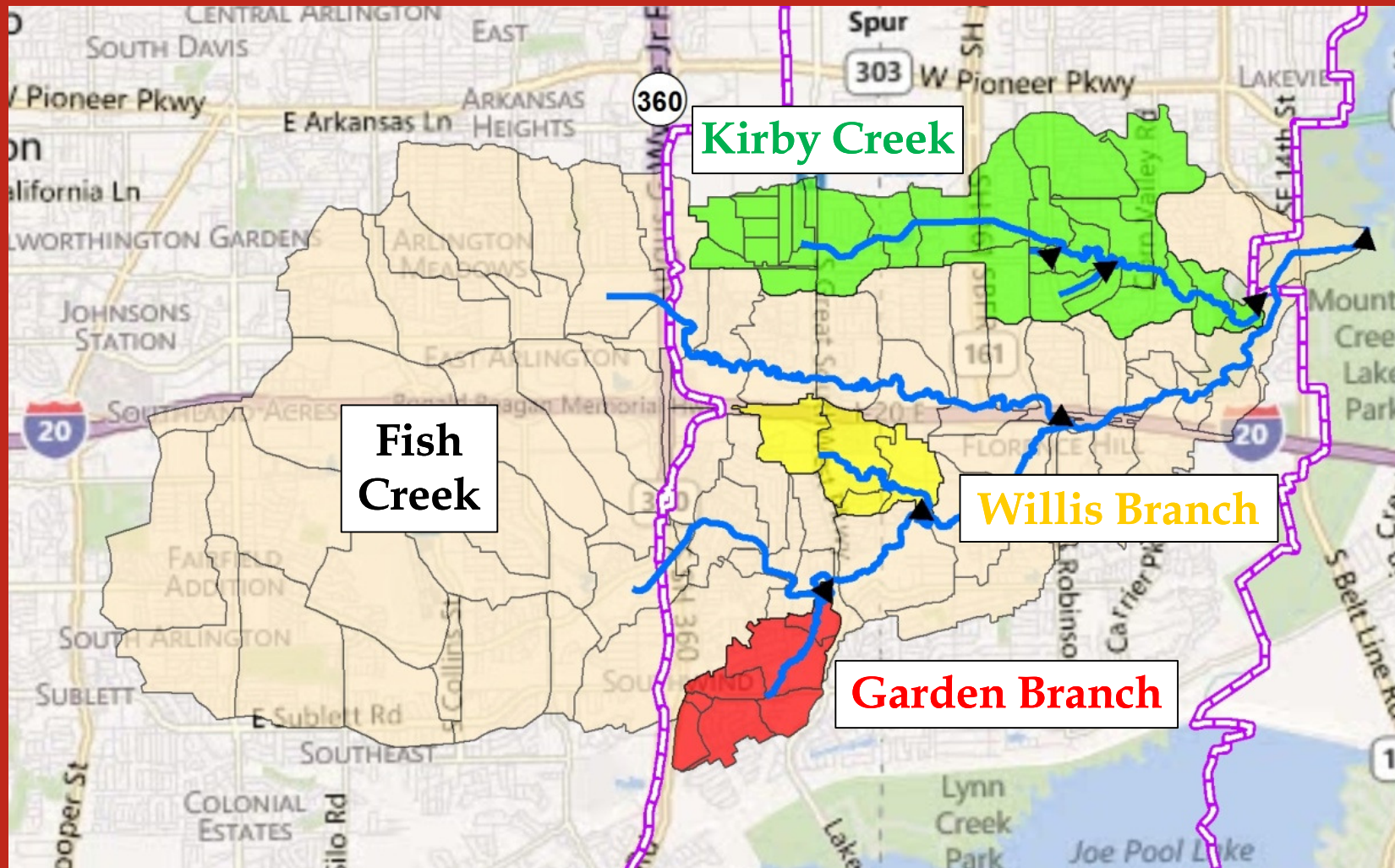


City of Grand Prairie Supplemental City-Wide Drainage Master Plan for Fish Creek (Y#0882) Garden Branch, Kirby Creek, & Willis Branch



February 2013

Prepared by



AVO 27930



RESOLUTION NO. 4615-2013

**A RESOLUTION APPROVING THE CITY OF GRAND PRAIRIE'S
CITY-WIDE DRAINAGE MASTER PLAN FOR GARDEN BRANCH,
WILLIS BRANCH AND KIRBY CREEK.**

WHEREAS, the "City-Wide Drainage Master Plan for Garden Branch, Willis Branch and Kirby Creek" (the Plan) is about providing comprehensive, updated technical data for the management of the Garden Branch, Willis Branch and Kirby Creek watersheds;

WHEREAS, the Plan addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages;

WHEREAS, the Plan provides the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements to help minimize existing and potential flood damages within the Garden Branch, Willis Branch and Kirby Creek watersheds;

WHEREAS, any revisions to the floodplain and the floodways identified in these studies shall also include ultimate development conditions and shall be for the whole creek as determined in these studies and not for portions of it to ensure that there are no downstream adverse effects; required submittals to FEMA shall be for the whole creek (as determined in these studies) and not for portions of it; and

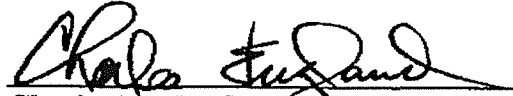
WHEREAS, the recommendations of this report shall be incorporated for all future development as well as CIP budget considerations.

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

SECTION 1. THAT the City of Grand Prairie, Texas, having developed the "City-Wide Drainage Master Plan for Garden Branch, Willis Branch and Kirby Creek" to cost-effectively manage flood or storm waters within budgeting constraints, approves and adopts the "City-Wide Drainage Master Plan for Garden Branch, Willis Branch and Kirby Creek" thereby setting the standard for future drainage master plans, addressing existing flooding problems and providing planning recommendation, alternatives and design concepts for future development, to include CIP as well as possible developer participation projects.

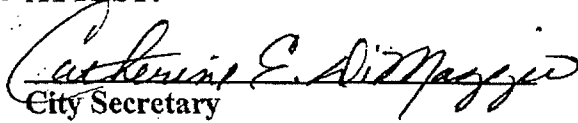
PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS, ON THIS THE 16TH DAY OF APRIL, 2013.

APPROVED:



Charles England, Mayor

ATTEST:



Catherine E. DiMaggio
City Secretary

APPROVED AS TO FORM:



City Attorney



February 5, 2013
AVO 27930

Mr. Romin Khavari, P.E., CFM
City Engineer
City of Grand Prairie
206 W. Church Street
P.O. Box 534045
Grand Prairie, TX 75053-4045

**Re: Supplemental City-wide Drainage Master Plan for Fish Creek (Y#0882)
Garden Branch, Kirby Creek, and Willis Branch – Final Report**

Dear Mr. Khavari:

Transmitted herewith is the Final Report for the Supplemental City-wide Drainage Master Plan for Fish Creek (Y#0882), including technical data and exhibits. This report compiles existing and newly developed technical data for the Garden Branch, Kirby Creek, and Willis Branch watersheds into a single comprehensive document. The report also includes a DVD containing HEC-HMS hydrologic models, HEC-RAS hydraulic models, PDFs, and GIS data for City review and use.

Please do not hesitate to call me or Stephen Crawford if you have any questions or concerns regarding the Supplemental CWDMP for the Fish Creek watershed.

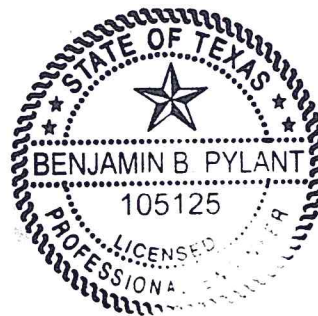
Sincerely,

HALFF ASSOCIATES, INC.

A handwritten signature in blue ink that reads "Bj. B. Pylant".

Benjamin B. Pylant, PE, CFM
Project Manager

Enclosures



FIRM # F-312

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EXECUTIVE SUMMARY

This report is intended to supplement the City-wide Drainage Master Plan (CWDMP) for Fish Creek with comprehensive, updated technical data for the management of three (3) watersheds within the Fish Creek basin: Garden Branch watershed, Kirby Creek watershed, and Willis Branch watershed. This report addresses flood dangers and erosion problems within each studied watershed and provides planning alternatives and design concepts to help alleviate potential damages to local residents and City infrastructure. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development and help minimize existing and potential flood damages within each studied watershed. This study is in compliance with the requirements set forth in the "City-wide Drainage Master Plan Roadmap." The City Council of Grand Prairie passed Resolution No. 4615-2013 approving this study on April 16, 2013.






No structures are currently inundated by the existing and ultimate conditions 100-year floodplain in the Garden Branch, Kirby Creek, or Willis Branch watersheds. The alternatives included in this report were ranked in two different categories: open channel alternatives and stream stability alternatives. The only open channel alternative is the resizing of the Martin Barnes Road crossing along Garden Branch and it is considered a long-term alternative. Twelve (12) stream stability alternatives were considered for short-term and long-term Capital Improvement Project (CIP) priorities. Five (5) stream stability alternatives to protect public infrastructure were considered short-term priorities. Seven (7) stream stability alternatives were considered for long-term implementation. All long-term stream stability alternatives were considered a private benefit except for the Phase 2 concrete lined channel replacement along Kirby Creek. See the following pages for a summary of the prioritization rankings and a location map.

Developable areas for the Garden Branch watershed, Kirby Creek watershed, and Willis Branch Watershed are 25%, 20%, and 30% respectively. As development occurs in the watershed, the Floodplain Workmaps and the Erosion Hazard Setbacks developed for this study should be utilized to assist in identifying a site as being in a high risk area for flooding, bank erosion or channel degradation. If the site is in a high risk area, then the developer should be alerted to the risk and mitigation should be considered.

This report is intended to be a living document that can be updated as additional information becomes available for the Garden Branch, Kirby Creek, or Willis Branch watersheds.

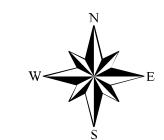
Figure XIII-1
CIP Location Map

Legend

-  Roadway Improvements
-  Erosion Alternative Locations
-  Kirby Creek Watershed
-  Garden Branch Watershed
-  Willis Branch Watershed

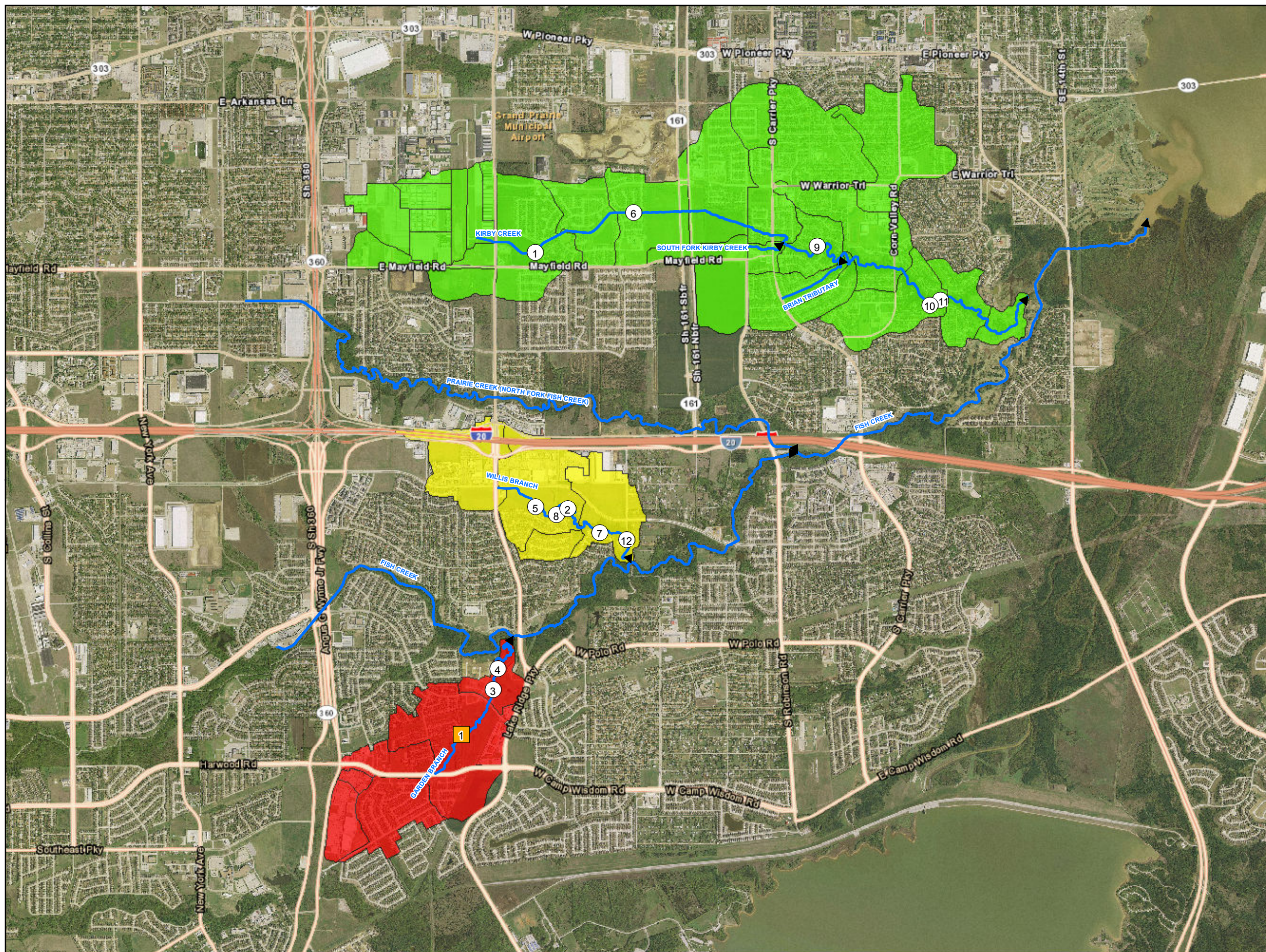
Notes:

1. See Section VII of this report for a detailed description of the Roadway Improvement at Martin Barnes Road.
2. See Section IX of this report for a detailed description of each stream bank & stream bed erosion alternative.



0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet



Capital Improvement Project Summary

Preliminary Short-Term Priorities & Long-Term Implementation

Rank	Stream	Capital Improvement Project	Short-Term/Long-Term	Public/Private	Probable Cost
Stream and Open Channel Alternatives					
1	Garden Branch	Replace Martin Barnes Road	Long-Term	Public	\$200,000
Stream Stability Alternatives					
1	Kirby Creek	Concrete Lined Channel Replacement - Phase 1	Short-Term	Public	\$290,000
2	Willis Branch	Install Rock Chutes	Short-Term	Public	\$160,000
3	Garden Branch	Install Rock Chutes	Short-Term	Public	\$120,000
4	Garden Branch	Place 24" Rock Rip-Rap Downstream of Low Water Crossing	Short-Term	Public	\$20,000
5	Willis Branch	Remove Debris Dam and Place 24" Rock Rip-Rap	Short-Term	Public	\$40,000
6	Kirby Creek	Concrete Lined Channel Replacement - Phase 2	Long-Term	Public	\$210,000
7	Willis Branch	Gabion Slope Protection - Abbington Lane	Long-Term	Private	\$550,000
8	Willis Branch	Gabion Slope Protection - Whitman Lane	Long-Term	Private	\$280,000
9	Kirby Creek	Gabion Slope Protection - Windhurst & Brandon	Long-Term	Private	\$1,280,000
10	Kirby Creek	Slope Reconstruction Alternative A - Estate Drive	Long-Term	Private	\$730,000
11	Kirby Creek	Slope Reconstruction Alternative B - Estate Drive	Long-Term	Private	\$970,000
12	Willis Branch	Place 24" Rock Rip-Rap Around Culvert at Private Drive	Long-Term	Private	\$50,000

I. Introduction

I. INTRODUCTION**A. ACKNOWLEDGMENTS**

Half Associates would like to acknowledge the significant contributions of all City of Grand Prairie staff in preparation of the City-Wide Drainage Master Plan. In particular, the following individuals have provided invaluable input and assistance:

Romin Khavari – City Engineer

Gabriel Johnson – Floodplain Administrator

Chris Agnew – Storm Drainage Engineer

B. PURPOSE OF STUDY

This study is in compliance with the requirements set forth in the "City-wide Drainage Master Plan Road Map." The purpose of this supplemental report to the City-wide Drainage Master Plan for Fish Creek is to provide comprehensive, updated technical data for the management of three (3) watersheds within the Fish Creek basin; Garden Branch watershed, Kirby Creek watershed, and Willis Branch watershed. This report addresses existing flooding, erosion, and sedimentation problems within each of these watersheds and provides planning alternatives and design concepts to help alleviate potential damages. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements (see Section I.C) and help minimize existing and potential flood and erosion damages within each watershed studied for this supplemental report.

Specific objectives of this supplemental report to the City-wide Drainage Master Plan for Fish Creek for the City of Grand Prairie, Texas for the management of the Garden Branch, Kirby Creek, and Willis Branch watersheds include:

1. Compile pertinent existing engineering data and newly developed information into a comprehensive report to include: an up-to-date, existing conditions and fully urbanized watershed (hereafter known as ultimate conditions), detailed hydrologic and hydraulic computer models, and existing 100-year floodplains. The existing and ultimate conditions 100-year and 500-year floodplains were compiled for the Kirby Creek watershed.

2. Prepare detailed descriptions of alternative improvement solutions (structural and non-structural) to help reduce or eliminate flooding problems for streams and open channels within the study watershed.
3. Perform a Channel Stability Assessment/Erosion Hazard Analysis to analyze factors influencing stream stability and formulate alternatives to help stabilize stream banks.
4. Evaluation of existing and future roadway crossings utilizing the City Master Thoroughfare Plan.
5. Locate and provide detailed description of dams/levees/detention, include table of existing drainage plan reviews, and include associated plans, photos, and descriptions of potential problems associated with these features.
6. Utilize the City's Storm Drain Outfall Assessment to provide detailed descriptions of locations where maintenance needs to occur.
7. Evaluate and Prioritize proposed alternative improvement projects and describe the methodology utilized to phase and implement the proposed alternative improvement projects.
8. Determine Short Term and Long Term Plan to prioritize proposed alternative improvement projects including benefit-cost analysis ratios.

C. CITY ORDINANCES AND DEVELOPMENT REQUIREMENTS

The City of Grand Prairie is especially progressive in their storm water management program. The City's Drainage Design Manual (DDM) was updated as recently as November 2012 and is intended to "...protect the general health, safety, and welfare of the public by reducing flooding potential, controlling excessive runoff, minimizing erosion and siltation problems, and eliminating damage to public facilities resulting from uncontrolled storm water runoff."

Articles 14 and 15 of the Unified Development Code, included in the City's Drainage Design Manual, contain the City ordinances for Drainage and Floodplain Management, respectively. Requirements include the elevation of new construction a minimum of one foot above the ultimate 100-year floodplain or two feet above the existing conditions floodplain, whichever is higher. Construction of detention basins is required when downstream facilities are not adequately sized to convey a design storm based on current City criteria for hydraulic capacity. Post project peak flows are not allowed to exceed the existing conditions peak flows unless sufficient

downstream capacity above existing discharge conditions is available. When required, detention facilities are to be designed such that peak discharges or velocities are not increased when compared to pre-project conditions for the 2-, 10- and 100-year floods.

The City ordinances allow for responsible development of the watershed such that flood risks to future structures can be minimized. The ordinances also allow for protection of existing structures so that future development will not increase the flooding hazard in areas that do not have the capacity to convey increased flood discharges. Upon review of the City's Drainage Design Manual and existing development requirements, it has been determined that the requirements in combination with the technical data provided in this report are adequate to properly manage the watershed going forward.

D. WATERSHED DESCRIPTION

The Fish Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie to a point where it discharges into Mountain Creek Lake. The Fish Creek basin has a drainage area of 28.2 square miles and has two major tributaries: Prairie (North Fork Fish) Creek and Kirby Creek, as well as twelve minor tributaries. This supplemental report to the City-wide Drainage Master Plan for Fish Creek will focus on three (3) watersheds within the Fish Creek basin: Garden Branch watershed, Kirby Creek watershed, and Willis Branch watershed. A detailed description of these watersheds can be found in Section II.B of this report.

1. Major Streams and Tributaries

The three watersheds studied for this report contain five (5) studied streams with a combined length of approximately eight (8) linear miles. Table I-1 lists these streams with their downstream limit, upstream limit, Federal Emergency Management Agency (FEMA) designation and length.

Table I-1 – Study Streams

Stream Name	Downstream Limit	Upstream Limit	Proposed FEMA Designation	Length (ft)*
Garden Branch	Confluence with Fish Creek	Camp Wisdom Road	Zone A	7,440
Willis Branch	Confluence with Fish Creek	Approximately 300' downstream of Great Southwest Parkway	Zone A	7,675
Kirby Creek	Confluence with Fish Creek	Great Southwest Parkway	Zone AE	23,850
South Fork of Kirby Creek	Confluence with Kirby Creek	Robinson Road	Zone AE	1,355
Brian Tributary	Confluence with Kirby Creek	Carrier Parkway	Zone A	2,605
* Note: These lengths were taken from centerline data in GIS and are based on the upstream and downstream limit of study.				

2. Unique Attributes of Watershed

The following is a brief description of the unique attributes of each studied watershed for this report:

Garden Branch

The northern portion of the Garden Branch watershed contains a large commercial/retail development along State Highway 360. Multiple commercial and residential detention ponds have been constructed to help regulate discharge rates upstream of the headwaters of Garden Branch just downstream of Camp Wisdom Road.

Kirby Creek

The Kirby Creek watershed is located just north of Interstate 20 and extends almost all the way from the eastern border to the western border of the Grand Prairie city limits. Kirby Creek crosses multiple north-south major thoroughfares including Carrier Parkway, Robinson Road, State Highway 161, and Great Southwest Parkway. The Grand Prairie Municipal Airport is also located in the northern portion of the Kirby Creek watershed.

Willis Branch

Bardin Road runs east-west through the middle of the Willis Branch watershed. North of Bardin Road is a large commercial/retail development along Interstate 20 and south of Bardin Road are large open fields combined with residential development. The watershed has potential to experience continued development in the remaining open areas along Bardin Road.

E. PRINCIPAL FLOODING PROBLEMS

1. Drainage Complaint Database

Half Associates, Inc. obtained the latest information from the City of Grand Prairie's Drainage Complaint Database for the Garden Branch, Kirby Creek, and Willis Branch watersheds from the City-wide Drainage Master Plan for Fish Creek developed by RPS Espey Consultants in July 2012. A combined one hundred and eighty (180) drainage complaints at one hundred and forty five (145) different locations have been filed with the City of Grand Prairie for the studied watersheds within this report. Of these complaints, seven (7) were structure flooding problems related to streets or storm drains, thirty-six (36) were street ponding problems, seventy (70) were lot-to-lot property flooding problems (primarily water standing in the yard due to grading issues), eleven (11) were complaints about debris obstructing drainage system flow, thirty-five (35) were related to stream bank erosion, and twenty-one (21) were unspecified complaints. Grade stabilization projects were constructed in 2008 along Kirby Creek to help address many of the complaints related to public stream bank erosion concerns. The remaining stream bank erosion complaints are addressed through proposed alternatives considered private benefit alternatives included in Section IX of this report. Complaints in the watershed primarily involved storm drainage system performance or local flooding due to grading issues.

