Rawhide Creek Basin

Stormwater System Assessment

and

Capital Improvement Program

Prepared For:

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and

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For the

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Acronyms and Definitions

The following list of acronyms and definitions is for frequently and generally used terms in the Town of Addison Stormwater System Assessment and Capital Improvement Program study reports. Not every term listed is used in this report.

BFE – Base Flood Elevation: FEMA term for the elevation that defines the level of flooding resulting from the one percent chance (100-year flood) storm event.

CCTV - Closed-Circuit Television: Video inspection method for underground stormwater systems.

cfs - cubic feet per second: Rate of flow.

Channel: Any river, stream, creek, brook, branch, natural or artificial depression, ponded area, lake, flowage, slough, ditch, conduit, culvert, gully, ravine, swale, wash, or natural or man-made drainageway, in or into which surface or groundwater flows, either perennially or intermittently.

Critical Facility: A facility that is critical to the community's public health and safety, is essential to the orderly functioning of a community, stores or produces highly volatile, toxic or water-reactive materials, or houses occupants that may be insufficiently mobile to avoid loss of life or injury. Examples of critical facilities include jails, hospitals, schools, fire stations, nursing homes, wastewater treatment facilities, water plants, and gas/oil/propane storage facilities.

CN - Curve Number: Empirical parameter used in hydrology for predicting direct runoff from rainfall.

Design Storm: A selected storm event, described in terms of the probability of occurring once within a given number of years, for which stormwater or flood control improvements are designed and built.

Detention Facility: A man-made structure for the temporary storage of stormwater runoff with controlled release during or immediately following a storm.

Drainage Area: The land area upstream of a given point that contributes stormwater to that point.

Emergency Overflow: The structure in a stormwater management system designed to protect the system in the event of a malfunction of the primary flow structure or a storm event greater than the system design. The emergency overflow capacity initiates at the facility design high water level or base flood elevation.

FEMA: Federal Emergency Management Agency and its regulations promulgated at 44 C.F.R. 59-79 effective as of October 1, 1986

FFE - Finished Floor Elevation: For this study, it is the elevation of the lowest floor of a structure.

Flood Frequency: A period of years, based on a statistical analysis, during which a flood of a stated magnitude may be expected to be equaled or exceeded.

Flood-Proofing: Any combination of structural or non-structural additions, changes, or adjustments to structures or property which reduce or eliminate flood damage to real estate, improved real property, water and sanitary facilities, structures and their contents.

GI - Green Infrastructure: A practice that manages stormwater and creates healthier urban environments, same as LID.

GIS - Geographic Information Systems: System designed to capture, store, manipulate, analyze, manage and present spatial or geographic data.

GPS - Global Positioning System: Navigation system to determine exact location.

HSG - Hydrologic Soil Group: An indicator of infiltration that is predetermined for each soil type. HSG is organized into 4 groups (A, B, C, and D). The letter A indicates rapid infiltration, and the letter D indicates that rainwater generally runs off the surface.

iSWM - integrated Stormwater Management: The integrated Stormwater Management program is a cooperative initiative of the North Central Texas Council of Governments (NCTCOG) that assists communities in achieving their water quality protection, streambank protection and flood mitigation goals, while also helping to meet their construction and post-construction obligations under TCEQ stormwater permits. NCTCOG facilitated the cooperative development of the *i*SWM Design Manual for Site Development and Design Manual for Construction.

LF - Linear Feet: Length measurement.

LID - Low Impact Development: Managing stormwater for less impact on the natural environment.

LiDAR - Light Detection and Ranging: Remote sensing method used to digitally examine the surface of the earth.

Mitigation: Measures taken to minimize flood risk and damage from stormwater overflows.

NCTCOG - North Central Texas Council of Governments: Association to assist local governments in planning for common needs, cooperating for mutual benefit, and coordinating for sound regional development.

NRCS - Natural Resources Conservation Service: Federal agency that provides technical assistance to farmers, private landowners and managers for the environment (formerly known as the Soil Conservation Service or SCS).

Overflow: Excessive stormwater in the street as a result of underground stormwater systems that cannot accommodate design flood event flows.

Ponding: Ponding is when stormwater pools/accumulates in a low area.

Post-Construction Stormwater Quality Features: Permanent stormwater facilities that minimize the impact of stormwater runoff rates and volumes, prevent erosion, and capture pollutants.

RCBC - Reinforced Concrete Box Culvert: Rectangular or square shaped concrete conduit used to convey or store water.

RCP - Reinforced Concrete Pipe: Circular shaped concrete conduit used to convey or store water.

Record Drawings: Upon completion of the land disturbance, a professional engineer licensed in the State of Texas or land surveyor shall certify construction drawings as to actual construction, documented in a set of record drawings.

ROW - Right-Of-Way: Publicly owned land for transportation, drainage and/or utility use.

Runoff: Stormwater generated from rainfall that flows over the ground surface.

SCS - Soil Conservation Service: See NRCS.

Spill: Stormwater runoff that flows from one system into another area that was not intended to receive the flow.

SSA/CIP - Stormwater System Assessment/Capital Improvement Program

SSURGO - Soil Survey Geographic Database: Digital soil data produced and distributed by NRCS.

Stormwater System: Combination of features that convey stormwater (pipe, box culvert, open channel, inlets, outfall, manholes, etc.).

Storm Drainage System: See stormwater system.

Structures Flooded: Structures where the flood level is higher than the lowest floor elevation of the structure.

Structures Potentially Flooded: Structures where the lowest floor elevation is less than 0.5 feet above a specified flood level, usually that of the 100-year flood.

Swale: A vegetated channel, ditch, or low-lying or depressional tract of land that is periodically inundated by conveying stormwater from one point to another.

SWMP - Stormwater Management Program: Established by the Town of Addison as part of the Texas Pollution Discharge Elimination System permit process to address stormwater quality.

T_C - Time of Concentration: The longest time required for a drop of water falling at the upper limit of a drainage area to travel to the point under consideration.

TIN - Triangular Irregular Network: Digital data structure used in GIS for the representation of a land surface.

TNRIS - Texas Natural Resources Information System: Principal state archive in Texas for natural resources data.

TCEQ – Texas Commission on Environmental Quality: An agency to protect the state's public and natural resources consistent with sustainable economic development.

TPDES - Texas Pollutant Discharge Elimination System: Permit to discharge stormwater from its Municipal Separate Storm Sewer Systems (MS4s) into surface waters of the State.

TR-55 - Technical Release 55 (Urban Hydrology for Small Watersheds): An NRCS publication that presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs.

USDA - United States Department of Agriculture: Federal organization that manages programs related to food, agriculture, natural resources, rural development and nutrition.

WSEL - Water Surface Elevation

XPSWMM - XP Stormwater Management Model: Proprietary software for planning, modeling and managing stormwater sustainable drainage systems. Hydraulically, flows are simulated in 1D channels and pipes, coupled to a 2D surface grid for comprehensive (dynamic, two-dimensional) flood modeling.

100-year Storm Event: Refers to rainfall or flood event that has one percent (1%) probability of occurring in any given year.

Executive Summary

Rawhide Creek is a tributary of Farmer's Branch Creek, which is a tributary of the Elm Fork of the Trinity River. Its headwaters, draining approximately 887 acres, are located mainly in the Town of Addison. A small portion of the drainage basin (37 acres) is located in the City of Carrollton and the City of Farmers Branch. A portion of Addison Airport lies within the Rawhide Creek Basin. The remaining portions of the basin in Addison are predominantly commercial and industrial land uses with some residential land use. The basin is virtually built out with only a few isolated vacant parcels remaining. Most of the stormwater runoff from this basin is discharged to Rawhide Creek in the City of Farmers Branch, just west of Marsh Lane and south of Belt Line Road. The rest of the stormwater runoff is discharged into small unnamed tributaries to Rawhide Creek further south, also west of Marsh Lane.

The Town of Addison was concerned about stormwater flooding within the Rawhide Creek Basin and commissioned this Stormwater System Assessment and Capital Improvement Program (SSA/CIP) study in January 2016. The approach used for SSA/CIP in Addison was developed in consultation with Addison staff prior to the first stormwater basin study undertaken in the Town in 2008. This approach is based on a philosophy somewhat different than that used for stormwater system design which is strictly ordinance and criteria driven (Rational Method, 100-year flood capacity). For SSA/CIP planning in Addison, flood risk is evaluated to determine not only the degree of flooding and its effect on public safety, but the frequency and consequences (damages) of flooding. The cost of mitigation is taken into account when determining recommendations for the SSA/CIP plan. Last, but not least, opportunities to incorporate Green Infrastructure (GI) into the stormwater recommendations are explored to provide water quality benefits along with some (usually minor) flood reduction benefit. This is consistent with the Town of Addison's Drainage Criteria Manual, adopted in 2011 and the Town's Texas Pollutant Discharge Elimination System (TPDES) permit to discharge stormwater from its Municipal Separate Storm Sewer Systems (MS4s) into surface waters of the State.

In 2012, Halff Associates, Inc. (Halff) conducted an exploratory study to develop a Conceptual Stormwater Plan for all of Addison in order to determine an estimate of the cost of service for a stormwater utility. The evaluation of existing storm drainage systems was based on traditional storm drainage design methods. As a result of the exploratory study, $17.1 million in drainage relief needs were identified in the Rawhide Creek Basin. In order to better understand the severity of the flooding problems in the Rawhide Creek Basin and to investigate drainage relief alternatives, this more detailed stormwater study was commissioned by the Town of Addison. Halff used dynamic, two-dimensional (2-D) flow software to provide a more realistic evaluation and determination of stormwater problems based on threats to public safety, damage to public and private property, cost, and environmental impacts. The main objectives of the detailed study are to identify and characterize flooding concerns, determine their severity, formulate and evaluate alternatives to address the most severe flooding problems, and recommend measures to manage stormwater in the Rawhide Creek Basin.

The SSA/CIP effort included field reconnaissance, survey, hydrologic and hydraulic evaluation, flood mapping, and development of alternatives to reduce flood risk, both to pedestrians and motorists and in terms of flood damage to private and public property. This report and related documents present the recommendations, findings, methodologies, data sources, and the approaches used in the SSA/CIP study.

The detailed analysis determined that the existing stormwater system does not have capacity to convey the 100-year Design Storm as required by the Town of Addison Drainage Criteria Manual. The analysis identified seventeen (17) areas of concern where flooding depths near buildings or roadways were equal to or greater than 0.5 feet. These areas of concern were analyzed further and prioritized based on the degree of hazard to the public. Problem areas where flooding does not affect any buildings, runways, and taxiways were considered a lower priority. Also, flooding depths of less than 1 foot in the streets were considered a lower priority. As a result, only six (6) problem areas within the Rawhide Creek Basin were considered high priority (Problem Areas No. 1, 2, 5, 6, 7, and 9). The following is a description of the problem areas based on priority.

