generally requires a slower release rate and a larger storage volume than a traditional detention facility.

Grassy Swales

A grassy swale is a specially designed channel. With very flat side slopes (4:1 or flatter), it is wider than it is deep. The flow line slope should be between one percent and five percent, and the surfaces must be covered with vegetation, generally close-growing, water-resistant grasses. The idea is simple: as runoff flows over and through the grass at a shallow depth and slow rate, particles tend to settle and biological uptake of pollutants tends to occur.

Vegetative Filter Strips

As suggested by the name, this technique involves long strips of vegetated area placed so that runoff will traverse their length in route to lower areas. The idea is to bring runoff to the strips in broad sheet flow or in uniform shallow overland flow, not in a concentrated manner. As stormwater moves through the strip(s) in very shallow flow at a slow rate, the vegetation tends to cause particles to settle and biological filtration of pollutants.

Sand Filter Systems

These systems can vary widely in their design but in any case require carefully specified and constructed components in order to be effective. Generally, two chambers are required, one for sedimentation and another for filtration. Runoff first enters the sedimentation chamber where larger solids are collected. Next it seeps through the sand bed in the filtration chamber. There, a specially designed sand bed composed of sand, gravel, and filter fabric in just the right combinations and having just the right physical characteristics, captures a range of other pollutants. Water is finally released through perforated collection pipe(s) situated beneath the sand bed system.

A "full sedimentation" system includes a wall with a riser pipe between the two chambers. This type requires the first chamber to be sized for the entire design capture volume. A "partial sedimentation" system includes a porous separation between the two chambers so larger solids may not pass into the filtration chamber. In this type, the two chambers together are sized for the entire design capture volume.

Wet Basins

In simplest terms a wet basin is designed to retain a pool of water year-round. Whereas a traditional detention facility has an outlet near its bottom, a wet basin has an outlet located near its top. With no lower outlet, the facility must fill to the level of the top outlet before any water is released, and it does not drain. In addition, a wet basin typically has a standing crop of water-tolerant vegetation along its usual waterline.

A wet basin should have two components: a sediment forebay and a main pool. Runoff first moves through the forebay where gross solids are captured. It then fills the main pool basin until overflowing through an outlet spillway. Properly sized, such a basin will capture the desired volume of water before allowing discharge. In this way it acts as a stilling basin allowing solids to settle. One objective is for the aquatic environment to eliminate pollutants through wetland plant uptake and microbial degradation. In dry climates supplemental water sources may be necessary in order to maintain a pool level supportive of the aquatic environment.

Constructed Wetlands

The concept of a constructed wetland is to gain the pollutant removal characteristics of a natural wetland environment. Among these are settling of solids, wetland plant uptake, and microbial degradation. Extremely wide variations in design are possible. The facility is similar to a wet basin because it must be wet year-round, but it is shallow and marsh-like, creating conditions supporting abundant vegetation and microbial population. Micro-pools, small islands for waterfowl habitat, and multiple species of trees, shrubs, and plants are among the design elements that must be balanced for the facility to be successful.

A constructed wetland has four principal components: a splitter box, a sedimentation forebay, the wetland zone (“pond”), and the outlet structure. The splitter box diverts flow from the main flow path to the entrance, keeping away anything more than the design flow (usually a 25-year storm). From the splitter box, runoff moves into the forebay where gross solids are captured before flowing into the wetland zone. In the wetland zone, runoff moves through multiple irregular flow paths and micro-pool areas filling the wetland “pond” to no more than two feet above its usual water surface elevation. The outlet structure must allow the water level to gradually decrease to its normal elevation. If storm flow rushes through the facility or keeps it inundated too long, the aquatic echosystem can be damaged. In dry climates supplemental water sources may be necessary in order to maintain a water level supportive of the aquatic environment.

Appendix F
Quality Control

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

BEST MANAGEMENT PRACTICES – STORMWATER QUALITY CONTROLS

	Construction Stages / Sequencing	Non-Structural	Structural
1	Pre-construction / Survey clearing / limited ground disturbance	• Establishment of Trees to protect (if desired) • Limited equipment (no tracked equipment)– no significant ground vegetation disturbance	
2	Install Detention Facilities – rough graded to capture runoff	• Install waste receptacles on site • Temporary Sanitary Facilities (port-a-potties) • Designate concrete / equipment washout area • Install Temporary Construction Access • Install storm sewer inlet protection (existing inlets)	• Silt Retention Devices (ex. Silt fence, check dams) • Sedimentation Traps / ponds / baffles • Rough grade detention ponds • Outlet structure installed • Slope protection measures
3	Full Clearing and Grading	• Dust Control (wetting disturbed areas) (daily) • Street Sweeping (daily)	• Maintain Silt Retention Devices • Rough Grade property to drain to ponds • Slope protection measures
4	Utility Infrastructure & Drainage System	• New Storm inlet protection • Proper directing of rainwater pumping from construction ditches	• storm sewers / inlets • Detention Pond • Onsite Utilities installed
5	Site Development (buildings)	• Utilize washout areas • Maintain trash and sanitary facilities • Installation of roof gutters directed to storm system • Dust Control (wetting disturbed areas) (daily) • Street Sweeping (daily)	• Install paving on site (minimize erosion) – done before building foundations
6	Site Stabilization	• Maintenance Bond (1 year) provided to cover public infrastructure and final site stabilization	• Full grass / landscape coverage and establishment • Removal of silt retention devices upon grass establishment

Appendix G
Glossary

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

Abbreviated Drainage Plan

A brief written plan stating and schematically showing how a small proposed **land development project** will satisfy stormwater management requirements of these **Guidelines**. Generally this is applicable only to projects that will be devoid of detention facilities and public stormwater infrastructure of any kind. This may be accomplished with a site plan showing vertical dimensional controls or a site grading plan.

Above-Project Area

Land area(s) adjoining or near a proposed **land development project** that contributes stormwater runoff to, or through, the project at the time of hydrologic analysis or in the future. Above-project areas are included in the **drainage study area**.

Anticipated Development

Full potential urbanization of a **basin** or **watershed** area in compliance with the Comprehensive Plan. Such an area may include one or more subdivisions, one or multiple property holdings, wholly undeveloped land or both developed and undeveloped land areas.

Area Engineer

The Bryan District Office of the Texas Department of Transportation (TxDOT) operates several Area Offices, each of which has responsibility for several counties. The engineer in charge of each Area Office has the title of **Area Engineer**.

Areas (Hydrologic)

For uniformity of meaning within these **Guidelines** land areas are defined according to the general hierarchy listed below. Specific definitions of each are included in the Glossary.

Watershed (area)
- **Basin** (area)
  - **Drainage Study Area**
    - **Project Area**
      - **Above-Project Area**
        - **Pathway Area**
          - **Design Drainage Area**

Base Flood

The flood having a one percent chance of being equaled or exceeded in any given year, also known as “100 year” flood.

Basin

A land area making up a portion of a **watershed**. A basin can be thought of as the entire area contributing storm flow to a **watercourse** serving as a tributary to a **principal named stream**. Several basins usually comprise a **watershed**.

B-CS Technical Specifications

All items pertinent to design or construction of stormwater facilities of any kind included in the latest adopted version of the Bryan-College Station Unified Techncial Specifications and Standard Details. See "**Technical Specifications**"

Buildout Condition

Full completion of any land development project in all of its phases, if any, representing the entire contiguously owned tract(s), whether proposed for near-term or possible future development. This refers to: completion of any single-lot site project; the final completion of any multi-stage project entailing a site project staged over time; or final completion of multiple subdivision projects collectively making up a parent tract (or preliminary plat submittal) representing ownership of an un-platted parcel of land regardless of size.

BFE – Base Flood Elevation

The high water surface elevation(s) along a **watercourse** resulting from the **base flood** passing down that **watercourse**.

CFS A measure of water flow in cubic feet per second

City Either the City of Bryan or the City of College Station as applicable

City Engineer

The official city engineer of Bryan or College Station as applicable

Cities

The cities of Bryan and College Station collectively, or each individually.

CLOMR

Conditional Letter of Map Revision as related to **FEMA** requirements for managing **FEMA**-designated flood prone areas

Comprehensive Plan

The urban general plan officially adopted by the **City**

Conveyance Pathway

An identifiable route by which concentrated (non-sheet flow) stormwater will travel within and from a **project area** to a discharge point at a main channel of the Primary Drainage System

County Engineer

The principal person in Brazos County government who has responsibility for engineering decisions.

Conveyance Pathway Area

See "**Pathway Area**"

Datum Any level surface to which elevations are referred (for example, mean sea level); is also referred to as datum plane, although it is not actually a plane

Design Drainage Area

The surface area contributing stormwater runoff to any particular point of design in a stormwater management system of any kind. Examples can range in size from the area contributing to a single curb inlet, to that contributing to a flood control facility astride a major stream. Depending on the point of design, the design drainage area can equal an entire **watershed**, an entire **basin**, a **drainage study area**, an **off-project ar**ea, a **project area** or portion(s) of any of these areas.

Detention

Temporary storage and metered release of stormwater

Detention Facility

A permanent facility designed for the temporary storage and metered release of stormwater without creating a permanent pool of water.

Discharge

Stormwater out flow from an area of any kind, or from a storm water feature such as a conduit or a detention facility.

Drainage Development Permit

A permit issued by the **City** that allows the start of clearing, grubbing, or earthwork as the early stage(s) of a land development project, based on an approved **drainage plan** or an approved **abbreviated drainage plan**.

Drainage Easement

An interest in land granted to the **City** for the maintenance of a **drainage facility**, on which certain uses are prohibited; and providing for the entry and operation of machinery and vehicles for maintenance purposes.

Drainage Facilities

All elements (public and private) necessary to manage and convey stormwater runoff from its initial contact with earth to its disposition in a **watercourse** making up the primary drainage system of the Bryan-College Station area. These may include but are not limited to storm sewers, improved channels, unimproved drainage ways, areas within **drainage easements** or **drainage right of way** providing concentrated or overland sheet flow, and all appurtenances to the foregoing, such as inlets, manholes, junction boxes, headwalls, culverts, etc.

Drainage Plan

A detailed representation of how stormwater will be managed as part of a proposed **land development project** (site or subdivision). Usually accompanied by (or incorporated into) an engineering report, it is to be based on an approved **preliminary drainage plan**

Drainage Report

A report, prepared by a Registered Professional Engineer, that presents the **drainage plan** for a **land development project** (site or subdivision) in compliance with the provisions of these **Guidelines**. It must document the hydrologic and hydraulic analyses accomplished to address the **project area**, **above-project area**(s) and **pathway area**(s), and any watercourse conveying stormwater to or from the **project area**.

Drainage Study

See "**Drainage Report**".

Drainage Study Area

The full extent of land area that must be analyzed for the effects of stomrwater runoff, whether part of a project, upland of the project, or contributing stormwater runoff to the **conveyance pathway** downstream of the project. The drainage study area is equal in size to the sum of the **project area,** the **above-project area**, if any, and the **pathway area**, if any.

Drainage Right Of Way

An area of land dedicated to the **City** for the purposes of conveying and containing stormwater flow, constructing drainage facilities, and/or allowing entry and/or operation of equipment for maintaining such drainage features and facilities.

Elevation

The vertical distance from a datum, usually the NGVD, to a point or object. For example, if the elevation of point "A" is 802.46 feet, point "A" is 802.46 feet above some datum.

Encroachment

Existing or proposed buildings, foundations, drainage structures, streets (including bridges and culverts), utilities, or earthwork of any kind which is situated in **floodplain**, or **flood fringe** areas, the geographic limits of which are defined on the official **Flood Insurance Rate Maps** of the **City**.

Equal Encroachment

Equitable **encroachment** into **floodplain** or **flood fringe** areas along a significant reach of both sides of a **watercourse**, as a function of "low side" and "high side" hydrologically proportionate areas.

Engineer

A Registered Professional Engineer duly authorized and licensed, under provisions of the Texas Engineering Practice Act, to practice the profession of engineering.

Erosion

The process whereby the surface of the earth is loosened and carried away by the action of wind, water, gravity, ice, or a combination thereof.

Existing Condition

The hydrologic condition of the **project area** or the **drainage study area** that exists (or existed) prior to any proposed land development work and at the time for which a hydrologic analysis is conducted. Where man-made topographic features predate adoption of these **Guidelines**, such features shall be considered "exiting condition".

Extraterrritorial Jurisdiction (ETJ)

Within the terms of the Texas Municipal Annexation Act, means the unincorporated area, not a part of any other city, which is contiguous to the Corporate Limits of the **City**, the outer boundaries of which are measured from the extremities of the corporate limits of the **City** outward for such distances as may be stipulated in the Texas Municipal Annexation Act, in which area, within the terms of the act, the **City** may enjoin the violation of its subdivision control ordinance.

FEMA Federal Emergency Management Agency of the US Government

F.H.A. Federal Housing Administration, an agency of the US Government.

Flood Insurance Map

See "**Flood Insurance Rate Map"**

Flood Insurance Rate Map

Any of a series of maps published by **FEMA** that depicts the geographic limits of flood prone areas along the principle **watercourse**s of the **Cities**, for the purpose of identifying those areas in which property owners are eligible to participate in the National Flood Insurance Program.

Floodplain

Overbank areas along a **watercourse** that are subject to inundation by stormflow due to unusually larger storms events.

Flood Study

The official study, or collection of studies, that defines the **flood plains, flood fringe,** and **floodways** of the primary drainage system and tributaries thereof as required in connection with the National Flood Insurance Program sponsored by **FEMA**.

Flooodway

The channel and adjacent overbank areas of a river or other **watercourse** that may not be filled or hydraulically altered if such fill or alterations will cause a cumulatively increase in the **base flood elevation** of more than one foot.

Freeboard

That portion of a channel bank, detention embankment, or other stormwater management facility that is above the water surface elevation expected to be generated by the design storm for which the facility is designed.

Guidelines

The design guidelines referenced in this document: "Bryan and College Station Uniform Stormwater Design Guidelines"

Hydraulics

A branch of science that deals with practical applications (such as the transmission of energy or the efforts of flow) of liquid (such as water) in motion

Hydrology

A science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere

Land Development Project

Any proposed site development or subdivision project requiring building permit(s) or platting under provisions of **City** ordinances.

Legal Lot

A parcel of land having been divided from a parent tract via a plat duly processed and approved by the City, and filed of record in county records under the platting provisions of Texas State Law.

LOMA Letter of Map Amendment as related to **FEMA** requirements for managing **FEMA**-designated flood prone areas

LOMAR

Letter of Map Revision as related to **FEMA** requirements for managing **FEMA**-designated flood prone areas

Lowest Floor

The lowest floor, or the lowest enclosed area (including basement), of a structure. An unfinished or flood resistant enclosure, usable solely for the parking of vehicles, building access or storage, in an area other than a basement area, is not considered a building's lowest floor, provided that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of **City** ordinances.

Master Drainage Plan

An official plan of the **City** for comprehensive management of stormwater runoff in an entire **basin** or **watershed,** or in specific **reaches** thereof.

Mean Sea Level (MSL)

The average height of the surface of the sea for all stages of the tide taken over a 19-year period.