2. Hot Spot Locations

The following hot spot locations were taken from the City of Grand Prairie CWDMP Road Map prepared in August 2010. These hot spot locations primarily involve inadequate storm drainage systems or local flooding due to grading issues. None of these locations coincide with riverine flooding or stream bank erosion.

- a. Meadows Drive and Summerfield Lane (Kirby Creek watershed)
- b. Santa Anna Drive East of Corn Valley (Kirby Creek watershed)
- c. Along Corn Valley Road north of Kirby Creek
- d. Ridgewood Drive south of Kirby Creek
- e. Green Hollow Drive (Kirby Creek watershed)

F. PERTINENT STUDY AND TECHNICAL DATA RELATED TO WATERSHED PRIOR TO THE MASTER PLAN PREPARATION

1. Existing Data

i. 2005 Kirby Creek Watershed Drainage & Erosion Master Plan

Half Associates along with two sub-consultants, Peter Allen, PhD, and CMJ Engineering, performed analyses to evaluate channel stability and prioritize erosion locations along Kirby Creek, South Fork Kirby Creek, and Brian Tributary. Some of the channel stability and erosion control alternatives developed from this study have already been implemented by the City of Grand Prairie.

ii. 2006 Capital Improvement Study Along Kirby, Prairie and Fish Creek Drainage Basins (Y#0460)

Half Associates was hired by the City of Grand Prairie to identify flood prone areas and analyze potential relief measures as part of a Capital Improvement Study for the Kirby, Prairie and Fish Creek drainage basins. Some of the proposed CIPs produced by this study have already been implemented along Kirby Creek including a regional detention pond upstream of Robinson Road, rock chutes to reduce down cutting, and other erosion control measures. Select stream bank stabilization alternatives from this study were incorporated into this report.

iii. 2007 Erosion Master Plan Study for Willis Branch

Half Associates developed detailed hydrologic and hydraulic models, identified channel stability and erosion problems, and recommended alternative channel improvements to help alleviate existing and potential future flood and erosion problems. Select stream bank and stream bed erosion alternatives from this study were incorporated into this report.

-
- iv. 2008 Mayfield Road Paving, Drainage, and Water Line Improvements
Halff Associates incorporated hydrologic data into the 2010 Kirby Creek Letter of Map Revision (LOMR) hydrologic model from the Grand Prairie Municipal Airport hydrology performed by KSA Engineers for the Mayfield Road Paving, Drainage, and Water Line Improvements from State Highway 360 to Great Southwest Parkway.
- v. 2010 Kirby Creek LOMR
Halff Associates was hired by the City of Grand Prairie to develop updated Zone AE floodplain mapping for Kirby Creek extending from Great Southwest Parkway to its confluence with Fish Creek. This LOMR study incorporated updated hydrology and hydraulics for the Kirby Creek watershed based on Grand Prairie 2009 Light Detection and Ranging (LiDAR) one-foot topography and the City of Grand Prairie Capital Improvement Study Along Kirby, Prairie and Fish Creek Drainage Basins (Halff Associates, April 2006). New survey information in the watershed was also included as part of the updated hydrology and hydraulics. The revised Kirby Creek hydraulic model was the basis for this supplemental CWDMP study to identify flood prone areas and potential alternatives.
- vi. City of Grand Prairie – Y#0882 FEMA FY10 Cooperating Technical Partner (CTP) Project
Existing conditions hydrology, hydraulics, and floodplain mapping for Garden Branch and Willis Branch were developed and submitted to FEMA by Halff Associates, Inc. in 2011 as part of the FEMA CTP studies funded in FY10. The models and mapping resulting from that study were the basis for this City-wide Drainage Master Plan report for Garden Branch and Willis Branch.
- vii. 2012 City-wide Drainage Master Plan for Fish Creek (Y# 0881)
RPS Espey Consultants was hired by the City of Grand Prairie to develop the City-wide Drainage Master Plan for Fish Creek. The fundamental objective of this study was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed historically for the Fish Creek watershed as well as to address existing flooding, erosion, and sedimentation within the basin.

2. Ongoing/Future Studies

There are no known ongoing/future studies within the Garden Branch, Kirby Creek, or Willis Branch watersheds.

II. Hydrologic Studies

II. HYDROLOGIC STUDIES

A. GENERAL

Hydrologic analyses were conducted by Halff Associates for the Garden Branch, Kirby Creek, and Willis Branch watersheds. Hydrologic analyses for Garden Branch and Willis branch were performed in 2011 as part of the City of Grand Prairie CTP Flood Study utilizing the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS, Version 3.5). Hydrologic analyses developed by Halff Associates for the Kirby Creek watershed in 2006 as part of the Capital Improvement Study Along Kirby, Prairie and Fish Creek Drainage Basins were the basis for the revised 2010 LOMR model included within this report.

The following hydrologic scenarios were developed for each of the studied watersheds:

1. Existing Land Use Conditions
2. Ultimate Land Use Conditions

Significant rainfall events considered for the hydrologic models were the 2-, 5-, 10-, 25-, 50-, 100- and 500-year frequency floods. Detailed watershed delineation, existing and ultimate land use determination, and the hydrologic soil coverage were used to develop the HEC-HMS hydrologic computer model for each studied watershed. The City's Drainage Design Manual and the Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55) Second Edition were used as guidelines for the hydrologic analyses or each studied watershed.

B. WATERSHEDS

The following is a brief description of each studied watershed as part of this supplemental report to the City-wide Drainage Master Plan for Fish Creek. An overall watershed map showing the Garden Branch, Kirby Creek, and Willis Branch watersheds in relation to the Fish Creek basin can be seen in Appendix A of this report.

Garden Branch Watershed

The Garden Branch watershed is located in southwestern Grand Prairie, Texas. Garden Branch is a tributary to Fish Creek and originates just north of Camp Wisdom Road and generally flows northeast before entering Fish Creek just upstream of Great Southwest Parkway. The total contributing watershed area draining to Garden Branch is about 0.80 square miles or approximately 512 acres.

The watershed is currently about 75% urbanized. The upper watershed, upstream of Camp Wisdom Road, consists of single family residential and commercial development. The central and lower watershed consists of mostly single family residential development with some industrial development. The Lake Parks North residential development is currently being constructed in the lower watershed near the confluence with Fish Creek. The new residential development is shown in the existing Garden Branch land use as under construction and as Single Family in the ultimate conditions land use.

Kirby Creek Watershed

The Kirby Creek watershed is located in southeastern Grand Prairie, Texas. Kirby Creek is a tributary to Fish Creek and originates just west of Great Southwest Parkway and generally flows east before entering Fish Creek at a location approximately 2,700 feet upstream of FM-1382. The South Fork of Kirby Creek Tributary and Brian Tributary to Kirby Creek were also included as part of the study of the Kirby Creek watershed. The total contributing watershed draining to Kirby Creek including its tributaries is about 3.70 square miles or approximately 2,370 acres.

The watershed is currently about 80% urbanized. Existing land use consists of primarily low density residential in the lower watershed, downstream of Carrier Parkway, with some parks/open space areas immediately surrounding Kirby Creek. The lower watershed is fully urbanized. The upper watershed, upstream of Carrier Parkway, is mostly industrial and low density residential with some large undeveloped areas. Potential future development

includes construction of Grand Prairie Airport hangars, further development of Traders Village, and development along the SH 161 Corridor.

Willis Branch Watershed

The Willis Branch watershed is located just south of Interstate 20 in southwestern Grand Prairie, Texas. Willis Branch is a tributary to Fish Creek and originates just east of Great Southwest Parkway and generally flows east before entering Fish Creek just upstream of Matthew Road. The total contributing watershed area draining to Willis Branch is about 0.72 square miles or approximately 460 acres.

The watershed is currently about 70% urbanized. The upper watershed along Interstate 20 consists primarily of commercial and retail development with some multi-family development. The central watershed consists of open space along Willis Branch with single family residential development in the lower watershed.

C. LAND USE

Land use for each studied watershed has been determined for both existing and ultimate conditions.

1. Existing Land Use

Existing land use conditions were based on the date of each study. Garden Branch and Willis Branch were studied in 2011 and Kirby Creek was studied in 2006.

The Garden Branch watershed is primarily single family residential use with a large commercial/retail development in the upper watershed along State Highway 360. The Willis Branch watershed consists of a large commercial/retail development in the upper watershed along Interstate 20 and single family residential in the lower watershed. Both the Garden and Willis Branch existing land use were developed based on the 2005 North Central Texas Council of Governments (NCTCOG) land use and updated with current aerial photography. The Kirby Creek watershed is the largest of the three watersheds and has the most diverse existing land use condition. The most prominent existing land use for Kirby Creek is single family residential with some commercial/retail development located sporadically. The Grand Prairie Municipal Airport is located in the upper watershed and South Grand Prairie High School is located in the lower watershed. The Kirby Creek existing land use was developed in 2005 for the Kirby Creek Watershed Drainage & Erosion Master Plan.

Existing land use maps for each studied watershed can be seen in Appendix A of this report.

2. Ultimate Land Use

Ultimate land use conditions for each studied watershed were based on the City of Grand Prairie's future land use conditions shapefile. The City's future land use zoning was not revised unless current aerial photography indicated land use with a higher percent impervious than the future land use designation. In these cases, the future land use designation was changed to match existing conditions. Ultimate land use maps for each studied watershed can be seen in Appendix A of this report.

D. IMPERVIOUS COVERAGE

Percent impervious is a function of the various land uses within a watershed basin. The percent impervious values for the Garden and Willis Branch watershed studies were obtained from the City's Drainage Design Manual (December 2010) Table 4.1a and Table 4.1c. The percent impervious values for the Kirby Creek watershed study were based on the City's Draft Storm Drain Design Manual at the time of the Kirby Creek Watershed Drainage & Erosion Master Plan performed by Halff Associates in January 2005. A composite percentage of impervious area was computed for all sub-basins within each studied watershed for both existing and ultimate conditions. The percent impervious values input into the HEC-HMS models represent the corresponding amount of existing or potential development. Tables II-1 and II-2 provide the specific land use classifications and the corresponding percent impervious values that were used for each study.

Table II-1 – Land Use and Percent Impervious for the Garden and Willis Branch Watersheds

Land Use Classification	Impervious (%) Condition
Impervious	98%
Open Space	0%
Single Family Residential	50%
Institutional	72%
Commercial	85%
Multi-Family Residential	65%
Industrial	72%
Under Construction	15%
Utilities	40%
Water	100%

Table II-2 – Land Use and Percent Impervious for the Kirby Creek Watershed

Land Use Classification	Impervious (%) Condition
Undeveloped Areas	2%
Parks/Golf Courses/Cemeteries/Open	15%
Residential/Single Family	35%
Residential/Multi-Family	75%
Commercial/Manufacturing/Industrial	85%

E. SOIL TYPES

Soil information for Garden and Willis Branch was obtained from the 2009 United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) 2.2 data models for Dallas and Tarrant counties. The most prominent hydrologic soil type for Garden and Willis Branch is Group D with Group B and C soils also present in both watersheds. The USDA Soil Survey of Dallas County and Soil Survey of Tarrant County, dated February 1980, were used to evaluate the hydrologic soils within the Kirby Creek watershed. The upper Kirby Creek watershed is almost entirely Group D soils. The lower watershed is predominantly Group D soils but contains some areas of Group B soils where Kirby Creek approaches the confluence with Fish Creek. Group B soils indicate soils having some content of gravelly sand with moderate infiltration rates and a low/moderate runoff potential. Group C soils indicate soils having moderately fine to fine texture and slow infiltration rates. Group D soils are defined as clayey with slow

infiltration rates and a high potential for runoff. The hydrologic soils for each studied watershed are illustrated in the hydrologic soil maps found in Appendix A of this report.

The antecedent moisture condition (AMC) defines the soil moisture condition prior to a storm. AMC-II, average soil moisture conditions, was used for each watershed study.

F. LOSS RATES

The loss rate of rainfall, caused by evaporation, interception, depression, storage, and infiltration, is typically evaluated and subtracted from the rainfall to determine rainfall excess for each time increment of a storm. For each watershed study, the National Resources Conservation Service (NRCS ,previously the Soil Conservation Service, (SCS)) Loss Rate Method was utilized to compute peak flood discharges based on land use, soil classification, and antecedent moisture conditions.

Baseline Curve Numbers (CN) were obtained from TR-55, Table 2.2c, for pasture, grassland, or range for AMC-II, average soil moisture conditions (See Appendix B). Curve Numbers were computed based on a composite percentage of soil types within each sub-basin. Group A soils were defined as having a CN of 39, Group B soils were defined as having a CN of 61, Group C soils were defined as having a CN of 74, and Group D soils were defined as having a CN of 80. Percent impervious values calculated based on land use were used in addition to Curve Numbers for hydrologic computations (Refer to Section II.D).

The initial abstraction (IA) for all watersheds was computed for AMC-II, average soil conditions using the following equation from TR-55:

$$IA = 0.2 \left(\frac{1000}{CN} - 10 \right)$$

A summary of Curve Numbers, percent impervious values and initial abstractions is included in Appendix B for each studied watershed.

G. SYNTHETIC UNIT HYDROGRAPH METHOD

The unit hydrograph technique is used to transform rainfall excess to sub-basin runoff. The NRCS Dimensionless Unit Hydrograph method was utilized to compute lag times for all sub-basins within each studied watershed to determine runoff hydrographs. Existing time of concentration was computed based on TR-55 methodology. Travel times for channel flow were based on velocities from the hydraulic model.

Half Associates computed lag times using the following equation:

$$t_p = 0.6 * \text{time of concentration}$$

Time of concentration was computed separately for existing and ultimate conditions for the Garden and Willis Branch watershed studies. Overland flow length was limited based on existing and ultimate land use conditions. Overland flow was limited to 100 feet for undeveloped and residential land use and 50 feet for industrial/commercial land use. Ultimate conditions shallow concentrated flow was assumed to be all paved.

A summary of lag times is also included in Appendix B for each studied watershed.

H. RAINFALL

Point rainfall depths were obtained from the City's Drainage Design Manual (December 2010), Table 5.4B, for five minute to twenty-four hour duration rainfall events. The rainfall data is summarized in Table II-3 below.

Table II-3 - Rainfall Depth / Duration for Each Studied Watershed

Return Period (years)	Point Rainfall Depths (inches)							
	5-min	15-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2 yr	0.49	1.04	1.85	2.22	2.45	2.91	3.45	3.95
5 yr	0.57	1.22	2.45	3.00	3.30	3.90	4.70	5.40
10 yr	0.63	1.36	2.86	3.55	3.85	4.65	5.50	6.40
25 yr	0.73	1.56	3.35	4.15	4.55	5.45	6.50	7.50
50 yr	0.80	1.71	3.82	4.65	5.15	6.20	7.35	8.52
100 yr	0.87	1.87	4.25	5.20	5.70	6.92	8.40	9.55
500 yr	1.00	2.20	5.40	6.60	7.40	8.80	10.50	12.00

Ref: City of Grand Prairie Storm Design Manual (December 2010) Table 5.4B

I. FLOOD ROUTING

The Modified Puls routing method was utilized for reaches modeled in HEC-RAS. The routing was used to establish storage-outflow relationships from steady-flow water surface profiles using the HEC-RAS hydraulic analyses. Storage-outflow relationships were determined for existing channel and floodplain conditions.

J. DETENTION & DIVERSIONS

Three (3) detention ponds were modeled in the Garden Branch watershed and two (2) detention ponds were modeled in the Kirby Creek watershed. These ponds were within the city limits and were designed specifically for detention with outlet structures and emergency overflow. Each pond was included in the hydrologic models either through elevation-area-discharge tables or through the Modified Puls routing. The outlet structure rating curves and storage volumes were typically taken from City design plans if the data was available.

There were no diversions identified or model in the studied watersheds.

III. Hydraulic Studies

III. HYDRAULIC STUDIES

A. HYDRAULIC ANALYSES

Half Associates developed detailed hydraulic models using existing and ultimate conditions hydrology for Garden and Willis Branch using the City of Grand Prairie LiDAR data (2009), aerial digital photography (2010), Marshall Lancaster & Associates, Inc. provided field surveys (July 2011), and field observations.

Hydraulic models developed by Half Associates for Kirby Creek and Tributaries in 2006 as part of the Capital Improvement Study Along Kirby, Prairie and Fish Creek Drainage Basins were the basis for the revised 2010 LOMR models included within this report. The revised models were updated with 2009 City of Grand Prairie one-foot LiDAR topography, 2009 Smith and Pardue property survey, the addition of the SH-161 north and southbound bridge crossing, and the addition of cross sections 20838, 17028, 16965, 16738, 16618, 15589, and 13693 to better define the channel geometry.

Computed flood profiles for Garden and Willis Branch were developed using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS, Version 4.1). Computed flood profiles for Kirby Creek were developed using HEC-RAS, Version 4.0. Half Associates developed HEC-RAS models for existing channel and bridge conditions with existing and ultimate land use conditions discharges.

Hydraulic cross-sections were extracted from the City of Grand Prairie LiDAR topographic data. Where detailed survey was available, the survey data was incorporated into the City of Grand Prairie LiDAR data to obtain composite cross sections with surveyed channel data and LiDAR overbank data. Flowlines and channels of non-surveyed hydraulic cross sections were interpolated based on nearby channel surveys when the LiDAR data was not sufficient to define the channels. The locations of hydraulic cross-sections for each studied stream are displayed in the Floodplain Workmaps included in Appendix A.

Bridge data was input to the hydraulic models for each studied stream for each inline structure based on survey data. Expansion and contraction coefficients of 0.3 and 0.5 were applied upstream and downstream of structures or other abrupt changes in floodplain width as appropriate. Ineffective flow areas were entered upstream and downstream of structures to account for loss of conveyance due to the structures. Ineffective flow limits were also used in situations where there was storage without conveyance. Normal depth was used as the starting boundary condition for the Garden Branch, Kirby Creek, and Willis Branch

hydraulic models. The energy based junction method in HEC-RAS was used to determine starting water surface elevations for the South Fork of Kirby Creek and Brian Tributary.

Channel roughness factors (Manning's n-values) were selected based on standard references, engineering judgment, aerial and field photographs, and field observations of the streams and floodplain areas. References included Chow's 1959 Open Channel Hydraulics, the City of Grand Prairie Drainage Design Manual, and the HEC-RAS program built-in references dialog windows.

Computed peak discharges from the Garden and Willis Branch HEC-HMS models for the existing 2-, 5-, 10-, 25-, 50-, 100-, and 500-year and ultimate 100-year frequency floods were included in the existing conditions and ultimate conditions hydraulic models, respectively. Based upon the results of the hydrologic analysis for Kirby Creek, it was determined that the average difference between the existing and ultimate land use conditions discharges were small, equal to or less than 5%. Therefore, the ultimate land use conditions were used for the 2010 Kirby Creek LOMR and computed peak discharges for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood events are applicable for both existing and ultimate conditions. The hydraulic results, including computed water surface elevations and profiles, are also discussed in Section IV.B, Hydraulic Study Results.

A floodway was not calculated as a part of the Garden Branch or Willis Branch study since these studies contained mostly Zone A floodplains. Revised floodway models for Kirby Creek and South Fork Kirby Creek were developed as part of the 2010 Kirby Creek LOMR since the floodplain were Zone AE designations.

A DVD containing copies of all hydraulic computer models, GIS shapefiles, and figures used in preparation of this report is included in Appendix F.

IV. Hydrologic and Hydraulic Study Results

IV. HYDROLOGIC AND HYDRAULIC STUDY RESULTS

A. HYDROLOGIC STUDY RESULTS

This section of the supplemental report to the City-Wide Drainage Master Plan for Fish Creek compiles the results of the detailed hydrologic computer models for the Garden Branch, Kirby Creek, and Willis Branch watersheds.

Hydrologic parameter data for all sub-basins modeled in each studied watershed are included in Appendix B. Detailed time of concentration calculations are included in hardcopy in Appendix B and on the DVD in Appendix F of this report.

Detailed HEC-HMS hydrologic computer models have been prepared for the Garden Branch, Kirby Creek, and Willis Branch watersheds. The existing and ultimate land use conditions were analyzed with channel flood routing data based on existing channels and bridges. Based on the results of the hydrologic analysis for Kirby Creek, it was determined that the average difference between the existing and ultimate land use conditions discharges were small, equal to or less than 5%. Therefore, only the ultimate land use conditions discharges were utilized in the hydraulic model for Kirby Creek. Tables IV-1, IV-2, and IV-3 contain available peak flood discharge information for existing and ultimate conditions at key locations along Garden Branch, Kirby Creek, and Willis Branch, respectively, for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood frequencies.

Table IV-1 – Summary of Discharges for Garden Branch

Location	Area (mi ²)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year		500-Year
		Existing	Existing	Existing	Existing	Existing	Existing	Ultimate	Existing
Downstream of Camp Wisdom Road	0.46	350	600	800	950	1,100	1,250	1,250	1,600
At Kingswood Boulevard	0.72	500	850	1,100	1,350	1,600	1,850	2,100	2,400
At confluence with Fish Creek	0.80	550	900	1,150	1,400	1,650	1,900	2,200	2,600

Table IV-2 – Summary of Discharges for Kirby Creek

Location	Area (mi ²)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year		500-Year
		Existing	Existing	Existing	Existing	Existing	¹ Existing	Ultimate	Existing
Kirby Creek									
Downstream of Great Southwest Parkway	0.54	300	400	450	550	600	-----	650	1450
Upstream of Kirbywood Trail	0.82	700	1,000	1,200	1,450	1,650	-----	1,800	2,200
Upstream of Waterwood Drive	0.98	400	700	850	1,100	1,350	-----	1,550	2,100
Upstream of SH 161	1.21	600	900	1,100	1,300	1,500	-----	1,750	2,400
Upstream of Robinson Road	1.46	550	950	1,250	1,600	1,900	-----	2,150	2,900
Upstream of Carrier Parkway	1.58	700	1,000	1,350	1,750	2,100	-----	2,400	3,200
At Confluence of South Fork of Kirby Creek	1.81	1,000	1,500	1,800	2,300	2,750	-----	3,150	4,150
Approximately 1,700 feet upstream of confluence of Brian Tributary	1.92	850	1,350	1,750	2,300	2,800	-----	3,200	4,250
At confluence with Brian Tributary	2.11	950	1,550	1,950	2,550	3,100	-----	3,600	4,750
Upstream of Corn Valley Road	2.67	1,400	2,250	2,800	3,400	4,050	-----	4,650	6,250
Downstream of Corn Valley Road	3.01	1,850	2,950	3,650	4,450	5,150	-----	5,900	7,700
Upstream of Ridgewood Drive	3.22	1,900	3,150	3,950	4,750	5,550	-----	6,350	8,300
Upstream of Country Club Bridge	3.33	1,850	3,100	3,900	4,800	5,600	-----	6,450	8,500
South Fork of Kirby Creek									
Downstream of Robinson Road	0.19	350	500	600	700	800	-----	850	1,050
Brian Tributary									
Downstream of Carrier Parkway	0.13	200	300	400	450	500	-----	600	700

¹Existing conditions peak discharges were considered equal to the ultimate conditions peak discharges in the Kirby Creek HEC-RAS hydraulic model. See explanation in above paragraph.