- Problem Area No. 5 is located at the intersection of Sherlock Drive and Winter Park Lane. At least one home in this area has flooded in recent years. The existing stormwater system does not have the capacity to convey the 100-year storm event causing the underground system to surcharge and stormwater to pond at the low area in the intersection of Sherlock Drive and Winter Park Lane. The analysis indicates a maximum 100-year flood depth of approximately 2.3 feet. Based on surveyed finished floor elevations, several houses are lower than the computed 100-year flood levels. Additionally, this level of flooding would be considered hazardous to vehicular traffic along Sherlock Drive and Winter Park Lane. Therefore, this Problem Area No. 5 was considered a high priority and one of the most severe problem areas in the Rawhide Creek Basin.
- The next high priority location, Problem Area No. 7, is located in the Les Lacs neighborhood southwest of the lake. During large flood events, stormwater spills out from the lake onto Waterside Court, one of three streets in the area. Flooding in this street reaches flood depths of a maximum 2 feet due to local area runoff, spill from the lake, and limited underground stormwater capacity. The other streets where ponding is significant during large flood events are Waterford Drive and Les Lacs Avenue.
- The third high priority area is Problem Areas No. 1 and 2, treated together because of their geographic and hydraulic relationship. Problem Area No. 1 is located north of Belt Line Road and between Surveyor Boulevard and Commercial Drive. Problem Area No. 2 is located along Belt Line Road. Stormwaters from this area are conveyed in an open channel into an undersized underground stormwater system. This underground system does not have capacity to convey the 100-year storm event causing the stormwater to spill into the adjacent parking lot to the west, flooding a commercial building. Overflows then spill into Problem Area No. 2, Belt Line Road west of Commercial Drive and continue to Marsh Lane. Flood depths along Belt Line Road reach up to 2 feet for most of the stretch.
- The fourth priority area, Problem Area No. 6, is located on the southwest side of the airport between Lindbergh Drive and Arapaho Road. The parking lot of the automotive rental facility in this area is subject to flood depths ranging from 2 to 3 feet, with stormwater ponding in the low-lying areas on this property.
- The last high priority problem area in the Rawhide Creek Basin is Problem Area No. 9. This problem area is at Fire Station #2 on Beltway Drive. The low area near the back of the building is poorly drained resulting in ponding of 1.2 feet for the 100-year flood depth at this critical facility.

Finished floor (FF) elevations of thirty-nine (39) residential and commercial structures within the Rawhide Creek Basin were surveyed in order to more accurately determine whether the structures are flooded by the 100-year storm event. The FF survey resulted in the number of affected structures as follows: seven (7) residential structures flooded by the 100-year storm event and fifteen (15) residential structures potentially flooded by the 100-year storm event. 'Structures flooded' are those where the flood level is higher than the lowest floor elevation of the structure. 'Structures potentially flooded' are those where the lowest floor elevation is higher, but still within 0.5 feet of the 100-year water surface elevation (WSEL).

Alternatives were developed to reduce flood risk for the 100-year storm event at Problem Areas No. 1, No. 2, No. 5, No. 6, No. 7, and No. 9. Drainage relief alternatives investigated including enlarging the underground stormwater system, installing new systems for stormwater relief or diversion, surface stormwater detention, and underground stormwater detention. Alternative designs are conceptual in nature and are generally consistent with the Town of Addison Drainage Design Manual. Once the proposed mitigation measures were formulated and analyzed, alternatives in the problem area were rated on factors such as flood risk reduction, project cost, neighborhood disruption, constructability, etc. The highest rated are then the recommended alternatives to reduce flood risk in their respective problem areas. More detailed descriptions of the alternative solutions are provided in Section IV.

Six (6) alternatives to reduce flooding in Problem Area No. 5 (Sherlock Drive/Winter Park Lane) were evaluated, including parallel underground stormwater systems, flume relief systems (dedicated emergency overflow), diversion, stormwater detention, acquisition of historically and potentially flooded structures, and a combination of property acquisition and detention. A letter report was submitted to the Town of Addison on December 16, 2016, explaining in detail the alternatives for this problem area. Surface detention was evaluated but not recommended because of the limited available sites around the problem area. In order to increase the capacity of the underground system, stormwater relief is needed. Adding a parallel underground relief system is the recommended solution. The estimated project cost for this solution is $1,100,000 and includes incorporation of a stormwater relief system to reduce flood risk for Problem Area No. 9 (Fire Station #2).

Alternatives to reduce flooding in Problem Area No. 7 (Les Lacs neighborhood) include enlarging the existing underground stormwater system, installing a new or a parallel underground system for stormwater relief, diversion, and minor re-grading along the lake edge at Waterside Court. Because flood levels in the lake during a 100-year storm event are higher than the elevation of the bank, stormwaters spill into the street (Waterside Court) and contribute to 100-year flood depths in the street that reach a maximum of 2 feet deep. A simple solution is to eliminate the spill by re-grading the bank so that the low point is elevated safely above the peak flood elevation in the lake. This proposed re-grading alone reduces the flood depth in Waterside Court to 1 foot. In addition to the regrading, additional underground stormwater improvements will be needed to relieve the flooding in the three streets (Waterside Court, Waterford Drive and Les Lacs Avenue) to depths less than 1 foot. The recommended alternative (Alternative No. 1) reduces the flood depths to less than 0.5 feet. The cost estimate for this recommended solution is $1,765,000.

Alternatives to reduce flooding in Problem Areas No. 1 and No. 2 included enlarging the underground stormwater, installing new systems for stormwater relief or diversion, and stormwater detention. Surface detention was an effective option, but requires acquisition of private property which would then be solely dedicated to stormwater management. Stormwater improvements alone were enough to increase the capacity of the downstream system and contain the spill, but this option requires mitigation to avoid increased flooding along Farmers Branch Creek in the City of Farmers Branch. Combinations of surface detention and underground stormwater improvements were developed and evaluated, but the cost of each solution was very expensive and, therefore, not recommended as an efficient flood risk reduction measure. Because flooding is largely contained in the street and in order to minimize risk to the public, this area is proposed to be included in a Town-wide Automated Flood Alert System. Such a system, combined with appropriate Emergency Response / Action Plan measures, would be used to alert the community of a flood hazard in the area. The estimated project cost of the emergency flood warning system for the entire Town is approximately $650,000, including the base station, rainfall gages, level monitors, and flashing warning lights. The Flood Alert System can be expanded in the future to provide warning for other flood problem areas throughout the town as they become known. More detailed descriptions of the alternative solutions are provided in Section IV.

Problem Area No. 6 occurs on privately owned property at the southwest corner of Addison Airport. This site is very low and a feasible plan for raising the site had previously been developed and approved by the Town of Addison. For this reason, other alternatives to reduce flooding at Problem Area No. 6 were not developed.

Flood risk at Problem Area No. 9 (Addison Fire Station #2) can be reduced by adding the necessary inlets to drain the low spot on the back of the fire station building. A new underground stormwater system is required from the proposed inlets to an existing system just to the east that serves Problem Area No. 5. This also requires capacity in the connecting system for the additional flow. This alternative is recommended to be included with the proposed solution for Problem Area No. 5. The estimated project cost for the Problem Area No. 9 solution is included with that for Problem Area No. 5 (Sherlock Drive / Winter Park Lane). More detailed descriptions of all alternative solutions are provided in Section IV.

Please note that the Town has a Texas Pollutant Discharge Elimination System (TPDES) permit to discharge stormwater from its Municipal Separate Storm Sewer Systems (MS4s) into surface waters of the State. The focus of the permit is the reduction or elimination of stormwater pollutants to the maximum extent practicable through the establishment and execution of a Stormwater Management Program (SWMP). The SSA/CIP described in this report is intended to be complementary to the SWMP outlined in the Town of Addison's TPDES Stormwater Permit. For example, consideration of Green Infrastructure (GI) and Low Impact Development (LID) opportunities is recommended in the implementation of this SSA/CIP alternative for the Rawhide Creek Basin. Additionally, as properties develop and/or redevelop in the basin, both GI/LID practices and stormwater detention should be incorporated in those sites in accordance with the Town of Addison Drainage Criteria Manual. This should improve stormwater quality consistent with some of the goals of the SWMP and should, in a small way, help to further reduce the flooding that has been identified in this study over and above the implementation of the SSA/CIP.

I. INTRODUCTION

The Town of Addison is served by an urban storm drainage system that consists of streets, curb inlets, underground pipes and box culverts, open (manmade) drainage channels and, in a few areas, natural streams. During periods of significant rainfall, storm runoff typically drains to the streets, then travels via the street gutter to an inlet (curb inlet or grate inlet). The inlet then collects the runoff and sends it to an underground stormwater system (pipe or box). The underground system typically sends the runoff to a series of larger underground systems, then ultimately discharges the storm runoff to a drainage channel or a natural stream.

Currently, the design standard used for a typical large storm drainage system in Addison is the 100-year storm event, which is defined as a flood having a one percent (1%) chance of happening at least once in any given year. Hydrologists and engineers cannot predict when the 1% flood event will occur due to the random nature of storm events. Such a flood event may not occur over a period of several hundred years, or conversely, may occur in two successive years. On average over a long period of time, the 1% flood event will be exceeded once every 100 years.

Drainage design criteria has changed over the years, as engineers have studied what happens in urban areas during and immediately after storm events. For example, 35 years ago, drainage engineers in Addison calculated that during a 1% flood event, the runoff draining to an inlet in a residential area would be based on a rainfall of 7 inches per hour. Current research shows the rainfall in this case to be 8 inches per hour as seen in Table 5.2 of the iSWM (integrated Stormwater Management) hydrology manual. Similar refinements have been made over the years and continue to be made for other criteria that are used to determine the design flood magnitude for urban storm drainage systems.

Drainage problems occur when storm runoff exceeds the capacity of the storm drainage system. For example, heavy rainfalls may result in excess stormwater on the street that exceeds the capacity of storm inlets. The excess stormwater will bypass the inlet and continue down the street, often collecting to significant depths in low areas that do not have an adequate emergency overflow provision. The underground stormwater system can become full, resulting in the system becoming "surcharged," a condition in which it cannot handle any additional runoff until the storm recedes. Typically, this causes excessive ponding in low areas and can result in significant flood risk to property, motorists, and pedestrians.

There are a number of measures that can be taken to address urban drainage problems. Those measures include:

- Enlargement/Parallel Relief – the portions of the existing system that lack capacity are replaced with larger systems or paralleled with a similar underground system to provide added capacity for the desired design storm.
- Diversion – stormwater runoff can be diverted around a problem area by an underground stormwater system if a suitable route is available.
- Stormwater Detention – stormwater runoff rates can be reduced by holding excess runoff volume and then slowly releasing it to the existing underground stormwater system as the flood event recedes.
- Property Acquisition – the Town of Addison could acquire and demolish properties that are at risk of flooding and use the resulting open space to accommodate floodwaters and as a neighborhood amenity.