Named Regulatory Watercourse

The major watercourses or streams in the Bryan-College Station region having been ascribed with names and listed in Table B-1, Appendix B.

Natural Land
The cover and topography of land before any man-made changes that would substantively affect the path or intensity of stormwater runoff.

Natural Watercourse
A stream, waterway, or channel more or less in the alignment created by natural forces, with our without man-made alteration of its surfacing and configuration at limited locations.

Pathway Area
Land area(s) that drain to the **conveyance pathway** of a project, but that are not included in the **project area** or **above-project** area(s). See **conveyance pathway area**.

Principal Named Streams (Watercourses)
See "**Named Regulatory Watercourses**"

Preliminary Drainage Plan
See "**Preliminary Drainage Report**"

Preliminary Drainage Report
A report showing a schematic representation of how stormwater will be managed as part of a proposed land development project. It will document pertinent topographic, hydrologic, and land ownership characteristics of all land areas contributing stormflow to a **project area**, as well as all hydrologic parameters proposed for analysis of design stormflow throughout the project.

Project Area
The entire land area of a proposed site development or subdivision project, at **buildout condition**, into which buildings, structures, and/or street and utility facilities are to be constructed. This area(s), together with any **above-project area**(s) and **pathway area**(s) make up the **drainage study area** that must be considered in developing plans for stormwater management facilities for the project.

Project Site
See "**Project Area**"

Reach A length or portion of a **watercourse**, whether wholly natural or influenced by man-made improvements or alterations.

Regional Detention
A flood control facility approved by the **City** as a mechanism for managing stormwater runoff form a large land area comprised of one or more subdivisions, one or multiple property holdings, developed and undeveloped land areas, or any combination of such areas.

Regulatory Watercourses
See "**Named Regulatory Watercourses**"

Regulatory Watershed

The total land area that contributes stormwater runoff to a **named regulatory watercourse** in the Bryan-College Station region. Each such watercourse has a watershed area that is made up of **basins**. The sum of the land area(s) in a watershed's **basins** equals the land area of the watershed.

Retention Facility

A facility that provides for the storage of stormwater flows by means of a permanent pool of water or a permanent pool in conjunction with a temporary storage component.

Right of Way

Land set aside for street and storm drain facilities or utilities, or exclusively for stormwater management purposes.

Rural Residential

A term referring to a category of land use zoning. See **Urban Estates**.

Rural Subdivision

An area of land divided by platting into lots none of which are smaller than one (1) acre, and which is served by roadways having a rural cross section (one characterized by presence of roadside ditches and no curb and gutter). See also **Urban Estates.**

Sedimentation

Deposits of detached soil particles or rock fragments after being transported from their site or origin by runoff water.

Site See "**Site Project**".

Site Project

A land area consisting of a single platted lot or two or more contiguous platted lots upon which a building project is planned, consisting of building structures, parking, and other facilities and exclusive of public streets. A site project may or may not include public utilities situated in easements, or stormwater management facilities situated in drainage right of way. See "**Site**"

Special Design

Any stormwater management facility or technique the design of which is not specifically addressed by these **Guidelines** or the B-CS Technical Specifications.

Standard Specifications for Construction

See **Technical Specifications**

Stormwater Planning Conference
A meeting between property owners/developers (including their representatives) and the **City Engineer** (or his/her designee) for the purpose of identifying how these Guidelines and the provisions of stormwater management ordinances relate to land area(s) proposed for near-term or future development.

Sructure
A walled and roofed building that is principally above the ground, as well as a manufactured home.

Study Limits
Associated with a drainage study for a **drainage report**, this is the geographic limits of the hydrologic and hydraulic analyses that are required for the study.

Subdivision Project
A land development project involving the division of land into lots and ROW for public streets and utilities or the dividing of land into individual lots for near term construction or planned long term construction of **site projects**.

Surveyor
A Registered Public Surveyor or Registered Land Surveyor as licensed by the State of Texas.

Swale A shallow drainage way characterized as having a "V" shape the sides of which have very flat slopes, generally on the order of sides 6 horizontal to 1 vertical (6:1) or flatter.

TAMU Texas A&M University

TAMUS The Texas A&M University System

Technical Design Summary
A drainage report format that may be used in lieu of a traditional prose report. Following a question/answer process, it is to use the forms provided in Appendix D, with attachments as needed.

Technical Specifications
See "**B-S Technical Specifications**"

Tributaries
Waterways, watercourses, streams, or creeks that directly flow into the Named Regulatory Watercourses of the Bryan and College Station region. Some may be referred to by a name on maps or other reference.

TxDOT Texas Department of Transportation.

Ultimate Development

This term generally relates to the extent to which impervious materials and plant growth will, at some future time, cover land contributing stormwater runoff to one or more design points in a stormwater management system. Of necessity this requires some plan or a series of assumptions about future characteristics of undeveloped areas. See **Anticipated Development**

Urban Estates

A class of zoning resulting in single family homes on relatively large lots, generally one acre or larger. See **Rural Subdivision**.

Watercourse

Any depression, channel, storm sewer, or culvert serving to give direction to a current of stormwater.

Watershed

See "**Regulatory Watershed**"

Appendix H
General References

Unified
Stormwater
Design Guidelines

City of College Station
City of Bryan

AUGUST 2012

APPENDIX H – REFERENCES

The following sources were consulted directly or indirectly by reference in the development of these Guidelines:

Drainage Criteria Manual, City of Temple, November 1996.

Drainage Criteria Manual, Montgomery County, 1989.

Drainage Design Guidelines, City of Bryan, 2003.

Drainage Manual, City of Austin, June 1993.

Drainage Policy and Design Standards, City of College Station, 1986

Environmental & Municipal Update, Lloyd Gosselink, Attorneys at Law, April 2005

Environmental & Municipal Update, Lloyd Gosselink, Attorneys at Law, January 2006.

Erosion and Sediment Control Guidelines for Developing Areas in Texas, Soil Conservation Service, US Department of Agriculture.

"Erosion and Sedimentation Control Measures", short course by Engineering Utilities and Public Works Training Institute, Texas Engineering Extension Service, Texas A&M University System, 2003.

Haestad Method's Culvert Master

Hydraulic Design Manual, Texas Department of Transportation, November 2002.

Mitigation Guidelines Regulatory Program, Fort Worth District, US Army Corps of Engineers, December 2003.

National Menu of Best Management Practices For Stormwater Phase II, US Environmental Protection Agency, August 2002.

Regulatory Program Overview, Fort Worth District, US Army Corps of Engineers, March 2003

Rossmiller, R.,L. “The Rational Formula Revisited”

Urban Hydrology for Small Watersheds, Technical Release No. 55, Soil Conservation Service (National Resource Conservation Service) US Department of Agriculture, June 1986.

Walsh (1989) from Chow (1959)

Water Resources and Environmental Engineering

Appendix M: Local Adoption Resolution

RESOLUTION NO. 3761

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF BRYAN, TEXAS, ADOPTING THE FLOOD MITIGATION PLAN THAT ESTABLISHES BOTH LONG TERM AND SHORT TERM GOALS FOR THE CITY OF BRYAN TO REDUCE FLOODING AND THE IMPACTS OF FLOODING THROUGHOUT THE CITY; AND PROVIDING AND EFFECTIVE DATE.

WHEREAS, the City of Bryan is located in a humid area of southeast Texas that receives substantial amounts of rainfall each year; and

WHEREAS, several of the creeks and their tributaries throughout the city overtop their banks during large rain events causing flooding; and

WHEREAS, the City of Bryan is dedicated to protecting the health and safety of its citizens and aims to provide the ability to obtain low cost flood insurance to all properties; and

WHEREAS, the City of Bryan is currently a member of the Community Rating System (CRS) administered through the National Flood Insurance Program. The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program requirements of FEMA, and as a result of being a CRS member, the City of Bryan provides a direct benefit to the citizens of Bryan by making available to them discounted rates on flood insurance policies that are purchased through the National Flood Insurance Program.

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF BRYAN, TEXAS AS FOLLOWS:

1.

The 2018 Flood Mitigation Plan as prepared and presented is hereby designated the official Flood Mitigation Plan of the City of Bryan.

2.

The Flood Mitigation Plan aims to educate and encourage support for projects that will prevent new flooding problems, reduce flood losses and protect the beneficial functions of our floodplains.

3.

The Flood Mitigation Plan states several goals including developing and improving outreach and public awareness of flooding dangers, protecting and enhancing natural floodplain/stormwater resources, providing fiscally responsible funding, and protecting the health and public safety of the citizens of Bryan.

4.

This resolution shall be effective immediately upon its adoption.

APPROVED AND ADOPTED BY THE CITY COUNCIL OF THE CITY OF BRYAN ON THE 12TH DAY OF JUNE 2018.

ATTEST:

Mary Lynne Stratta, City Secretary

CITY OF BRYAN:

~~Andrew Nelson~~, Mayor Pro Tem

APPROVED AS TO FORM:

Janis Hampton, City Attorney

Appendix N: Review Possible Activities Worksheets

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Preventive

Activity	Applicable (Y/N)	Pros	Cons
Floodplain Mapping and data	Yes	Impact analysis, preventive planning	Cost, accuracy
Open Space Preservation	Yes	Preserving natural resources	Not efficient for development
Floodplain Regulations	Yes	Prevent destruction and construction in natural floodplain reserves	Maintenance, not efficient for development
Erosion Setbacks	Yes	Protects property damage from occurring	Takes potential developable land
Planning and zoning	No		
Stormwater management	Yes	Limit impacts on natural resources	Funding
Drainage system maintenance	Yes	Limit impacts on natural resources	Funding
Building codes	No		

Goal 2: Provide fiscally responsible funding.

Preventive

Activity	Applicable (Y/N)	Pros	Cons
Floodplain Mapping and data	Yes	Preventative planning, impact analysis	Take away from other programs
Open Space Preservation	No		
Floodplain Regulations	No		
Erosion Setbacks	No		
Planning and zoning	No		
Stormwater management	Yes	Reduce flooding	Compete for funding
Drainage system maintenance	Yes	Maintain existing drainage capacity	Compete for funding
Building codes	No		
Create CIP Program	Yes	Prevent flooding, buyouts	Takes away from other programs

Goal 3: Develop and improve outreach and public awareness.

Preventive

Activity	Applicable (Y/N)	Pros	Cons
Floodplain Mapping and data	Yes	Shows public where problems are	Accuracy and funding
Open Space Preservation	No		
Floodplain Regulations	Yes	Educate the citizens about requirements to help reduce flooding	Limits on development
Erosion Setbacks	No		
Planning and zoning	Yes	Educate the citizens, developers, engineers, and contractors about design standards to help reduce flooding	Increased development costs
Stormwater management	No		
Drainage system maintenance	Yes	Educate the citizens to help reduce flooding, reporting issues to the city ahead of a flood, clogged storm drain	Funding
Building codes	Yes	Educate the citizens, developers, engineers, and contractors to help reduce flooding	Funding

Goal 4: Protect health and safety of the public.

Preventive

Activity	Applicable (Y/N)	Pros	Cons
Floodplain Mapping and data	Yes	Understand current and potential impacts	Funding of data, accuracy
Open Space Preservation	Yes	Preserves natural & beneficial functions	Not efficient for development
Floodplain Regulations	Yes	Preventing construction in the FP	Feasibility for owners/developers
Erosion Setbacks	Yes	Protects private/public property	Development restriction
Planning and zoning	Yes	Plan for preservation of the FP	Feasibility for owners/developers
Stormwater management	Yes	Planning and maintenance of systems	Funding
Drainage system maintenance	Yes	Planning and maintenance of systems	Funding
Building codes	Yes	Responsible building relative to flood threats	Feasibility for owners/developers

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Property Protection

Activity	Applicable (Y/N)	Pros	Cons
Relocation	No		
Acquisition	Yes	Owned by public, no longer under private control	Cost, relocating residents
Building elevation	No		
Retrofitting	No		
Sewer backup protection	Yes	Protecting aquatic life, protecting natural habitats, maintains good stormwater quality	Cost to install new/upgrade infrastructure
Insurance	No		

Goal 2: Provide fiscally responsible funding.

Property Protection

Activity	Applicable (Y/N)	Pros	Cons
Relocation	No		
Acquisition	No		
Building elevation	No		
Retrofitting	No		
Sewer backup protection	No		
Insurance	No		

Goal 3: Develop and improve outreach and public awareness.

Property Protection

Activity	Applicable (Y/N)	Pros	Cons
Relocation	No		
Acquisition	No		
Building elevation	No		
Retrofitting	No		
Sewer backup protection	No		
Insurance	No		

Goal 4: Protect health and safety of the public.

Property Protection

Activity	Applicable (Y/N)	Pros	Cons
Relocation	Yes	Removes people and property from flood prone areas	Uproots people from home, cost
Acquisition	Yes	Removes people and property from flood prone areas	Uproots people from home, cost
Building elevation	Yes	Mitigates flood damage, limits exposure to flooding	Might open up floodplain for development (perception), development cost increased, may affect structure integrity
Retrofitting	Yes	May solve some drainage issues	May give false sense of security
Sewer backup protection	Yes	Protects public from raw sewage	Cost, inconveniences to existing neighborhoods
Insurance	Yes	Protects from limited financial distress	Cost, no direct benefit

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Natural Resource Protection

Activity	Applicable (Y/N)	Pros	Cons
Wetlands protection	Yes	Protecting areas for water storage	Could cost money
Erosion and sediment control	Yes	Protects natural areas from eroding away	Disrupts natural look
Natural area preservation	Yes	Preserves natural areas	Restrictive
Natural area restoration	Yes	Helps downstream areas from erosion	Costly
Water quality improvement	No		
Coastal barrier protection	No		
Environmental corridors	No		
Natural functions protection	No		

Goal 2: Provide fiscally responsible funding.

Natural Resource Protection

Activity	Applicable (Y/N)	Pros	Cons
Wetlands protection	No		
Erosion and sediment control	Yes	Saves from future large and expansive restoration	Man power and money
Natural area preservation	No		
Natural area restoration	Yes	The longer an area is restored the better	Man power and cost
Water quality improvement	Yes	Saves from future water quality issues	Where do you start?
Coastal barrier protection	No		
Environmental corridors	No		
Natural functions protection	No		

Goal 3: Develop and improve outreach and public awareness.

Natural Resource Protection

Activity	Applicable (Y/N)	Pros	Cons
Wetlands protection	No		
Erosion and sediment control	No		
Natural area preservation	No		
Natural area restoration	No		
Water quality improvement	No		
Coastal barrier protection	No		
Environmental corridors	No		
Natural functions protection	No		

Goal 4: Protect health and safety of the public.

Natural Resource Protection

Activity	Applicable (Y/N)	Pros	Cons
Wetlands protection	Yes	Natural filter and provides more preferable area for bugs to exist	Restrict developable land
Erosion and sediment control	Yes	Minimizes erosion related hazards	Cost and not always beautiful
Natural area preservation	Yes	Provides trails and parks for mental and physical health	Maintenance and cost
Natural area restoration	Yes	Restore repetitive loss to natural areas	Cost, impacts developable land
Water quality improvement	No		
Coastal barrier protection	No		
Environmental corridors	No		
Natural functions protection	No		

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Emergency Services

Activity	Applicable (Y/N)	Pros	Cons
Hazard threat recognition	No		
Hazard warning	No		
Hazard response operations	No		
Critical facilities protection	Yes	Keep critical facilities out of floodplain	May have facilities already in floodplain
Health and safety maintenance	Yes	Preserving floodplain would add an effective emergency response by limited excessive development	Cost associated with maintenance
Post-disaster mitigation actions	No		

Goal 2: Provide fiscally responsible funding.