Table IV-3 – Summary of Discharges for Willis Branch

Location	Area (mi ²)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year		500-Year
		Existing	Existing	Existing	Existing	Existing	Existing	Ultimate	Existing
Approximately 270 feet downstream of Great Southwest Parkway	0.22	325	450	550	650	750	800	850	1,000
Approximately 2,930 feet downstream of Great Southwest Parkway	0.49	550	850	1,000	1,200	1,350	1,550	1,600	1,950
Approximately 2,000 feet upstream of Private Drive	0.54	600	900	1,100	1,350	1,500	1,700	1,750	2,100
At confluence with Fish Creek	0.72	600	1,000	1,250	1,550	1,750	1,950	2,100	2,600

B. HYDRAULIC STUDY RESULTS

This section of the supplemental report to the City-wide Drainage Master Plan for Fish Creek compiles the results of the detailed hydraulic computer models for Garden Branch, Kirby Creek, and Willis Branch.

The computed peak flood discharges from each studied watershed were used in their respective HEC-RAS hydraulic models to compute existing water surface elevations for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood frequencies and ultimate water surface elevations for the 100-year flood frequency.

The HEC-RAS hydraulic computer models for Garden Branch and Willis Branch and the City of Grand Prairie LiDAR data (2009) were used to delineate their respective existing conditions 100-year floodplains (Refer to the Floodplain Workmaps in Appendix A of this report). The HEC-RAS hydraulic computer model for Kirby Creek and the City of Grand Prairie LiDAR data (2009) were used to delineate the ultimate conditions 100-year floodplain (Refer to the Floodplain Workmaps in Appendix A of this report). A DVD included in Appendix F contains all the hydraulic models and mapping shapefiles developed as part of this report. Flood profiles are included in Appendix B of this report. The water surface elevations for the existing 10-, 50-, 100, and 500-year frequency events and the ultimate 100-year frequency event are shown for all profiles.

C. QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance / quality control for the 2011 hydrologic and hydraulic studies of Garden Branch and Willis Branch was performed by Halff Associates, Inc. as part of the City of Grand Prairie – Y#0882 FEMA FY10 CTP Project. Storm events were added to the models during the preparation of this report and were also reviewed by Halff Associates, Inc.

The Kirby Creek hydrologic and hydraulic studies were also reviewed internally by Halff Associates as well as FEMA reviewers as part of the LOMR submittal process.

V. Floodplain Mapping

V. FLOODPLAIN MAPPING

Halff Associates compiled floodplain mapping for the Garden Branch, Kirby Creek, and Willis Branch watersheds from two sources: The 2011 City of Grand Prairie CTP Flood Study and the 2010 Kirby Creek LOMR. The floodplains are connected through bridges whether the bridge is overtopped or not per FEMA Mapping guidance. The profile should be referenced to determine if a bridge is overtopped as the mapping will always be connected. The floodplains through culverts were delineated based on the modeled conditions through the culvert. If the culvert is not overtopped, the floodplain will be disconnected on either side of the culvert.

Halff Associates re-mapped the existing 100-year floodplain for Garden Branch and Willis Branch as part of the 2011 City of Grand Prairie CTP Flood Study. The BFEs were finalized per the FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C, dated November 2009. Floodways were not modeled for Garden Branch or Willis Branch as part of the CTP study. The results of the CTP project were submitted to FEMA in October 2011. Refer to Appendix A for Floodplain Workmaps of Garden Branch and Willis Branch. Floodplain shapefiles are included on the DVD in Appendix F.

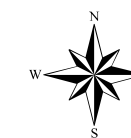
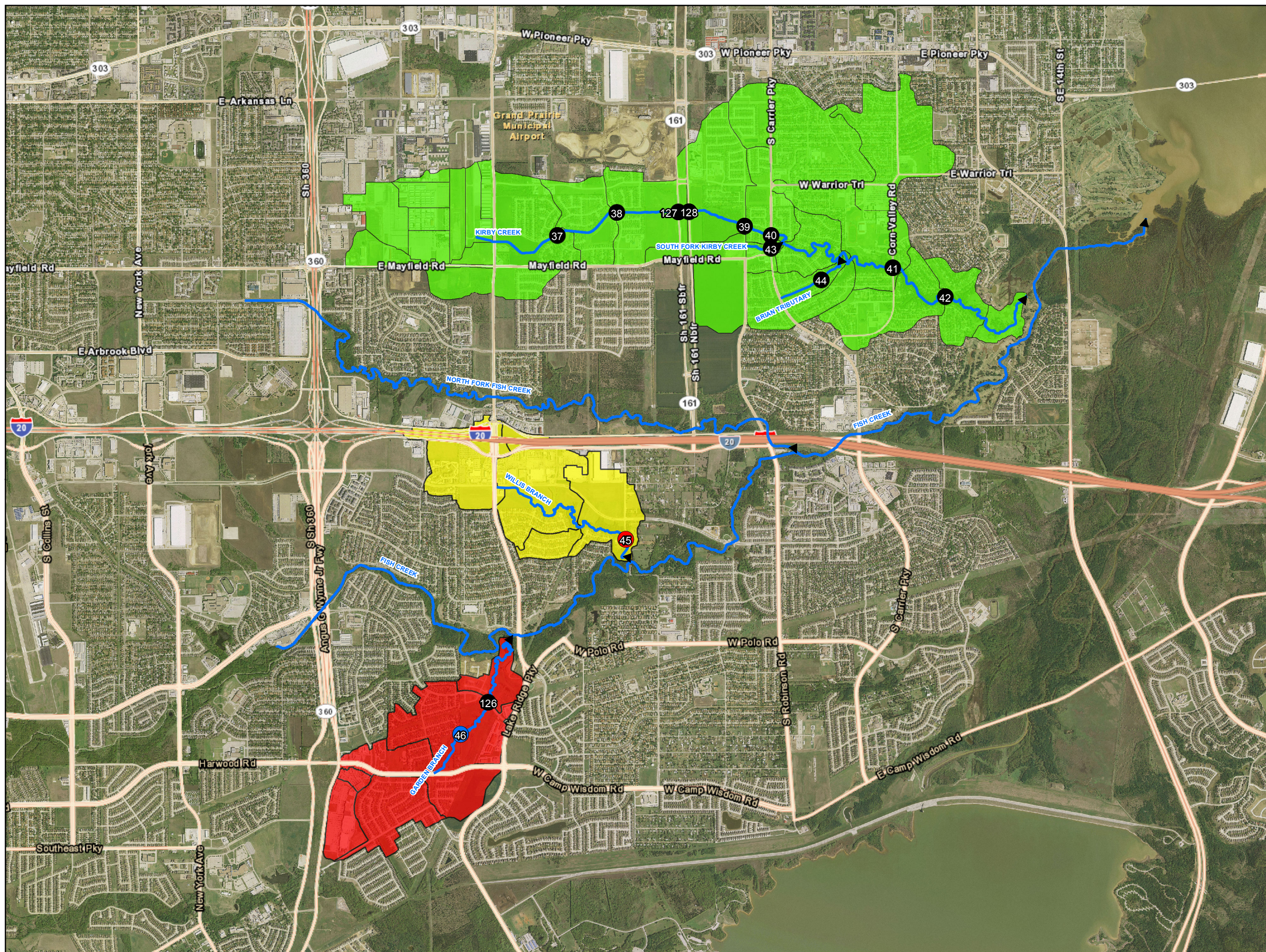
Halff Associates developed updated floodplain mapping for Kirby Creek as part of the 2010 LOMR for Kirby Creek and tributaries. Based on the results of the hydrologic analysis for Kirby Creek, it was determined that the average difference between the existing and ultimate land use conditions discharges were small, equal to or less than 5%. Therefore, only the ultimate land use conditions discharges were utilized for the Kirby Creek LOMR. Updated technical data including revised HEC-HMS and HEC-RAS models for this LOMR included the following streams: Kirby Creek, South Fork of Kirby Creek, and Brian Tributary. Revised mapping included the 100-year and 500-year floodplains and updated BFEs. Revised floodway mapping was included for Kirby Creek and South Fork of Kirby Creek. Refer to Appendix A for Floodplain Workmaps of Kirby Creek, South Fork Kirby Creek, and Brian Tributary. Floodplain shapefiles are included on the DVD in Appendix F.

VI. Roadway Crossings

Figure VI-1
Existing Roadway
Crossings

Legend

- 10% Event Overtops Road
- 2% Event Overtops Road
- 1% Event Does Not Overtop Road
- Kirby Creek Watershed
- Garden Branch Watershed
- Willis Branch Watershed



0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet

VI. ROADWAY CROSSINGS

A. EVALUATION OF EXISTING ROADWAY CROSSINGS

Existing roadway crossings along each studied stream were evaluated on their level of protection against the existing 10%, 2%, and 1% (10-year, 50-year, and 100-year) annual chance flood events. The following tables include the current hydraulic model, the station and description of the roadway crossing, and if the roadway crossing is overtopped by the existing 10%, 2%, or 1% annual chance flood event. Water Surface Elevations (WSEL) refer to the upstream face of the structure.

Table VI-1 - Existing Bridge Crossings

Stream: Garden Branch						
Model: Garden_Branch_Watershed.prj (HEC-RAS)						
River Station		Roadway Crossing	Min. Top of Road Elev.	10% Event Overtops Road	2% Event Overtops Road	1% Event Overtops Road
46.	57+22	<i>Martin Barnes Road</i>	535.96	No WSEL=535.27	Yes WSEL=536.79	Yes WSEL=537.11
126.	40+44	<i>Kingswood Boulevard</i>	532.01	No WSEL=524.84	No WSEL=526.37	No WSEL=527.25

Table VI-1 - Existing Bridge Crossings

Stream: Willis Branch						
Model: Willis_Branch_Watershed.prj (HEC-RAS)						
River Station		Roadway Crossing	Min. Top of Road Elev.	10% Event Overtops Road	2% Event Overtops Road	1% Event Overtops Road
45.	10+95	<i>Private Driveway</i>	501.62	Yes WSEL=503.79	Yes WSEL=504.28	Yes WSEL=504.45

Table VI-1 - Existing Bridge Crossings

Stream: Kirby Creek						
Model: Kirby Creek 2009 Update.prj (HEC-RAS)						
River Station		Roadway Crossing	Min. Top of Road Elev.	10% Event Overtops Road	2% Event Overtops Road	1% Event Overtops Road
37.	21+171	<i>Kirbywood Drive</i>	552.00	No WSEL=549.56	No WSEL=550.71	No WSEL=551.07
38.	18+996	<i>Waterwood Drive</i>	543.70	No WSEL=539.22	No WSEL=540.79	No WSEL=541.35
127.	17+013	<i>SH 161 SB Frontage Road</i>	534.19	No WSEL=533.51	Yes WSEL=534.48	Yes WSEL=535.16
128.	16+684	<i>SH 161 NB Frontage Road</i>	534.48	No WSEL=528.69	No WSEL=529.48	No WSEL=529.89
39.	14+814.5	<i>Robinson Road</i>	526.00	No WSEL=520.63	No WSEL=522.69	No WSEL=523.54

Table VI-1 - Existing Bridge Crossings (continued)

40.	13+870	<i>Carrier Parkway</i>	520.68	No WSEL=517.27	No WSEL=519.58	No WSEL=520.53
41.	72+10	<i>Corn Valley Road</i>	498.80	No WSEL=489.03	No WSEL=490.82	No WSEL=491.60
42.	46+55	<i>Ridgewood Drive</i>	482.17	No WSEL=478.67	No WSEL=480.98	No WSEL=482.09

Table VI-1 - Existing Bridge Crossings

Stream: Brian Tributary (Woodacre Channel)						
Model: Kirby Creek 2009 Update.prj (HEC-RAS)						
River Station		Roadway Crossing	Min. Top of Road Elev.	10% Event Overtops Road	2% Event Overtops Road	1% Event Overtops Road
44.	11+90	<i>Beatty Drive</i>	517.28	No WSEL=510.15	No WSEL=511.91	No WSEL=514.38

Table VI-1 - Existing Bridge Crossings

Stream: South Fork Kirby Creek						
Model: Kirby Creek 2009 Update.prj (HEC-RAS)						
River Station		Roadway Crossing	Min. Top of Road Elev.	10% Event Overtops Road	2% Event Overtops Road	1% Event Overtops Road
43.	5+75	<i>Carrier Parkway</i>	522.32	No WSEL=515.15	No WSEL=517.00	No WSEL=517.78

Overtopped roadways owned by the City were resized for the ultimate 1% (100-year) annual chance flood event. A summary of the roadway improvement alternatives is included in Table VI-2. Refer to Section VII for detailed descriptions of conceptual existing roadway crossing improvements. Roadway improvements were not considered for Private Drive along Willis Branch or SH 161 SB Frontage Road, since they are not City owned. SH 161 SB Frontage Road at the stream crossing is above the 100-year WSEL and overtopping actually occurs in the right overbank.

Table VI-2 – Existing Roadway Proposed Alternatives

Stream Name	Roadway	Approx. River Station	100-Year Ultimate Discharge	Existing Crossing	Minimum Top of Road Elevation		Approx. Bridge Span/Improvement	100-Year Ult WSEL at US XS	Change in WSEL
					Existing	Proposed			
			(cfs)	(ft)			(ft)	(ft)	(ft)
Garden Branch	Martin Barnes Road	57+22	1,250	1-10'x10' Box Culvert	535.96	537.00	20' Bridge Span	535.00	-2.13

B. EVALUATION OF PROPOSED AND FUTURE ROADWAY CROSSINGS

According to the City of Grand Prairie’s Master Thoroughfare Plan, there are no planned major thoroughfares within any of the studied watersheds that are not currently modeled in the hydraulic models included in this report. The existing roadway classifications match the planned roadway classifications indicating there is no intention currently to resize these roadways in the future.

VII. Alternatives for Streams and Open Channels

VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS

Halff Associates considered proposed bridge alternatives for Martin Barnes Road since it was shown to be overtopped by the existing 100-year flood event. The proposed bridge alternative was sized to pass the 100-year ultimate discharge so that the roadway was not overtopped. Mitigation was not considered for proposed bridge alternatives but could be used to reduce the required bridge span and/or height for the final design. A detailed cost estimate for the flood control alternative can be found in Section XII of this report. The total annual cost given with the estimate is based on a 50-year project life and a 7% discount rate.

The City of Grand Prairie 2009 LiDAR data deliverables included a shapefile for buildings that were identified during the data acquisition. This building shapefile was intersected with the delineated existing 100-year floodplain for Garden Branch, Willis Branch, and the delineated ultimate 100-year floodplain for Kirby Creek to identify potentially flooded structures. There were no structures identified within the 100-year floodplain for any of the studied streams, therefore no flood protection alternatives were considered for inundated structures.

Garden Branch is considered waters of the United States. Construction of improvements within the waters of the United States requires permitting by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. Bridge improvements can typically be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements. Refer to Appendix G for more information regarding Section 404 Permits.

The following is a brief description of the proposed conceptual improvement for Martin Barnes Road. Refer to Table VI-2 for a summary of conceptual existing bridge crossing improvements.

1. **MARTIN BARNES ROAD AT GARDEN BRANCH (STREAM STATION 57+22)**

The existing bridge crossing at Martin Barnes Road consists of one 10'x10' box culvert. The culvert at Martin Barnes Road has the capacity to pass the 10-year storm event without the roadway being overtopped. Martin Barnes Road is overtopped by the existing 25-year storm event with the ultimate 100-year storm event overtopping the roadway by more than 1.0 foot. Table VII-1 below shows the level of protection for Martin Barnes Road.

Table VII-1 – Martin Barnes Road Level of Protection

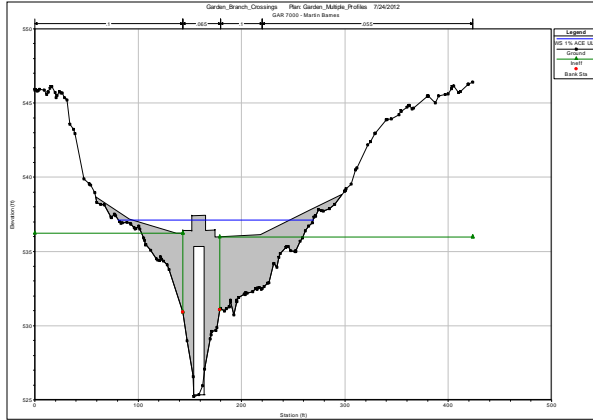
Stream: Garden Branch									
Model: Garden_Branch_Watershed.prj (HEC-RAS)									
River Station		Roadway Crossing	Min. Top of Road Elev.	Ex. 50% Event Overtops Road	Ex. 20% Event Overtops Road	Ex. 10% Event Overtops Road	Ex. 4% Event Overtops Road	Ex. 2% Event Overtops Road	Ex. 1% Event Overtops Road
46.	57+22	Martin Barnes Road	535.96	No WSEL= 531.29	No WSEL= 533.64	No WSEL= 535.27	Yes WSEL= 536.36	Yes WSEL= 536.79	Yes WSEL= 537.11

Alternative 1

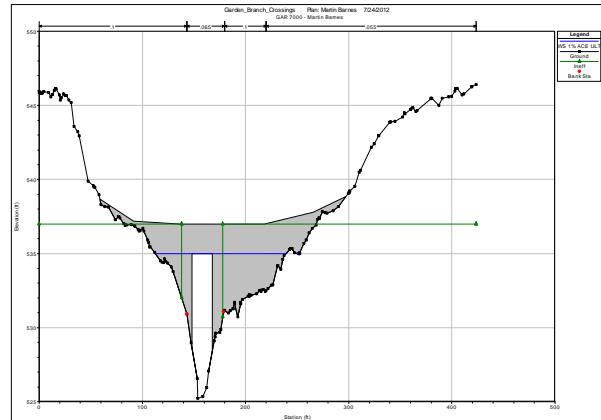
- Elevate minimum Top of Road to 537.00’
- Remove 10’x10’ box culvert and replace with 20’ bridge span

STATEMENT OF PROBABLE COST - 2012	
Subtotal	\$146,000
25% Contingency	\$36,500
CONSTRUCTION TOTAL	\$183,000
10% for Engineering and Survey	\$18,300
TOTAL	\$200,000

Refer to Section XII of this report for a detailed breakdown of the preliminary cost estimate. If the Alternative 1 improvements at Martin Barnes Road were implemented, the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations are lowered up to 1.11’ upstream of Martin Barnes Road as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. Valley storage loss should be minimal, but will need to be checked for the final bridge design and mitigation plan prior to construction. A FEMA Letter of Map Revision will be necessary after construction of the improvements to incorporate floodplain mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.



Martin Barnes Road Existing Conditions



Martin Barnes Road Proposed Conditions

VIII. Storm Water Infrastructure Analysis

VIII. STORM WATER INFRASTRUCTURE ANALYSIS

A. OVERVIEW

Storm water infrastructure analysis was not performed as part of the FEMA CTP and Road Map Drainage Master Plan (Y#0882) contract.

IX. Channel Stability Assessment & Erosion Hazard Analysis

IX. CHANNEL STABILITY ASSESSMENT & EROSION HAZARD ANALYSIS**A. INTRODUCTION**

Half Associates was tasked to prepare an analysis of stream bank and channel stabilization alternatives along with preliminary quantities/estimates of probable cost for Garden Branch, Kirby Creek, and Willis Branch. The critical data utilized for this analysis comes from Geomorphic Stream Assessments and field inspections performed at various dates for each studied stream. Alternatives considered to be a public benefit were proposed as part of this study. The City of Grand Prairie Resolution 3919 found in Appendix E addresses the City policy concerning public and private benefits. The following sections will describe standard erosion prevention measures (structural and non-structural) for stream bank and channel stabilization and recommended alternatives at key locations along each studied stream.

B. EROSION HAZARD SETBACKS (NON-STRUCTURAL)

As defined by the City's Drainage Design Manual, an Erosion Hazard Setback (EHS) is defined as the minimum horizontal distance from the toe of the slope of the bank of a watercourse that a structure must be constructed or placed to be outside the erosion hazard area. It is recommended that no building, fence, wall, deck, swimming pool or other structure should be located, constructed, or maintained within the area encompassing the setback. Stream bank erosion hazard setbacks may be required to extend beyond the limits of the regulatory floodplain.

The procedure for determining the stream bank erosion hazard setback zone per Section 2.6.F of the City's Drainage Design Manual is as follows:

1. Locate the toe of the natural stream bank.
2. From this toe, construct a line sloping at 4 horizontal to 1 vertical towards the bank until it intersects natural ground.
3. From this intersection, add 10 feet in the direction away from the stream to locate the outer edge of the erosion hazard setback.

As previously stated, setbacks established for the purposes of stream bank erosion hazard protection may extend beyond the limits of the regulatory floodplain limits. If the exercise above yields an erosion setback limit within the regulatory floodplain limits, then Halff recommends utilizing the limits of the regulatory floodplain (as shown in Appendix A) at a minimum as the outer limits of the erosion setback zone.

Potential situations may occur where stream bank erosion hazard setback lines could be reduced where stream banks consist entirely or partly of rock. In these areas, the interface of the stream bank with the top of the unweathered rock strata should be located with the assistance of a qualified geotechnical engineer. This point on the surface of the slope will be the toe of a 3:1 slope intersecting natural ground. The actual setback line should then be located 25 feet beyond this intersection (City standard criteria is 10 feet beyond this intersection), assuming it is beyond the regulatory limits. Once again, setback lines should take into account future widening and downcutting of existing channels.

As an alternative to the setback, the developer or landowner may submit to the City Engineer a plan to stabilize and protect stream banks threatened by erosion. Stabilization shall be of a permanent nature, consistent with the guidelines established in this study and by the City of Grand Prairie, and shall be designed and sealed by a licensed professional engineer. It is recommended that these limited erosion protection measures be used as a guideline to plan erosion protection alternatives in each studied watershed.

C. EROSION CONTROL MEASURES (STRUCTURAL)

Halff Associates identified several structural erosion control methods that could be used to help control the effects of erosion on Garden Branch, Kirby Creek, and Willis Branch. Typically, grade control structures are used to help prevent channel erosion and the corresponding downstream deposition. Hard and soft surface armor slope protection is used to help prevent bank erosion. Following is a brief description of the different erosion control methods included in this report.