- Town-wide Automated Flood Warning Systems/Flood Emergency Action Plans – a Town-wide Automated Flood Warning System can provide early warning to allow the Town to activate the flood response components of its emergency action plan (flashing warning lights, barricades, etc.). The system can also capture specific flood and rainfall data for post-event analysis. Complementary programs exist at both the state and regional level that can potentially increase the effectiveness of an Addison Automated Flood Warning System and may even be a source of some funding.
- Combinations of the above mitigation measures are often the most effective approach to reducing flood risk.

This report provides a summary of the study findings and recommendations for the Rawhide Creek Basin Stormwater System Assessment and Capital Improvement Program (SSA/CIP). Additional detailed information is contained in the appendices which are provided electronically.

As stated previously, the focus of the TPDES permit is the reduction or elimination of stormwater pollutants to the maximum extent practicable through the establishment and execution of a Stormwater Management Program (SWMP). The SWMP includes six required Minimum Control Measures:

- Public Education, Outreach and Involvement.
- Illicit Discharge Detection and Elimination.
- Construction Site Stormwater Runoff Control.
- Post-Construction Stormwater Management in New Development and Redevelopment.
- Pollution Prevention and Good Housekeeping for Municipal Operations
- Industrial Stormwater Sources.

The SSA/CIP described in this report is intended to be complementary to the SWMP outlined in the Town of Addison's TPDES stormwater permit particularly in areas such as Post-Construction Stormwater Management in New Development and Redevelopment.

A. Study Location

Rawhide Creek is a tributary of Farmer's Branch. Its headwaters drain approximately 887 acres, of which 850 acres lie within the Town of Addison. The southern part of Addison Airport lies within the Rawhide Creek Basin. **Figure I-1** shows the location of the Rawhide Creek Basin.

The Rawhide Creek storm drainage system in Addison conveys stormwater to Rawhide Creek in Farmers Branch, Texas, west of Midway Road and south of Belt Line Road.

B. Purpose and Study Scope

The purpose of this SSA/CIP is to identify flood risk and determine effective measures to mitigate significant adverse impacts to life, safety, and public and private infrastructure as a result of natural and human-made drainage system overflows. The SSA/CIP study characterizes the problems and analyzes alternatives to reduce flood risk based on the 100-year storm event. Both one-dimensional (1-D) and more advanced two-dimensional (2-D) modeling tools are extremely effective for this type of study.

The primary objective is to develop a recommended plan of sustainable, efficient and cost-effective measures to reduce life safety risks and the potential for flood impacts to roads, commercial buildings and homes. The study identifies and evaluates existing flooding problem concerns within the basin based on future land use and assesses the effectiveness of proposed alternatives.

Alternative improvements investigated in this study included replacement/enlargement of underground stormwater systems, installing parallel underground stormwater relief systems, installing new systems to divert flows for stormwater relief, surface detention, underground stormwater detention and flood warning system integration into the Town's emergency action plan. Detailed descriptions of alternative solutions are provided in Section IV.

This scope of the Rawhide Creek Basin study includes the following:

- Collecting stormwater system data from the Town of Addison as-built drainage plans and existing Geographic Information System (GIS) files.
- Performing field reconnaissance to verify drainage patterns and stormwater system infrastructure.
- Performing stormwater feature surveys where record (as-built) plans are not available to obtain information such as size and depth for the system.
- Modeling of the stormwater systems using the XP Stormwater Management Model (XPSWMM) to evaluate the existing stormwater system and identify potential problem areas.
- Performing finished floor elevation surveys for those structures in contact with the 100-year flood inundation mapping to confirm whether or not the structure is actually flooded by the 100-year storm event.
- Development of conceptual alternatives for reduction of flood risk in problem areas.
- Evaluation of conceptual flood risk reduction alternatives and development of a recommended Stormwater Capital Improvement Program with estimates of probable project costs.

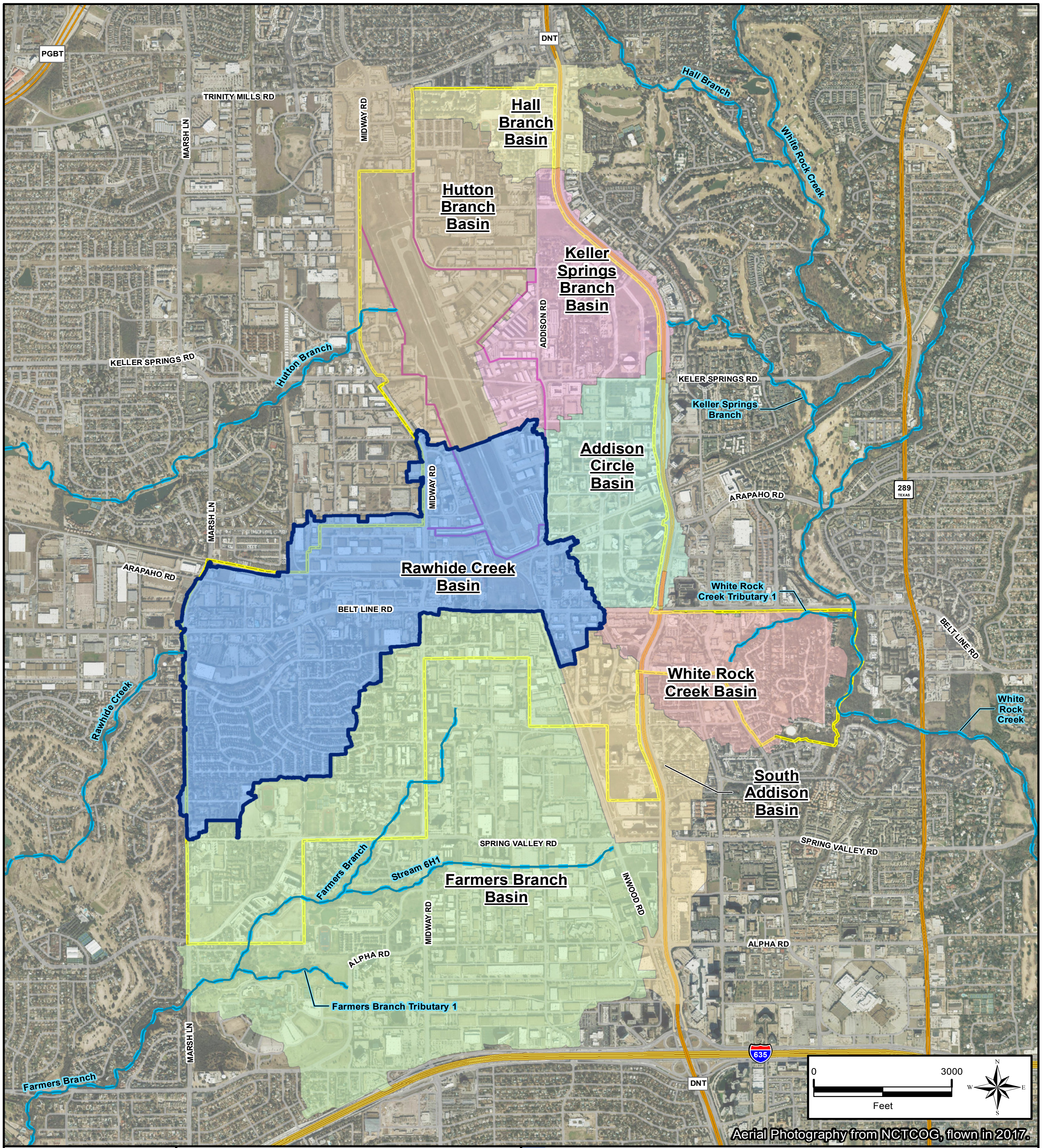


Figure I-1

Location Map

Rawhide Creek Basin
Stormwater System Assessment & Capital Improvement Program

ADDISON

HALFF

KEY TO FEATURES

- Streams
- Interstate
- Highway
- Roads
- Airport Boundary
- Addison City Limits
- Rawhide Creek Overall Basin

Other Drainage Basins

- Addison Circle
- South Addison
- Farmers Branch
- Hall Branch
- Hutton Branch
- Keller Spring
- White Rock Creek

II. DATA COLLECTION AND GENERATION

The first phase of the Stormwater System Assessment study consists of gathering existing data relevant to the project study area. The data includes locations of existing stormwater systems (inlets, manholes, outfalls, ditches, pipes, etc.) and available as-built plans. Stormwater system as-built plans were obtained from the Town of Addison. A GIS stormwater database, created by the Town and refined by Halff in 2012 was used for this study. Field inspections were conducted to verify the location of the storm drainage features and drainage patterns. Also, surveys of the above ground stormwater features were performed in order to define the system where record (as-built) plans are not available. This data was then used to create a digital model of the existing storm drainage system using the XP Stormwater Management Model (XPSWMM) software analysis tool.

A. Data Received

Data was obtained from the Town of Addison as summarized below.

1. GIS Data

The stormwater GIS database completed in 2012 for the entire Town of Addison was used to determine the initial storm drainage system layout. This database was created as part of the stormwater system inventory performed by Halff beginning in 2010. This database is useful in the Stormwater System Assessment study as it provides a link to digital copies of the as-built plans for most stormwater systems in the Town. It also provides information regarding inlet sizes, types, and pipe size. The locations of the surface stormwater infrastructure features were validated and located using a handheld Global Positioning System (GPS) data collection device.

2. Record Plans

The Town of Addison provided the majority of the record (as-built) underground stormwater system plans for the systems draining the Rawhide Creek Basin. However, in some areas, record plans could not be located in the Town's archives. Please Refer to Figure A-1 in Appendix A for the schematic of the existing stormwater system within the Rawhide Creek Basin. Note that 'As-Built Plan Profile' means horizontal and vertical data is available on the record plans while 'No As-Built Plan Profile' means that vertical data is not included and was obtained in the field when possible.

B. Field Data

The stormwater GIS database supplied data for the majority of the drainage systems within the Rawhide Creek Basin. However, additional information was needed to completely define the existing drainage system. This additional data was collected by field reconnaissance of the Rawhide drainage system using mobile GIS tools. The field inspection involved coordination with the Town of Addison and with the Airport. The areas that lacked data or where existing data was suspect were inspected. These areas included: inlets throughout the basin without detailed specifications on plans, Landmark Boulevard, Lindbergh Drive, Addison Road, Richard Byrd Drive, Surveyor Boulevard, and Business Avenue. In these areas, assumptions were made based on field observations and best available topography to completely define the existing stormwater system.

In order to confirm the location of the above ground stormwater features a customized tablet-based GIS application with GPS was used to collect this data.