Emergency Services

Activity	Applicable (Y/N)	Pros	Cons
Hazard threat recognition	No		
Hazard warning	Yes	Alert personnel and resident when, where, how bad	Reliability
Hazard response operations	Yes	Ability to respond	Cost with purchasing equipment, training
Critical facilities protection	No		
Health and safety maintenance	Yes	Readiness and ability to respond	Cost for maintaining equipment, training, man power
Post-disaster mitigation actions	Yes	Data collection from emergency services could support grant applications and CIP	Overhead cost with gathering data

Goal 3: Develop and improve outreach and public awareness.

Emergency Services

Activity	Applicable (Y/N)	Pros	Cons
Hazard threat recognition	Yes	Risk communication	Information reliability and accuracy in time of need
Hazard warning	Yes	Forecasting, education	Information reliability and accuracy in time of need
Hazard response operations	Yes	Notify evacuation routes, road closures	Information reliability and accuracy in time of need
Critical facilities protection	Yes	Talking with public facilities and owners	Cost of resources
Health and safety maintenance	Yes	Educating public on health and safety	Cost of resources
Post-disaster mitigation actions	Yes	Lessons learned with public	Cost of man power, access to good information

Goal 4: Protect health and safety of the public.

Emergency Services

Activity	Applicable (Y/N)	Pros	Cons
Hazard threat recognition	Yes	Early warning for preventing loss of life	Cost of manpower, resources, buy in, endorsement, reconciling, public vs. private vs. tax exempt, critical facilities
Hazard warning	Yes	Notifying public and translating PSAs	
Hazard response operations	Yes	Evacuation, rescue, road closures	
Critical facilities protection	Yes	Hospitals, schools, churches all protected	
Health and safety maintenance	Yes	Education for evacuation plans	
Post-disaster mitigation actions	Yes	Reviewing or upgrading obsolete mitigation action plans	

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Structural Projects

Activity	Applicable (Y/N)	Pros	Cons
Reservoirs	Yes	Could control erosion through sensitive areas	Costly
Levees/floodwalls	No		
Diversions	No		
Channel modifications	Maybe	Eliminate erosion, resolve a sustainable cross section, features to enhance adequate ecosystems	Hard to preserve natural while digging up creek
Storm drain improvements	No		

Goal 2: Provide fiscally responsible funding.

Structural Projects

Activity	Applicable (Y/N)	Pros	Cons
Reservoirs	Yes	Could impact small and large areas	Large scale ponds costly with land acquisition etc. on top of design/construction
Levees/floodwalls	Yes	Could impact large areas	Stricter rules for freeboard, etc. & cost
Diversions	Yes	Could be large or small scale	Vary greatly
Channel modifications	Yes	Could impact larger areas	Costly and time consuming to do, large scale
Storm drain improvements	Yes	May have biggest impact on local flooding	Hard to address river/creek flooding

Goal 3: Develop and improve outreach and public awareness.

Structural Projects

Activity	Applicable (Y/N)	Pros	Cons
Reservoirs	No		
Levees/floodwalls	No		
Diversions	No		
Channel modifications	No		
Storm drain improvements	No		

Goal 4: Protect health and safety of the public.

Structural Projects

Activity	Applicable (Y/N)	Pros	Cons
Reservoirs	Yes	Affective	Time and money, space, impact to environment
Levees/floodwalls	No		
Diversions	No		
Channel modifications	Yes	Affective	Impact to environment
Storm drain improvements	Yes	Affective	Costly

Review Possible Activities

The plan reviews different **activities that could prevent or reduce the severity of the problems**. The review, including the pros and cons of each activity, must be included in the plan document. Figure 510-4 lists some of the types of activities that could be reviewed under each of the six credited categories.

Goal 1: Protect and enhance natural floodplain and storm water resources.

Public Information

Activity	Applicable (Y/N)	Pros	Cons
Map information	Yes	Visual	Too technical
Outreach projects	Yes	Teach and train	Have to want to learn
Real estate disclosure	No		
Library	No		
Technical assistance	No		
Environmental education	Yes	Teach and train	Have to want to learn

Goal 2: Provide fiscally responsible funding.

Public Information

Activity	Applicable (Y/N)	Pros	Cons
Map information	Yes	Visual	Too technical
Outreach projects	No		
Real estate disclosure	No		
Library	No		
Technical assistance	No		
Environmental education	No		

Goal 3: Develop and improve outreach and public awareness.

Public Information

Activity	Applicable (Y/N)	Pros	Cons
Map information	Yes	Visual	Too technical
Outreach projects	Yes	Teach & train	Have to want to learn
Real estate disclosure	Yes	Public education	Affects market value
Library	Yes	A complete resource for public education	How to assume public understands
Technical assistance	Yes	Human interaction, aid public with technical translation	How to access, access is time consuming/costly
Environmental education	Yes	Teach & train	Have to want to learn

Goal 4: Protect health and safety of the public.

Public Information

Activity	Applicable (Y/N)	Pros	Cons
Map information	Yes	Visual	Too technical
Outreach projects	Yes	Teach & train	Have to want to learn
Real estate disclosure	Yes	Public education	Affects market value
Library	Yes	A complete resource for public education	How to assume public understands
Technical assistance	Yes	Human interaction, aid public with technical translation	How to access, access is time consuming/costly
Environmental education	Yes	Teach & train	Have to want to learn

Appendix O: LAN 2D Model Report

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

DRAFT

MEMORANDUM

PLANNING

ENGINEERING

PROGRAM MANAGEMENT

Est. 1935

AUSTIN, TX
CHICAGO, IL
COLLEGE STATION, TX
COPRUS CHRISTI, TX
DALLAS, TX
FLINT, MI
FORT WORTH, TX
HOUSTON, TX
HUNTINGTON BEACH, CA
LANSING, MI
LAS VEGAS, NV
LOS ANGELES, CA
MIAMI, FL
MILPITAS, CA
ORANGE, CA
PHOENIX, AZ
SACRAMENTO, CA
SAN ANTONIO, TX
SAN MARCOS, TX
TAMPA BAY, FL
WACO, TX

Routing	

DATE: March 6, 2017 **Data Code:**

TO: Paul Kaspar, PE, CFM; Johnnie Price, PE, CFM

FROM: Matt Manges, PE, CFM Jacob Torres, Ph.D., P.E.; CFM; Beth O'Brien, EIT; David Coburn, EIT

PROJECT NO.: 120-11934-000

PROJECT: City of Bryan – City Wide 2D Flooding Analysis

SUBJECT: City Wide 2D Flooding Analysis

1.0 Purpose

The purpose of this memorandum is to summarize Lockwood, Andrews, and Newnam's, Inc. (LAN) City Wide 2-Dimensional (2D) Flooding Analysis. This evaluation is in support of an ongoing partnership with the City of Bryan (the City) to help quantify the City's existing level of drainage infrastructure performance, identify hydraulically deficient areas, and improve the overall understanding of the City's inherent flood risks to better manage future improvements. The following sections describe LAN's 1D/2D model development, scenario-based output analyses, and model limitations. This level of effort is in compliance with the Scope of Basic Engineering Services and subsequent discussions with held with the City on the identification of areas for secondary evaluation.

2.0 Study Area

The study area (or model domain) encompasses the full city limits. **Exhibit 1** illustrates current Effective FEMA floodplain. At the City's request, primary areas of interest were modeled at higher computational mesh resolution. **Figure 1** shows the study area, areas of primary evaluation, and additional areas of model interest. These areas included Castle Heights, Villa Maria Road crossing at Burton Creek, drainage conditions near Carter Creek Parkway and Garden Lane, and Texas Avenue near the railroad. The Castle Heights neighborhood is located along State Highway 21 East, north of State

Highway 6 (N. Earl Rudder Freeway), and is historically prone to repetitive flooding. Near the Tejas Center, a group of homes north of Willow Bend Drive and south of Melba Circle at the crossing near Burton Creek consistently experiences localized backyard ponding. The area near Carter Creek Parkway has recurring issues with drainage channel overflows across property boundaries into a subsurface pipe before out falling into the detention pond. Pipe surcharge leads to backwater ponding for upstream properties. Lastly, Texas Avenue railroad embankments can cause damming effects of drained flow under heavy rainfall events.

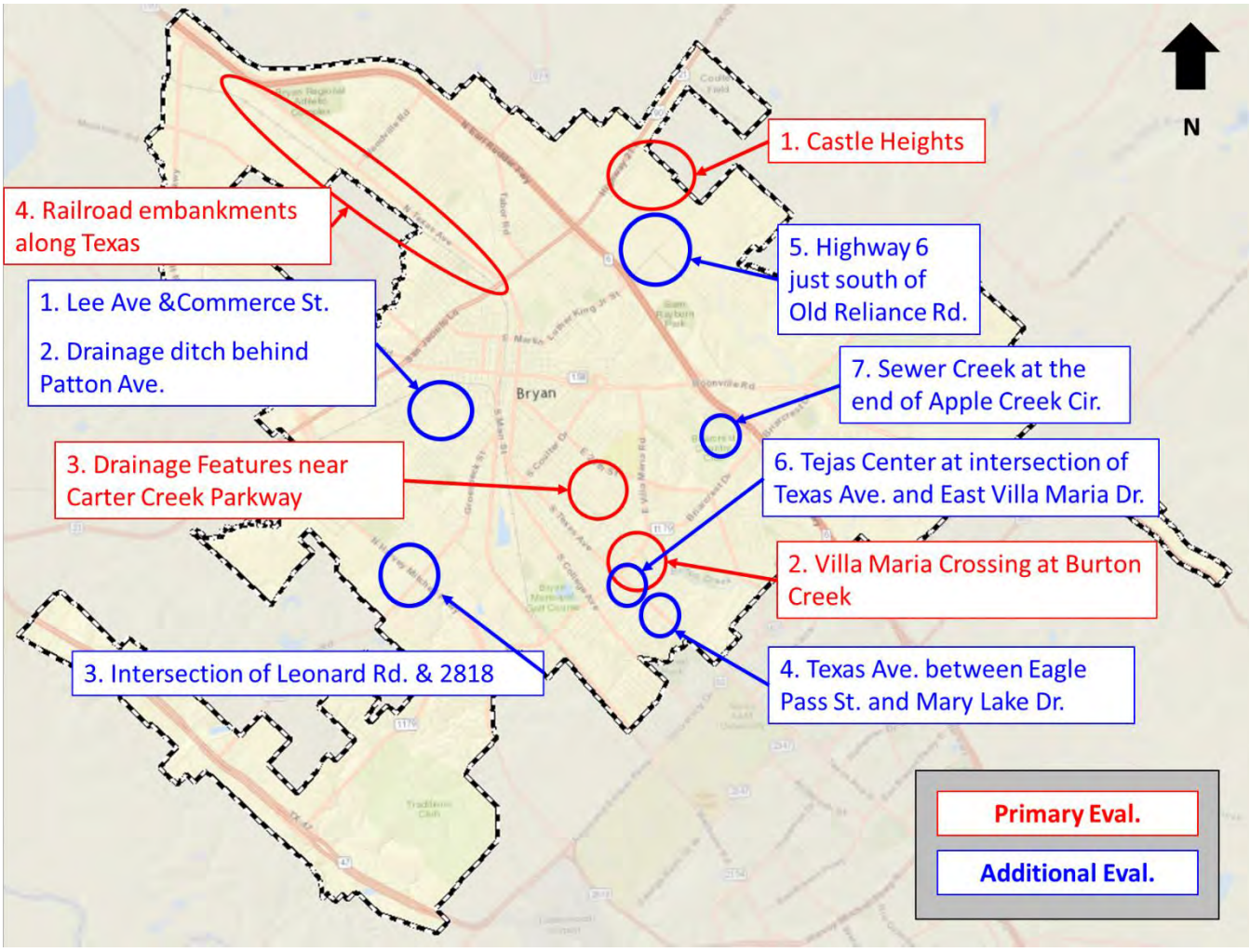


Figure 1. Study area and locations of evaluation interest.

The land use for the study area is a combination of medium density commercial and residential. The modeled stormwater infrastructure consists of approximately 4,500 pipe segments ranging in type from reinforced concrete boxes (RCB), corrugated metal pipe (CMP), and plastic. RCB's in

the City range anywhere from an 8 feet span by 4 feet rise near Blinn College to a 1.5 feet span by 1 foot rise at Hardy Street and South College Avenue. CMPs range from 84 inch span by 56 inch rise arches at South Coulter Drive and Texas Avenue to an 8 inch diameter pipe near an apartment complex south of Booneville Road, west of Eastchester Drive. Plastic pipes range in size from a 5 feet diameter pipe near Broadmoor Drive and Biarcreek Court to several 1 foot pipes throughout the City. Creeks and open channels through the City include Briar Creek, Burton Creek, Carter Creek, Cottonwood Branch, Hudson Creek, and Turkey Creek. All of these channels serve as primary outfall locations for the City's storm sewer network.

3.0 Data Collection

LAN's development and testing of a comprehensive and robust City Wide 1D/2D storm sewer model is largely attributed to the City's investment in high-quality Geographic Information System (GIS) storm sewer and asset data. The City provided LiDAR, storm sewer information, and relevant flood study reports. Storm sewer information included information on inlets, manholes, outfalls, culverts, channels/ditch alignments, detention pond location with storage volume data, building footprints, and land use information.

Design storm rainfall hyetograph for the 2-, 10-, 25-, and 100-year storm frequencies were collected from the Unified Drainage Criteria Manual (Bryan-College Station 2012). The 1-year storm frequency data was not included in the manual, so it was extrapolated from the other storm frequency data. The storm information was entered into a simple HEC-HMS model that output the rainfall data in 5-min intervals over a 24-hr period. Table C-6 of the BCS Unified guidelines has the rainfall depth values for varying storm durations.

During the model development, a major storm event occurred. Heavy rains and at least one tornado was recorded in the Brazos Valley on May 26, 2016. The City provided LAN with videos of the major storm event. The video showed the flooding that occurred in key location around the City. The images of the flooding compared to the model outputs are shown in **Figure 2**. The comparison of the model to the event validated model, even in its early stages.