1. Grade Control Structures

i. Purpose

Grade control structures are utilized to provide stability to the streambed (refer to Appendix D). The most common method of establishing grade control is the construction of in-channel grade control structures or “hard point”. Two basic types of grade control structures exist. One type is a “bed control” structure as

it is designed to provide a hard point in the streambed that is capable of resisting the erosive forces of a degradational zone. The second type is referred to as a “hydraulic control” structure since it functions by reducing the energy slope along the degradational zone to the point that the stream is no longer capable of scouring the bed. Important factors must be considered when siting grade control structures.

ii. Hydraulic Considerations

Hydraulic siting of grade control structures is a critical element of the design process, especially determining the anticipated drop at the structure. Procedures for hydraulic siting of these structures are also described in Appendix D. The primary factors affecting the final equilibrium slope upstream of a structure include sediment concentration and load, the channel characteristics (slope, width, depth, roughness, etc.), and the hydraulic effect of the structure. Also important is the time it takes for the equilibrium slope to develop, which could be over a period of a few hydrographs or over many years.

iii. Other Considerations

In some cases, traditional bank stabilization measures may not be feasible where system-wide instabilities exist. In these instances, grade control structures may be more of an appropriate solution. Grade control structures can enhance the bank stability of the bed, can reduce bank heights due to sediment deposition, and can reduce velocities and scouring potential by creating a backwater situation. For flood control, considerations should be given to the potential to cause overbank flooding. Grade control structures are often designed to be hydraulically submerged at flows less than bank-full so the frequency of overbank flooding is not significantly affected. Final siting of grade control structures should also try to minimize adverse environmental impacts to the system and instead provide direct environmental benefits to streams (scour holes and man-made pools provide fish habitat).

iv. Existing Structures

Grade control structures can have adverse as well as beneficial effects on existing structures. For structures upstream of hydraulic control measures, the potential exists for increased stages within the structure and also for sediment deposition. Many structures already provide some measure of grade control (usually culverts), however they may not be able to be relied on to provide long-term grade control. Grade control structures can also be implemented

during planned improvements to existing structures and as new structures are being built.

v. Local Site Conditions

When planning grade control structures, the final siting is often adjusted to accommodate local site conditions or local drainage situations. A stable upstream alignment that provides a straight approach for a grade control structure is critical. In a very sinuous channel, this could require straightening the channel to provide an adequate approach (with considerations for USACE jurisdictional waters). Upstream meanders should also be stabilized prior to implementing a downstream grade control structure.

vi. Downstream Channel Response

Since grade control structures affect the sediment delivery to downstream reaches, it is necessary to consider the potential impacts to the downstream channel when grade control structures are planned. Bed control structures reduce the downstream sediment loading by preventing the erosion of the bed and banks, while hydraulic control structures have the added effect of trapping sediments. The concern is that reduced sediment loads to downstream areas will cause degradational problems downstream. A solution would be to reduce the number of grade control structures upstream or add additional grade control structures in the downstream reach.

vii. Typical Grade Control Structures

Examples of typical grade control structures are included in Appendix D, including hydraulic grade control structures such as Loose Rock Dams and bed control structures such as Rock Chutes and Gabion Check Dams. Various other grade control structure types do exist; however, the typical structures included in this report are the basis for cost estimating purposes. The City of Grand Prairie is not required to solely utilize these typical structures since actual channel/site conditions may require different structure types, and Halfpenny would recommend that other cost-effective solutions be evaluated prior to actual design of the grade control structures.

2. Armored Slope and Channel Protection

i. Soft Armor Slope Protection

Some typical soft armor slope protection solutions include brush mattresses, contour wattling, and/or soil retention blankets/turf reinforcement mats

(TRMs). For the purposes of this report, Halff primarily investigated soil retention blankets and turf reinforcement mats as viable solutions for some of the slope protection needs of the studied tributaries. Turf reinforcement mats and soil retention blankets act to supplement the natural ability of vegetation (usually grass) to prevent soil erosion (in comparison to rock riprap). The reinforcement mats do this by providing a permanent net structure that acts as an additional barrier between flowing water and the underlying soil and also acts to reinforce vegetation as it grows through the matting's net structure. However, a turf reinforcement mat cannot provide permanent protection without vegetation. Therefore, design of these solutions must consider three phases: 1 – analyzing the channel in an unvegetated state to determine if the matting alone will handle the needed protection before vegetation establishment, 2 – a partially vegetated state to examine how the matting with immature vegetation can control soil erosion, and 3 – a permanent state with vegetation fully established and reinforced by the matting's permanent net structure.

Soil retention blankets and TRMs can be used for general slope protection purposes (hill slopes or shoreline) and as a flexible channel liner (stream portions). They can handle shear stresses from 0 pounds per square foot up to approximately 12 pounds per square foot. Typical examples of installation methods (provided by North American Green) are also included in Appendix D.

Halff recommends that soft armor protection be utilized along steeper slopes, slumps, and bank erosion areas where there are opportunities to lay back slopes to a 3:1 (horizontal to vertical) slope or less steep. Halff also recommends that the soft armor protection be utilized in areas with little or no significant tree growth, root exposure, or rock outcrops along the banks.

ii. Hard Armor Slope and Channel Protection

Hard armor slope and channel protection involves utilizing hard materials such as concrete, rock riprap, or gabions to provide very strong, massive structures to help control the effects of bank and channel erosion. Rock riprap and gabion slope protection were primarily utilized for estimates in this study. If development encroaches into areas where slope protection is needed, the City may desire to have additional erosion hazard setbacks to prevent the encroachment or require the developer to design, construct, and implement the hard armor solutions with the development.

The hard armor solutions, including rock riprap, gabion mattress, and gabion basket walls can be used for erosion situations involving high velocities, high shear stresses, and extremely steep slopes (0.5:1 to 2:1).

Recommendations for hard armor solutions are as follows and examples are provided in Appendix D:

1. For 2:1 slopes, utilize 12” gabion mattress slope protection or 18” to 24” thick rock riprap protection,
2. For 1:1 to 1.5:1 slopes, utilize 3’ x 1.5’ gabion basket staired wall
3. For slopes steeper than 1:1, utilize 3’x3’ gabion basket walls (Gravity or Tieback depending on height)

Hard armor solutions are also more expensive and sometimes less aesthetically pleasing solutions than the softer armor, but would have a longer life span and more of an impact on reducing the effects of erosion.

D. U.S. ARMY CORPS OF ENGINEERS SECTION 404 PERMITS

For any future channel or slope improvements to Garden Branch, Kirby Creek, or Willis Branch, considerations must be made to impacts to jurisdictional waters of the United States. A wetland investigation and determination should be performed prior to construction of any proposed improvements within the channel. Minor improvements to jurisdictional waters may fall into a Nationwide Permit category, where more extensive modifications of jurisdictional waters would require an extensive Individual Permit process. Refer to Appendix E to locate current Nationwide Permit descriptions and descriptions of and an application for a USACE Individual Permit. Nationwide Permits that could apply to potential channel and development improvements include:

- Nationwide Permit 3 – Maintenance
- Nationwide Permit 13 – Bank Stabilization
- Nationwide Permit 14 – Linear Transportation
- Nationwide Permit 27 – Stream and Wetland Restoration Activities
- Nationwide Permit 29, 39 – Residential, Commercial, and Institutional Activities
- Nationwide Permit 41 – Reshaping of Existing Drainage Ditches

The USACE web-site has more information on the current permits. Please visit <http://www.swf.usace.army.mil/> for additional information.

E. OVERVIEW OF ALTERNATIVES TO HELP STABILIZE STREAM BEDS AND BANKS ALONG GARDEN BRANCH, WILLIS BRANCH, AND KIRBY CREEK

This section of the supplemental report to the City-wide Drainage Master Plan for Fish Creek provides a summary of channel stability and erosion issues along with recommended channel improvements for Garden Branch, Kirby Creek, and Willis Branch. Alternatives for each stream were developed by Halff Associates from various studies performed at different dates.

The Garden Branch alternatives were developed as part of this study and were based on the findings of the Garden Branch Stream Assessment performed by Freese & Nichols, Inc. in June 2012. The Garden Branch Stream Assessment can be found in Appendix C of this report.

The Willis Branch alternatives were developed in 2007 as part of the Erosion Master Plan Study for Willis Branch. Alternatives developed for this study addressed existing and potential erosion problems along Willis Branch. Only projects that addressed existing erosion problems were included as part of the alternative prioritization for this report.

The Kirby Creek alternatives were developed in 2005 as part of the Kirby Creek Watershed Drainage & Erosion Master Plan. Select alternatives from this study that have not already been implemented were included as part of the alternative prioritization for this report. The improvements to the existing concrete lined channel between stations 23+396 & 18+096 along Kirby Creek were based on field inspections performed by Halff Associates in August 2012.

Halff Associates considered the following alternatives for prioritization for each studied stream as part of this report. Each Erosion site was ranked based on severity of erosion and likelihood of impending slope failure with consideration to the project cost of each proposed alternative. Halff Associates utilized these rankings to establish a prioritization of erosion sites as illustrated in Table IX-1 below. See Appendix A for a location map of proposed stream stability and erosion hazard alternatives.

Table IX-1 – Stream Stability and Erosion Hazard Alternatives for Garden Branch, Willis Branch and Kirby Creek

Rank	Stream	Location	Proposed Alternative	Owner
1	Kirby	Reaches 4 & 6 (Refer to the Alternative Workmaps in Appendix A for reach locations)	Concrete Lined Channel Replacement – Phase 1	Public
2	Willis	Stations 18+25, 32+40, 44+75 & 66+50	Install Rock Chutes	Public
3	Garden	Stations 13+50, 34+90 & 61+40	Install Rock Chutes	Public
4	Garden	Station 26+15	Place 24” Rock Rip-Rap DS of Low Water Crossing	Public
5	Willis	Station 61+00	Remove Debris Dam and Place 24” Rock Rip-Rap	Public
6	Kirby	Reaches 1, 2, 3, & 5 (Refer to the Alternative Workmaps in Appendix A for reach locations)	Concrete Lined Channel Replacement – Phase 2	Public
7	Willis	2324 Abbingdon Lane	Gabion Slope Protection	Private
8	Willis	4106 Whitman Lane	Gabion Slope Protection	Private
9	Kirby	Windhurst Drive & Brandon Street	Gabion Slope Protection	Private
10	Kirby	Between 528 & 536 Estate Drive	Slope Reconstruction – Alt. A	Private
11	Kirby	Between 528 & 536 Estate Drive	Slope Reconstruction – Alt. B	Private
12	Willis	Private Drive (Station 10+95)	Place 24” Rock Rip-Rap Around Culvert	Private

1. CONCRETE LINED CHANNEL REPLACEMENT – PHASE 1 (KIRBY CREEK)

Halff Associates performed a field inspection of the concrete lined channel from stations 23+396 & 18+096 along Kirby Creek. Six (6) different reaches of the channel were identified experiencing either lateral cracking in the concrete side slope and/or buckling of the channel bottom. The level of deterioration for each reach varies between severe, moderate, and slight for the condition of the concrete lined channel. Halff recommends a two phased approach to addressing each reach experiencing deterioration, beginning with the Phase 1 reaches discussed below. Refer to Appendix A for the location of the Phase 1 alternative reaches.

reaches are experiencing structural failure in the channel side slope and buckling of the channel bottom.

- *Reach 4 (Station 19+270 to 19+410)* – Replace approximately 180' of concrete lined channel. Existing channel dimensions: 25' bottom, 1:1 side slopes
- *Reach 6 (Station 21+660 to 22+460)* – Replace approximately 800' of concrete lined channel. Existing channel dimensions: 20' bottom, 1:1 side slopes

2. ROCK CHUTES ALONG WILLIS BRANCH

Rock Chutes are proposed as a stream bed stabilization alternative along Willis Branch to serve as hard points to help control the down-cutting effects of the stream in these areas. Four (4) rock chutes were strategically located at approximate stream stations 18+25, 32+40, 44+75 & 66+50 at existing “knickpoints” observed during the field inspection of Willis Branch as part of the 2007 Channel Stability Assessment report (Note: Current knickpoint locations need to be field confirmed prior to construction of each proposed rock chute). Knickpoints are locations along the creek where there is a short, steep slope in the active channel. The proposed rock chutes would consist of 3'x3' gabion baskets across the channel at the upstream and downstream ends to act as toe walls to prevent lifting, undermining, and/or sliding of the rock chutes. The remainder of the rock chute would consist of 24" rock rip-rap across the bottom of the channel and along the bank side slopes up to the bankfull elevation. A typical section of the proposed rock chutes is illustrated in Appendix D of this report. “Bankfull” can be described as the area immediately above the down cutting location. The gabion mattress and rock rip-rap would be situated along the channel side slopes and tied in at the bankfull elevation. Minimum 2:1 side slopes for placement of rock rip-rap is recommended for a stable rock slope. Each proposed rock chute location will need to be evaluated on a case-by-case basis to determine the bankfull elevation and side slope gradients. The length of each rock chute will need to be determined in the field and dictated by the depth of each knickpoint.

3. ROCK CHUTES ALONG GARDEN BRANCH

Rock Chutes are proposed as a stream bed stabilization alternative along Garden Branch to serve as hard points to help control the down-cutting effects of the stream in these areas. Three (3) rock chutes were strategically located at approximate stream stations 13+50, 34+90 and 61+40 at existing “knickpoints” observed during the field inspection of Garden Branch as part of the Stream Assessment. Knickpoints are locations along the creek where there is a short, steep slope in the active channel. The proposed rock chutes

would consist of 3'x3' gabion baskets across the channel at the upstream and downstream ends to act as toe walls to prevent lifting, undermining, and/or sliding of the rock chutes. The remainder of the rock chute would consist of 24" rock rip-rap across the bottom of the channel and along the bank side slopes up to the bankfull elevation. A typical section of the proposed rock chutes is illustrated in Appendix D of this report. "Bankfull" can be described as the area immediately above the down cutting location. The gabion mattress and rock rip-rap would be situated along the channel side slopes and tied in at the bankfull elevation. Minimum 2:1 side slopes for placement of rock rip-rap is recommended for a stable rock slope. Each proposed rock chute location will need to be evaluated on a case-by-case basis to determine the bankfull elevation and side slope gradients. The length of each rock chute will need to be determined in the field and dictated by the depth of each knickpoint.

4. ROCK RIP-RAP PLACEMENT DOWNSTREAM OF LOW WATER CROSSING (GARDEN BRANCH)

A concrete low water crossing that protected a pipeline is experiencing severe downstream erosion at approximate stream station 26+15 along Garden Branch. This structure is acting as a hard point along Garden Branch, preventing further upstream down-cutting effects of the stream. Halff recommends the placement of 24" rock rip-rap at the downstream end of this structure to prevent further erosion. The rock rip-rap will help protect the structural integrity of the low water crossing so it can continue to serve as a hard point. The rock rip-rap should extend a minimum of twenty-five (25) feet downstream of the low water crossing.

5. REMOVE DEBRIS DAM AND PLACE 24" ROCK RIP-RAP (WILLIS BRANCH)

Station 61+00 is located near an area of ponding caused by a debris dam. Once the debris is removed, the velocities in this area will be increased and erosion may eventually affect the property at 4102 Devon Court. The debris needs to be cleared and removed to re-establish active channel flow. The flowline may need to be graded to ensure an adequate downstream slope to alleviate standing water. After the debris has been removed, 24" rock rip rap should be placed along the south bank of Willis Branch adjacent to the property at 4102 Devon Court to prevent future erosion. Minimum 2:1 side slopes for placement of rock rip rap were recommended by the Geotechnical Engineer for a stable rock slope.

6. CONCRETE LINED CHANNEL REPLACEMENT – PHASE 2 (KIRBY CREEK)

Halff Associates performed a field inspection of the concrete line channel from stations 23+396 & 18+096 along Kirby Creek. Six (6) different reaches of the channel were

identified experiencing either lateral cracking in the concrete side slope and/or buckling of the channel bottom. The level of deterioration for each reach varies between severe, moderate, and slight for the condition of the concrete lined channel. Halff recommends a two phased approach to addressing each reach experiencing deterioration. The Phase 1 reaches of the concrete lined channel are experiencing severe deterioration and should be considered high priority, short-term projects. The Phase 2 reaches should be monitored and replaced when the condition of the channel shows a greater degree of deterioration. Refer to Appendix A for the location of the Phase 2 alternative reaches.

Phase 2 – Four (4) reaches of the concrete lined channel are experiencing slight to moderate deterioration, which need to be monitored. All four reaches are experiencing lateral cracking in the channel side slope. Immediate replacement is not needed for these reaches as they appear to be stable and functioning despite the signs of deterioration; however, Halff recommends the City consider these reaches for long-term replacement.

- *Reach 1 (Station 18+145 to 18+325)* – Replace approximately 180' of concrete lined channel. Existing channel dimensions: 45' bottom, 1:1 side slopes
- *Reach 2 (Station 18+435 to 18+495)* – Replace approximately 60' of concrete lined channel. Existing channel dimensions: 40' bottom, 1:1 side slopes
- *Reach 3 (Station 18+690 to 18+770)* – Replace approximately 80' of concrete lined channel. Existing channel dimensions: 25' bottom, 1:1 side slopes
- *Reach 5 (Station 20+535 to 20+675)* – Replace approximately 140' of concrete lined channel. Existing channel dimensions: 25' bottom, 1:1 side slopes

7. GABION SLOPE PROTECTION AT ABBINGTON LANE (WILLIS BRANCH)

Gabion slope protection is proposed for the south channel bank (side slope) of Willis Branch along properties at 2320, 2324, 2328, and 2332 Abbington Lane. The gabion slope protection should be implemented as an additional structural measure, along with the proposed rock chutes, to help stabilize bank erosion at these locations. Existing side slopes adjacent to the referenced addresses range from near vertical to about 1:1 (Horizontal:Vertical). Halff has performed field surveys and field observations at these locations for verification. In addition to the gabions, 24" rock rip rap will be installed along the bottom of the channel flowline and along the northern channel bank up to the bankfull elevation. The rip rap will form a hardpoint that will help prevent further down-cutting.

The south slope of Willis Branch along properties at 2320, 2324, 2328, and 2332 Abbington Lane is too unstable to install erosion protection. First, the slope will need to

be cleared of trees and debris and reconstructed with select fill properly compacted to a 0.5:1 (H:V) slope. Halff recommends construction of a gabion tieback wall to provide bank stability for the reconstructed slope and help reduce erosion on adjacent properties. The wall is necessary due to the extreme slope and close proximity of adjacent properties. A plan view of the proposed slope protection is shown on Figure IX-1. A typical cross-section for the tieback gabion wall is shown on Figure IX-2.

Constructability/Access – The proposed gabion slope protection would consist of constructing 3'x 3' gabion baskets for the tieback gabion wall. Construction of the gabion wall should be implemented using proper gabion assembly techniques, including the tying of the baskets, placement of gabions, filling the gabions with rock, installing necessary tiebacks, and closing the gabions. At each end of the gabion slope structure where it ties into the existing natural slope, the gabions should be wrapped around into the slope. This wrapping is performed to produce a cut-off wall at the natural slope tie-in to help eliminate stream flow from getting behind and undermining the gabion slope protection structures.

Construction of the gabion wall should mainly involve placement of fill associated with the slope reconstruction, but some cutting into the existing slopes may be necessary. Where fill is being used, proper compaction will be required.

Severe gulley erosion exists along the northwest corner of the fence at 2324 Abbington adjacent to the Willis Branch channel bank. Consideration should be made to address this issue at the time of construction. A drain may be necessary to carry runoff to the channel.

Access to the proposed protection areas could be through the open area to the north of Willis Branch. Also, additional temporary access easements may need to be obtained from some property owners adjacent to the construction locations. Locations of the proposed slope protection areas shown in Figure IX-1 are approximate.

8. GABION SLOPE PROTECTION AT WHITMAN LANE (WILLIS BRANCH)

Gabion slope protection is proposed for Willis Branch channel banks (side slopes) along properties at 4106 and 4110 Whitman Lane. The gabion slope protection should be implemented as an additional structural measure, along with the proposed rock chutes, to help stabilize bank erosion at these locations. Existing side slopes adjacent to the mentioned addresses range from near vertical to about 1.5:1 (Horizontal:Vertical). Halff has performed field surveys and field observations at these locations for verification. In

addition to the gabions, 24" rock rip rap should be installed along the bottom of the channel and along the northern channel bank up to the bankfull elevation. The rip rap will form a hardpoint that will help prevent further down-cutting.

For this alternative, two different types of gabion slope protection are proposed. The first type is a stepped gabion slope protection that could be implemented along side slopes ranging from 1:1 (H:V) to 1.5:1 (H:V). These types of slopes exist along the property at 4110 Whitman Lane. A typical cross-section and description for this type of slope protection is shown on Figure IX-4. For slopes steeper than 1:1 (H:V) or in areas where the eroded bank is too close to the adjacent property, Halff recommends implementation of a tieback gabion wall. The property at 4106 Whitman Lane is representative of an area that requires a tieback gabion wall. A typical cross-section for the tieback gabion wall is shown on Figure IX-5. A plan view of the proposed slope protection area is shown on Figure IX-3.

Constructability/Access – The proposed gabion slope protection would consist of constructing gabion baskets, either 1.5'x3' for the stair-stepped slope protection or 3'x 3' for the tieback gabion wall. Construction of the gabion slopes and gabion wall should be implemented using proper gabion assembly techniques, including the tying of the baskets, placement of gabions, filling the gabions with rock, installing necessary tiebacks, and closing the gabions. At each end of the gabion slope structure where it ties into the existing natural slope, the gabions should be wrapped around into the slope. This wrapping is performed to produce a cut-off wall at the natural slope tie-in to help eliminate stream flow from getting behind and undermining the gabion slope protection structures.

Construction of the slope protection should involve cutting into the existing slopes, but in the areas where fill is necessary, proper compaction of fill material will be required.

Access to the proposed protection areas could be through the open area to the north of Willis Branch. Also, additional temporary access easements may need to be obtained from some property owners adjacent to the construction locations. Locations of the proposed slope protection areas shown in Figure IX-3 are approximate.

9. GABION SLOPE PROTECTION AT WINDHURST DRIVE & BRANDON STREET (KIRBY CREEK)

Gabion slope protection is proposed for Kirby Creek channel banks (side slopes) along properties at 402, 410, 414, and 430 Windhurst and at 505 Brandon Street. The gabion slope protection shall be implemented as an additional structural measure, along with the

proposed rock chutes, to help stabilize bank erosion at these locations. Existing side slopes adjacent to the mentioned addresses range from near vertical to about 1.5:1 (Horizontal:Vertical). Halff has performed field surveys and field observations at these locations for verification. Fallen trees and exposed root systems of trees are prevalent along side slopes of the site.

For this alternative, two different types of gabion slope protection are proposed. The first type is a stepped gabion slope protection that could be implemented along side slopes ranging from 1:1 (H:V) to 1.5:1 (H:V). These types of slopes exist along the properties at 505 Brandon Street and 410, 414, and 430 Windhurst. Typical cross-sections and descriptions for these types of slope protection are shown on Figures IX-7 and IX-8. For slopes steeper than 1:1 (H:V), Halff recommends implementation of a tieback gabion wall. This steep section is representative of the slope along the property at 402 Windhurst. A typical cross-section for the tieback gabion wall is shown on Figure IX-9. A plan view of the proposed slope protection areas is shown on Figure IX-6.

Constructability/Access – The proposed gabion slope protection would consist of constructing gabion baskets, either 1.5'x3' for the stair-stepped slope protection or 3'x 3' for the tieback gabion wall. Construction of the gabion slopes and gabion wall should be implemented using proper gabion assembly techniques, including the tying of the baskets, placement of gabions, filling the gabions with rock, installing necessary tiebacks, and closing the gabions. At each end of the gabion slope structure where it ties into the existing natural slope, the gabions should be wrapped around into the slope. This wrapping is performed to produce a cut-off wall at the natural slope tie-in to help eliminate stream flow from getting behind and undermining the gabion slope protection structures.

Construction of the slope protection should mainly involve cutting into the existing slopes, but if fill is necessary, proper compaction of fill material will be required.

Severe gully erosion exists along the northwest corner of the fence at 430 Windhurst adjacent to the Kirby Creek channel bank. Consideration must be made to address this issue at the time of construction of gabion slope protection in this area.