C. Survey

Field survey of the existing stormwater system were conducted in October of 2016 to obtain information such as: ground elevation, size of inlet, size of the conduit, and depth of the underground system (conduit). Surveys were performed where record plans (as-built) could not be located and where access to the underground stormwater system is available. In total, six (6) locations throughout the basin required surveying. Additionally, finished floor elevations of thirty-nine (39) structures were surveyed to confirm whether or not the structure is actually flooded by the 100-year storm event based on the existing conditions flooding results. Appendix G includes the location of the surveys along with the data collected.

D. Stormwater GIS Database Updates

The existing stormwater database was developed for the Rawhide Creek Basin in 2012 by Halff. The database was updated with new, and in some cases, more detailed information (size of conduit, slope of conduit, number of barrels, length of conduit, and invert elevation) collected in this study.

E. Study Area Topography and Aerial Photography

Topographic data covering the Rawhide Creek Basin was based on the North Central Texas Council of Governments (NCTCOG) 2015 Light Detection and Ranging (LiDAR) terrain data for the Town of Addison. This data was used to delineate drainage sub-basins, define flowpaths, and create a Triangular Irregular Network (TIN) surface for 2-D stormwater modeling and mapping.

III. STORMWATER SYSTEM MODELING

The Rawhide Creek drainage system, as modeled, consists of 97,578 linear feet (LF) of underground pipes, the majority of which is within the Town of Addison. There are some manmade small channels and swales within this basin. The system serves parts of the Airport, along with commercial, industrial, and residential areas in Addison.

Using both the one-dimensional (1-D) and two-dimensional (2-D) capabilities of XPSWMM version 2016.1, a model was created to represent the existing stormwater system within the Rawhide Creek Basin. The 1-D model was developed to analyze the underground conduits; the 2-D model was developed to analyze the surface and open channel flooding. One (1) XPSWMM model was generated for the existing stormwater system (existing conditions) based on estimates of the fully developed land uses in the basin. The XPSWMM digital model is submitted separately as part of Appendix I. More detailed information regarding the hydrologic and hydraulic methodology used to develop the XPSWMM models is provided in Appendix A.

A. Hydrology

The purpose of the hydrologic analysis was to develop stormwater runoff hydrographs as input for the dynamic 1-D/2-D hydraulic analysis of the Rawhide Creek Basin.

XPSWMM was used to produce runoff hydrographs for each drainage sub-basin for the 2-, 10-, and 100-year storm events based on the following hydrologic parameters:

- Drainage sub-basin area delineation, generally at each inlet or group of inlets.
- Typical rainfall distribution for the North Texas area.
- Rainfall depths from the North Central Texas Council of Governments (NCTCOG) iSWM manual.
- Time of Concentration (T_C).
- Soil Type Classification.
- Curve Number (CN) – based on Land Use and Soils.

B. Hydraulics

XPSWMM was used to develop the 1-D underground stormwater network for the Rawhide Creek Basin in Addison. The 1-D model was used to evaluate the capacity of the underground system. The stormwater conduits and channels are represented by links in the model. Inlets, manholes, and locations where there is a change in pipe size or slope are represented by nodes in the model. Overland flow, street flow, channel flow, and spills were analyzed using the 2-D capabilities of XPSWMM. The 2-D domain is represented by a grid of square cells containing topographic information. This study uses the North Central Texas Council of Governments (NCTCOG) 2015 Light Detection and Ranging (LiDAR) terrain data for the Town of Addison to represent existing topography. The XPSWMM model plan schematic for the existing system is shown in Appendix A, Figure A-1.

C. Mapping

Approximate flood inundation boundaries for the existing storm drainage system (fully developed land use) were mapped based on the 2-D XPSWMM analysis results for the 2-, 10-, and 100-year storm events. Flooded areas for the 2-, 10-, and 100-year storm events are shown in Appendix A (Figures A-6 through A-8).

D. Existing System Capacity Analysis

Based on flood mapping for various flood magnitudes generated from the 2-D results of the XPSWMM model, the existing stormwater system was reviewed to determine its capacity in terms of storm severity. The results confirm that the storm drainage systems in the Rawhide Creek Basin generally do not have capacity for the 100-year storm event as called for in Addison's Drainage Criteria Manual. The flood inundation map for the 100-year storm event (Figure A-8, in Appendix A) reflects significant street ponding and overflows bypassing from inlet to inlet. Typically, this is due to surcharged underground stormwater systems. A review of the smaller 10-year storm event (Figure A-7, in Appendix A) indicates that much of the Rawhide Creek storm drainage system is also not sufficient for the 10-year storm event. At the 2-year storm event level, the analysis generally reflects that the existing system has capacity except for one particularly low site just at the southwest corner of the Airport.

E. Design Criteria

The Town of Addison Drainage Criteria Manual (2011) and The NCTCOG iSWM criteria manual were used for guidance in this study. Both documents state that the 100-year event should be the design storm for significant urban drainage systems. The Town of Addison drainage manual specifies that the design storm frequency for closed conduits in streets should be 10-year event contained within the underground stormwater system and 100-year event within the drainage or street right-of-way (ROW). The design storm frequency for systems draining low areas should be the 100-year event with the provision of positive overflow for larger events. Generally, this (100-year event) requirement governs the flood risk reduction alternatives developed for this study.

F. Problem Areas

The results of the existing stormwater system analysis for the 100-year storm event were evaluated to identify flooding concerns (Potential Problem Areas) within the Rawhide Creek Basin in Addison. Initially, locations of flood depths equal to or greater than 0.5 feet in streets or near buildings were noted as areas of concern. This resulted in seventeen (17) locations identified as potential problem areas due to flooding. **Figure III-1** shows the location of the potential problem areas. Appendix A, shows all potential problem areas in more detail (Figure A-9 through Figure A-21). Additional information for all potential problem areas is provided on **Table III-1**.

These areas were analyzed further and prioritized based on the degree of hazard to the public, the degree of hazard to structures, the duration of flooding, the consequences of flooding (public safety, damage) and flood depths greater than 1 foot in the streets. Areas where flooding does not adversely affect buildings were not considered as high priority for storm drainage relief. Also, flood depths of less than 1 foot in streets were not considered a high priority for storm drainage relief. As a result, only six (6) areas within the Rawhide Creek Basin were considered as high priority for storm drainage relief. These high priority problem areas are Problem Areas No. 1, 2, 5, 6, 7, and 9.

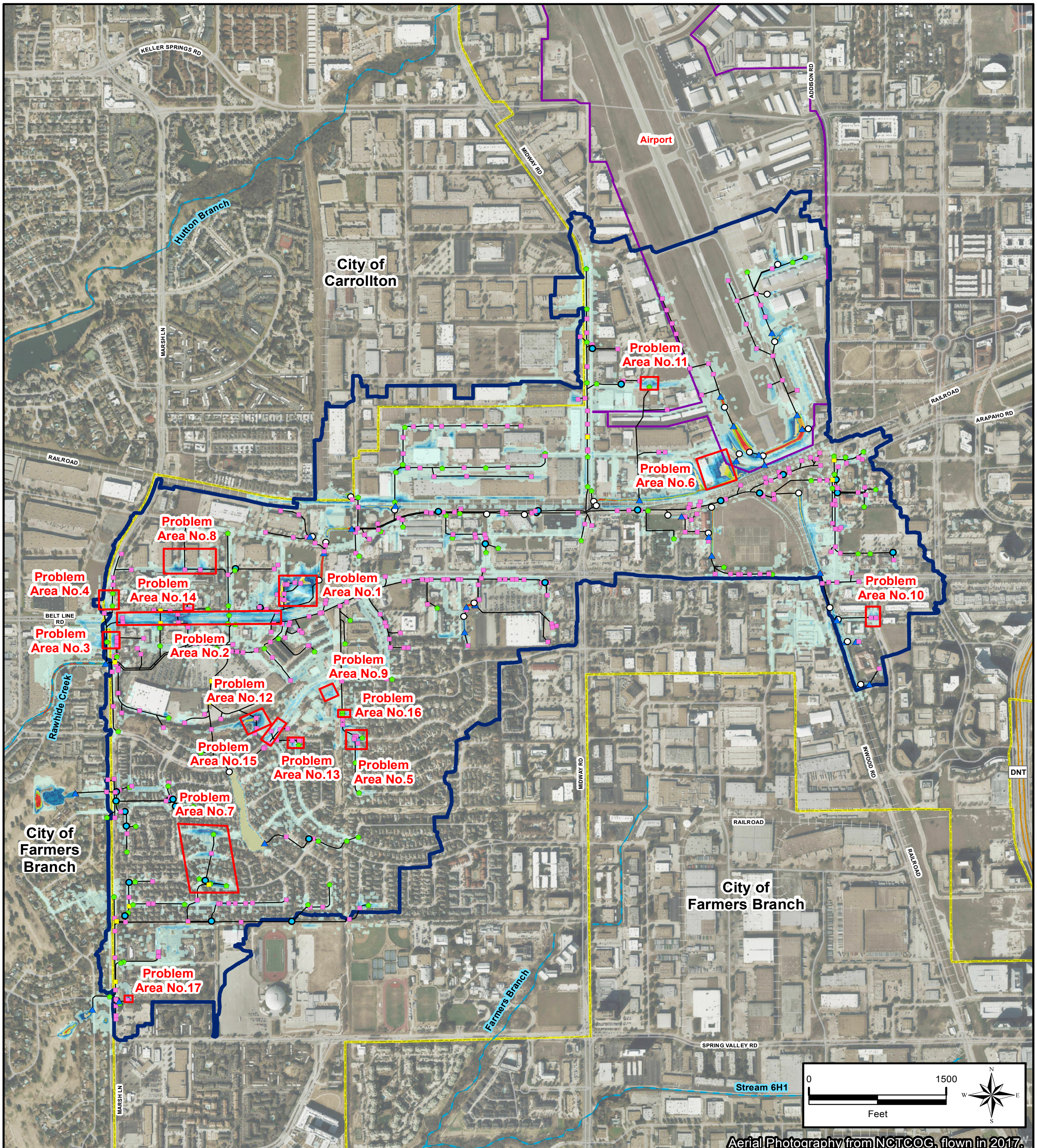
Problem Area No. 1 is located north of Belt Line Road between Commercial Drive and Surveyor Boulevard and Problem Area No. 2 is located along Belt Line Road. These two problem areas were evaluated together as Problem Area No. 2 (Belt Line Road) is affected by stormwater spilling from Problem Area No. 1. There is a large (660 cfs) spill from the open channel just downstream (south) of Arapaho Road for the 100-year storm event (220 cfs for the 10-year storm event). The spill contributes to maximum flood depths of 2.9 feet in the adjacent parking lot, 3.2 feet in Commercial Drive, and 2.3 feet in Belt Line Road. The 10-year storm event has flooding of 2.3 feet, 2.1 feet, 1.2 feet in the same locations.