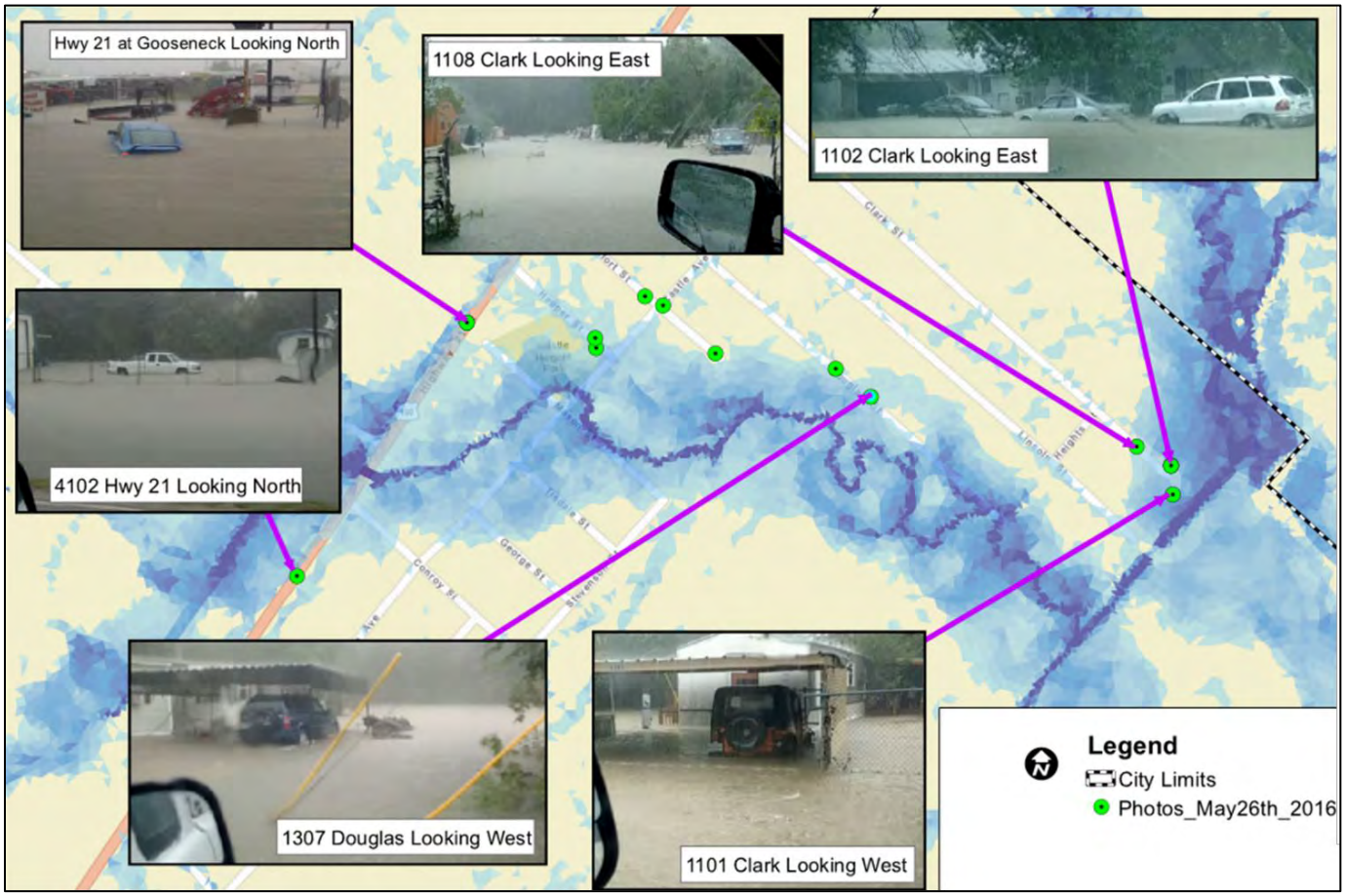


Figure 2. Flooding in Castle Heights on May 26th 2016 compared to the computed 100-year floodplain.

4.0 Existing Conditions Model Analysis

LAN started by performing a high level simulation of the study area. For computational feasibility, the City model domain was divided into two zones, with North Bryan serving as Zone 1 and South Bryan as Zone 2. Refer to **Figure 3** for modeled zone limits. The limits of the model were decided based on major drainage divides through the City.

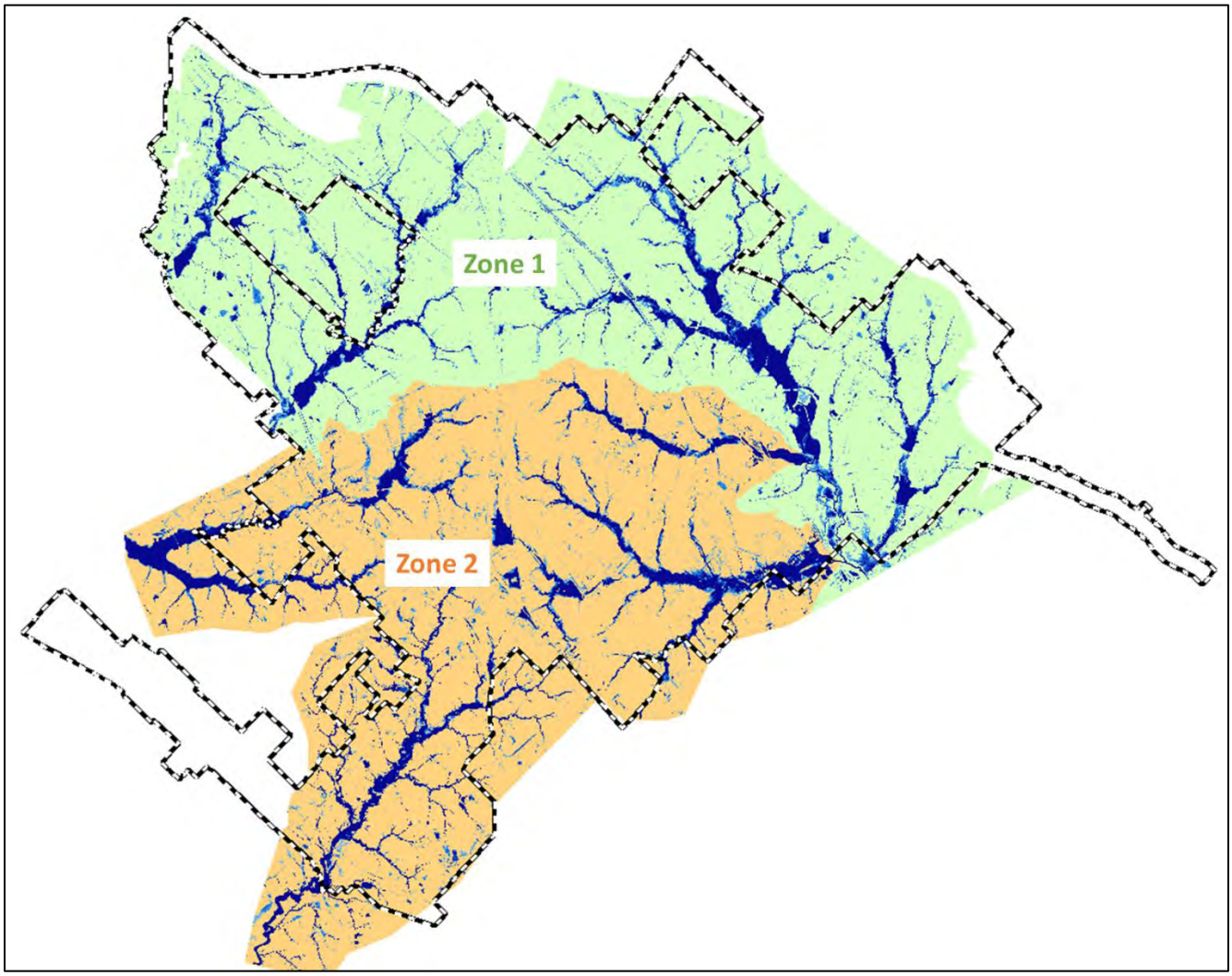


Figure 3. Modeled zone extents.

A computational grid mesh representing the City was generated from LiDAR and rainfall hyetographs for the 1-, 2-, 10-, 25-, and 100-year storms were applied to the surface. The model was made more detailed by adding roughness values from land use information. Roughness polygons were developed, and the roughness values were taken from the City standards. LAN exported the LiDAR digital terrain model (DTM) data to an InfoWorks ICM compatible raster file. LAN then determined which areas required increased surface resolution. Digital drainage infrastructure such as subsurface storm sewer systems for the City was also included. The hydrologic data was revised by LAN for consistency with City requirements and methodology.

The storm sewer network was created with nodes and link representing features like culverts, cross culverts, bridges, storm sewer inlets, and storm sewer pipes. The features were based on available survey data, City GIS information, and previously provided data. The network is shown in **Figure 4**.

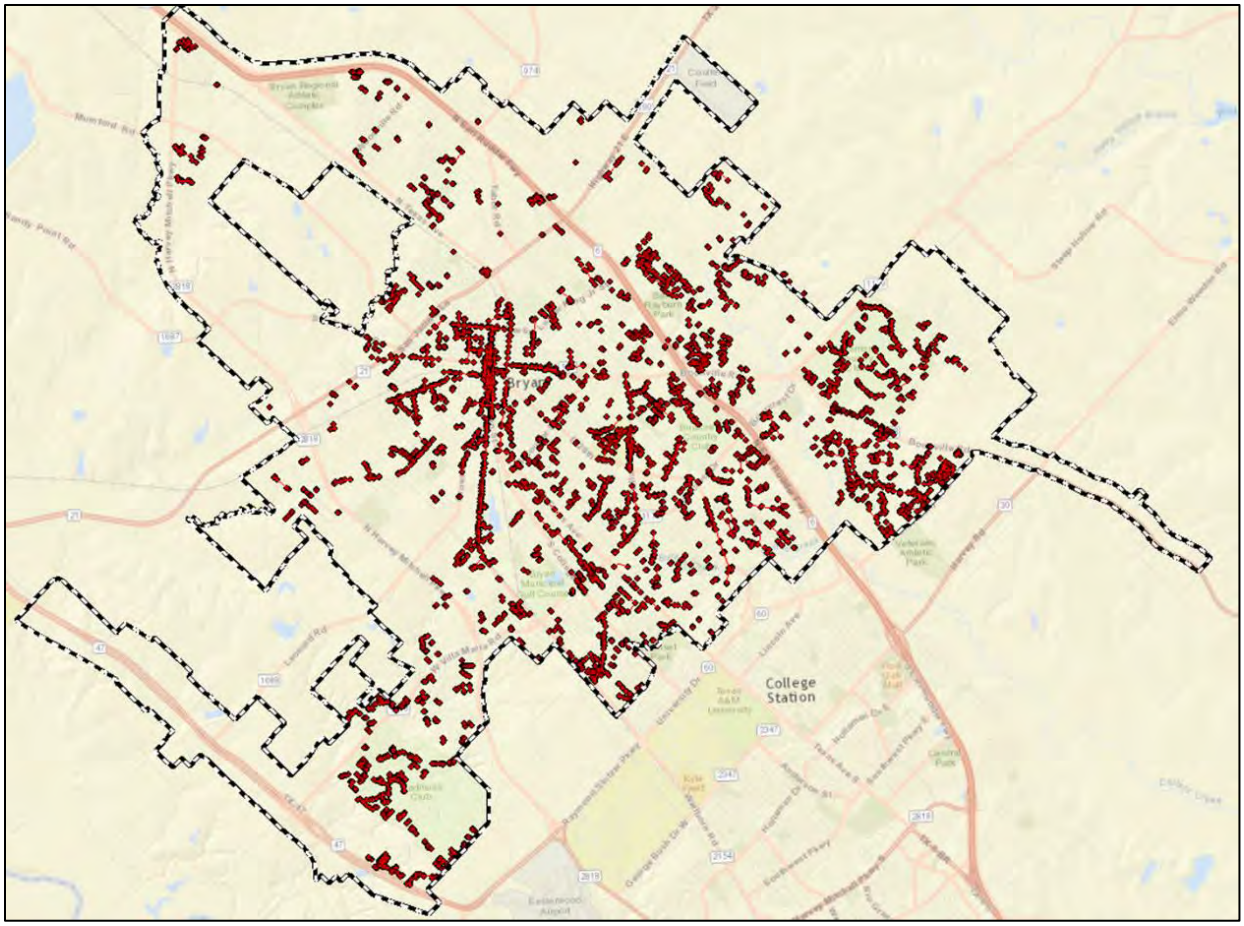


Figure 4. Pipe and Node Network from InfoWorks model

Exhibits 2 through **6** illustrate the computed flood risk (with maximum depths) for the 100-, 25-, 10-, 2-, and 1-year events.

5.0 Model Output Analysis

From the model output, LAN worked to identify structures at risk of flooding, major arterials at risk of flooding, single access point neighborhoods at risk of flooding, and areas outside of the public right-of-way (ROW) that flood. All feature classes created for analysis are included in this submittal.

5.1 Structures at Risk

To determine structures at risk of flooding, LAN started with the shapefile of the 2016 building footprints provided by the City. Columns were added to the attribute table for flooded in a 100-, 25-, 10-, 2-, and 1-year return period storms. Flood risk was determined through a spatial analysis in GIS based on the results of the flooding analysis. The threshold for a structure to be flooded was set at the average slab height, 6 inches. The attribute table was then populated with "Yes" and "No" if the building was flooded or not. It was calculated that approximately 3,865, 3,241, 2,835, 2,091, and 1,142 structures are at risk for the 100-, 25-, 10-, 2-, and 1-year return period storms respectively. Refer to **Exhibits 7** through **Exhibit 11** for a maps of structures at risk for each return period.

5.2 Major Arterials at Risk

To determine major arterials at risk of flooding, LAN started with the shapefile of street centerlines, downloaded from the City's website. The website's data was updated in November of 2016. A definition query was used to limit the shapefile to centerlines or roads classified as "Minor Arterials" and "Principal Arterials" refer to **Exhibit 12**. Each or the roads are broken down into segments based on intersections, this made the analysis more detailed. Columns were added to the attribute table for flooded in a 100-, 25-, 10-, 2-, and 1-year return period storms. Risk of flooding was determined through a spatial analysis in GIS based on the results of the flooding analysis. The threshold for a road to be flooded was set at 6 inches. The attribute table was then populated with "Yes" and "No" if the road segment was flooded or not. 326, 290, 264, 230, and 168 road segments are at risk of flooding for the 100-, 25-, 10-, 2-, and 1-year return period storms respectively. Refer to **Exhibit 13** through **Exhibit 17** for maps of the road segments at risk of flooding for each return period.

5.3 Single Access Point Neighborhoods at Risk

To determine single access point neighborhoods at risk of flooding, LAN started with a shapefile of the subdivisions from the appraisal district. Neighborhoods with a single point of access were determined using GIS. **Exhibit 18** shows the neighborhoods with a single access point. An additional shapefile was created that put a point at the intersection of the access road into the neighborhood. A neighborhood was considered at risk if that point was flooded. Columns were added to the attribute table for flooded in a 100-, 25-, 10-, 2-, and 1-year return period storms. Flood risk was determined through a spatial analysis in GIS based on the results of the flooding analysis. The threshold for a flooded access point was set at 6 inches. The attribute table was then populated with "Yes" and "No" if the access point was flooded or not. Out of the 34 neighborhoods with a single access point, 6, 6, 6, 4, and 1 neighborhood(s) are at risk for the 100-, 25-, 10-, 2-, and 1-year return period storms respectively. Refer to **Exhibit 19** for a map of the at risk neighborhoods for the 100-year return period. Those six neighborhoods are Symphony Park, Park Village, Smith, Fuller Farm, Park Meadow, and Cache Cove. Cache Cove is the only neighborhood at risk during a 1-year storm event.