Access to the proposed protection areas could be through the open area between 640 Beatty and 628 Beatty. Also, additional temporary access easements will need to be obtained from some property owners adjacent to the construction locations. Locations of the proposed slope protection areas shown in Figure IX-6 are approximate.

10. SLOPE RECONSTRUCTION AT ESTATE DRIVE ALTERNATIVE A (KIRBY CREEK)

The existing southern slope of Kirby Creek between properties at 528 Estate Drive and 536 Estate Drive is indicative of a slope failure (532 Estate Drive was vacant at the time of this report). Geotechnical investigation yielded failed soils along the slope and recommends a complete reconstruction of the slope. Property improvements at 528 and 536 Estate Drive are currently being encroached upon by the slope failure. Observations after recent summer storm events (2006) seem to demonstrate advancement of the slope failure further south. The failed slope in this area is not indicative of the channel evolution, but instead it is indicative of improper fill material and improper placement of the fill for this area. The slope reconstruction will help stabilize the slope along this reach. Halff has performed field surveys and field observations at these locations for verification of these conditions.

Per the Geotechnical Investigation by CMJ Engineering, Inc., at this location, it is recommended that the failed slope be completely reconstructed. Their analysis states “failure plane soils should be removed and the slope reconstructed with the minimum thickness of higher quality material in the lower portion of the reconstructed slope.”

Alternative A – Alternative A includes a proposed earthen slope reconstruction for the southern bank of Kirby Creek at 528 and 532 Estate Drive and a 12” gabion mattress along the bank at 536 Estate Drive. The earthen slope reconstruction shall follow instructions set forth in the geotechnical report which include the use of select granular fill and a reconstructed slope of 3:1. The 12” gabion mattress to be placed at 536 Estate Drive is recommended due to steeper slopes of approximately 2:1. Recommended improvements in Alternative A will result in the loss of usable property at 532 Estate Drive, which was vacant at the time of this report. Proposed slope improvement locations and typical slope sections for Alternative A are shown on Figures IX-10, IX-11 and IX-12.

Constructability/Access – The proposed slope reconstruction improvements would follow the recommended specific earthwork procedures as listed in the Geotechnical Investigation (See Appendix E). Along locations where a 3:1 slope can be achieved, a natural grassed slope shall be implemented. Along locations where 2:1 slopes will be necessary, likely at 536 Estate Drive, proposed 12” gabion mattress slopes shall be implemented. It should also be noted that the property at 536 Estate has a French drain along the fence line of the property that ties into the current top of slope. This French drain seems to be contributing to the slope erosion problem at this location due to down cutting of the slope from the French drain to the toe of slope. A solution to this problem could be to connect the French drain to the toe of slope with a concrete flume or an extended pipe that outfalls at the toe of slope.

The actual design of the slope reconstruction improvements should take into account an existing TRA sanitary sewer line located adjacent to Kirby Creek. Necessary permits and excavation/fill requirements will need to be coordinated with TRA before construction occurs.

Access to the proposed slope reconstruction improvements could be located through the lot at 532 Estate Drive, which was vacant at the time of this report. Temporary access and permanent drainage easements may need to be obtained from property owners at 528, 532, and 536 Estate Drive for the actual construction of the slope improvements and future maintenance that may be required. These properties extend from Estate Drive to north of the Kirby Creek channel. Locations of the proposed slope protection areas shown in Figure IX-10 are approximate.

11. SLOPE RECONSTRUCTION AT ESTATE DRIVE ALTERNATIVE B (KIRBY CREEK)

The existing southern slope of Kirby Creek between properties at 528 Estate Drive and 536 Estate Drive is indicative of a slope failure (532 Estate Drive was vacant at the time of this report). Geotechnical investigation yielded failed soils along the slope and recommends a complete reconstruction of the slope. Property improvements at 528 and 536 Estate Drive are currently being intruded by the slope failure. The failed slope in this area is not indicative of the channel evolution, but instead it is indicative of improper fill material and improper placement of the fill for this area. The slope reconstruction will help stabilize the slope along this reach. Halff has performed field surveys and field observations at these locations for verification of these conditions.

Per the Geotechnical Investigation by CMJ Engineering, Inc., at this location, it is recommended that the failed slope be completely reconstructed. Their analysis states “failure plane soils should be removed and the slope reconstructed with the minimum thickness of higher quality material in the lower portion of the reconstructed slope.”

Alternative B – Alternative B includes a proposed 12” gabion mattress along the southern bank of Kirby Creek at 528, 532 and 536 Estate Drive. The 12” gabion mattress at 528 and 532 Estate Drive is proposed to be constructed at a slope of approximately 2:1. Recommended improvements in Alternative B will allow the reclamation of approximately 30 feet of the usable property at 532 Estate Drive. Proposed slope improvement locations and typical slope sections for Alternative B are shown on Figures IX-13 and IX-14.

Constructability/Access – The proposed slope reconstruction improvements would follow the recommended specific earthwork procedures as listed in the Geotechnical Investigation

(See Appendix E). Along locations where a 3:1 slope can be achieved, a natural grassed slope shall be implemented. Along locations where 2:1 slopes will be necessary, likely at 536 Estate Drive, proposed 12" gabion mattress slopes shall be implemented. It should also be noted that the property at 536 Estate has a French drain along the fence line of the property that ties into the current top of slope. This French drain seems to be contributing to the slope erosion problem at this location due to down cutting of the slope from the French drain to the toe of slope. A solution to this problem could be to connect the French drain to the toe of slope with a concrete flume or an extended pipe that outfalls at the toe of slope.

The actual design of the slope reconstruction improvements should take into account an existing TRA sanitary sewer line located adjacent to Kirby Creek. Necessary permits and excavation/fill requirements will need to be coordinated with TRA before construction occurs.

Access to the proposed slope reconstruction improvements could be located through the lot at 532 Estate Drive, which was vacant at the time of this report. Temporary access and permanent drainage easements may need to be obtained from property owners at 528, 532, and 536 Estate Drive for the actual construction of the slope improvements and future maintenance that may be required. These properties extend from Estate Drive to north of the Kirby Creek channel. Locations of the proposed slope protection areas shown in Figure IX-13 are approximate.

12. ROCK RIP-RAP PLACEMENT AROUND PRIVATE DRIVE CULVERT (WILLIS BRANCH)

The Private Drive Culvert near Matthew Road is experiencing some erosion on the upstream and downstream side of the culvert. The existing erosion protection consists mostly of broken concrete that is inadequate to protect the structure from erosion when velocities are increased during large storm events. Halff recommends replacing the existing erosion protection with 24" rock rip rap upstream and downstream of the culvert. The slopes must be graded to a minimum 2:1 slope (H:V), sufficient for the rock rip rap protection. The rock rip rap should extend a minimum of twenty-five (25) feet upstream and downstream of the culvert.

X. Dams/Levees/Detention/Drainage Reviews

X. DAMS / LEVEES / DETENTION / DRAINAGE REVIEWS

A. DAMS/LEVEES

RPS Espey Consultants examined all dams/levees within the Fish Creek watershed as part of the City-wide Drainage Master Plan for Fish Creek. Refer to Section X of the Fish Creek CWDMP for the condition of each dam/levee located with the Garden Branch, Willis Branch, and Kirby Creek watersheds.

B. DETENTION PONDS

RPS Espey Consultants performed a visual inspection of all detention ponds located within the Fish Creek watershed as part of the City-wide Drainage Master Plan for Fish Creek. Refer to Section X of the Fish Creek CWDMP for the condition and photos of each detention pond located with the Garden Branch, Willis Branch, and Kirby Creek watersheds.

One (1) regional detention pond located along Kirby Creek just west of Robinson Road was not included within the City-wide Drainage Master Plan for Fish Creek. This regional detention pond was proposed by Halff Associates as part of the 2006 Capital Improvement Study along Kirby, Prairie and Fish Creek Drainage Basins to reduce peak discharges downstream. Figure X-1 below shows a picture of the regional detention pond taken by Halff Associates in August 2012 during a field inspection of Kirby Creek.

Figure X-1 – Regional Detention Pond Along Kirby Creek



C. DETENTION POND MAINTENANCE

Refer to Section X of the City-wide Drainage Master Plan for Fish Creek prepared by RPS Espey Consultants for maintenance recommendations for detention ponds located within the Garden Branch, Willis Branch, and Kirby Creek watersheds. Halff Associates performed a visual inspection of the regional pond located along Kirby Creek just west of Robinson Road in August 2012. The regional pond was in good condition and no corrective maintenance is needed at this time. Halff recommends continued regular inspections of the regional detention pond.

D. DRAINAGE REVIEWS

There are approximately 200 total drainage reviews to date in the City of Grand Prairie. A total of twenty-seven (27) drainage reviews are from Garden Branch, Kirby Creek, and Willis Branch watersheds combined. Halff Associates compiled the completed drainage reviews for each studied watershed into one single spreadsheet. This spreadsheet provides a detailed summary of the drainage reviews including the project name, City project number,

description of review, and indicates if detention was included in the project. The spreadsheet is included in Table X-1 below.

XI. Storm Drain Outfall Assessment

XI. STORM DRAIN OUTFALL ASSESSMENT

RPS Espey Consultants examined photographs provided by the City of Grand Prairie for each storm drain outfall located within the Fish Creek watershed as part of the City-wide Drainage Master Plan for Fish Creek. All storm drain outfalls within the Garden Branch, Kirby Creek, and Willis Branch watersheds were included within this review. Refer to Section XI of the Fish Creek CWDMP for the condition of each outfall located with each studied watershed mentioned above.

XII. Preliminary Quantities/ Estimates of Probable Cost

XII. PRELIMINARY QUANTITIES/ESTIMATES OF PROBABLE COST

Preliminary quantities and estimates of probable cost were calculated for stream and open channel alternatives from Section VII of this report.

The roadway improvement cost estimate was based on the existing roadway width. Any future expansion of this roadway will need to be accounted for with an update to the included cost estimates.

The following estimates of probable cost were prepared using standard cost estimate practices and it is understood and agreed that these statements are estimates only.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT Supplemental CWDMP for Fish Creek
Garden Branch at Martin Barnes Road - Alt. 1
Total Replacement (stream station 57+22)

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
Garden Branch at Martin Barnes Road Imp.					
1	Mobilization	LS	1	\$20,000	\$20,000
2	Traffic Control	LS	1	\$25,000	\$25,000
3	Remove and Dispose Existing Bridge	SF	250	\$15	\$3,750
4	New Bridge Construction	SF	500	\$70	\$35,000
5	Sawcut for Removal of Pavement	FT	100	\$5	\$500
6	Pavement Repair	SF	2,500	\$7	\$17,500
7	Compacted Backfill (Select Material)	CY	1,000	\$20	\$20,000
8	Furnish and Install 24" Rock Rip-Rap	CY	100	\$120	\$12,000
9	Furnish and Install Turf Reinforcing Mat	SY	1,000	\$10	\$10,000
10	Furnish and Install Seeding	SY	1,000	\$2	\$2,000
				Subtotal	\$145,750
				25% Contingency	\$36,400
				CONSTRUCTION TOTAL	\$182,000
	Engineering, Surveying, and Environmental			10% of Construction	\$18,200
				TOTAL	\$200,000
				TOTAL ANNUAL	\$14,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Kirby Creek - Concrete Lined Channel Replacement
Phase 1

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Mobilization	LS	1	\$20,000	\$20,000
2	Remove/Dispose Concrete Channel	CY	500	\$80	\$40,000
3	Concrete Channel Replacement (Assumed concrete channel thickness of 5")	CY	500	\$300	\$150,000
				Subtotal	\$210,000
				25% Contingency	\$52,500
				CONSTRUCTION TOTAL	\$263,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$26,300
				TOTAL	\$290,000
				TOTAL ANNUAL	\$21,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Willis Branch - Install Four Rock Chutes

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$10,000	\$10,000
2	Furnish and Install 24" Rock Rip-Rap	CY	120	\$120	\$14,400
3	Filter Fabric for 24" Rock Rip-Rap	SY	240	\$2	\$480
4	3 'x 3' Gabions (PVC Wiring)	CY	20	\$250	\$5,000
5	Filter Fabric for 3 'x 3' Gabions	SY	60	\$2	\$120
6	Channel Excavation	CY	150	\$12	\$1,800
7	Grass Sodding	SY	50	\$10	\$500
				Subtotal	\$32,300
				25% Contingency	\$8,100
				CONSTRUCTION TOTAL	\$40,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$4,000
				TOTAL for Individual Rock Chute	\$40,000
				TOTAL for Four Rock Chutes	\$160,000
				TOTAL ANNUAL	\$12,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Garden Branch - Install Three Rock Chutes

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$10,000	\$10,000
2	Furnish and Install 24" Rock Rip-Rap	CY	120	\$120	\$14,400
3	Filter Fabric for 24" Rock Rip-Rap	SY	240	\$2	\$480
4	3 'x 3' Gabions (PVC Wiring)	CY	20	\$250	\$5,000
5	Filter Fabric for 3 'x 3' Gabions	SY	60	\$2	\$120
6	Channel Excavation	CY	150	\$12	\$1,800
7	Grass Sodding	SY	50	\$10	\$500
				Subtotal	\$32,300
				25% Contingency	\$8,100
				CONSTRUCTION TOTAL	\$40,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$4,000
				TOTAL for Individual Rock Chute	\$40,000
				TOTAL for Three Rock Chutes	\$120,000
				TOTAL ANNUAL	\$9,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Garden Branch - Place 24" Rock Rip-Rap
Downstream of Low Water Crossing (Station 26+15)

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$5,000	\$5,000
2	Furnish and Install 24" Rock Rip-Rap	CY	60	\$150	\$9,000
3	Filter Fabric for 24" Rock Rip-Rap	SY	500	\$2	\$1,000
				Subtotal	\$15,000
				25% Contingency	\$3,800
				CONSTRUCTION TOTAL	\$19,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$1,900
				TOTAL	\$20,000
				TOTAL ANNUAL	\$1,000

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Willis Branch - Remove Debris Dam and Place
24" Rock Rip-Rap (Station 61+00)

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$7,500	\$7,500
2	Removal of Debris Causing Dam	LS	1	\$5,000	\$5,000
3	Furnish and Install 24" Rock Rip-Rap	CY	100	\$120	\$12,000
4	Filter Fabric for 24" Rock Rip-Rap	SY	150	\$2	\$300
5	Grass Sodding	SY	50	\$10	\$500
				Subtotal	\$25,300
				25% Contingency	\$6,300
				CONSTRUCTION TOTAL	\$32,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$3,200
				TOTAL	\$40,000
				TOTAL ANNUAL	\$3,000

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Kirby Creek - Concrete Lined Channel Replacement
Phase 2

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Mobilization	LS	1	\$20,000	\$20,000
2	Remove/Dispose Concrete Channel	CY	350	\$80	\$28,000
3	Concrete Channel Replacement (Assumed concrete channel thickness of 5")	CY	350	\$300	\$105,000
				Subtotal	\$153,000
				25% Contingency	\$38,300
				CONSTRUCTION TOTAL	\$191,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$19,100
				TOTAL	\$210,000
				TOTAL ANNUAL	\$15,000

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Willis Branch - Construct Tieback Gabion Wall with
Rock Rip-Rap Hardpoint - Abbington Lane

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
Tieback Gabion Wall					
1	Site Preparation/Access/Care of Water	LS	1	\$100,000	\$100,000
2	Compacted Backfill (Select Material)	CY	1,400	\$20	\$28,000
3	Furnish and Install Gabion Basket Wall with Tiebacks	CY	500	\$450	\$225,000
4	Filter Fabric for Stepped Gabions	SY	700	\$2	\$1,400
5	Fence Removal/Replacement	LF	350	\$25	\$8,750
6	Miscellaneous Drainage Improvement	LS	1	\$15,000	\$15,000
7	Grass Sodding	SY	225	\$10	\$2,250
8	Furnish and Install Seeding	SY	275	\$2	\$550
Rock Chute Constructed with Tieback Gabion Wall					
1	Furnish and Install 24" Rock Rip-Rap	CY	100	\$150	\$15,000
2	Filter Fabric for 24" Rock Rip-Rap	SY	150	\$2	\$300
3	3 'x 3' Gabions (PVC Wiring)	CY	15	\$250	\$3,750
4	Filter Fabric for 3 'x 3' Gabions	SY	50	\$2	\$100
5	Channel Excavation	CY	150	\$12	\$1,800
6	Grass Sodding	SY	50	\$10	\$500
				Subtotal	\$402,400
				25% Contingency	\$100,600
				CONSTRUCTION TOTAL	\$503,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$50,300
				TOTAL	\$550,000
				TOTAL ANNUAL	\$40,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Willis Branch - Construct Tieback Gabion Wall with
Rock Rip-Rap Hardpoint - Whitman Lane

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
Tieback Gabion Wall					
1	Site Preparation/Access/Care of Water	LS	1	\$50,000	\$50,000
2	Channel Excavation	CY	100	\$12	\$1,200
3	Compacted Backfill (Select Material)	CY	150	\$20	\$3,000
4	Furnish and Install Gabion Basket Wall with Tiebacks	CY	250	\$450	\$112,500
5	Filter Fabric for Stepped Gabions	SY	500	\$2	\$1,000
6	Fence Removal/Replacement	LF	150	\$25	\$3,750
7	Miscellaneous Drainage Improvement	LS	1	\$5,000	\$5,000
8	Grass Sodding	SY	200	\$10	\$2,000
9	Furnish and Install Seeding	SY	350	\$2	\$700
Rock Chute Constructed with Tieback Gabion Wall					
1	Furnish and Install 24" Rock Rip-Rap	CY	100	\$150	\$15,000
2	Filter Fabric for 24" Rock Rip-Rap	SY	150	\$2	\$300
3	3 'x 3' Gabions (PVC Wiring)	CY	15	\$250	\$3,750
4	Filter Fabric for 3 'x 3' Gabions	SY	50	\$2	\$100
5	Channel Excavation	CY	100	\$12	\$1,200
6	Grass Sodding	SY	50	\$10	\$500
				Subtotal	\$200,000
				25% Contingency	\$50,000
				CONSTRUCTION TOTAL	\$250,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$25,000
				TOTAL	\$280,000
				TOTAL ANNUAL	\$20,000
<p>This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.</p>					

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Kirby Creek - Construct Tieback Gabion Wall at
Windhurst Drive & Brandon Street

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
Tieback Gabion Wall along 410, 414 & 430 Windhurst					
1	Site Preparation/Access/Care of Water	LS	1	\$20,000	\$20,000
2	Furnish and Install Gabion Basket Wall with Tiebacks	CY	1,500	\$450	\$675,000
3	Filter Fabric for Stepped Gabions	SY	3,200	\$2	\$6,400
4	Channel Excavation	CY	1,650	\$12	\$19,800
5	Gulley Erosion Repair at 430 Windhurst	LS	1	\$5,000	\$5,000
6	Fence Removal/Replacement	LF	550	\$25	\$13,750
Tieback Gabion Wall along 505 Brandon					
1	Site Preparation/Access/Care of Water	LS	1	\$8,000	\$8,000
2	Furnish and Install Gabion Basket Wall with Tiebacks	CY	380	\$450	\$171,000
3	Filter Fabric for Stepped Gabions	SY	900	\$2	\$1,800
4	Channel Excavation	CY	420	\$12	\$5,040
5	Fence Removal/Replacement	LF	120	\$25	\$3,000
				Subtotal	\$928,790
				25% Contingency	\$232,200
				CONSTRUCTION TOTAL	\$1,161,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$116,100
				TOTAL	\$1,280,000
				TOTAL ANNUAL	\$93,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Kirby Creek - Slope Reconstruction at Estate Drive
Alternative A

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$14,000	\$14,000
2	Excavation for Natural Slope Section	CY	8,200	\$15	\$123,000
3	Compacted Backfill (Select Material)	CY	12,700	\$20	\$254,000
4	Excavation for Gabion Mattress Section	CY	450	\$10	\$4,500
5	Furnish and Install 12" Gabion Mattress	CY	450	\$275	\$123,750
6	Filter Fabric for 12" Gabion Mattress	SY	1,300	\$2	\$2,600
7	Concrete Flume at French Drain	SY	40	\$150	\$6,000
8	Fence Repair	LS	1	\$3,000	\$3,000
				Subtotal	\$530,850
				25% Contingency	\$132,700
				CONSTRUCTION TOTAL	\$664,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$66,400
				TOTAL	\$730,000
				TOTAL ANNUAL	\$53,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Kirby Creek - Slope Reconstruction at Estate Drive
Alternative B

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$14,000	\$14,000
2	Excavation for Natural Slope Section	CY	8,200	\$15	\$123,000
3	Compacted Backfill (Select Material)	CY	15,200	\$20	\$304,000
4	Excavation for Gabion Mattress Section	CY	450	\$10	\$4,500
5	Furnish and Install 12" Gabion Mattress	CY	900	\$275	\$247,500
6	Filter Fabric for 12" Gabion Mattress	SY	2,600	\$2	\$5,200
7	Concrete Flume at French Drain	SY	40	\$150	\$6,000
8	Fence Repair	LS	1	\$3,000	\$3,000
				Subtotal	\$707,200
				25% Contingency	\$176,800
				CONSTRUCTION TOTAL	\$884,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$88,400
				TOTAL	\$970,000
				TOTAL ANNUAL	\$70,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT: Supplemental CWDMP for Fish Creek
Willis Branch - Place 24" Rock Rip-Rap Around
Private Drive Culvert (Station 10+95)

DATE: 8/30/2012
PREPARED BY: bp/sr
AVO: 27930

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
1	Site Preparation/Access/Care of Water	LS	1	\$10,000	\$10,000
2	Removal of Existing Broken Concrete	LS	1	\$5,000	\$5,000
3	Furnish and Install 24" Rock Rip-Rap	CY	175	\$120	\$21,000
4	Filter Fabric for 24" Rock Rip-Rap	SY	250	\$2	\$500
5	Channel Excavation	CY	75	\$12	\$900
6	Grass Sodding	SY	100	\$10	\$1,000
				Subtotal	\$38,400
				25% Contingency	\$9,600
				CONSTRUCTION TOTAL	\$48,000
	Engineering, Surveying, and Environmental Design			10% of Construction	\$4,800
				TOTAL	\$50,000
				TOTAL ANNUAL	\$4,000

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that the Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

XIII. Evaluation & Prioritization/ Phasing & Implementation

XIII. EVALUATION & PRIORITIZATION/PHASING & IMPLEMENTATION

A. EVALUATION & PRIORITIZATION

Half Associates developed one (1) stream and open channel alternative for this supplemental report to the City-wide Drainage Master Plan for Fish Creek that is described in detail in Section VII of this report. A process of assigning ranking factors is typically utilized to rank short-term and long-term priority projects based on criteria from Section II.G of the City of Grand Prairie City-Wide Drainage Master Plan Road Map. Even though there is only one open channel alternative included in this watershed, ranking criteria was still assigned to allow this project to be incorporated into the overall City-wide implementation plan. Table XIII-1 at the end of Section XIII shows the ranking criteria assigned to Martin Barnes Road. The following is a brief summary of the criteria and methodology utilized to rank short-term and long-term priority projects.