Problem Area No. 5 is located at the intersection of Sherlock Drive and Winter Park Lane. The 100-year flood depth at the intersection is approximately 2.3 feet and the duration of flooding (more than 0.5 feet of depth) is approximately 70 minutes. Additionally, flood damage has occurred in the adjacent properties as recently as May 2015 during a large rainfall event. As a result, this area was considered a high priority candidate for storm drainage relief.

Problem Area No. 6 is located southwest of the airport along an open channel. The 100-year flood depth is 3.6 feet at one location this low-lying parking lot, approximately 2 feet next to a small building on the site, and 1 foot near some larger buildings. The duration of flooding for the 100-year storm event is approximately 18 hours. Additionally, the 2-year storm has flood depths up to 2.6 feet and a flood duration of approximately 16 hours in the low-lying parking lot.

Problem Area No. 7 is located east of Marsh Lane and south of Beltway Drive and includes flooding in Waterside Court, Waterford Drive, and Les Lacs Avenue. Flooding in those streets reaches depths of 2.1 feet, 1.3 feet, and 1.9 feet respectively. Flood duration greater than 0.5 feet is about 75 minutes for Waterside Court, 65 minutes for Waterford Drive and about 35 minutes for Les Lacs Avenue.

Problem Area No. 9 is located at Fire Station #2 on Beltway Drive. The 100-year flood depth in the fire-station parking lot is 1.2 feet and with a flood duration of 35 minutes.



ADDISON

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Figure III-1

Problem Areas

(100-YR Storm Event)

Rawhide Creek Basin

Stormwater System Assessment & Capital Improvement Program

KEY TO FEATURES

Floodplain Depths (ft)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 - 4
- > 4

XP Model Nodes and Links

- Group Inlet
- Headwall
- Inlet
- Junction
- Manhole
- Outfall
- XP Model Storm Sewer Lines
- Problem Areas
- Rawhide Creek Overall Basin
- Airport Boundary
- Addison City Limits

Table III-1: Potential Problem Areas Based on the 100-year and 10-year Storm Events

Appendix A	Location	Description	Max Depth of Flooding (100yr/10yr)	Duration of Flooding	Land Owner	Priority
Problem Area No. 1 (Figure A-09)	Commercial Drive, north of Belt Line Road	Stormwaters pond in this area to a maximum depth of 3.2 feet for the 100-year and 2 feet for the 10-year along the edges of the Commercial Drive. The entire road floods largely due to a very large spill of 660 cfs (100-year) and 220 cfs 10-year from an open channel to the east. The parking lot to the east also floods to depths of 2.9 feet for the 100-year and 2.3 feet for the 10-year flood.	3.2 feet / 2.3 feet	The duration of flooding > 0.5 feet of depth is approx. 55 min for the 100-year flood and approx. 20 min for the 10-year flood.	Public/Private	High
Problem Area No. 2 (Figure A-10)	Belt Line Road, west of Commercial Drive to Marsh Lane	Stormwaters pond in this area to a maximum depth of 2.3 feet for the 100-year and 1.2 feet for the 10-year event. Flooding in Problem Area 1 spills into Belt Line directly via Commercial Drive and continues to flow east to Marsh Lane. Flooding occurs for the entire stretch of road, particularly in low lying areas.	2.3 feet / 1.2 feet	The duration of flooding > 0.5 feet of depth is approx. 120 min for the 100-year and approx. 75 min for the 10-year.	Public	High
Problem Area No. 3 (Figure A-11)	Marsh Lane, south of Belt Line Road	Stormwaters pond in this area to a maximum depth of 1.5 feet for the 100-year and 1.0 feet for the 10-year event. Flooding in Problem Area 2 spills into Marsh Lane causing flooding in the road. For the 100-year event, a large overflow totaling about 300 cfs spills from Addison into the City of Carrollton and the City of Farmers Branch. Along Belt Line Road west of Marsh Lane there is 180 cfs of overflow, and south of Belt Line Road there is 120 cfs of overflow through parking lots and businesses. For the 10-year event the spill into the adjacent cities is negligible.	1.5 feet / 0.5 feet	The duration of flooding > 0.5 feet of depth is approx. 50 min for the 100-year and more than 24 hrs for the 10-year.	Public	Low
Problem Area No. 4 (Figure A-11)	Marsh Lane, north of Belt Line Road	Stormwaters pond in this area to a maximum depth of 1.3 feet for the 100-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge at multiple locations.	1.3 feet*	The duration of flooding > 0.5 feet of depth is approx. 30 min for the 100-year.	Public	Low
Problem Area No. 5 (Figure A-12)	Sherlock and Winter Park Lane	Stormwaters pond in this area to a maximum depth of 2.3 feet for the 100-year and 1.4 feet for the 10-year event. The capacity of the existing underground stormwater system serving this area is exceeded, which causes the system to surcharge at multiple locations. Flood events in recent years have caused damage to surrounding homes.	2.3 feet / 1.4 feet	The duration of flooding > 0.5 feet of depth is approx. 70 min for the 100-year and approx. 45 min for the 10-year.	Public/Private	High
Problem Area No. 6 (Figure A-13)	Enterprise Rent-A-Car off of Lindbergh Drive, south of the airport	Stormwaters pond in this area to a maximum depth of 3.6 feet for the 100-year and 2.9 feet for the 10-year event. Flooding here is primarily caused by the low-lying topography of the site.	3.6 feet / 2.9 feet	The duration of flooding > 0.5 feet of depth is approx. 18 hrs for the 100-year and 16 hrs for the 10-year.	Private	High
Problem Area No. 7 (Figure A-14)	Waterside Court, Waterford Drive, and Les Lacs Avenue	Stormwaters pond in this area to a maximum depth of 2.0 feet for the 100-year and 0.7 feet for the 10-year event. At these locations, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge at multiple locations	2.0 feet / 0.7 feet	The duration of flooding > 0.5 feet of depth is approx. 75 min for the 100-year and approx. 25 min for the 10-year.	Public	High
Problem Area No. 8 (Figure A-15)	Marsh Business Park, southeast of the intersection of Marsh Lane and Arapaho Road	Stormwaters pond in this area to a maximum depth of 2.5 feet for the 100-year and 1.3 for the 10-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge at multiple locations.	2.5feet / 1.3 feet	The duration of flooding > 0.5 feet of depth is approx. 35 min for the 100-year and more than 24 hrs for the 10-year.	Private	Low
Problem Area No. 9 (Figure A-12)	Town of Addison Fire Station, off of Beltway Drive	Stormwaters pond in this area to a maximum depth of 1.2 feet for the 100-year and 0.6 for the 10-year event. Flooding at this critical facility is caused by overflow from the southeast and the lack of drainage features in the area.	1.2 feet / 0.6 feet	The duration of flooding > 0.5 feet of depth is approx. 30 min for the 100-year and unknown for the 10-year.	Public	High
Problem Area No. 10 (Figure A-16)	Landmark Boulevard, south of Belt Line Road	Stormwaters pond in this area to a maximum depth of 1.4 feet for the 100-year and 1.1 for the 10-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	1.4 feet / 1.1 feet	The duration of flooding > 0.5 feet of depth is approx. 50 min for the 100-year and approx. 30 min for the 10-year.	Public	Low
Problem Area No. 11 (Figure A-17)	Wiley Post Road and Morris Ave	Stormwaters pond in this area to a maximum depth of 1.7 feet for the 100-year and 1.0 feet for the 10-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	1.7 feet / 1.0 feet	The duration of flooding > 0.5 feet of depth is approx. 65 min for the 100-year and approx. 40 min for the 10-year.	Public	Low
Problem Area No. 12 (Figure A-18)	Les Lacs Park by Beltway Drive and Proton Drive intersection	Stormwaters pond in this area to a maximum depth of 3.2 feet for the 100-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	3.2 feet*	The duration of flooding > 0.5 feet of depth is approx. 90 min for the 100-year.	Public	Low

* Areas not adversely affected by the 10-year storm event.

Table III-1: Characteristics of Potential Problem Areas Based on the 100-year and 10-year Storm Events (cont.)

Appendix A	Location	Description	Max Depth of Flooding (100yr/10yr)	Duration of Flooding	Land Owner	Priority
Problem Area No. 13 (Figure A-18)	Azure Lane	Stormwaters pond in this area to a maximum depth of 2 feet for the 100-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	2 feet*	The duration of flooding > 0.5 feet of depth is approx. 25 min for the 100-year.	Public	Low
Problem Area No. 14 (Figure A-19)	Chick-fil-A Parking Lot, north side of Belt Line Road	Stormwaters pond in this area to a maximum depth of 1.3 feet for the 100-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	1.3 feet*	The duration of flooding > 0.5 feet of depth is approx. 20 min for the 100-year.	Private	Low
Problem Area No. 15 (Figure A-20)	Beltway Drive, northeast of intersection with Proton Drive	Stormwaters pond in this area to a maximum depth of 1.5 feet for the 100-year and 0.9 feet for the 10-yr event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	1.4 feet / 0.9 feet	The duration of flooding > 0.5 feet of depth is approx. 75 min for the 100-year and approx. 30 min for the 10-year.	Public	Low
Problem Area No. 16 (Figure A-20)	West end of Mormon Lane	Stormwaters pond in this area to a maximum depth of 1.2 feet for the 100-year and 0.7 feet for the 10-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	1.2 feet / 0.7 feet	The duration of flooding > 0.5 feet of depth is approx. 30 min for the 100-year and more than 24 hrs for the 10-year.	Public	Low
Problem Area No. 17 (Figure A-21)	Shadowood Apartment Homes	Stormwaters pond in this area to a maximum depth of 2.2 feet for the 100-year and 1.7 feet for the 10-year event. At this location and upstream, the capacity of the existing underground stormwater system is exceeded, which causes the system to surcharge.	2.2 feet / 1.7 feet	The duration of flooding > 0.5 feet of depth is approx. 120 min for the 100-year and approx. 70 min for the 10-year.	Private	Low

* Areas not adversely affected by the 10-year storm event.

IV. STORM DRAINAGE RELIEF ALTERNATIVES

High priority problem areas were identified based on the degree of hazard to the public, the degree of hazard to structures, the duration of flooding, the consequences of flooding (public safety and damages), and flood depths greater than 1 foot in the street. Based on these criteria, five (5) problem areas were identified as high priority and alternatives for flood reduction were developed. These problem areas are: Problem Area No. 1, 2, 5, 7, and 9. A feasible solution for elevating the low-lying Problem Area No. 6 above 100-year flood levels was previously developed by the facility owner and approved by the Town of Addison. Alternatives for the remaining priority problem areas were formulated and evaluated based on the 100-year storm event.

A number of flood risk reduction measures were considered. Underground system enlargement involves the replacement of the insufficient stormwater system with adequately sized conduits and, where required, additional inlets. One benefit of replacement of the existing system is that this generally minimizes utility conflicts, which can be significant in urban areas. In-line replacement would also help to address any problems associated with the aging stormwater system infrastructure. However, in-line replacement of existing systems typically results in high construction costs due to the larger conduit sizes and phasing constraints associated with the removal of the existing system. Often, system enlargement can be achieved by construction of a parallel stormwater underground system, if the existing system is in good shape and adequate right-of-way (ROW) is available.