5.4 Flooding Outside of Public Right of Way

To determine flooding outside of public ROW, LAN started with the shapefile of parcels, downloaded from the appraisal district's website. Public ROW was identified as parcels own by the City, and the ROW for roads. Columns were added to the attribute table for flooded in a 100-, 25-, 10-, 2-, and 1-year return period storms. Flood risk was determined through a spatial analysis in GIS based on the results of the flooding analysis. The threshold set at 6 inches. The attribute table was then populated with "Yes" and "No" if the parcel was flooded or not. 9934, 9181, 8680, 7829, and 6583 parcels have flooded portions for the 100-, 25-, 10-, 2-, and 1-year return period storms respectively. Refer to **Exhibit 20** for a map of the flooded parcels for the 100-year return period.

5.5 Areas of Interest

Looking at the areas of interest help to confirm the reasonableness of the model. **Figure 5** illustrates the model outputs at the areas of interest. **Figure 5(a)** shows Castle heights along US-21 east of HWY-6 and the area that needs drainage relief to reduce flood risk to structures. **Figure 5(b)** shows the East Villa Maria crossing at Burton Creek and the localized ponding issues for the group of homes north of Willow Bend, and south of Melba Circle. **Figure 5(c)** shows the drainage features near Carter Creek Parkway that have issues with drainage channel flows flowing across property lines. **Figure 5(c)** also shows the backwater ponding for upstream properties. **Figure 5(d**) shows the damming effects of the railroad embankments along Texas Avenue.

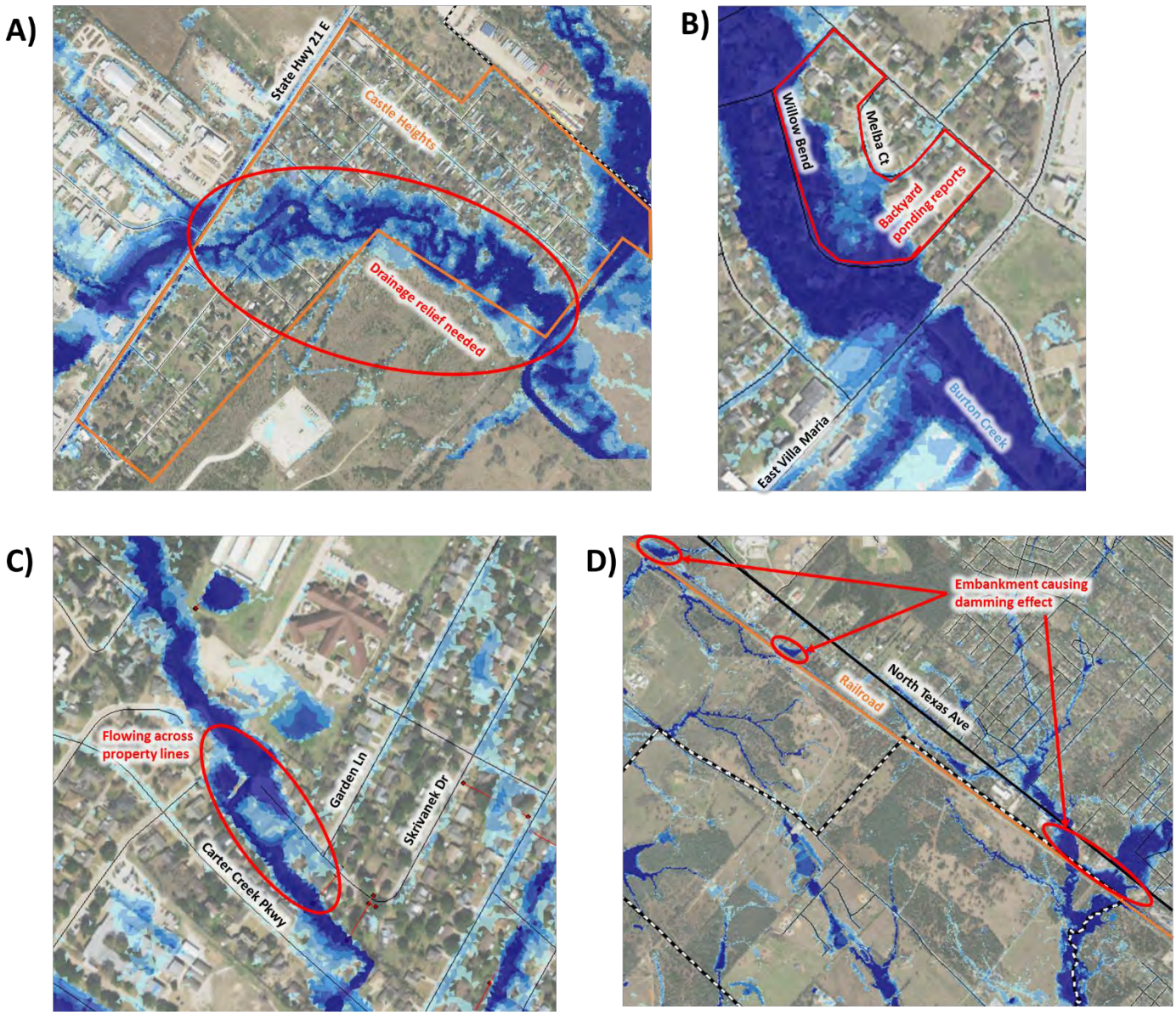


Figure 5. Model outputs at areas of interest (a) Castle heights, (b) East Villa Maria crossing at Burton Creek, (c) drainage features near Carter Creek Parkway, (d) railroad along Texas Ave.

5.6 Additional Areas for Evaluation

Following a January 2017 status meeting, additional locations were identified by the City and communicated to LAN for further documentation. These locations are illustrated in **Figure 6**. The locations were evaluated to verify if certain inconsistencies between the modeled and reported flood events were owed to either a lack of GIS information incorporated into the model or an identifiable drainage deficiency worthy for larger consideration by the City.

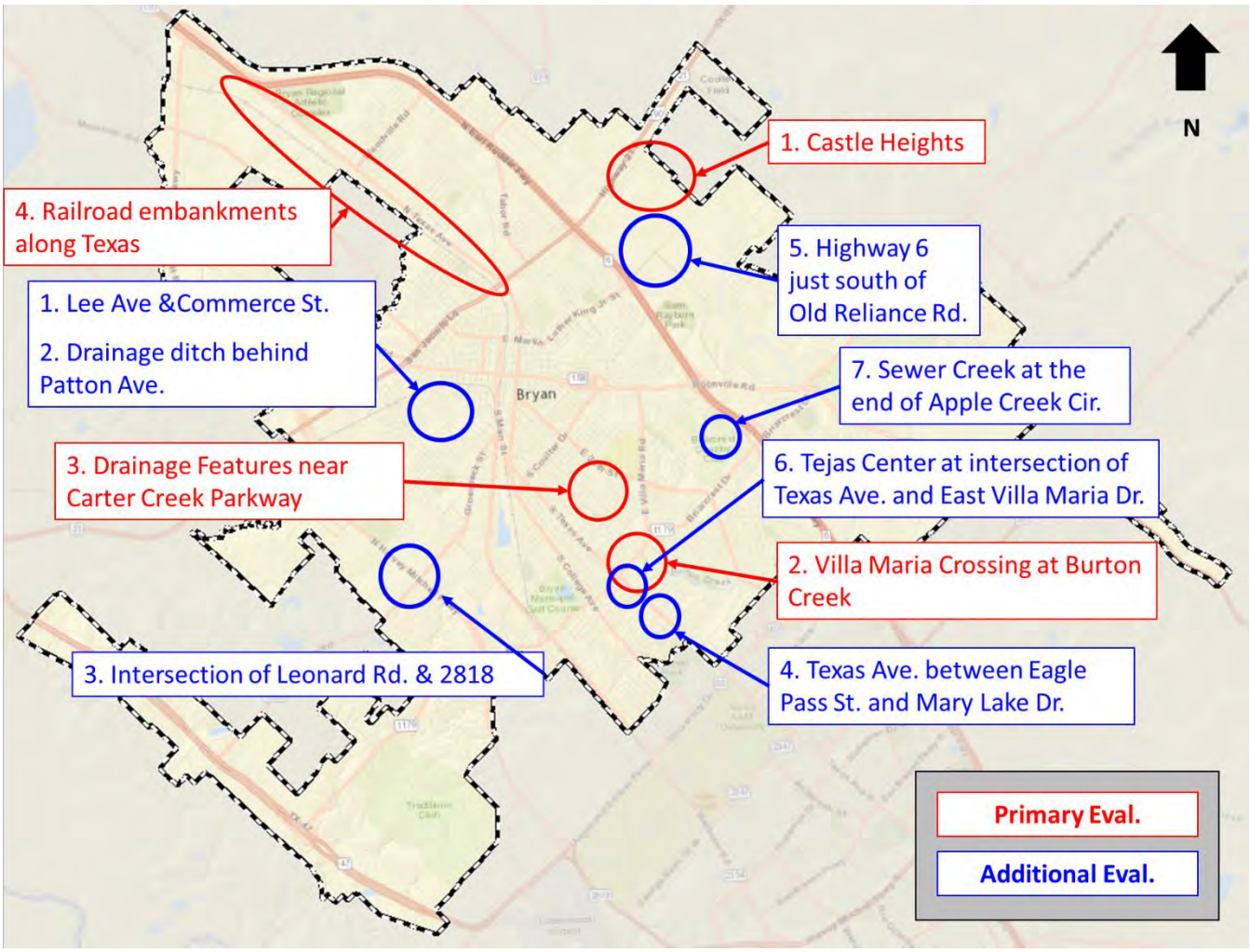


Figure 6. Additional locations (in blue font) for additional evaluation (**Figure 1** re-produced).

Location 1 – Commerce Street and Lee Avenue, just south of 28th street

- Note: It is believed the flooding in this area should be less than what was shown in the model. LAN found that the inlet box was not included in the 2D model.
- Conclusion: While the Lee Avenue improvements were beneficial, LAN believes they did not completely solve the area's standing drainage issues. For example, the modeled 100-year hydraulic gradeline at Lee Avenue outfall is above the ground and therefore additional downstream improvements would be needed. It appears this area is well served by the 1 year level of service, as there still appears to be significant ponding for the 10-year event. Additional refinement could also be done to better represent the detention basins downstream.

Location 2 – Drainage ditch, west of Palasota Drive, around Eisenhower Ave. and Patton Ave

- Note: There is a slight discrepancy between the model and the FEMA delineated floodplain.
- Conclusion: LAN acknowledges this discrepancy and attribute this a few facets, such as the high-level modeling doesn't pick up the driveway culverts that are present in that area, LiDAR data may not be as accurate in this area because of woods, and assumption in the floodplain map will be very different than the assumptions in the model because of the distinction in modeling frameworks between 1D steady state and 1D/2D coupled unsteady.

Location 3 – Ponded area north of Leonard Road and 2818

- Note: Existing culverts that may be undersized.
- Conclusion: LAN found that the culverts under 2818 were not included in the GIS data provided by the City. Inclusion of these culverts would reduce the ponding on the north side of 2818, even if they are undersized.

Location 4 – Texas Avenue large crossing between Eagle Pass Street and Mary Lake Drive

- Note: Model showing water shown over crossing.
- Conclusion: LAN validated with aerial imagery the existence of this culvert crossing. This culvert was removed for the purpose of achieving model stability in the presence of not having detailed bridge data on all bridge crossings.

Location 5 – Highway 6 bypass just south of Old Reliance Road

- Note: Water shown over crossing.
- Conclusion: LAN stated that the culverts under Highway 6 were modeled as channels per the agreed upon modeling approach

Location 6 – Flooded parking lot of Tejas Center at Texas Ave. and East Villa Maria Drive.

- Note: There is a large culvert under the Tejas center that should be preventing this flooding (it discharges into Burton Creek).
- Conclusion: LAN found that there was not a culvert directly under the Tejas Center included in the GIS data provided by the City.

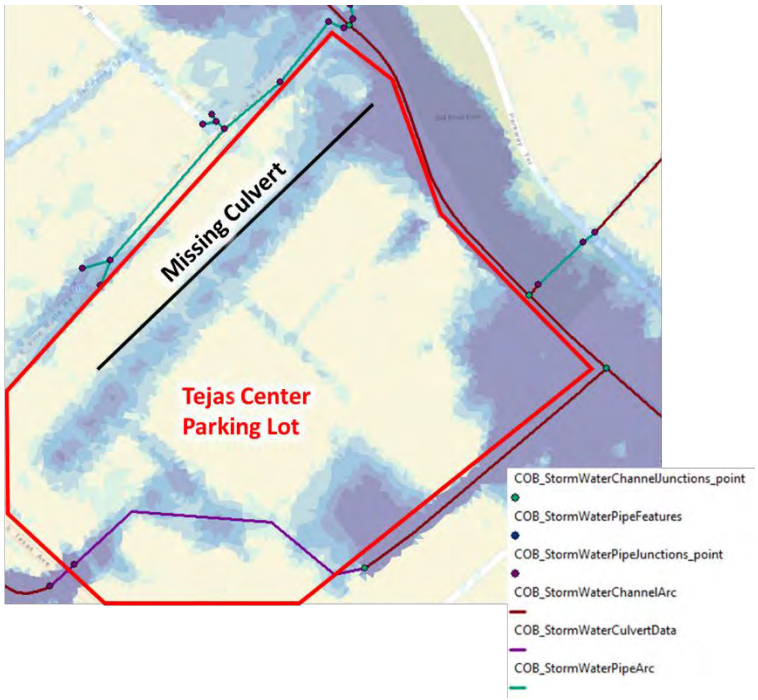


Figure 7. Available storm sewer data near Tejas Center.

Location 7 – Sewer Creek at end of Apple Creek Circle

- Note: High water level in Sewer Creek. Channel improvements and culvert are in place along Sewer Creek that should be reducing that water level.
- Conclusion: LAN found that channel improvements were not included in the available GIS data.

General – Water ponding along State Highways

- Note: Review TxDOT roads to verify storm water conveyance can pass though roads.
- Conclusion:
  - It is worth noting, to circumvent the limitation of accurate bridge data, LAN opted to "burn the bridges" to improve model runtime and stability. This entailed the full LiDAR feature removal of bridges and culverts over creeks in order to model one continuous creek running through the crossing footprint. This led to some of the results showing ponding in and around bridge crossings. This can be seen in **Figure 7** with the 2818 crossing of Cottonwood Branch Creek.
  - State Highway 21 East just south of Marino Road
    - LAN found that the culvert was not included in the GIS data provided by the City. Culvert will allow water to pass under Highway 21.
  - State Highway 21 creek crossing south of W Martin Luther King Dr.
    - LAN identified this as a result of the bridge/culvert removal process. The model shows the crossing as a channel over the road, but in reality there is a bridge over the creek.
  - Crossing of 2818 and Cottonwood Branch Creek at Shiloh Avenue
    - LAN identified this as a result of the bridge/culvert removal process. The creek is modeled as a channel flowing over 2818, but a bridge does exist over the creek.
  - State Highway 21 East drainage ditch crossing just south of Gooseneck Dr.
    - LAN identified this as a result of the bridge/culvert removal process. It was modeled as a channel crossing over Highway 21.