1. Ranking Criteria:

- i. Number of properties/structures benefited* – The number of structures benefited by the reduction in flood damage was determined for each proposed CIP. Due to the lack of development at the majority of proposed CIP locations, there were no structures benefited by the reduction in flood damage.
- ii. Estimates of probable cost* – A preliminary cost-estimate was determined for each proposed CIP and then categorized as follows:
 - **Small Projects** – Less than \$500,000
 - **Medium Projects** - \$500,000 to \$1,500,000
 - **Large Projects** – \$1,500,000 to \$5,000,000
 - **Extra-Large Projects** – \$5,000,000 to \$10,000,000
 - **Super Size Projects** – Greater than \$10,000,000
- iii. Roadway Type Benefited* – Each proposed CIP roadway was categorized based on existing roadway type. Categories include **HWY, P7U, P6D, P4D, P3U, M5U, M4U, M3U, C2U**, and **No Roadway** (if no roadway benefits are included with project).
- iv. Roadway Flood Event Protection* – The level of flood protection, if no improvements were made, was determined for each proposed CIP roadway crossing. Half Associates described existing roadway crossing protection based on the

following storm events: 2-year, 5-year, 10-year, 25-year, 50-year, or 100-year (existing).

- v. *Roadway Citizens Protected/Impacted* – Per Ranking Factor #3 below, an approximate percentage of total roadway citizens impacted was determined for each proposed CIP if no improvements were made.
- vi. *Ultimate 100-Year Discharge* – The ultimate 100-year discharge was determined for each proposed CIP location.

2. Ranking Methodology:

- i. *Ranking Factor #1*- The initial ranking factor was based on the estimate of probable cost versus the number of properties/structures benefited:

Determine Initial Ranking Factor		No. of Properties/Structures Benefited		
		High > 10	Medium 5 to 10	Small < 5
Estimate of Probable Cost (\$)	Small < \$500k	1	2	3
	Medium \$500k - \$1.5Mil	2	3	4
	Large > \$1.5Mil	3	4	5
	X-Large (> \$5M)	6	7	8
	Super-Size (>\$10M)	9	10	11

- ii. *Ranking Factor #2* - A second ranking factor was determined based on the number of citizens impacted, by potential for roadway shutdowns if no improvements were made on existing roadways, and by a cost to benefit ratio of proposed improvements per roadway citizens impacted.

Step 1 – Determine Existing Roadway Type

Roadway Type
HWY
P7U
P6D
P4D
P3U
M5U
M4U
M3U
C2U

Step 2 – Determine Existing Conditions Roadway Flood Event Protection and Percentage of Roadway Citizens Protected

Roadway Flood Event Protection	Percentage of Citizens Protected ¹
1-Year	0%
2-Year	15%
5-Year	35%
10-Year	50%
25-Year	70%
50-Year	85%
100-Year	100%

¹Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% and with 100-Year Event protecting 100%

Step 3 – Determine Percentage of Roadway Citizens Impacted
 100% minus percentage of citizens protected

Step 4 – Determine Number of Roadway Citizens Impacted

Roadway Type Benefited	Percentage of Citizens Protected ¹
HWY	20800
P7U	12740
P6D	11700
P4D	7800
P3U	5460
M5U	8450
M4U	6760
M3U	5070
C2U	2730

¹Based on percentage of citizens impacted multiplied by [No. Lanes * 4 hours impacted * hourly volume per lane * Level of Service C Traffic Volume (see table below)]

Grand Prairie Classification	NCTCOG Classification	Lanes	Hourly Service Vol./lane	NCTCOG LOS*			Current UDC "LOS C" Traffic Volume
				Roadway Capacity LOS E	LOS D	LOS C	
P7U	Principal Arterial-Undiv.	7	700	49,000	39,200	31,850	42,000
P6D	Principal Arterial-Divided	6	750	45,000	36,000	29,250	42,000
P4D	Principal Arterial-Divided	4	750	30,000	24,000	19,500	28,000
P3U	Principal Arterial-Undiv.	3	700	21,000	16,800	13,650	18,000
M5U	Minor Arterial	5	650	32,500	26,000	21,125	28,000
M4U	Minor Arterial	4	650	26,000	20,800	16,900	22,000
M3U	Minor Arterial	3	650	19,500	15,600	12,675	18,000
C2U	Collector	2	525	10,500	8,400	6,825	10,000
L2U	Local Street	2	525	10,500	8,400	6,825	8,000
LU	Local Street	1	525	5,250	4,200	3,413	8,000
R2U	Rural Street	2	525	10,500	8,400	6,825	8,000

* = from the Dallas-Fort Worth Regional Travel Model Manual, Exhibits 23 and 24
 NCTCOG capacity: LOS E = (# lanes) * 10 * (NCTCOG Hourly Service Volume per Lane)
 NCTCOG capacity: LOS D = (LOS E) * .8
 NCTCOG capacity: LOS C = (LOS E) * .65

Step 5 – Divide Cost to Benefit of Roadway Number of Citizens Impacted

Divide the estimate of probable cost by the results from Step 4 to determine the cost to benefit ratio (in dollars)

Step 6 – Develop Second Ranking Factor with highest rank being the lowest cost to benefit ratio

- iii. *Ranking Factor #3* – A third ranking factor was determined based on the total tax value of all the properties with structures that are benefited by the project from Ranking Factor #1. The Third Ranking Factor was based on the table below.

Total Tax Value of Properties with Structures Benefited	Third Ranking Factor
\$2,000,000 +	1
≥ \$1,900,000	2
≥ \$1,800,000	3
≥ \$1,700,000	4
≥ \$1,600,000	5
≥ \$1,500,000	6
≥ \$1,400,000	7
≥ \$1,300,000	8
≥ \$1,200,000	9
≥ \$1,100,000	10
≥ \$1,000,000	11
≥ \$900,000	12
≥ \$800,000	13
≥ \$700,000	14
≥ \$600,000	15
≥ \$500,000	16
≥ \$400,000	17
≥ \$300,000	18
≥ \$200,000	19
\$0 to \$199,999	20

- iv. *Initial Ranking* - A total ranking factor was determined using the summation of Ranking Factors #1, #2, and #3. The initial ranking of proposed CIPs was determined with the top ranked (#1) project having the lowest total ranking factor.
- v. *Final Ranking* - If two or more projects had the same initial ranking, the projects were sorted further using the ultimate 100-year discharge at each project location. The higher ranked of these projects was the one with the greatest ultimate 100-year discharge at the project location. If two projects in different watersheds had the same initial ranking and similar ultimate 100-year discharges (within 500 cfs) then the projects were ranked in order of the lowest estimate of probable cost.

B. PHASING & IMPLEMENTATION**1. Final Short-term Priorities Implementation**

Short-term Priority CIPs could generally be described as those projects with an initial ranking factor of 1, 2, or 3 from the matrix under Ranking Factor #1 above. The Short-term Priority projects would become the City's key Capital Improvement Projects for immediate implementation, contingent upon City Council approval and allocated funding. Prior to beginning the construction process on these projects, the following key issues may need to be examined:

- Public or private participation in funding and implementation
- Drainage right-of-way or easement needs
- Permitting – FEMA, NCTCOG, U.S. Army Corps of Engineers, Texas Commission on Environmental Quality (TCEQ), or Environmental Protection Agency (EPA)
- Public or neighborhood meetings to describe project and receive citizen feedback
- Adherence of project to City's ordinances and standards for construction

2. Final Long-term Plan Implementation

All other CIPs not classified as Short-term priorities will be considered **Long-term CIPs**. These need to be planned properly with funding allocated for future construction, contingent on City Council approval. Projects that could be constructed by phasing (i.e., will phasing provide immediate benefits or does the whole project need to be constructed for benefits to occur) would need to be re-evaluated by each Phase and re-ranked accordingly with the other CIPs.

For the Long-term projects, the following key issues may need to be examined:




- All the Short-term issues listed above
- Longer range funding plans for larger projects, including phasing (look into State and Federal grants and construction loans)
- More global view, watershed-wide or regional type projects (look into cooperative efforts with U.S. Army Corps of Engineers, NCTCOG, or adjacent communities)
- Examine how increased development of the City's flood warning system could provide further benefits to these areas until funding is allocated for project implementation
- Non-structural measures including:
 - **Buy-out program** – City would need to decide on perpetual maintenance of property or re-selling property after measures are taken to remove lot from

flood hazard. Recommend pursuit of City funding, if available, or associated grants (see CWDMP Roadmap Section II.D – Funding Opportunities), if applicable

- Enforce **new and/or improved development standards** to restrict future development in flood hazard areas

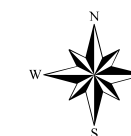
Figure XIII-1
CIP Location Map

Legend

-  Roadway Improvements
-  Erosion Alternative Locations
-  Kirby Creek Watershed
-  Garden Branch Watershed
-  Willis Branch Watershed

Notes:

1. See Section VII of this report for a detailed description of the Roadway Improvement at Martin Barnes Road.
2. See Section IX of this report for a detailed description of each stream bank & stream bed erosion alternative.



0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet

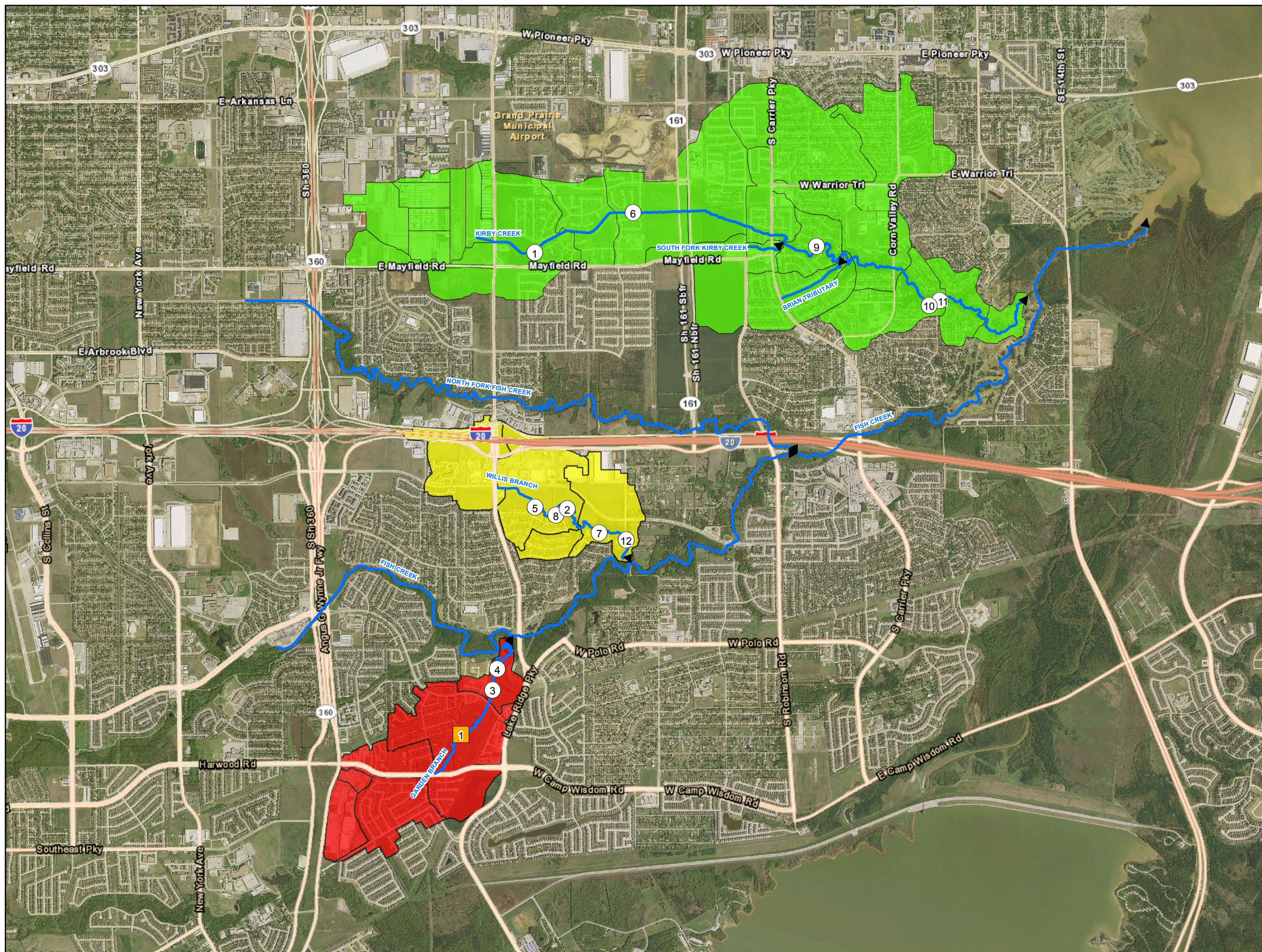


Table XIII-1 Stream and Open Channel Capital Improvement Projects

Supplemental City-wide Drainage Master Plan for Fish Creek

Capital Improvement Project	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited ¹			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted ²							Step 3 - Tax Value of Benefited Property Structures ⁷		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
		# Structures	Cost	1st Factor ¹	Type	Roadway Flood Event Protection	Roadway % Citizens Protected ³	Roadway % Citizens Impacted ⁴	Roadway # Citizens Impacted ⁵	Cost to Benefit Roadway # Citizens Impacted ⁶	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank ⁸	Ultimate Q ₁₀₀	Sorting ⁹	Rank ¹⁰
1 Alt. 1 - Martin Barnes Road at Garden Branch	Small/Long-Term	0	\$200,000	3	R2U	10	50%	50%	1365	\$146.52	1	\$0	20	24	1	1,250		1

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
 2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
 3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
 4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
 5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
 6 Cost of CIP divided by Roadway # Citizens Impacted
 7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
 8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
 9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
 10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6

Additional Notes:
 a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)
 b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

Table XIII-2 Stream Stability Capital Improvement Projects
Preliminary Short-Term Priorities & Long-Term Implementation

Rank	Stream	Capital Improvement Project	Short-Term/Long-Term	Public/Private	Probable Cost
1	Kirby Creek	Concrete Lined Channel Replacement - Phase 1	Short-Term	Public	\$290,000
2	Willis Branch	Install Rock Chutes	Short-Term	Public	\$160,000
3	Garden Branch	Install Rock Chutes	Short-Term	Public	\$120,000
4	Garden Branch	Place 24" Rock Rip-Rap Downstream of Low Water Crossing	Short-Term	Public	\$20,000
5	Willis Branch	Remove Debris Dam and Place 24" Rock Rip-Rap	Short-Term	Public	\$40,000
6	Kirby Creek	Concrete Lined Channel Replacement - Phase 2	Long-Term	Public	\$210,000
7	Willis Branch	Gabion Slope Protection - Abbington Lane	Long-Term	Private	\$550,000
8	Willis Branch	Gabion Slope Protection - Whitman Lane	Long-Term	Private	\$280,000
9	Kirby Creek	Gabion Slope Protection - Windhurst & Brandon	Long-Term	Private	\$1,280,000
10	Kirby Creek	Slope Reconstruction Alternative A - Estate Drive	Long-Term	Private	\$730,000
11	Kirby Creek	Slope Reconstruction Alternative B - Estate Drive	Long-Term	Private	\$970,000
12	Willis Branch	Place 24" Rock Rip-Rap Around Culvert at Private Drive	Long-Term	Private	\$50,000

XIV. Short Term Priorities & Long Term Plan

XIV. SHORT TERM PRIORITIES & LONG TERM PLAN

A. SHORT-TERM PRIORITIES IMPLEMENTATION

There are five (5) short-term capital improvement projects identified within this supplemental report to the City-wide Drainage Master Plan for Fish Creek. All five short-term CIPs are stream stability alternatives intended to protect public infrastructure and prevent future erosion to stream beds and stream banks. The erosion hazard setback zone referenced in Section IX of this report has been delineated by Halff Associates for Garden Branch, Kirby Creek, and Willis Branch and is included on the DVD in Appendix F of this report. It is recommended that the setback shapefile be utilized to help manage future development in each studied watershed. Table XIV-1 below lists each short-term CIP along with stream name, location, and proposed improvements. See Table IX-1 in Section IX of this report for the prioritized ranking of each stream stability alternative.

Table XIV-1 – Short-Term Priority CIP Alternatives

Stream	Location	Proposed Alternative	Public/Private
Kirby	Reaches 4 & 6 (Refer to the Alternative Workmaps in Appendix A for reach locations)	Concrete Lined Channel Replacement – Phase 1	Public
Willis	Stations 18+25, 32+40, 44+75 & 66+50	Install Rock Chutes	Public
Garden	Stations 13+50, 34+90 & 61+40	Install Rock Chutes	Public
Garden	Station 26+15	Place 24” Rock Rip-Rap DS of Low Water Crossing	Public
Willis	Station 61+00	Remove Debris Dam and Place 24” Rock Rip-Rap	Public

B. LONG-TERM PLAN IMPLEMENTATION

There are eight (8) long-term CIPs identified within this supplemental report to the City-wide Drainage Master Plan for Fish Creek. Seven of the long term CIPs are stream stability alternatives. Table XIV-2 below lists each long-term stream stability CIP along with stream name, location, and proposed improvements. All long-term stream stability CIPs are considered “private” except for the Phase 2 concrete lined channel replacement along Kirby Creek. See Table IX-1 in Section IX of this report for the prioritized ranking of each stream stability alternative.

Table XIV-2 – Long-Term Stream Stability CIP Alternatives

Stream	Location	Proposed Alternative	Public/Private
Kirby	Reaches 1, 2, 3, & 5 (Refer to the Alternative Workmaps in Appendix A for reach locations)	Concrete Lined Channel Replacement – Phase 2	Public
Willis	2324 Abbingdon Lane	Gabion Slope Protection	Private
Willis	4106 Whitman Lane	Gabion Slope Protection	Private
Kirby	Windhurst Drive & Brandon Street	Gabion Slope Protection	Private
Kirby	Between 528 & 536 Estate Drive	Slope Reconstruction – Alt. A	Private
Kirby	Between 528 & 536 Estate Drive	Slope Reconstruction – Alt. B	Private
Willis	Private Drive (Station 10+95)	Place 24” Rock Rip-Rap Around Culvert	Private

There is one long-term stream and open channel CIP located along Garden Branch. The proposed bridge re-sizing at Martin Barnes Road along Garden Branch should be considered by the City as a long-term project since the proposed alternative does not directly benefit any structures. A benefit-to-cost ratio could not be calculated because there are no directly quantifiable benefits from the roadway improvement alternatives at this time.

Table XIV-3 – Long-Term Stream and Open Channel CIP Alternatives

Stream	Location	Proposed Alternative	Public/Private
Garden	Martin Barnes Road	Elevate minimum Top of Road to 537.00’ – Remove 10’ x 10’ box culvert and construct a 20’ bridge span	Public

Prior to implementation of this long-term CIP, Halff Associates recommends a “passive” approach to warning citizens of potential danger due to flooding at Martin Barnes Road. A passive flood warning approach involves the placement of flood warning signage at potentially overtopped roadway crossings. An “active” approach involves incorporating a roadway crossing into the City’s flood warning system; however, this is not recommended at this time for Martin Barnes Road since the time from the rainfall event to the peak discharge at Martin Barnes does not allow enough lead time to be included in the City’s current active flood warning system. Improved methods of incorporating this crossing to the active flood warning system could be evaluated.

XV. Master Plan Study Wrap-up & Recommendations

XV. MASTER PLAN STUDY WRAP-UP & RECOMMENDATIONS

This supplemental report to the City-wide Drainage Master Plan for Fish Creek provides comprehensive, updated technical data for the management of the Garden Branch, Kirby Creek, and Willis Branch watersheds and their tributaries. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential damages. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development and help minimize existing and potential flood damages within each studied watershed.

Based on the findings of this report, Halff Associates recommends the following actions:

A. STREAMS AND OPEN CHANNELS

No structures are currently inundated by the 100-year floodplain in the Garden Branch, Kirby Creek, or Willis Branch watershed. The proposed re-sizing of the Martin Barnes Road crossing along Garden Branch serves to mitigate roadway flooding and does not directly benefit any structures. Halff recommends that the City include this alternative in the evaluation of future Capital Improvement Projects and place flood warning signage at Martin Barnes Road until this alternative can be implemented.

B. STREAM BANK STABILITY

Five (5) short-term stream stability alternatives located in Table XIV-1 were developed between Garden Branch, Kirby Creek, and Willis Branch to protect public infrastructure and prevent future erosion to stream beds and stream banks. Halff recommends that the City implement these alternatives in order of their ranking provided in Section IX of this report. Halff also recommends that the City adopt the Erosion Hazard Setbacks delineated as part of this study to manage new development in each studied watershed.

C. MAINTENANCE

Maintenance should be considered an ongoing task in the Garden Branch, Kirby Creek, and Willis Branch watersheds and should follow the recommendations of the City of Grand Prairie City-Wide Drainage Master Plan Road Map Section F.6.

1. Storm Drain Outfalls

Refer to Section XI of the City-wide Drainage Master Plan for Fish Creek developed by RPS Espey Consultants for the condition of each outfall located within the Garden Branch, Kirby Creek, and Willis Branch watersheds. Halff Associates recommends the City proceed with maintenance and repairs for the outfalls with a condition of poor as soon as possible. Remedial maintenance of the fair outfalls and continued field inspection for the good outfalls should be conducted in a regularly scheduled cycle determined by the City.

2. Detention Ponds

Refer to Section X of the City-wide Drainage Master Plan for Fish Creek performed by RPS Espey Consultants for the condition of detention ponds located within the Garden Branch, Willis Branch, and Kirby Creek watersheds. Halff Associates performed a visual inspection of the regional pond located along Kirby Creek just west of Robinson Road in August 2012. The regional detention pond was in good condition and no corrective maintenance is needed at this time. Halff recommends remedial maintenance of the fair condition detention ponds and continued field inspections for good condition detention ponds should be conducted in a regularly scheduled cycle determined by the City.

D. FUTURE STUDIES & REPORT UPDATES







Future studies and technical data should be incorporated into this report as they become available. Maintenance of this CWDMP document will be critical to keeping the document accurate and current. Future LOMRs and watershed studies should be included as attachments in this same document. Final hydrology and hydraulic models should be added to Appendix F.