Diversion is sometimes used to relieve undersized systems. This involves the redirection of a portion of the contributing drainage area away from the undersized system using new or otherwise adequate drainage facilities.

Stormwater detention facilities, either underground or surface, can be used to capture and temporarily store floodwaters to reduce peak downstream discharges. The amount of flow released from a detention facility must be limited so that the capacity of the downstream stormwater system is not exceeded and downstream flooding conditions are not worsened.

When more than one alternative was evaluated per problem area a rating process was implemented to evaluate and compare the alternatives. The alternatives were rated on factors such as neighborhood disruption, flood risk reduction, project cost, constructability, etc. The highest rated are then the recommended alternatives to reduce flood risk in their respective problem areas. More detailed descriptions of the alternative solutions are provided in Part C of this section.

Photo IV-1: Problem Area No. 5

(Looking northeast across the corner of Sherlock Drive and Winter Park Lane - Storm Event of June 12, 2016)

Sherlock Drive and Winter Park Lane (Problem Area No. 5) is ranked as a high priority for flood relief in the Rawhide Creek Basin. A rain event on May 29, 2015 caused significant flooding at this location. The total rainfall depth for the May 29 storm (about 6 hours in duration) was approximately 3.6 inches based on NOAA's Multisensor Precipitation Estimates (MPE). This is equivalent to a 5-year storm event based on the Intensity Duration Frequency (IDF) curves (refer to Appendix H for details). According to Town staff, the owner of 14727 Sherlock Drive reported $40,000 worth of flood damage for this storm. Another storm occurred more recently on June 12, 2016 that also prompted complaints from the homeowners in the area. The combination of existing flooding complaints with documentation and risk to residential property are factors making this one of the highest priority areas for flood risk reduction in the Rawhide Creek Basin. The existing conditions model shows a maximum flood depth of approximately 2.3 feet in the street for the 100-year storm event.

A finished floor elevation survey performed at seven (7) homes in this area (Sherlock Drive and Winter Park Lane) determined that three (3) homes would be flooded by the 100-year storm event (3907 Winter Park Lane, 14727 Sherlock Drive, and 14725 Sherlock Drive) and two (2) homes would be potentially flooded by the 100-year storm event. 'Structures flooded' are those where the flood level is higher than the lowest floor elevation of the structure. 'Structures potentially flooded' are those where the lowest floor elevation is higher, but still within 0.5 feet of the 100-year WSEL. Six (6) flood risk reduction alternatives were investigated for Problem Area No. 5. These alternatives include: parallel relief underground stormwater system, flume relief system (provision of a dedicated emergency overflow facility), diversion, stormwater detention, property acquisition, and a combination of property acquisition with bio-retention.

Problem Area No. 7 is a high priority for flood relief due to overflows in streets and through residential lots for the 100-year storm event. Stormwater spills from the Les Lacs pond into Waterside Court adding to the flooding caused by an undersized underground stormwater system serving the area. Stormwaters build up to 2 feet deep in Waterside Court and spill through residential lots into Waterford Drive. For this reason, it is recommended that the pond edge be re-graded to eliminate the low spot and therefore, spill from the lake. By doing this re-grading alone, the flood depth is reduced to 1 foot at Waterside Court. Finished floor (FF) elevations of twenty-eight (28) residential structures were surveyed in the Les Lacs neighborhood and an apartment complex east of Marsh Lane. The FF surveys determined that one (1) residential structure is flooded by the 100-year storm event in the 14600 Marsh Lane apartment complex (apartment #1051) and thirteen (13) residential structures are potentially flooded. In order to reduce the flood depth to less than 1 foot at the low portions of Waterside Court, Waterford Drive, Les Lacs Avenue, and reduce the spills coming from this system to the south, the construction of a new stormwater system, along with a parallel relief system, and enlargement of the existing system are recommended.

Problem Areas No. 1 and No. 2 are the third high priority due to the flood risk to one commercial building and Belt Line Road, a major thoroughfare. During large flood events, stormwater spills out of an open channel and will flood the building at 3939 Belt Line Road by about 1 foot and the related parking lot to depths up to 2.9 feet (100-year storm event). Stormwater continues to pond in this area and spills into Commercial Drive, contributing to maximum flood depths of 3.2 feet. These two areas represent Problem Area No. 1. For large (100-year) floods, stormwater continues to overflow into Problem Area No. 2, Belt Line Road. During the 100-year storm, about 2,000 feet of Belt Line Road has all lanes flooded to a minimum depth of at least 0.5 feet. The FF surveys determined that one (1) commercial structure and one (1) parking lot would be flooded by the 100-year storm event at 3939 Belt Line Road. Reduction of flooding in this problem area will require a three-step approach: 1) eliminate the spill from the open channel, 2) construct underground stormwater improvements in Belt Line Road and 3) mitigation (stormwater detention) to reduce downstream impacts due to the structural storm drainage improvements. To eliminate the spill, different combinations of grading, surface stormwater detention, and downstream underground stormwater improvements were evaluated. Reducing street flooding in Belt Line Road can be achieved by underground stormwater improvements and the addition of inlets in Belt Line Road. To mitigate for increased downstream flooding, stormwater detention, either surface or underground, is required for each alternative.

Problem Area No. 9 is a high priority area due to flooding around Fire Station No. 2 (a critical facility) at 3950 Beltway Drive. Stormwaters pond on the south side of the fire station due to a lack of adequate drainage in this low area. The best solution for this problem area is to add an inlet(s) in the low area and construct a connection to the system to the east at a point where capacity exists to accommodate the added flow. This alternative is combined with Problem Area No. 5.

Alternative drainage relief concepts for the problem areas in the Rawhide Creek Basin were formulated and evaluated as described below.

A. Cost Estimates

Conceptual level cost estimates were prepared for each feasible alternative. All costs presented in this report are in 2017 dollars. Unit prices for the cost estimates are based on average low unit price bid data from organizations such as the Texas Department of Transportation (TxDOT). Other sources were also incorporated, particularly the experience gained from similar municipal projects. Contingency costs to cover unknowns at this conceptual stage were included (40% of the civil construction cost). An allowance of 20% for professional services (design and construction phase) fees and a utility relocation allowance of 10% of the construction cost are also included in the project cost estimates.

B. Summary of Alternatives

Alternatives were evaluated in order to reduce flood risk at each high priority area in the Rawhide Creek Basin mentioned above. The goal of the alternatives is to reduce flood risk to residential and commercial buildings and reduce flood depths in streets to 0.5 feet. Alternatives considered include underground stormwater system relief by replacement and enlargement, parallel relief, local diversion and reduction of flood flows by stormwater detention. For more detail on alternatives, refer to Appendix D. Table D-1 through Table D-3 in Appendix D summarizes all the alternatives analyzed for the Rawhide Creek Basin.

A detailed cost estimate for each alternative can be found in Appendix E of this report.

1. Problem Area No. 5 - Sherlock Drive and Winter Park Lane

Six (6) conceptual alternatives were analyzed for Problem Area No. 5. **Table IV-1** provides a summary of the alternatives analyzed. For more detail on alternatives, refer to Appendix D.

Table IV-1: Summary of Alternatives – Problem Area No. 5 and No. 9

Alternative	Description of Alternative	Approx. Cost
Alternative No. 1	1. Add Parallel Underground Stormwater System 2. New Underground Stormwater System for the Fire Station	$1,100,000(1)
Alternative No.2	1. Concrete or Grass Flume Relief	$61,000
Alternative No. 3	1. Stormwater Surface Detention	$1,008,000
Alternative No. 4.1	1. Diversion - 4 acres through Dome Park	Not determined(2)
Alternative No. 4.2	1. Diversion - 8 acres through Dome Park	Not determined(2)
Alternative No.5	1. Property Acquisition	$807,000
Alternative No. 6	1. Property Acquisition with Bio Retention	$601,000

(1)Cost include the fire station improvements
(2)Cost not determined because is not an effective solution

Alternative No. 1 proposes the construction of a parallel underground stormwater relief system ranging in size from 39-inch to 54-inch reinforced concrete pipe (RCP) adjacent to the existing system to adequately convey the design flow. Flood depths were significantly reduced from 2.3 feet to generally less than 0.5 feet. Two locations exhibited flood depths of 0.7 feet, likely due to minor inconsistency with the LiDAR at the intersection. This alternative would also enable flood reductions from 1.2 feet to 0.25 feet at the Fire Station for the 100-year storm event, if combined with this alternative. No significant adverse downstream impacts are caused by this alternative, if constructed.

Alternative No. 2 (Flume) reduced flooding at the intersection from 2.3 feet to 1.3 feet, but caused additional flooding downstream. The flume would discharge to the alleyway paralleling Sherlock Drive which does not have capacity to convey the additional flow without causing additional flooding.

Alternative No. 3 includes an off-line stormwater surface detention facility located in the park west of the intersection of Sherlock Drive and Winter Park Lane. This requires the addition of an underground stormwater system to divert flow into the detention facility. This alternative reduced the flow depth at the intersection from 2.3 feet to 1.1 feet.

Alternative No. 4 considers of two different diversion scenarios. Diverting stormwater along Dome Drive through Dome Park reduced the contributing stormwater to the problem area but did not significantly reduce flood depths. Diverting flow along Bobbin Lane was also considered, but this alternative would have involved extensive re-grading of Sherlock Drive and Dome Park. A diversion to a bio-detention area was also considered, but it was not feasible to create the storage needed to relieve the existing system. For these reasons, cost estimates for the diversion alternatives were not developed.

Alternative No. 5 consists of acquisition of the affected properties (14727 Sherlock Drive and 3907 Winter Park Lane). The homes would be demolished and the resulting open space would be dedicated to park and stormwater management purposes.

Alternative No. 6 reduced the flood depth at Problem Area No. 5 from 2.3 feet to 1.1 feet. This alternative consists of voluntary buyout by the Town of the affected property at 14727 Sherlock Drive only. It also includes a landscape bio-retention swale to be constructed in the resulting open space and includes a trail connection from the intersection to the existing trail system within the Oncor right-of-way (ROW). This alternative is a combination of Alternative No. 2, No. 3, and No. 5.