Figure 7. Example of "burning bridges" modeling limitation at North Harvey Mitchell Parkway (2818).

6.0 Summary

LAN developed a high resolution comprehensive combined 1D/2D stormwater drainage model for evaluating regional storm water infrastructure alternatives and associated performance under variable hydrologic conditions. LAN's modeling efforts are in support of an ongoing partnership between LAN and the City to help quantify the City's existing storm sewer infrastructure level of service, identify hydraulically deficient areas, and improve the overall understanding of the City's inherent flood risks to better manage future capital improvement projects and storm sewer/roadway rehabilitation. LAN's model drainage model development entailed the coupling of the City's extensive 1D storm sewer network and a high density 2D overland topographic mesh using InfoWorks Integrated Catchment Modeling (ICM) V6.5. Based on modeled results, LAN worked to identify features at risk of flooding under the 100-year event such as: commercial, residential, and public structures, major arterials, single access point neighborhoods, and areas outside of the City's Right-of-Way. In addition to using the City's full boundary limits as the complete model domain, LAN, in coordination with the City, evaluated up to ten additional neighborhoods (e.g. Castle Heights, Tejas Center, Holt & Commerce Streets) at a keen level of interest for the purpose of confirming repetitive and nuisance flooding complaints from local residents and historical records.

LAN believes the greatest investment from this model is best served when viewed as platform to provide valuable hydraulic insights for confirming flood losses, validating nuisance complaints, and holistic assessments of no adverse impacts from ongoing land development practices. Other recommendations for future work would entail a refined evaluation of the Commerce and Holt Street areas, in particular the level of drainage service following the recent Lee Avenue storm sewer improvements. The model in its current form can continue to "evolve" with added storm water infrastructure detail and topographic and land use refinements – such as critical bridge crossing data – and enhanced mesh resolutions. In addition, the attainment of post-processed and calibrated radar to run real-time hind-casted events would greatly communicate flood risks to City residents and staff under various proposed conditions scenarios.

7.0 References

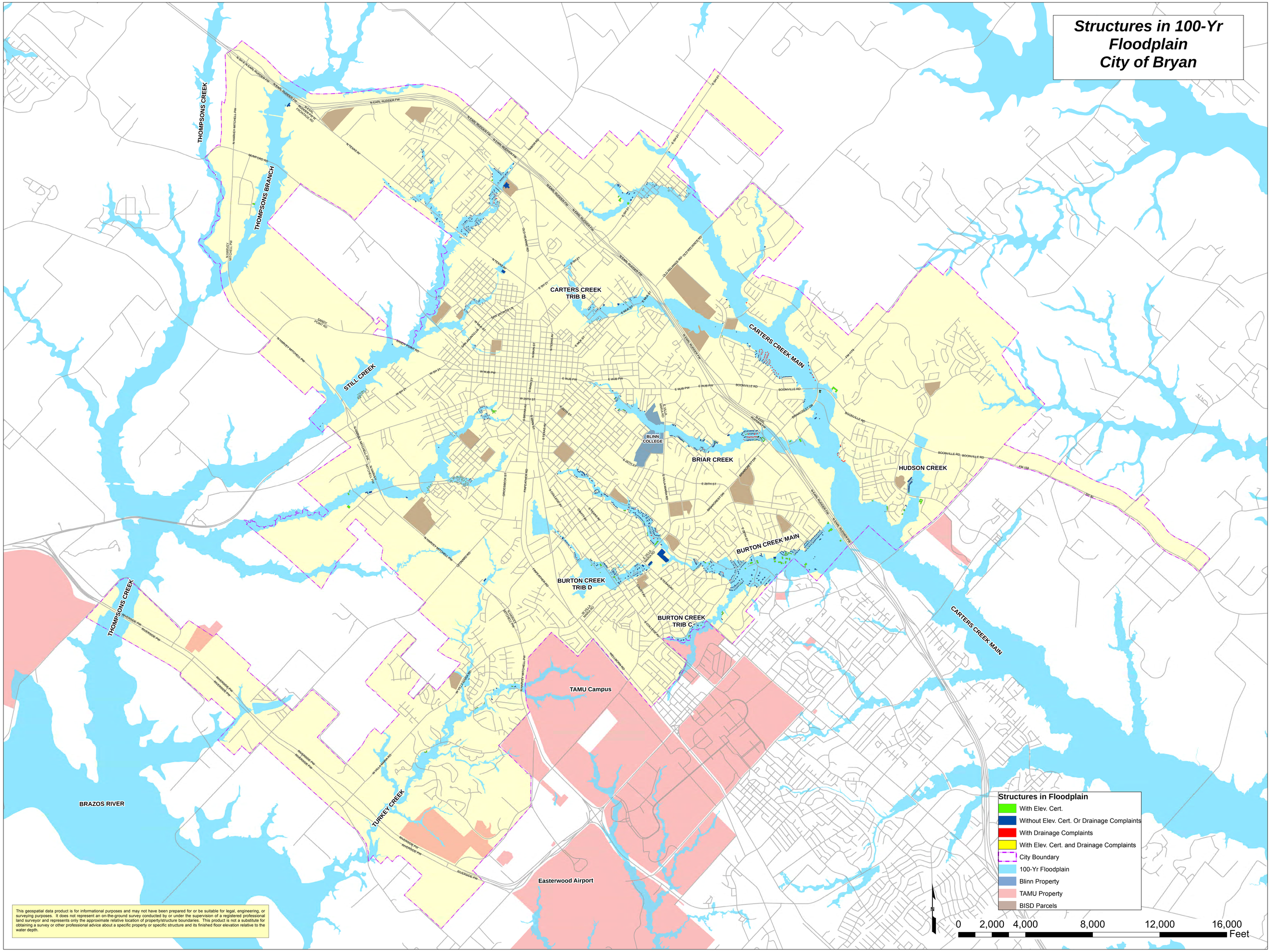
City of Bryan, City of College Station. (2012). "Unified Stormwater Design Guidelines," updated August 2012.

Harris County Flood Control District. (2009). "Hydrology & Hydraulics Guidance Manual," updated December 2009.

Harris County Flood Control District. (2010). "Policy Criteria & Procedure Manual," updated December 2010.

Exhibit 1: Overall Structures in the Floodplain

Structures in 100-Yr Floodplain
City of Bryan



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Exhibits 2-5: Structures in the Floodplain (panels 1-4)

Structures in Floodplain
City of Bryan
April 2018
Quadrant 1

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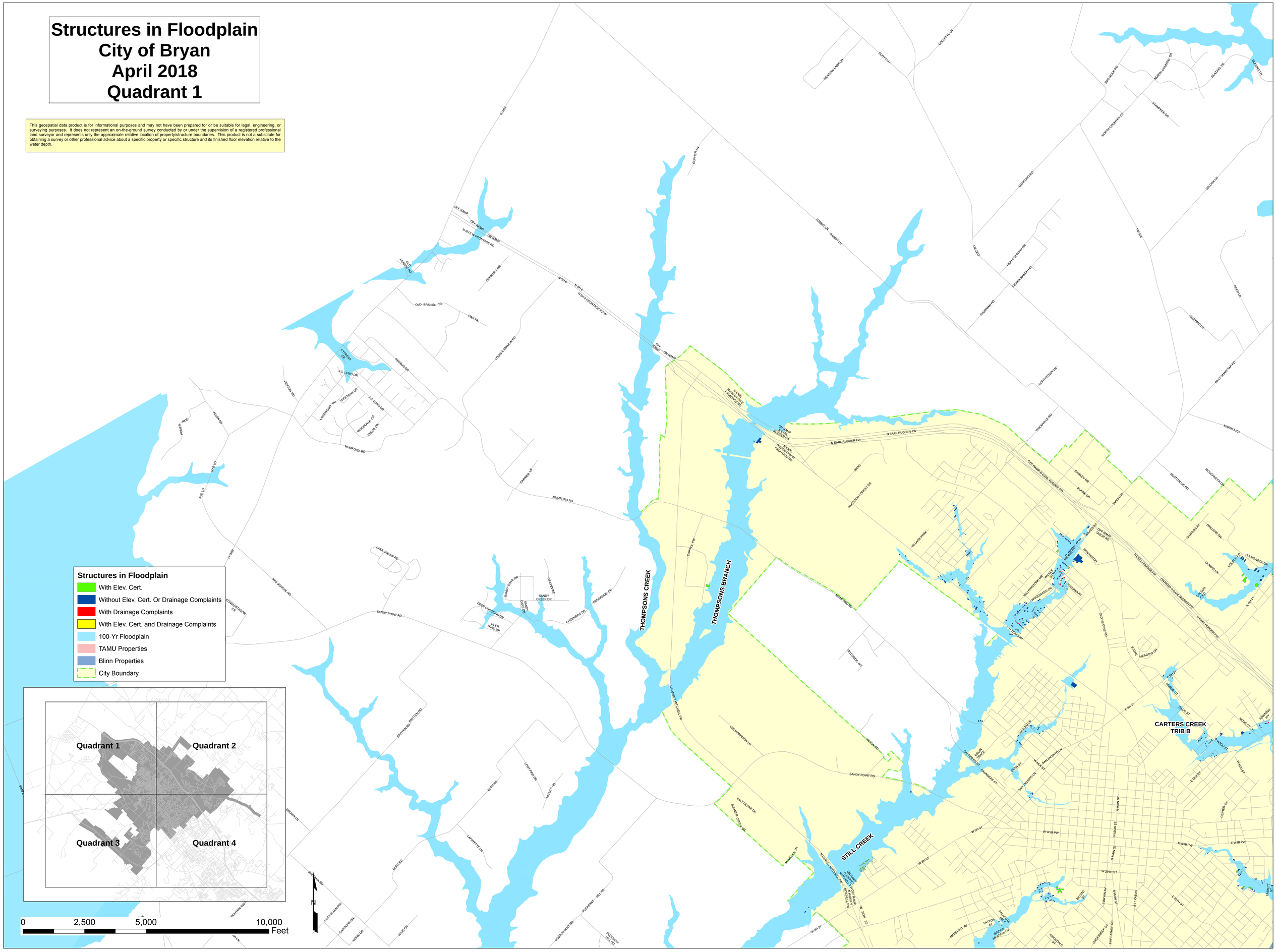

Structures in Floodplain
City of Bryan
April 2018
Quadrant 2

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Structures in Floodplain

- With Elev. Cert.
- Without Elev. Cert. Or Drainage Complaints
- With Drainage Complaints
- With Elev. Cert. and Drainage Complaints
- 100-Yr Floodplain
- TAMU Properties
- Blinn Properties
- City Boundary

Quadrant 1
Quadrant 2
Quadrant 3
Quadrant 4

0 2,500 5,000 10,000 Feet

CARTERS CREEK TRIB B
CARTERS CREEK MAIN
BRIAR CREEK
BLINN COLLEGE

Structures in Floodplain
City of Bryan
April 2018
Quadrant 3

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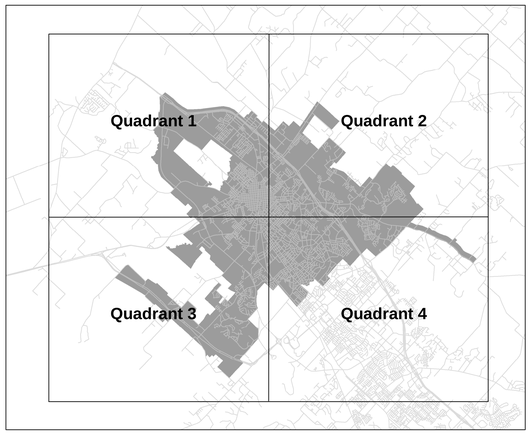
Structures in Floodplain

- With Elev. Cert.
- Without Elev. Cert. Or Drainage Complaints
- With Drainage Complaints
- With Elev. Cert. and Drainage Complaints
- 100-Yr Floodplain
- TAMU Properties
- Blinn Properties
- City Boundary