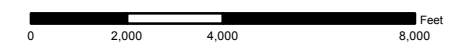
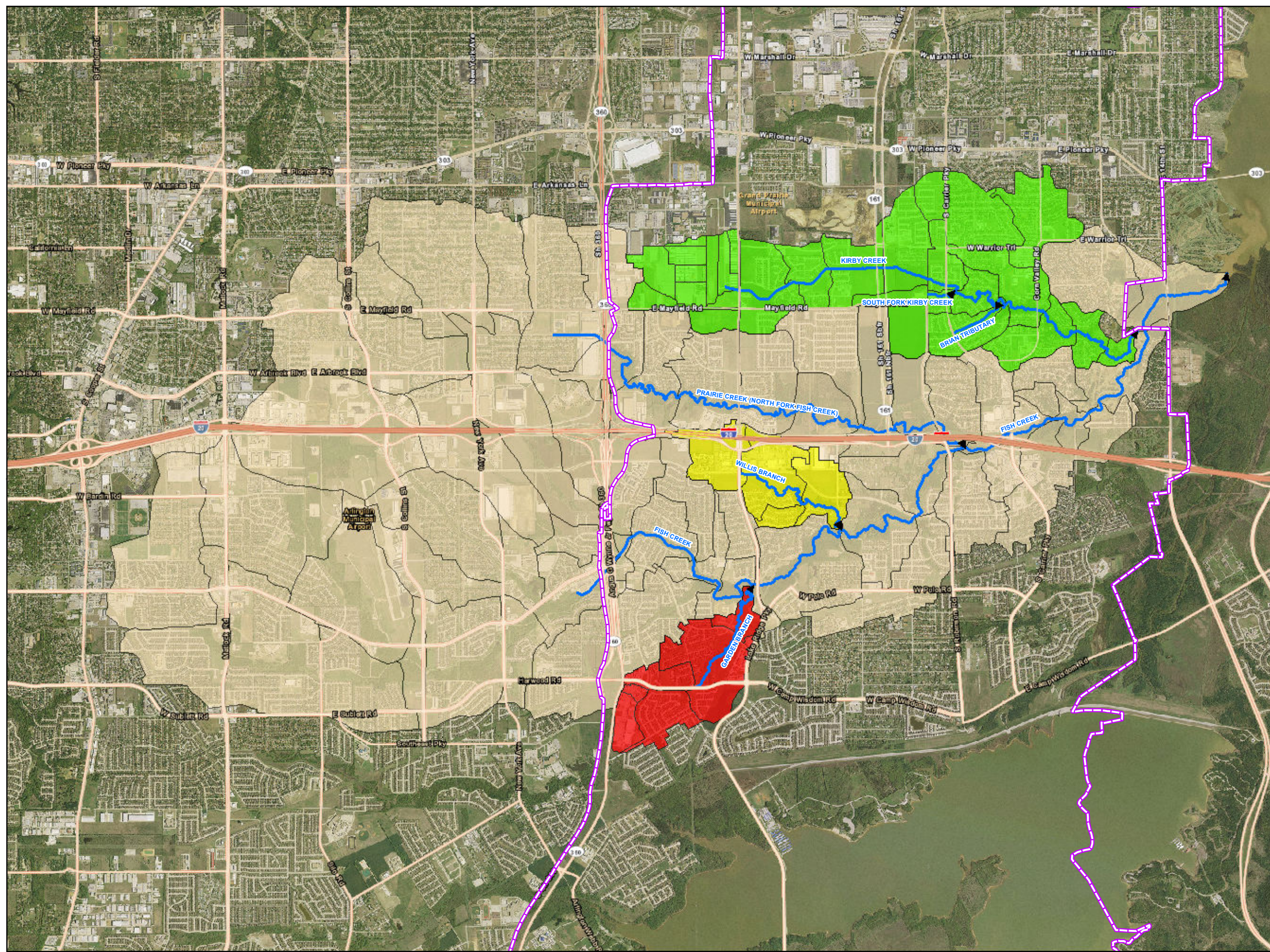
Appendix A
Figures

Overall Watershed Map

Overall Watershed Map

Legend

-  Grand Prairie City Limit
-  Kirby Creek Watershed
-  Garden Branch Watershed
-  Willis Branch Watershed
-  Fish Creek Watershed
-  Stream Centerline



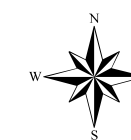
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Existing Landuse Map

Existing Landuse Map

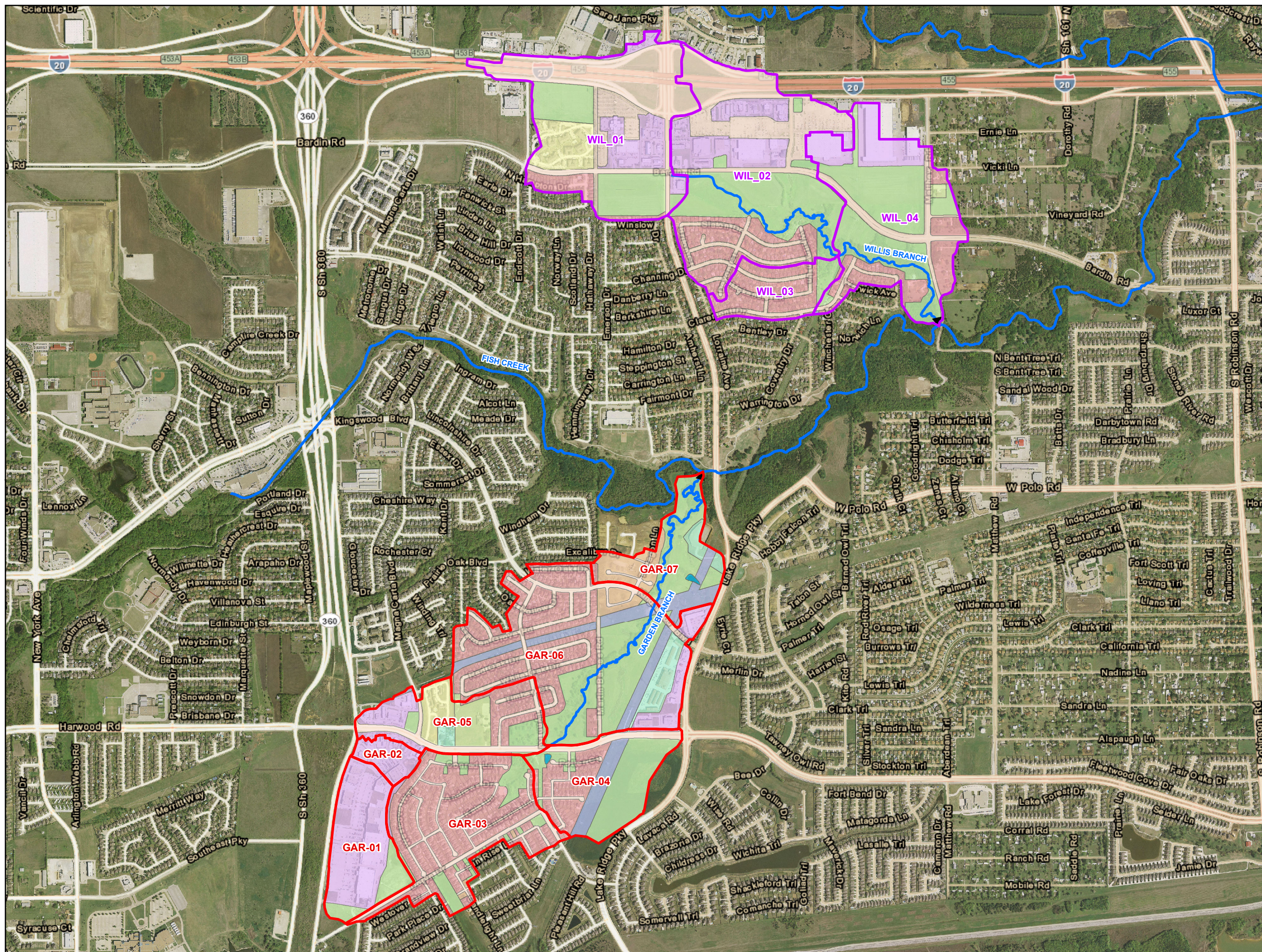
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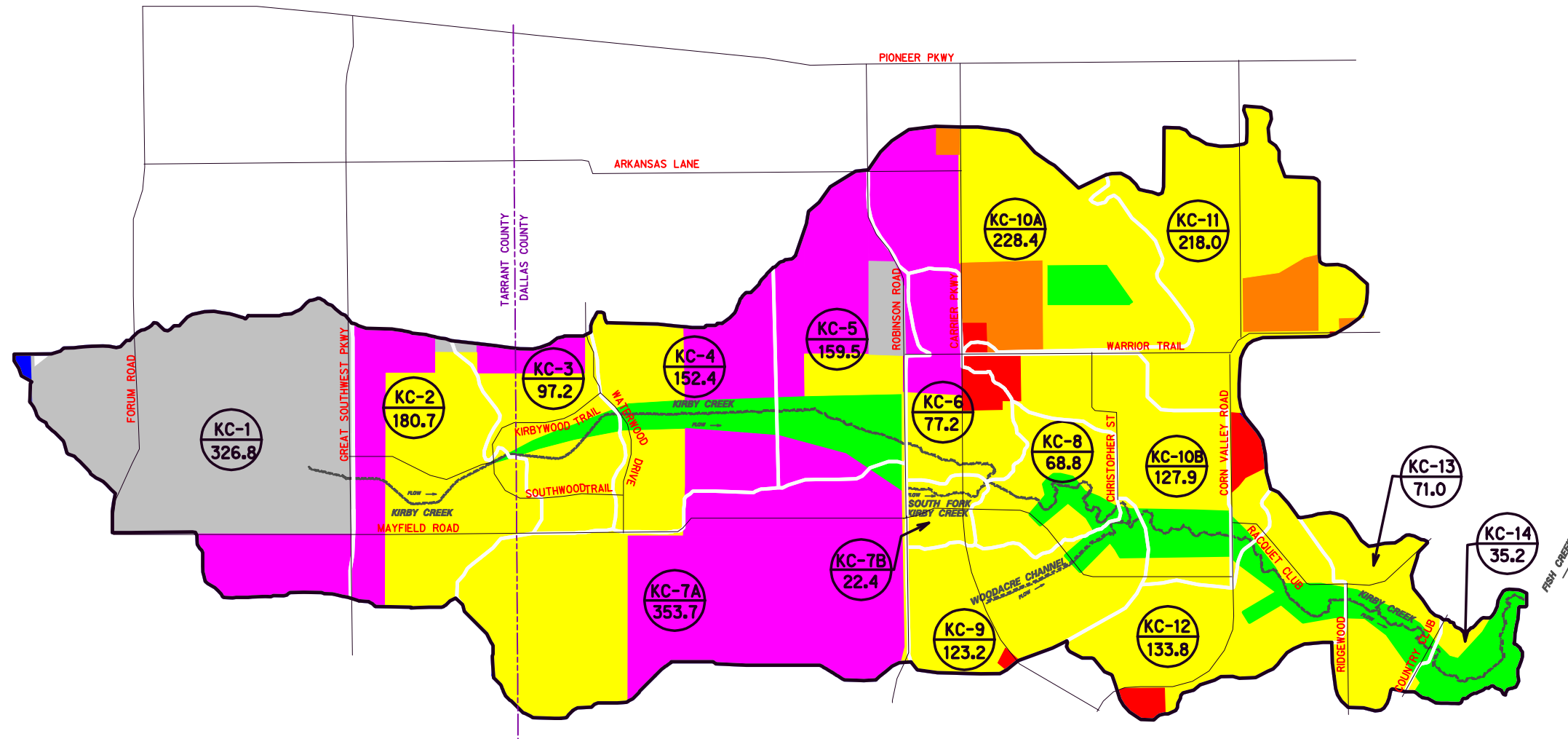
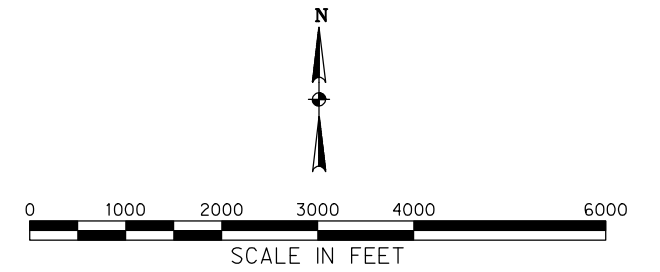
- Willis Branch Watershed
 - Garden Branch Watershed
- Existing Landuse**
- Commercial
 - Impervious
 - Industrial
 - Institutional
 - Multi Family
 - Open Space
 - Single Family
 - Under Construction
 - Utilities
 - Water



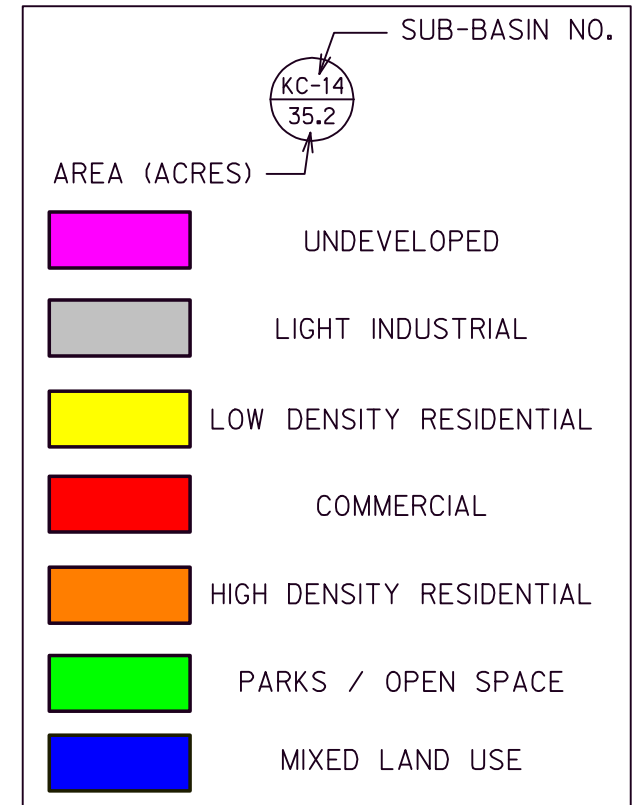
0 750 1,500 3,000 Feet

1 inch = 1,500 feet





LEGEND



NOTES

1. LAND USAGE FROM CITY OF GRAND PRAIRIE COMPREHENSIVE PLAN (1999)
2. UNDEVELOPED AREAS DETERMINED FROM AERIAL PHOTOGRAPHS FLOWN BY LANDISCOR (2002)

NO.	REVISION	BY	DATE

SBC/SFB
DESIGNED
SBC/SFB
DRAWN
HALFF
CHECKED

SCALE
1" = 2000'

Half Associates
ENGINEERS • ARCHITECTS • SCIENTISTS • PLANNERS • SURVEYORS
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FORT WORTH, TEXAS 76137
(817)847-1422

PRELIMINARY - FOR INTERIM REVIEW ONLY
These documents are for Interim Review and not intended for Construction, Bldg., or Permit Purposes. They were prepared by, or under the supervision of:
STEPHEN B. CRAWFORD 89249 10-24-03
Name PE # Date

WORK ORDER NO. #531.05
DECEMBER 2003
AVO: 21524
FILE: 524EXISTLAND



KIRBY CREEK EXISTING CONDITIONS LAND USE
CITY OF GRAND PRAIRIE
KIRBY CREEK WATERSHED DRAINAGE AND EROSION MASTERPLAN (W.O. #531.05)

2
CITY FILE No.

Ultimate Landuse Map

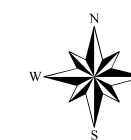
Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930

Ultimate Landuse Map

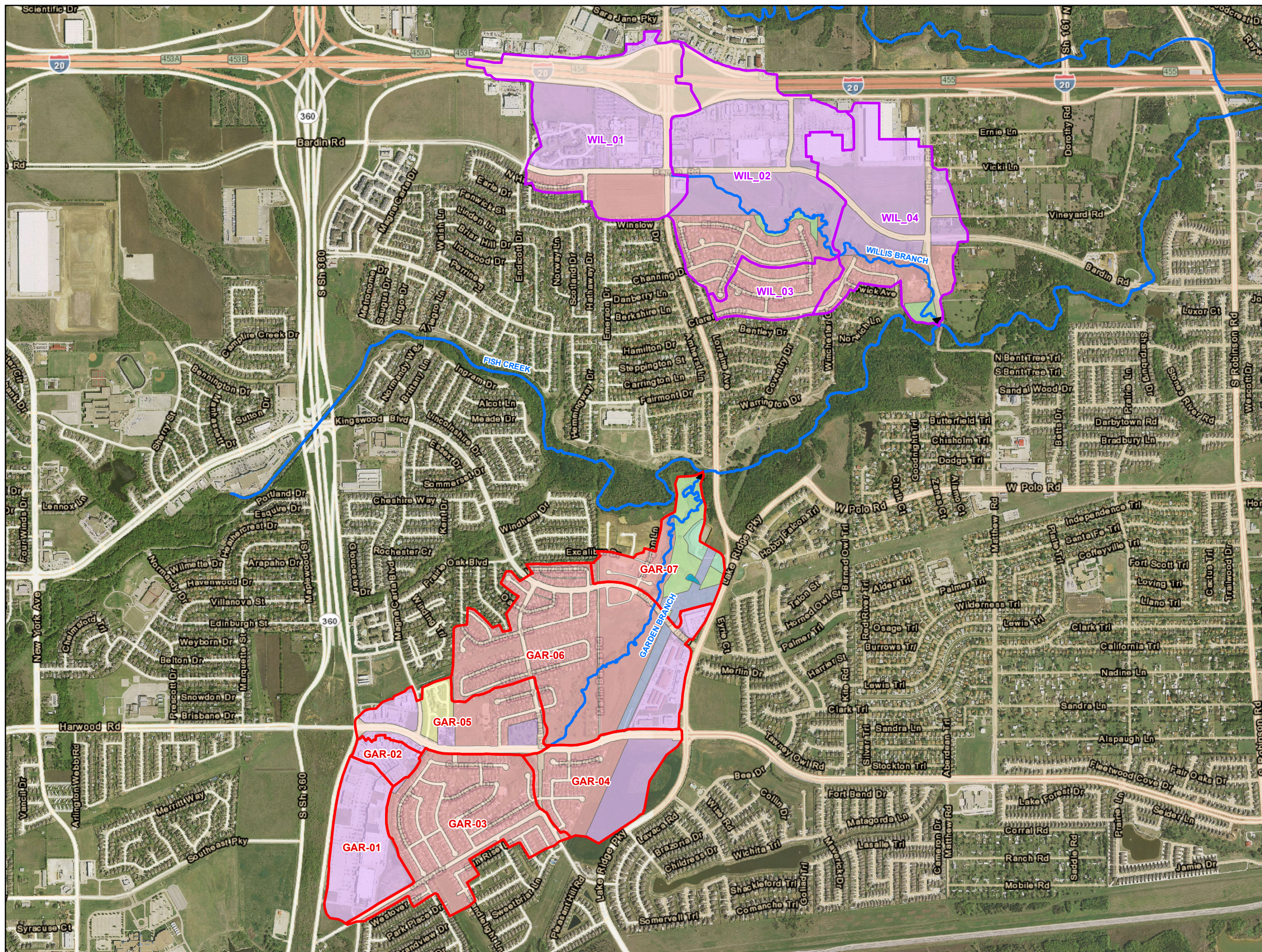
Legend

- Willis Branch Watershed
 - Garden Branch Watershed
- Existing Landuse**
- Commercial
 - Impervious
 - Industrial
 - Institutional
 - Multi Family
 - Open Space
 - Single Family
 - Under Construction
 - Utilities
 - Water



0 750 1,500 3,000 Feet

1 inch = 1,500 feet

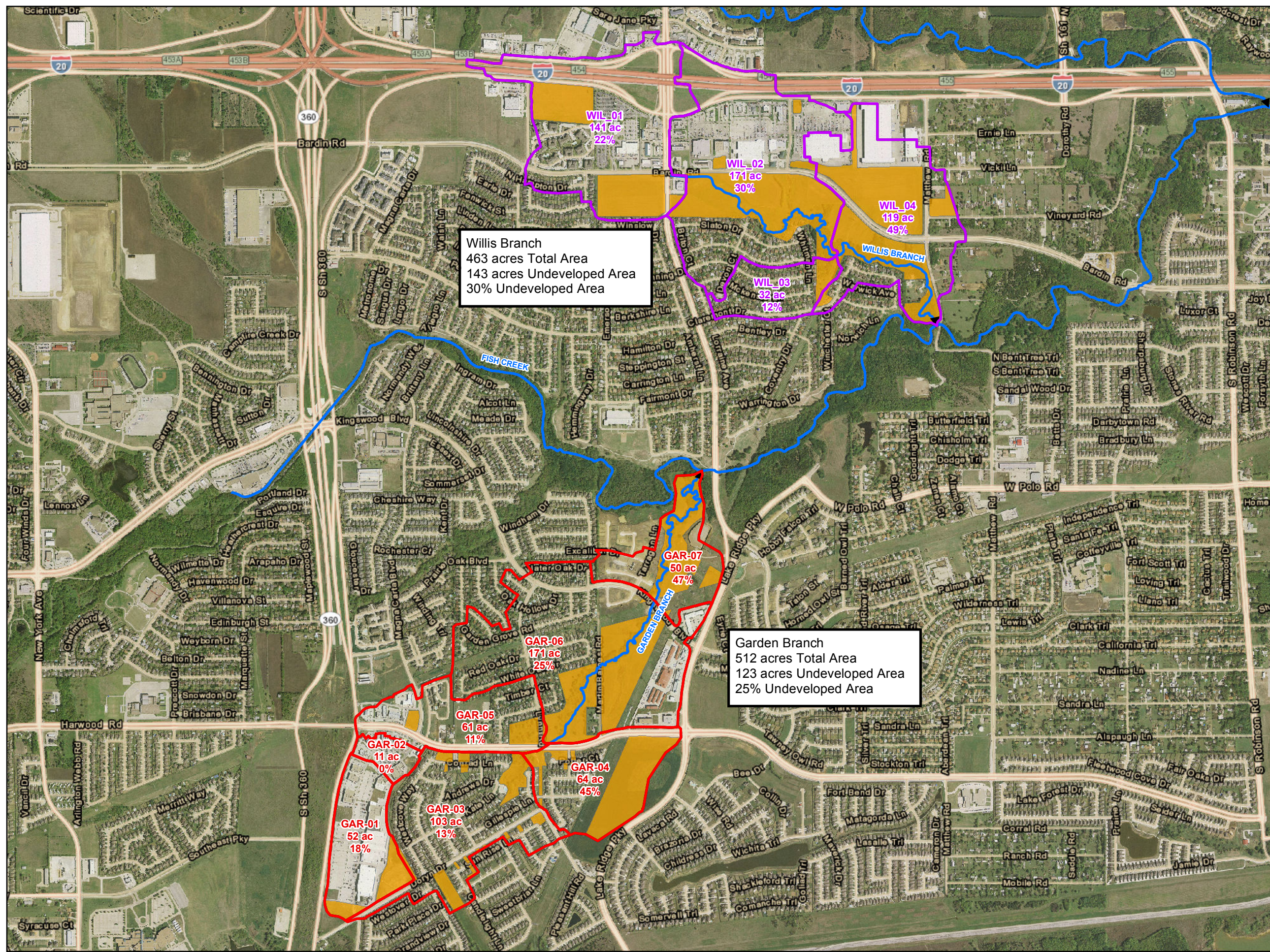
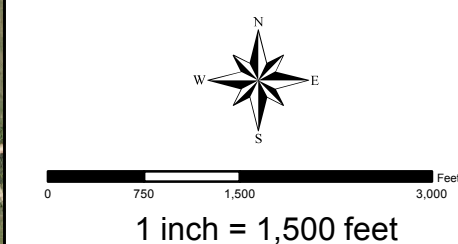


Undeveloped Area Map

Undeveloped Areas Map

Legend

- Willis Branch Watershed
- Garden Branch Watershed
- Undeveloped Area





Willis Branch
463 acres Total Area
143 acres Undeveloped Area
30% Undeveloped Area

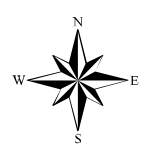
Garden Branch
512 acres Total Area
123 acres Undeveloped Area
25% Undeveloped Area

Kirby Creek Undeveloped Areas Map

Kirby Creek
2155 acres Total Area
624 acres Undeveloped Area
20% Undeveloped Area