2. Problem Area No. 7 – Les Lacs Neighborhood

Two factors contribute to flooding along low areas in the streets west of Les Lacs Pond and east of Les Lacs Avenue: 1) spill from the Les Lacs Pond during large storm events and 2) local runoff coupled with limited capacity in the existing underground stormwater system. The underground stormwater system draining this neighborhood runs generally south between homes. Therefore, replacement of the existing underground stormwater system would be extremely difficult to achieve. The first approach or step to evaluate solutions to reduce flood depth in this area was to eliminate the Les Lacs Pond spill by the construction of an elevated berm. The berm alone effectively reduce flooding at Waterside Court from 2 feet to 1.1 feet in depth. However, this alone does not reduce flood depths at Waterford Drive, and Les Lac Avenue. Since the construction of the berm has a positive impact at Waterside Court, it was included in all alternatives evaluated for Problem Area No. 7. Three (3) conceptual alternatives were analyzed for Problem Area No. 7.

All three (3) of these alternatives also include a proposed underground stormwater relief systems west (along Waterside Court and Waterford Drive) and then south along Les Lacs Avenue, ultimately re-connecting to the existing underground stormwater system. Along Beau Park Lane, a parallel underground stormwater relief system is proposed. Improvements downstream of this point differ between Alternatives 1, 2 and 3. Alternative 1 adds a parallel underground stormwater system to the existing system along the linear park for increased capacity. Alternative 2 replaces and enlarges the existing underground stormwater system along the linear park to increase capacity. Alternative 3 replaces and enlarges the existing underground stormwater system along the linear park and diverts flow along Woodway Drive through an apartment complex parking lot. Alternative No.3 requires easement acquisition. All of these alternatives also include underground stormwater detention to mitigate any impact downstream. The alternatives are effective at reducing the flood depths in the problem areas to less than 0.5 feet.

Table IV-2 provides a summary of the alternatives considered for Problem Area No. 7. For more detail on alternatives refer to Appendix D.

Table IV-2: Summary of Alternatives – Problem Area No. 7

Alternative	Description	Approx. Cost
Alternative No. 1	1. Add Berm 2. New Underground Stormwater System 3. Add Parallel Underground Stormwater System 4. Offline Underground Stormwater Detention for Mitigation	$1,765,000
Alternative No.2	1. Add Berm 2. New Underground Stormwater System 3. Add Parallel Underground Stormwater System 4. Underground Stormwater System Replacement 5. Offline Underground Stormwater Detention for Mitigation	$2,207,000
Alternative No. 3	1. Add Berm 2. New Underground Stormwater System 3. Add Parallel Underground Stormwater System 4. Underground Stormwater System Replacement 5. Diversion 6. Offline Underground Stormwater Detention for Mitigation	$2,384,000

3. Problem Area No. 1 and 2 – Belt Line Road

Alternatives to mitigate flooding in Problem Areas No. 1 and 2 may involve several components. First, measures to reduce the spill from the open channel connecting Arapaho Road and Belt Line Road are needed. Secondly, some improvements to the Belt Line Road underground stormwater system may be required to accommodate the spills from areas north of this major thoroughfare. Lastly, mitigation for increased flooding in downstream areas, including the City of Farmer's Branch, should be investigated and incorporated into structural solutions as necessary. **Table IV-3** provides a summary of the alternatives considered for Problem Area No. 1 and No. 2. For more detail on alternatives refer to Appendix D.

Table IV-3: Summary of Alternatives – Problem Areas No. 1 and No. 2

Alternative	Description	Approx. Cost
Alternative No. 1	1. Berm along channel 2. (3) Offline Stormwater Surface Detention Sites 3. New Underground Stormwater System 4. Underground Stormwater System Replacement 5. (1) Offline Stormwater Surface Detention for Mitigation	$3,970,000
Alternative No.2	1. Berm along channel 2. (2) Offline Stormwater Surface Detention Sites 3. New Underground Stormwater System 4. Underground Stormwater System Replacement 5. Add Parallel Underground Stormwater System 6. (1) Offline Stormwater Surface Detention for Mitigation	$6,007,000
Alternative No. 3	1. Berm along channel 2. (2) Offline Stormwater Surface Detention sites 3. New Underground Stormwater System 4. Underground Stormwater System Replacement 5. (1) Offline Stormwater Surface Detention for Mitigation	$4,418,000
Alternative No. 4	1. Berm along channel 2. New Underground Stormwater System 3. Underground Stormwater System Replacement 4. (1) Offline Stormwater Surface Detention for Mitigation	$6,520,000
Alternative No. 5	1. Nonstructural (Automated Flood Alert System)	$650,000(1)

(1) Automated Flood Alert System for the entire Town of Addison

C. Alternatives Evaluation

Table IV-1 through **Table IV-3** show a comparison of the different alternatives developed for the Rawhide Creek Basin. These alternatives were rated based on factors presented on **Table IV-4**. The relative importance of each factor considered during the selection of an alternative was predetermined and classified from 1 to 10 (with 1 being the least effective and 10 being the most effective).

Table IV-4: Factors in Rating Alternatives

Factors in Rating Problem Area Alternatives	Relative Importance	Description
1. Flood Risk Reduction	10	Property damage (number of residential & commercial structures where flood risk has been reduced significantly).
2. Public Safety Benefits	10	Reduced flood hazard to: roads, sidewalks and trails (pedestrians & vehicles), critical facilities (hospitals, emergency facilities, other government facilities), hazardous material storage facilities, etc.
3. Airport Operation & Master Plan	9	When applicable, consider and compare impacts to airside operations and evaluate consistency with the Airport Master Plan.
4. Constructability	8	Consider factors such as: conflicts with runways, taxiways, conflicts with major utilities, conflicts with buildings, restricted work areas and integration with future major projects such as DART's Cotton Belt Regional Rail.
5. Project Cost	8	Capital project cost, professional services, construction phase services, etc.
6. Meets Design Criteria for Drainage Relief	7	Goals and Objectives: flood depth < 1 foot for the 100-yr storm event (secondarily, flood depth < 1 for the 10-yr storm event), reduced duration of flooding, avoidance of downstream flood impacts in adjacent cities.
7. Neighborhood Disruption	5	Consider disruption to residences, businesses, and traffic due to construction activities.
8. Maintenance Costs	4	Compare the ongoing and long term maintenance needs and costs for the alternative.
9. Real Estate	3	Consider real estate factors such as the need to purchase ROW, acquire easements, or relocate homes / businesses.
10. Environmental Impacts	5	Consider benefits to or impacts on water quality, habitat, receiving waters and parks/open space due to the proposed alternative.
11. Street repair / Replacement	1	Consider existing pavement conditions and planned street reconstruction projects for storm drainage relief alternatives requiring the construction in or the crossing of existing streets.

V. CONCLUSIONS AND RECOMMENDATIONS

A detailed stormwater analysis reveals that the existing Rawhide Creek drainage system has seventeen (17) potential problem areas. These potential problem areas were characterized based on the degree of flooding and hazard to adjacent properties. Areas with flooding depths greater than 1 foot that would potentially affect structures were considered high priority for stormwater relief alternatives. Based on the analysis, one of the highest priority locations within the Rawhide Creek Basin for drainage relief is Problem Area No. 5 at the intersection of Sherlock Drive and Winter Park Lane. Problem Areas No. No. 1, No. 2, No. 6, No. 7, and No. 9 are also considered high priority areas. Flooding in these areas is aggravated by unintended spills and underground stormwater systems with insufficient capacity for the 100-year storm event. Alternatives include re-grading of banks/berms, detention and various underground stormwater relief systems. Other potential problem areas in Addison are lower priority for stormwater relief, and alternatives were not developed in these areas. Problem Area locations are shown on **Figure III-1** in Section III of this report.

Alternatives were developed to reduce flood risk at Problem Areas No. 1, 2, 5, 7, and 9. A flooding solution for Problem Area No. 6 was previously developed by a third party and has been approved by the Town of Addison. For the remaining sites, drainage relief alternatives investigated including replacement of the existing underground stormwater system, installing new underground stormwater systems for relief or diversion, surface stormwater detention, and underground stormwater detention. Alternative designs are conceptual in nature and are generally consistent with the Town of Addison Drainage Criteria Manual. Where more than one alternative was developed, a rating system was implemented to select the preferred alternative based on factors such as flood risk reduction, project cost, neighborhood disruption, constructability, etc. (see Table IV-4).

The recommended alternatives to reduce flood risk at each high priority problem area can be found in **Table V-1** and seen in **Figures V-1** and **V-2**. Together, these represent the recommended Stormwater Capital Improvement Program plan for the Rawhide Creek Basin. Detailed descriptions of the alternative solutions are provided in Appendix D.

Table V-1: Recommended Alternatives

Problem Area	Location	Alternative	Description of Alternative	Estimated Project Cost
No. 5 & No. 9	Sherlock Drive and Winter Park Lane	Alternative No. 1	1. Add Parallel Underground Stormwater System 2. New Underground Stormwater System for the Fire Station	$1,100,000
No. 7	Les Lacs Neighborhood	Alternative No. 1	1. Add Berm 2. New Underground Stormwater System 3. Add Parallel Underground Stormwater System 4. Offline Underground Stormwater Detention for Mitigation	$1,765,000
No. 1 & No. 2	Belt Line Road	Alternative No. 5	1. Nonstructural (Automated Flood Alert System)	$650,000(1)

(1) Automated Flood Alert System for the entire Town of Addison

Costs of structural drainage relief alternatives were found to be very expensive at Problem Area No.1 and 2. Predicted flooding for the 100-year flood event along Belt Line Road is expected to only cause minor property damage based on estimated finished floor elevations for buildings in the area. Predicted flooding for the 10-year event is significantly less. Flooding in Problem Area No. 1 and 2 can be considered more of a public safety issue rather than a significant flood risk to property for the 100-year flood event. Therefore, it is recommended that the Town implement a Town-wide Automated Flood Alert System and develop or modify the Emergency Action Plan (EAP) to include this area when storms threaten Addison. The approximate cost of the Town-wide Flood Alert System including warning lights is approximately $650,000. Implementation and/or funding assistance may be available through State (Texas Water Development Board) and regional (NCTCOG) organizations. A detailed cost estimate can be found in Table F-8 (Appendix F) of the Hutton Branch report. Please refer to the Town-wide Executive Summary for the recommended layout of the Town-wide Flood Alert System (Figure IV-I). Please note that this report is limited to providing conceptual level design information and cost estimates.

Other Stormwater System Assessment and Capital Improvement Program recommendations include:

- Drainage Systems Maintenance: Much of the Rawhide Creek Basin underground drainage system is comprised of reinforced concrete pipe (RCP) and reinforced concrete box culverts (RCBC). RCP and RCBC are very durable and long-lasting when properly installed and maintained. However, problems such as dropped and damaged joints, linear cracking, exposed rebar and heavy accumulation of debris can occur. Cleaning and/or repairs are recommended for problems such as these. Typically, problems in underground RCP and RCBC are found by Closed-Circuit Television (CCTV) inspections. That portion of the stormwater system that is open channel also requires regular inspection and maintenance.
- Closed-Circuit Television (CCTV): CCTV inspection of existing underground storm drainage systems can be performed in order to determine condition, direction, and change in conduit size. In conjunction with the CCTV process, pipe cleaning is often performed to facilitate the video inspection activities and/or to improve system performance. Priorities for CCTV can be established based on suspected problems, age of conduit and needs for determining system size, etc. where plans are not available and access to the underground system is limited. Otherwise, systems are recommended for CCTV inspection every 10 or even 20 years. CCTV inspection of the underground stormwater system just east of the Airport in Addison was performed in 2009. **Photo V-1** shows an image of one problem area from the CCTV footage.