0 2,500 5,000 10,000 Feet

N

BRAZOS RIVER

TURKEY CREEK

BURTON CREEK TRIB D

TAMU HSC

Easterwood Airport

W SH 21

W 28TH ST

BECK ST

N HARVEY MITCHELL PW

S HARVEY MITCHELL PW

RIVERSIDE PW

LEONARD RD

FLIGHT LINE RD

ORDINANCE RD

AIRFIELD DR

GOODSON BEND RD

OLIVER HILL RD

FOWLER DR

JONES RD

FOSTER RD

JONES RD

RAYMOND STOTZER PW

RAYMOND STOTZER FRONTAGE

RAYMOND STOTZER PW TO RIVERSIDE PW

RIVERSIDE PW TO RAYMOND STOTZER PW

MCKENZIE TERMINAL RD

EASTERWOOD SERVICE RD

NUCLEAR SCIENCE RD

MAINTENANCE RD

TURK RD

LIGIA DR

EQUINE COMPLEX

F & B RD

DAIRY CENTER RD

AGRONOMY RD

GOLF DR

STELLSON RD

PARKVIEW RD

SHARON DR

S TEXAS AV

S COLLEGE AV

CANTY AV

ROBERTS DR

W CARSON ST

UNION ST

ATKINS ST

FAIRLENE RD

MAE BELLAMIE

JORDAN LO

BITTLE LN

ALICE ST

KRENEK'S

GROSSBECK ST

BIDDLE ST

MARSHALL AV

PATTON AV

PALADIN DR

BRIDGE MEADOW LN

BRYANT ST

S BRYAN AV

S MAIN ST

E 29TH ST

SHILOH AV

STONE CITY DR

INDUSTRIAL BL

BIRCH RD

BLUE HERON RD

CYPRESS RD

LEONARD RD

LINDA LN

CHERK LN

POLARIS DR

MARVALEY DR

DUMFRIES DR

BENSKI DR

W VILLA MARIA RD

ROCKWOOD DR

PINEWOOD DR

GALWOOD VI

MAMMREDD CR

WESTWOOD MAN

SYCAMORE TR

N TRADITIONS DR

S TRADITIONS DR

BOXELDER DR

HICKORY RIDGE CR

WALNUT CREEK CT

ELM CREEK CT

POINSON CREEK DR

WILLOW RIDGE DR

ELDER DR

CASITA CT

ATLAS PEAK DR

MAYOGAN DR

TURKEY CREEK RD

S TRADITIONS DR

HSC PW

BIOMEDICAL WY

RAYMOND STOTZER PW

MEMORIAL CEMETERY DR

ROCKDALE LO

ROCKDALE BYPASS DR

ACTS BRIDGE DR

RIVERSIDE PW FRONTAGE RD

FIFER LN

BANWOOD DR

IMPERIAL LO

WELCOME LN

WHITE CREEK RD

LOS ROBLES DR

WHISPERING RIDGE

VALLEY VIEW DR

HYTEES CREEK RD

UNNAMED

SMITH LN

RAYMOND STOTZER PW

OAK HILLS DR

LADY WELL RD

MCALLISTER LN

STEWARTS BLUFF

OLD JONES RD

LIGHTSEY LN

TWELVE OAKS

DEW RD

RIVER RD

RUNAWAY RD

FORTEN LN

VINCENT RD

KEMP RD

Structures in Floodplain
City of Bryan
April 2018
Quadrant 4

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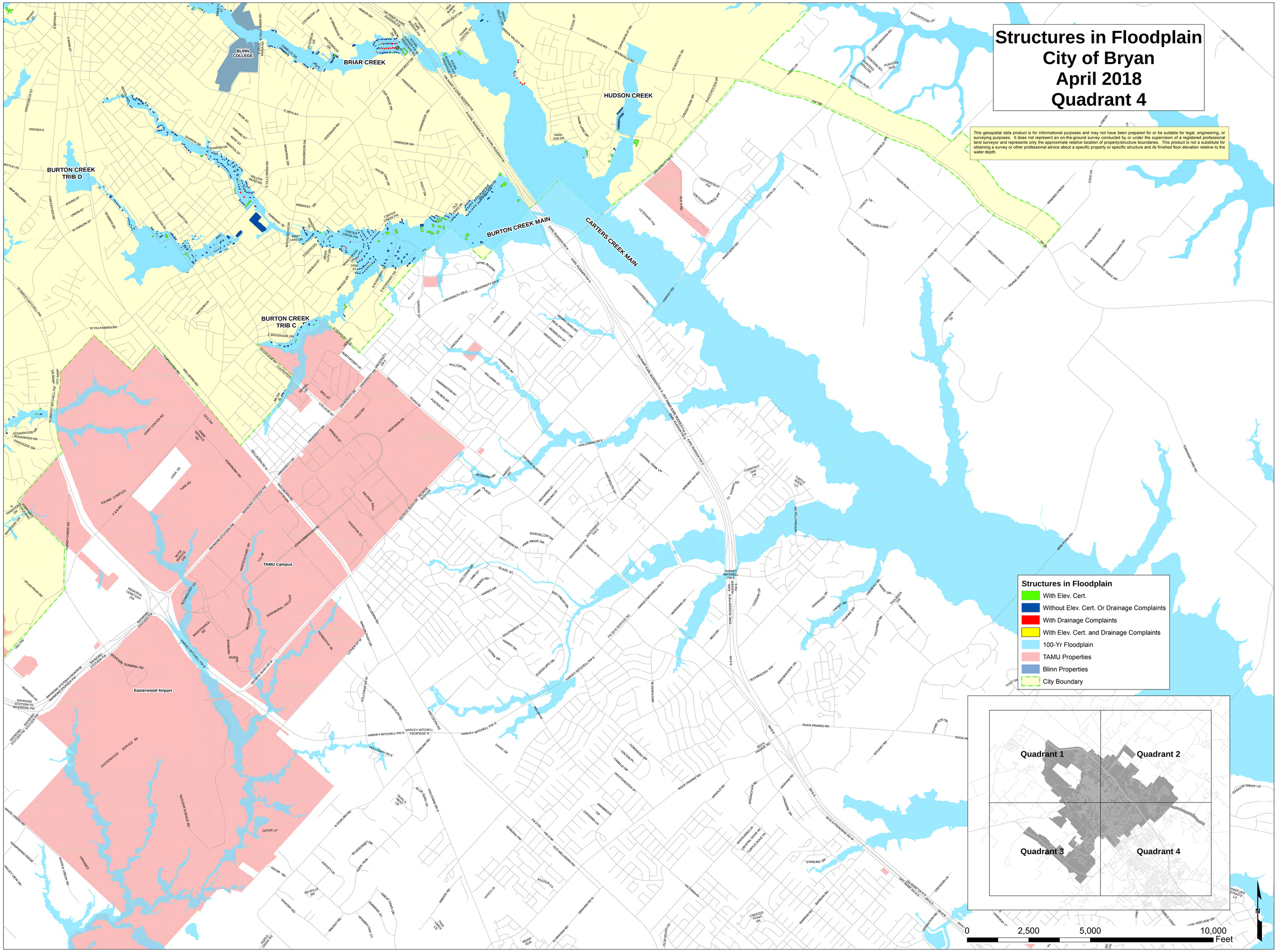

Exhibit 6: Critical Facilities Map

Critical Facilities
City of Bryan
April 2018

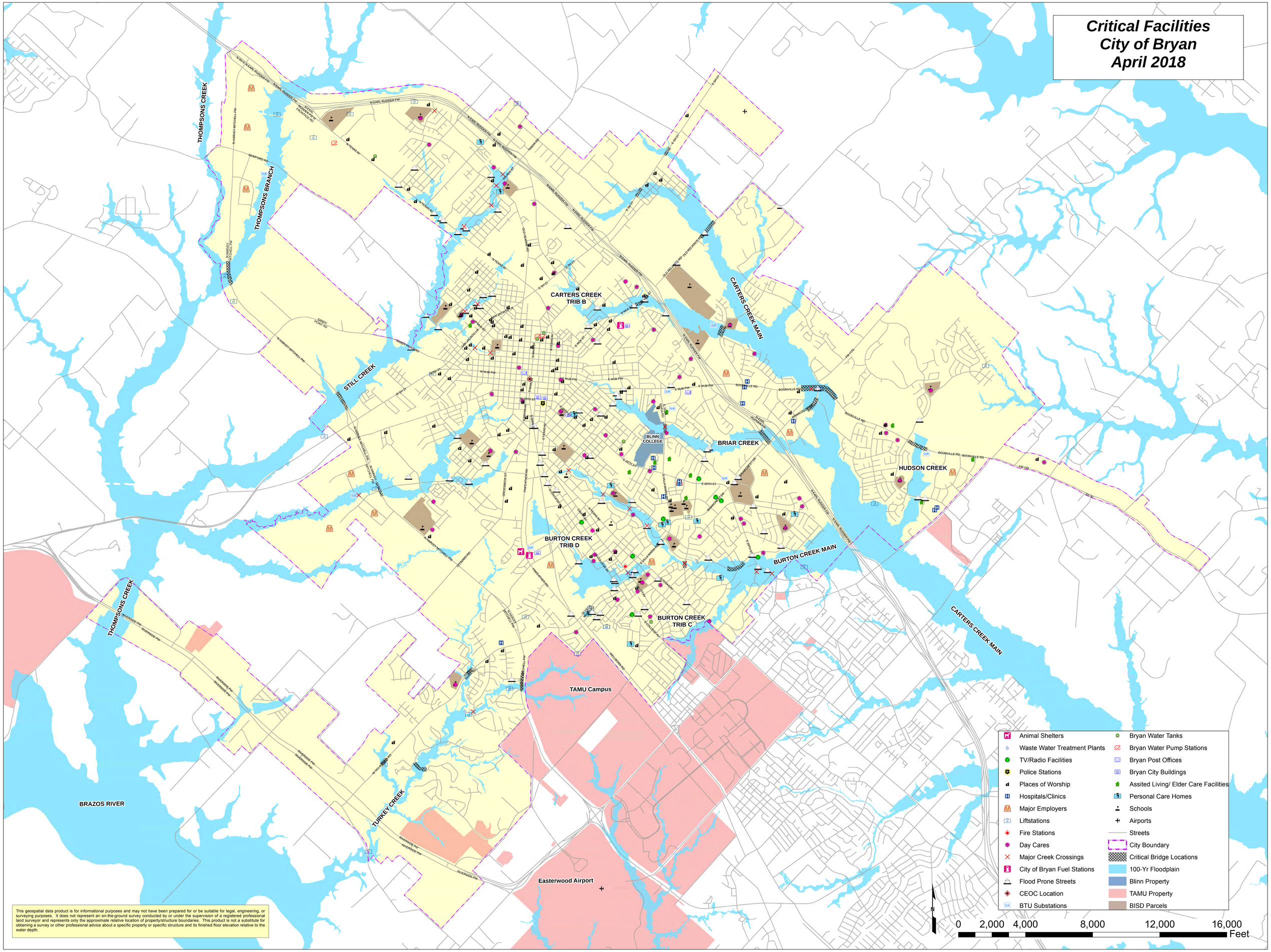

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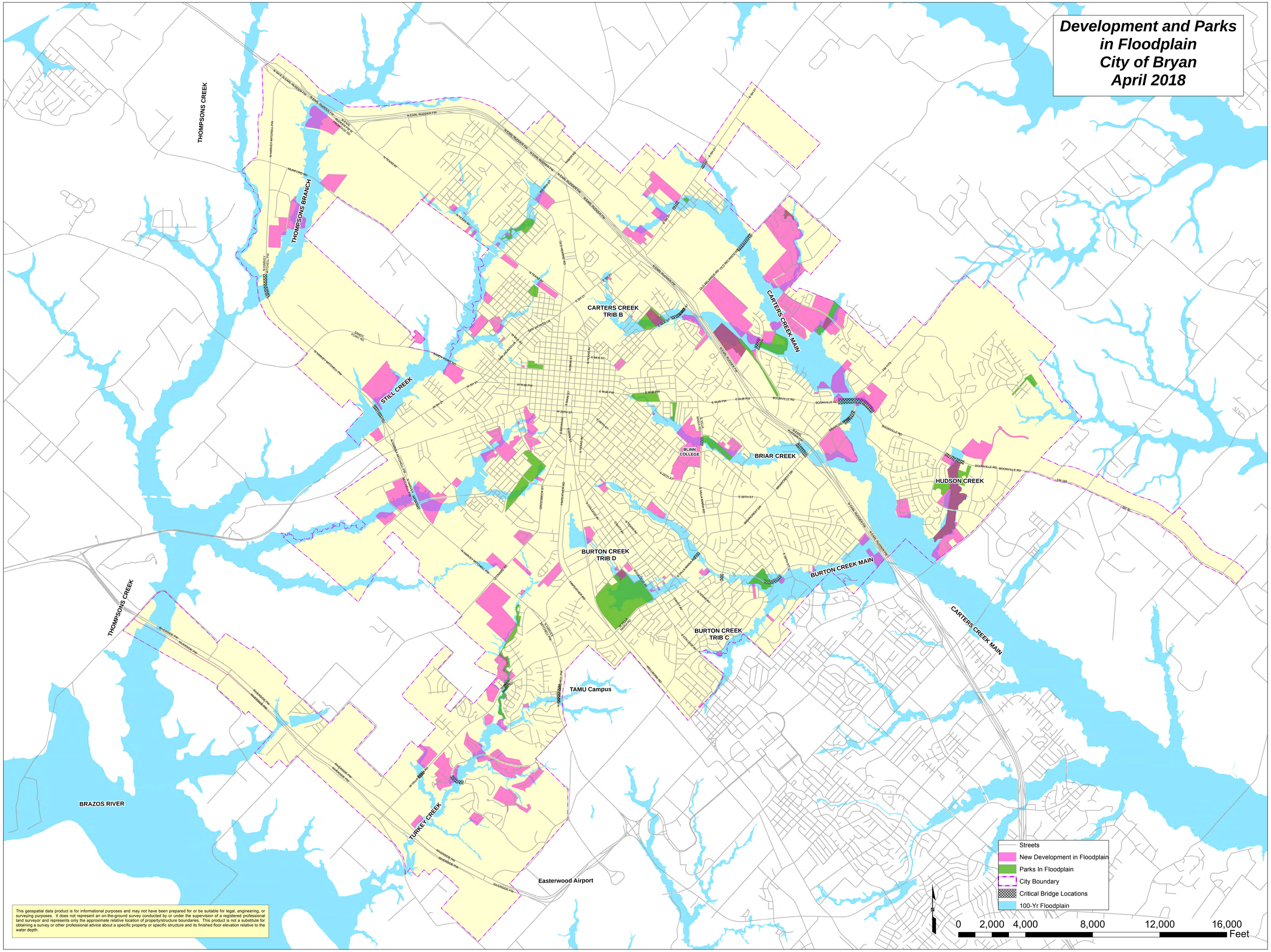
Exhibit 7: Development and Parks in the Floodplain

Development and Parks in Floodplain City of Bryan April 2018



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Exhibits 8-11: LAN City Wide 2D Model Structures in the Flood Prone Areas Map (panels 1-4)

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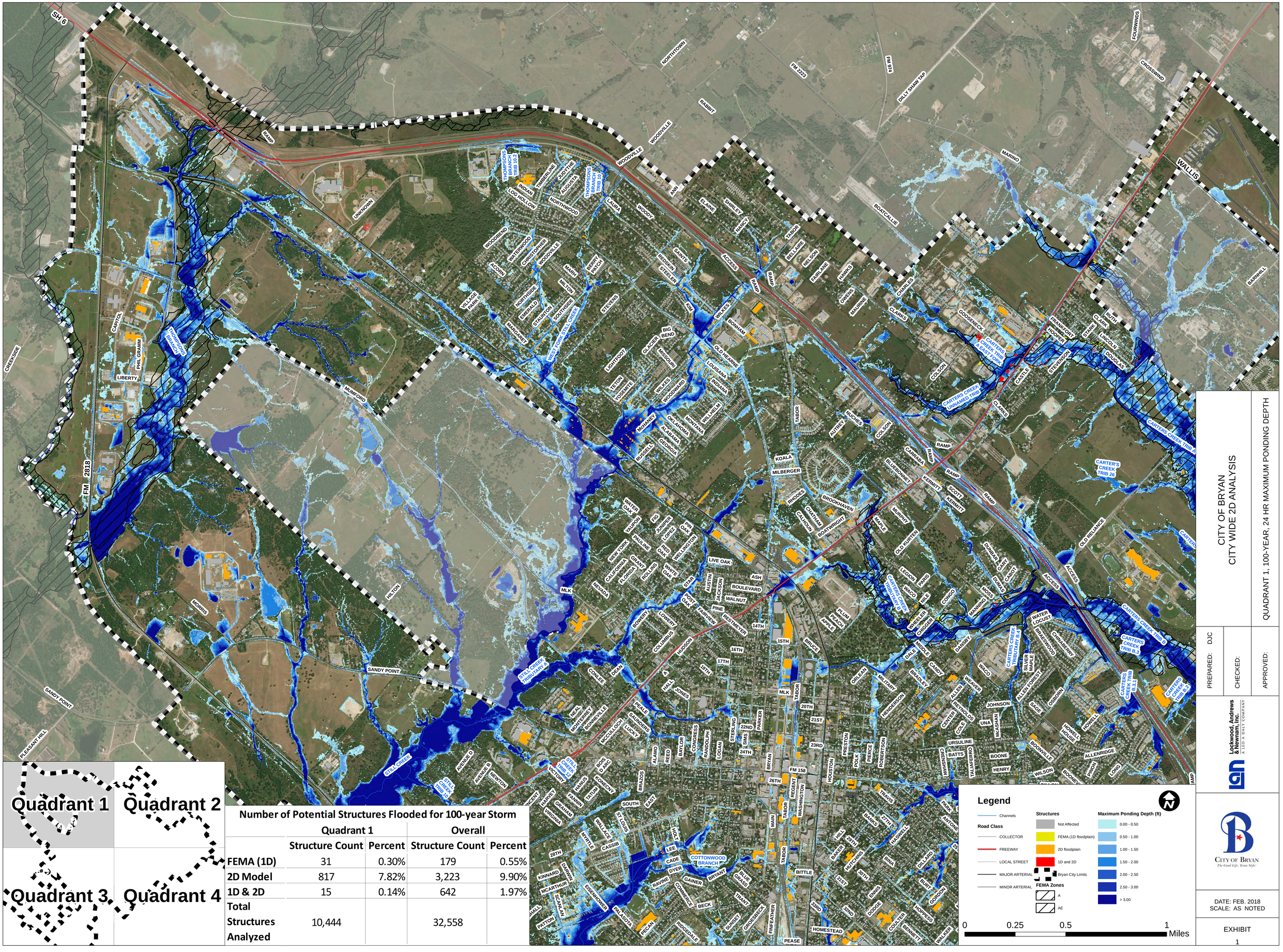