Photo V-1: CCTV Image of Problem Area in the Keller Springs Branch Basin

CCTV inspection is recommended for the Rawhide Creek Basin drainage system in Addison to identify needed maintenance and repairs that may affect the capacity of the underground stormwater system. At this time, there have been no reports of severe problems. Therefore, the inspections can be conducted in phases. CCTV for the system that drains Sherlock Drive (Problem Area No. 5) has been recently performed. Generally, the existing RCP was in good condition with one encroachment into the pipe apparently by a franchised utility. A good candidate area for the next CCTV phase in the basin is the system in the Les Lacs neighborhood that runs between homes.

- Site Development: New and/or re-development sites should include stormwater detention facilities to mitigate offsite increases in flooding in downstream areas.
- Street Reconstruction: As streets in this part of Addison become candidates for reconstruction and/or heavy maintenance, the potential problem areas in the Rawhide Creek Basin that are not a part of the Recommended Stormwater Capital Improvement Program should be re-evaluated and mitigated, if practical.
- Low Impact Development (LID) / Green Infrastructure (GI): As properties develop and redevelop in the basin, GI and LID practices should be incorporated in accordance with the Town of Addison's Drainage Criteria Manual and the TPDES permit with its Stormwater Management Program goals. This can help to slightly reduce flooding that has been identified in this study. LID and GI methods are presented in Appendix F.
- Proposed Cotton Belt Regional Rail System: Dallas Area Rapid Transit (DART) is proposing Regional Rail System improvements along the Cotton Belt right-of-way which may include significant drainage improvements in the Rawhide Creek Basin. At this time (Summer 2017) the drainage improvement plans for DART's Cotton Belt Regional Rail System (Cotton Belt) have not been made public. Generally, there are no severe drainage problem areas along the Cotton Belt in the Rawhide Creek Basin in Addison. The Town of Addison and DART should work together to make sure that DART provides adequate and safe drainage as a part of the Cotton Belt project.

KEY TO FEATURES

- Proposed New Storm Drainage
- Proposed Storm Drainage (Parallel)
- XP Model Storm Sewer Lines
- Roads

0 200
Feet

N W E S

Rawhide Creek Basin

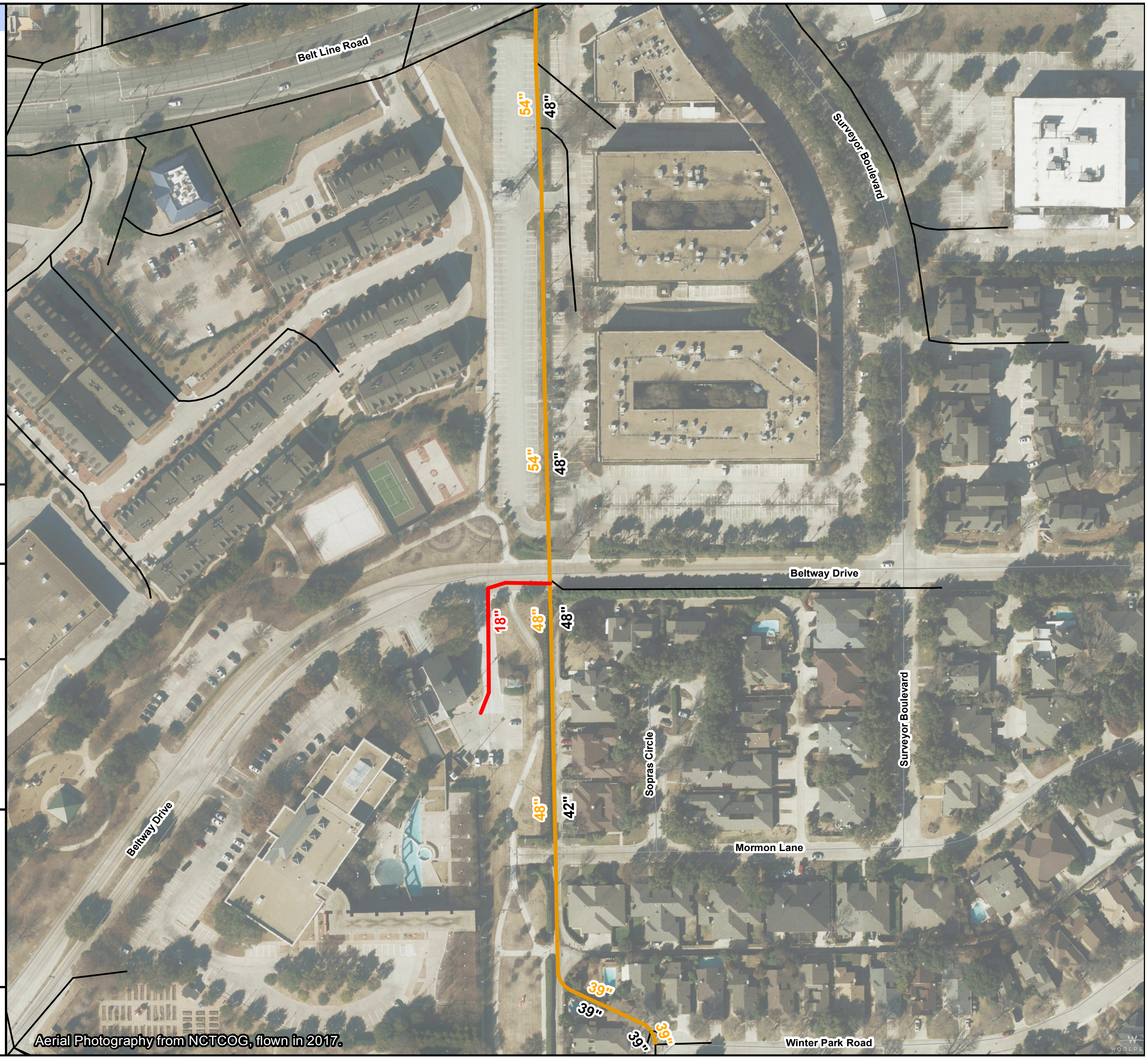
Stormwater System Assessment & Capital Improvement Program

Recommended Plan (Problem Area No. 5 & 9)

Figure V-1

ADDISON

HALFF



KEY TO FEATURES

- Berm
- Proposed New Storm Drainage
- Proposed Storm Drainage (Parallel)
- XP Model Storm Sewer Lines
- Roads
- Rawhide Creek Overall Basin
- Addison City Limits

0 250
Feet

N W E S

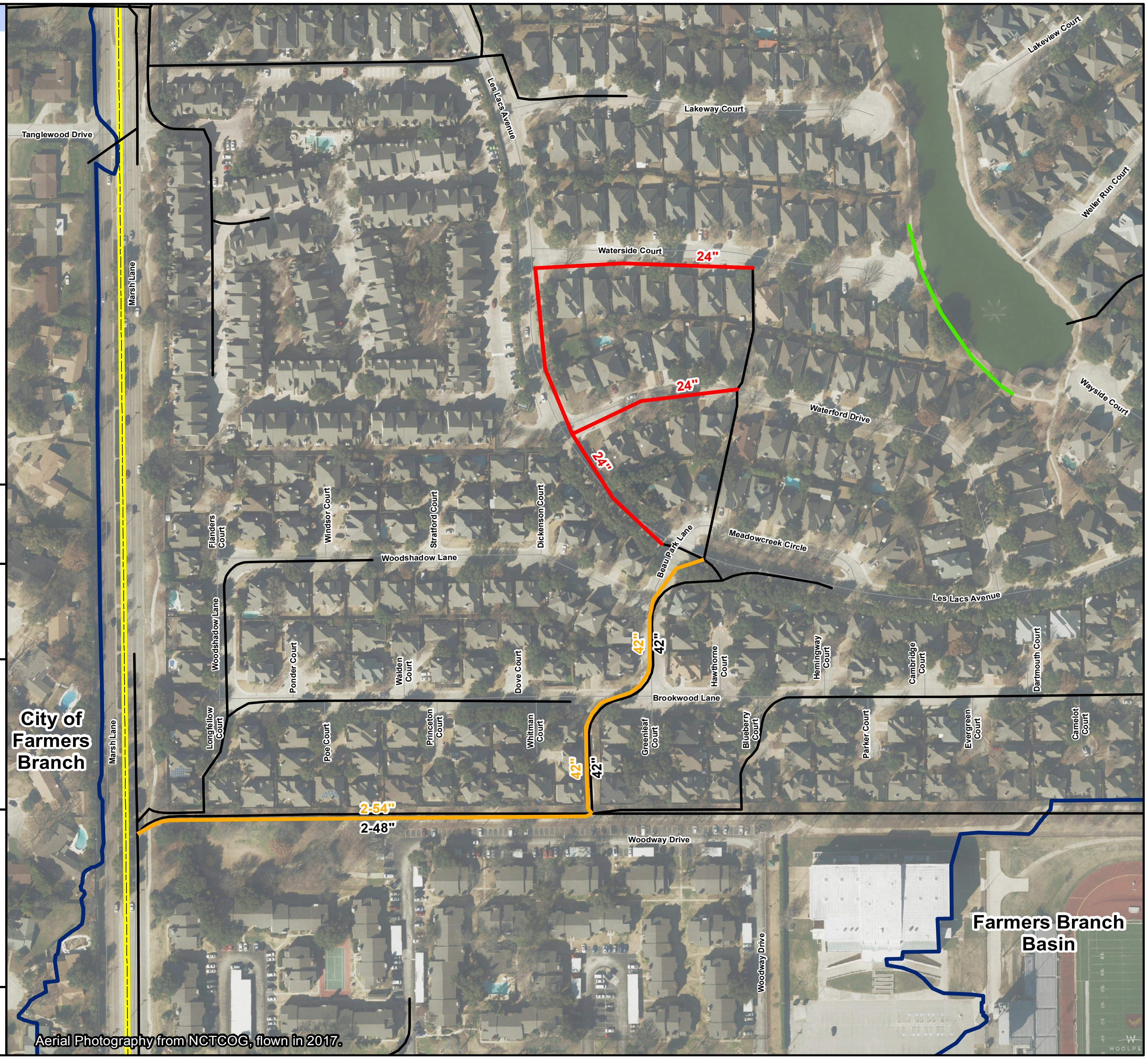
Rawhide Creek Basin
Stormwater System Assessment & Capital Improvement Program

Recommended Plan (Problem Area No. 7)

Figure V-2

ADDISON

HALFF



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