Number of Potential Structures Flooded for 100-year Storm

	Quadrant 1		Overall	
	Structure Count	Percent	Structure Count	Percent
FEMA (1D)	31	0.30%	179	0.55%
2D Model	817	7.82%	3,223	9.90%
1D & 2D	15	0.14%	642	1.97%
Total Structures Analyzed	10,444		32,558	

CITY OF BRYAN
CITY WIDE 2D ANALYSIS

QUADRANT 1, 100-YEAR, 24 HR MAXIMUM PONDING DEPTH

PREPARED: DJC

CHECKED:

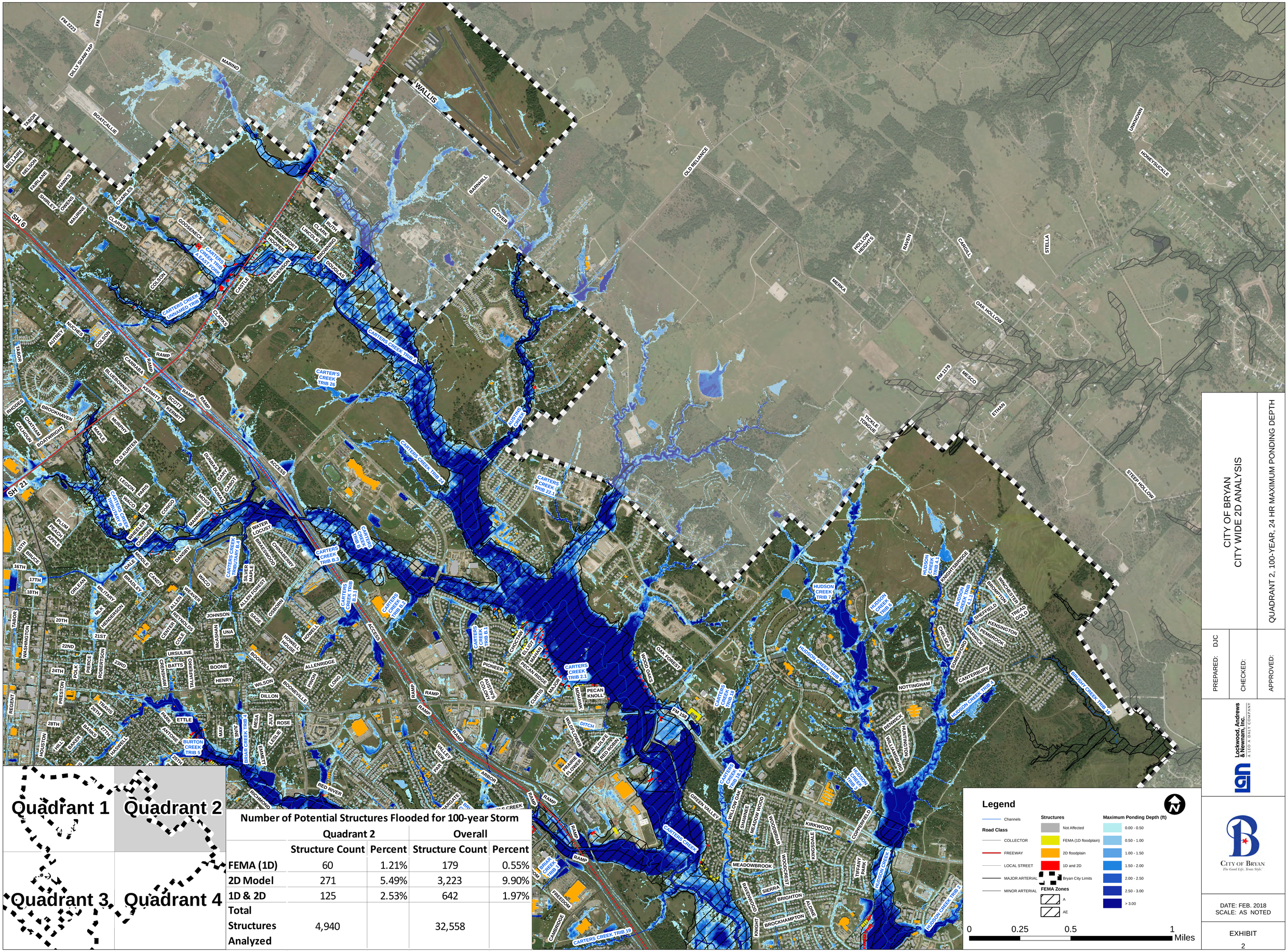
APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

CITY OF BRYAN
The Good Life. Texas Style.

DATE: FEB. 2018
SCALE: AS NOTED

EXHIBIT
1



Number of Potential Structures Flooded for 100-year Storm

	Quadrant 2		Overall	
	Structure Count	Percent	Structure Count	Percent
FEMA (1D)	60	1.21%	179	0.55%
2D Model	271	5.49%	3,223	9.90%
1D & 2D	125	2.53%	642	1.97%
Total Structures Analyzed	4,940		32,558	

CITY OF BRYAN
CITY WIDE 2D ANALYSIS

QUADRANT 2, 100-YEAR, 24 HR MAXIMUM PONDING DEPTH

PREPARED: DJC

CHECKED:

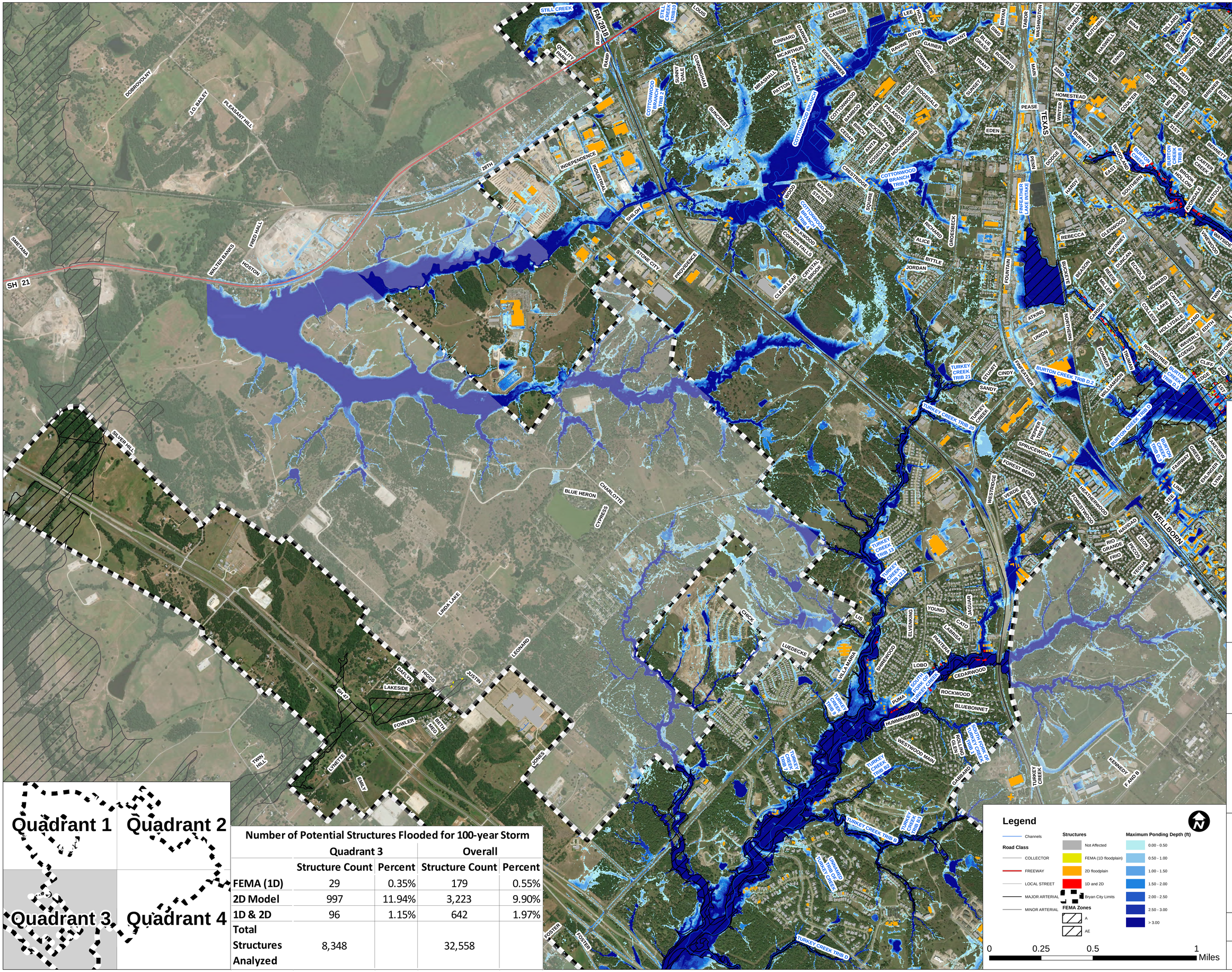
APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

CITY OF BRYAN
The Good Life. Texas Style.

DATE: FEB. 2018
SCALE: AS NOTED

EXHIBIT
2



Number of Potential Structures Flooded for 100-year Storm

	Quadrant 3		Overall	
	Structure Count	Percent	Structure Count	Percent
FEMA (1D)	29	0.35%	179	0.55%
2D Model	997	11.94%	3,223	9.90%
1D & 2D	96	1.15%	642	1.97%
Total Structures Analyzed	8,348		32,558	

CITY OF BRYAN
CITY WIDE 2D ANALYSIS

QUADRANT 3, 100-YEAR, 24 HR MAXIMUM PONDING DEPTH

PREPARED: DJC

CHECKED:

APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

CITY OF BRYAN
The Good Life. Texas Style.

DATE: FEB. 2018
SCALE: AS NOTED

EXHIBIT
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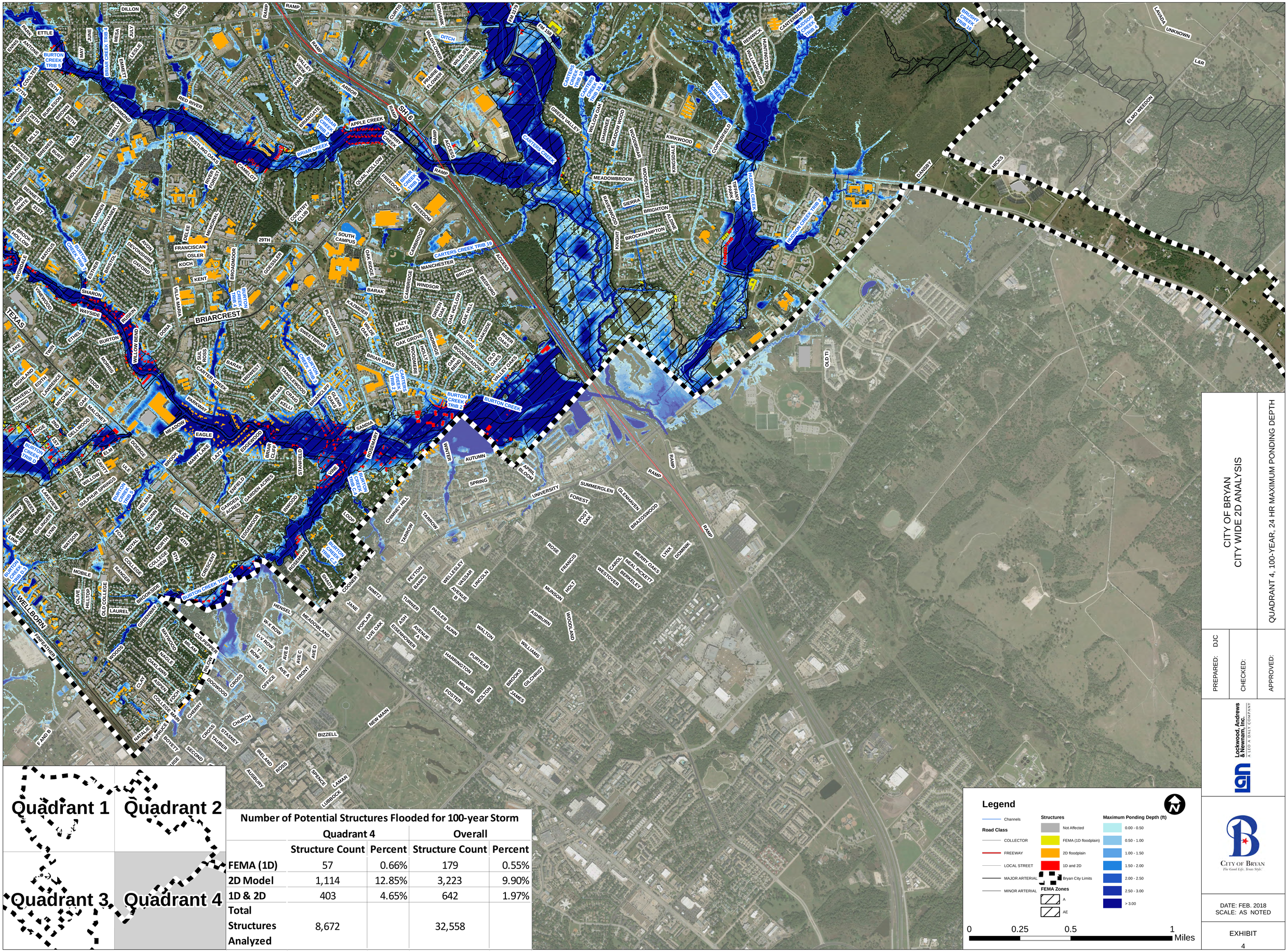

Number of Potential Structures Flooded for 100-year Storm	Quadrant 4		Overall	
	Structure Count	Percent	Structure Count	Percent
FEMA (1D)	57	0.66%	179	0.55%
2D Model	1,114	12.85%	3,223	9.90%
1D & 2D	403	4.65%	642	1.97%
Total Structures Analyzed	8,672		32,558	

CITY OF BRYAN
CITY WIDE 2D ANALYSIS

QUADRANT 4, 100-YEAR, 24 HR MAXIMUM PONDING DEPTH

PREPARED: DJC

CHECKED:

APPROVED:

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

CITY OF BRYAN
The Good Life. Texas Style.

DATE: FEB. 2018
SCALE: AS NOTED

EXHIBIT
4