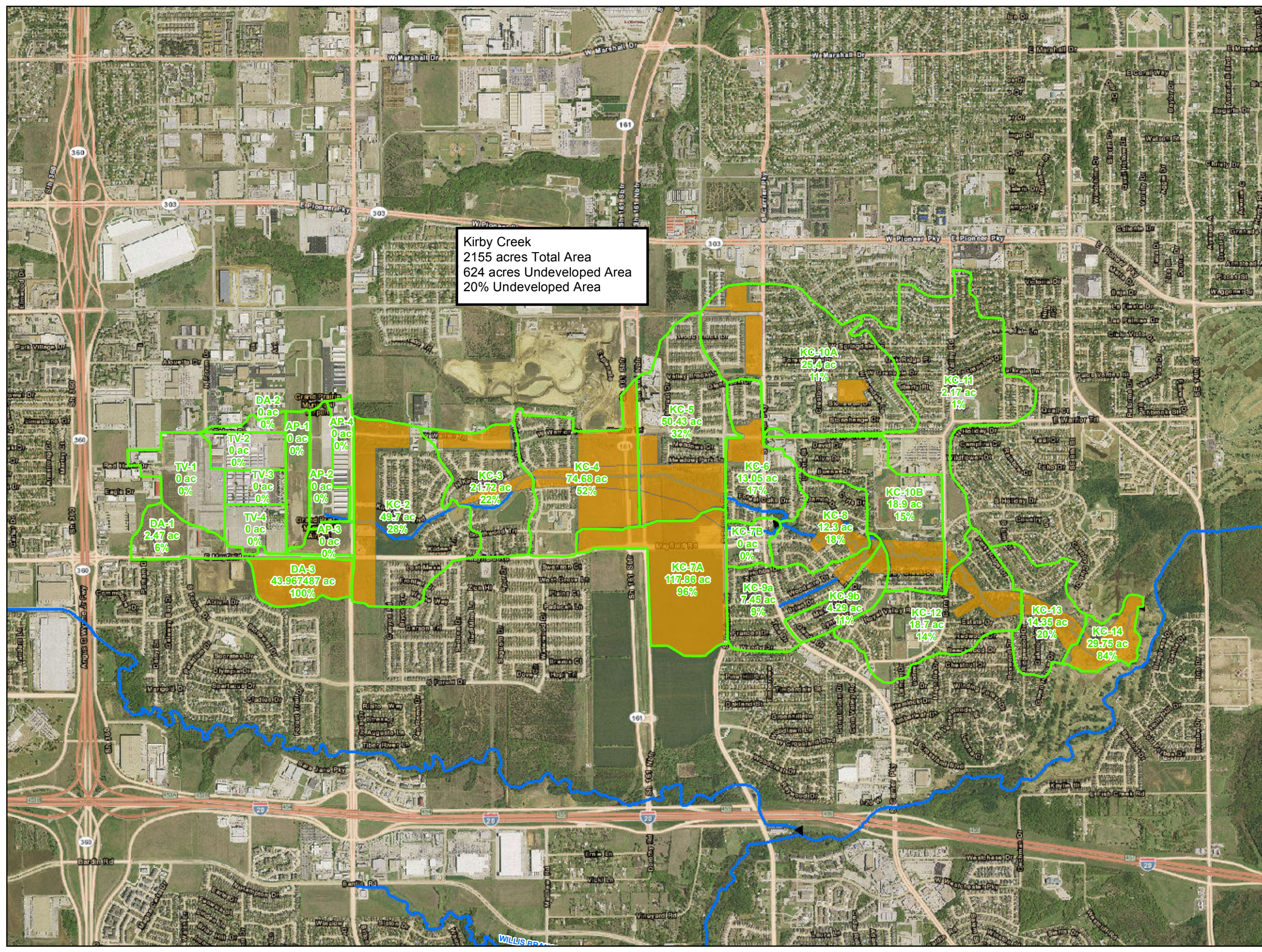
Legend

-  Kirby Creek Watershed
-  Undeveloped Areas



0 750 1,500 3,000 Feet

1 inch = 2,000 feet





Hydrologic Soils Map

Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930

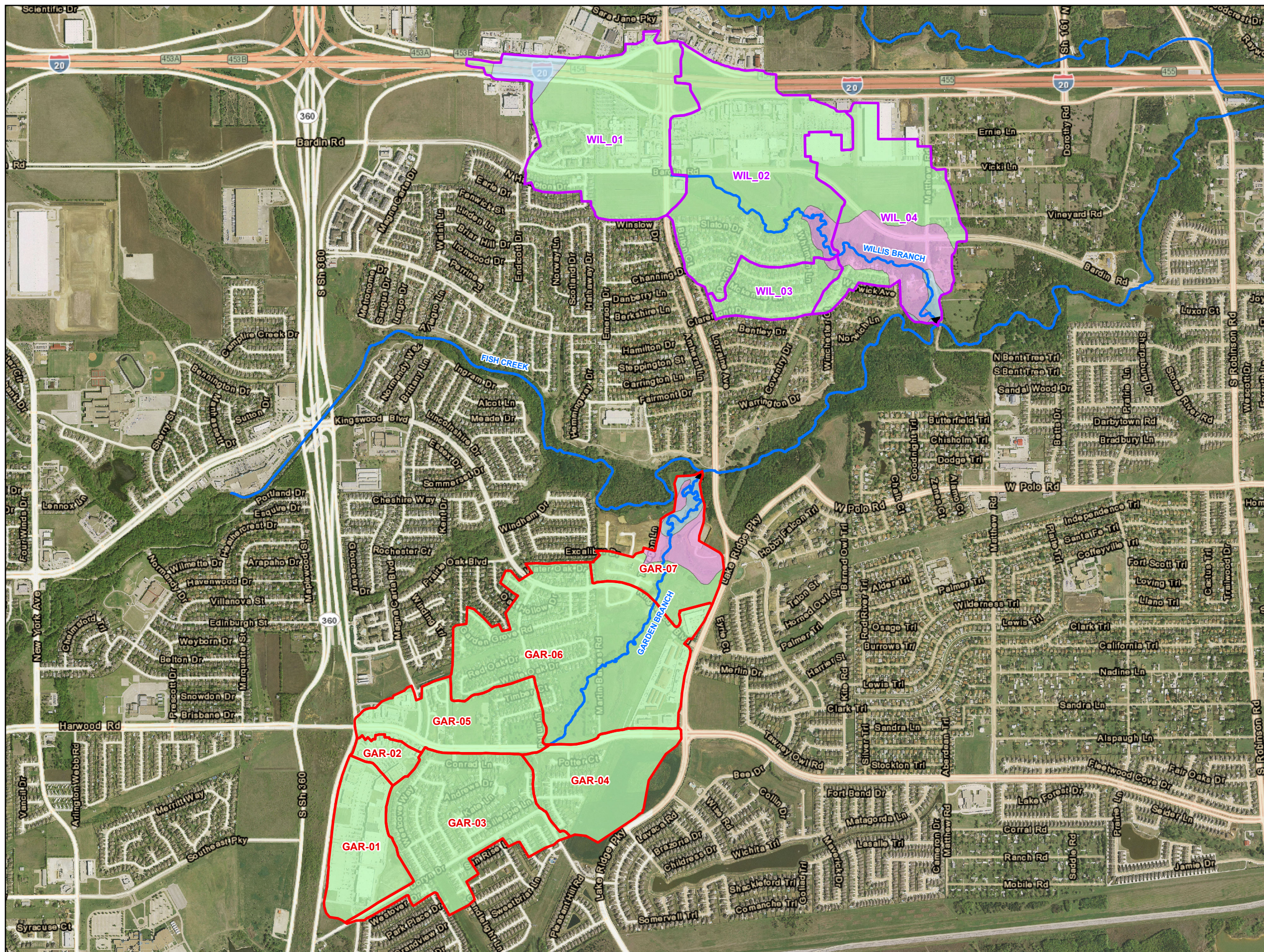
Hydrologic Soils Map

Legend

-  Willis Branch Watershed
-  Garden Branch Watershed

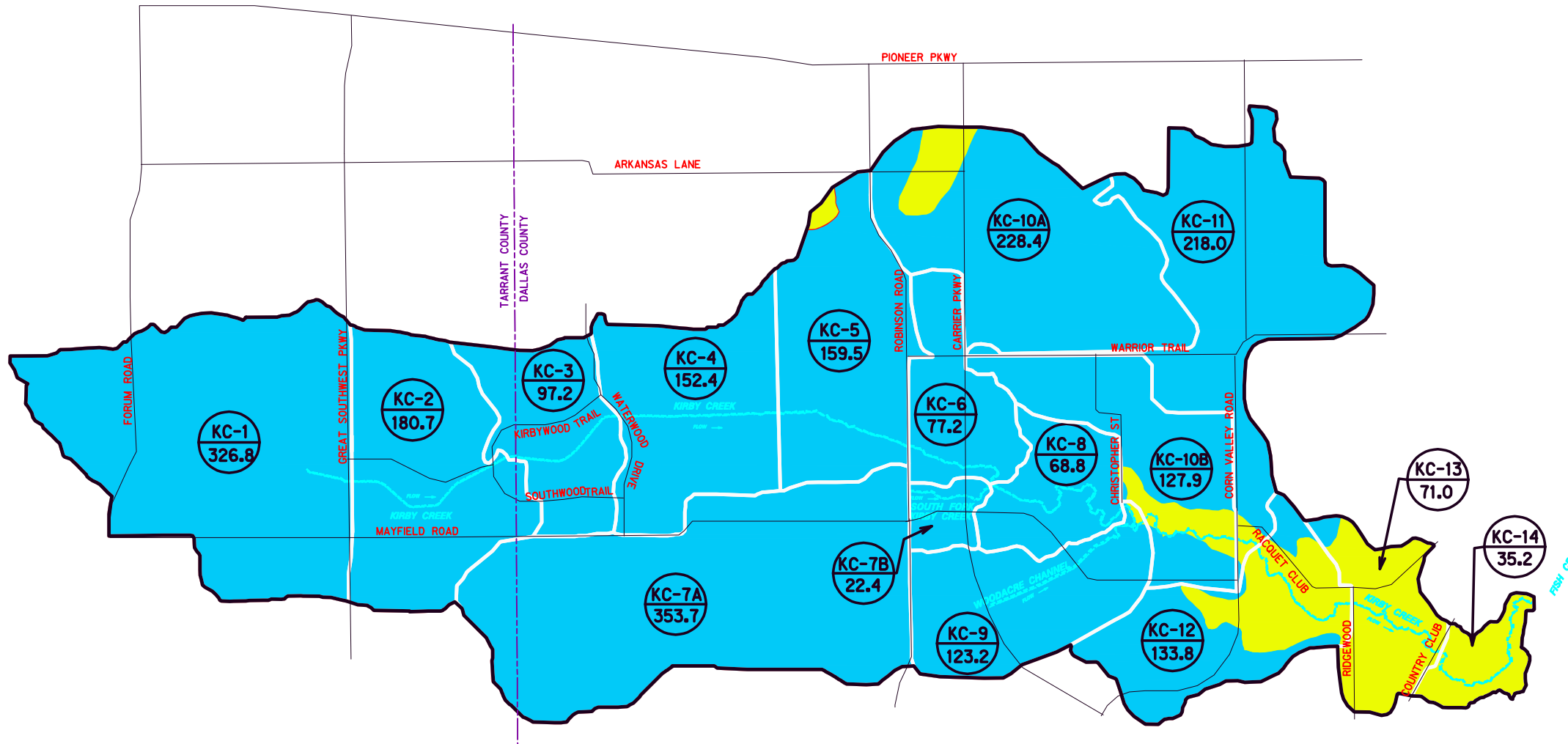
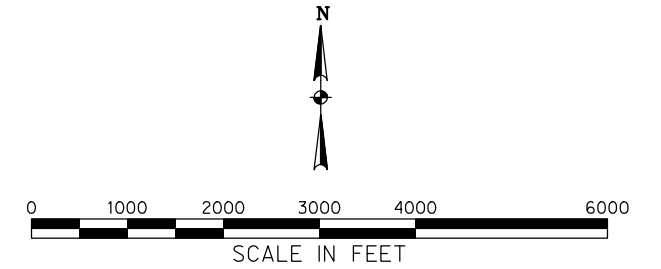
Hydrologic Soil Group

-  B
-  C
-  D

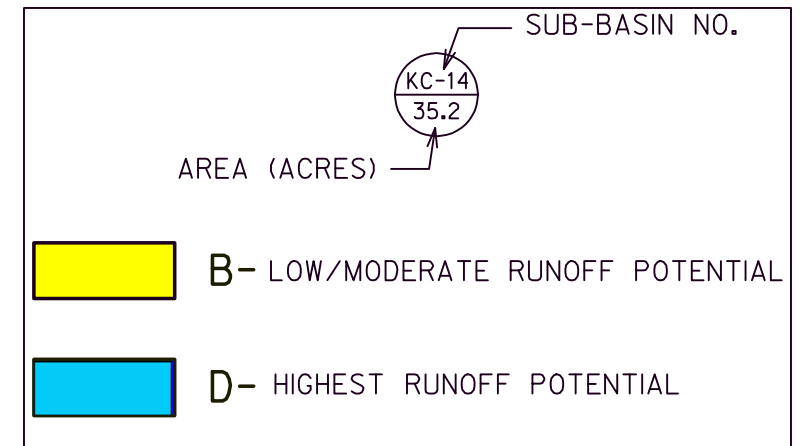


0 750 1,500 3,000 Feet

1 inch = 1,500 feet



LEGEND



NOTES

1. TYPES OF SOILS ARE DETERMINED FROM SOIL SURVEY OF DALLAS COUNTY AND SOIL SURVEY OF TARRANT COUNTY

NO.	REVISION	BY	DATE

SBC/SFB
DESIGNED
SBC/SFB
DRAWN
HALFF
CHECKED

SCALE
1" = 2000'

Halff Associates
ENGINEERS • ARCHITECTS • SCIENTISTS • PLANNERS • SURVEYORS
4000 FOSSIL CREEK BLVD.
FORT WORTH, TEXAS 76137
(817)847-1422

PRELIMINARY - FOR INTERIM REVIEW ONLY
These documents are for Interim Review and not intended for Construction, Bidding, or Permit Purposes. They were prepared by, or under the supervision of:
STEPHEN B. CRAWFORD 89249 10-24-03
Name PE * Date

WORK ORDER NO. **#531.05**
DECEMBER 2003
AVO: 21524
FILE: 524SOILS

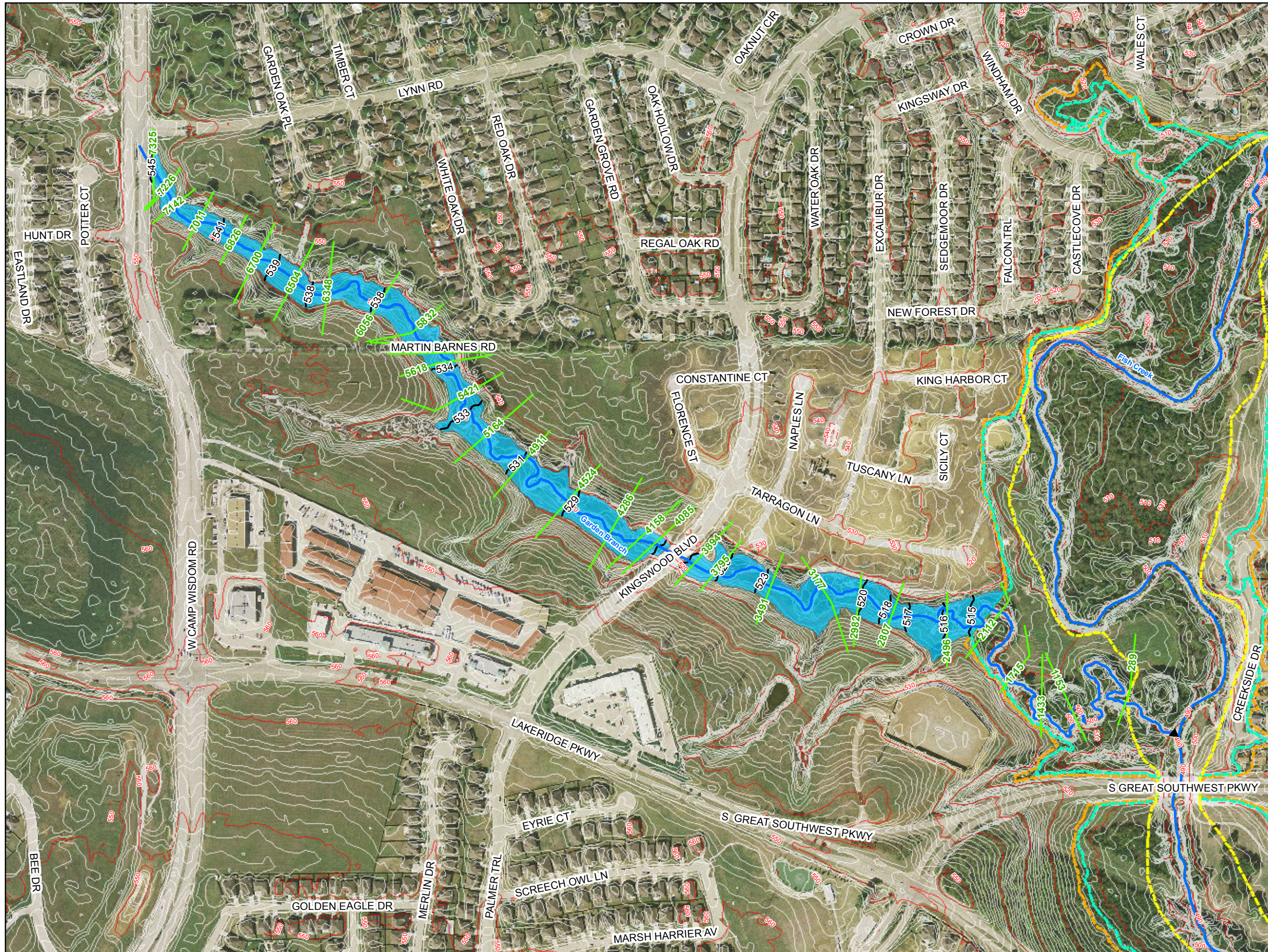


KIRBY CREEK HYDROLOGIC SOILS
CITY OF GRAND PRAIRIE
KIRBY CREEK WATERSHED DRAINAGE AND EROSION MASTERPLAN (W.O. #531.05)

Floodplain Workmaps

Floodplain Workmap

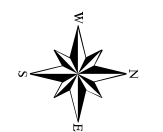
GARDEN BRANCH



Legend

- BFE
- Floodway
- Existing 100yr Floodplain
- Existing 500yr Floodplain
- Fish CTP Floodway
- Fish CTP 100yr Floodplain
- Fish CTP 500yr Floodplain

- Notes:
- 1) Contours reflect the City of Grand Prairie 2009 Lidar Data.
 - 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



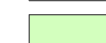
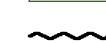





0 200 400 800 Feet
1 inch = 400 feet

Floodplain Workmap

KIRBY CREEK MAP 1

Legend

-  Floodway
-  Existing 100yr Floodplain
-  Existing 500yr Floodplain
-  BFE
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

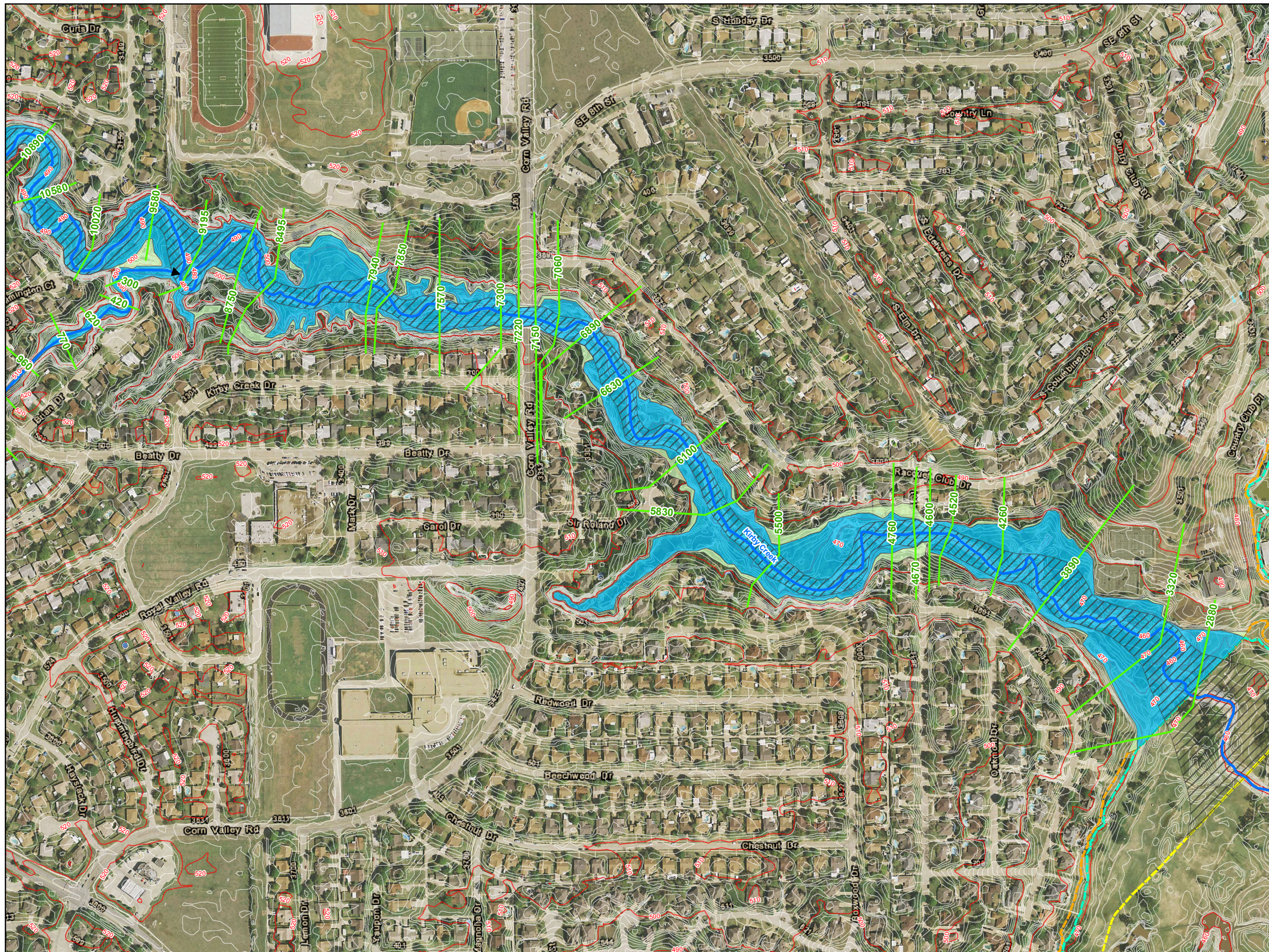
Notes:

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- 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet



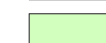
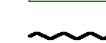



1 inch = 400 feet



Floodplain Workmap

KIRBY CREEK MAP 2

Legend

-  Floodway
-  Existing 100yr Floodplain
-  Existing 500yr Floodplain
-  BFE
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

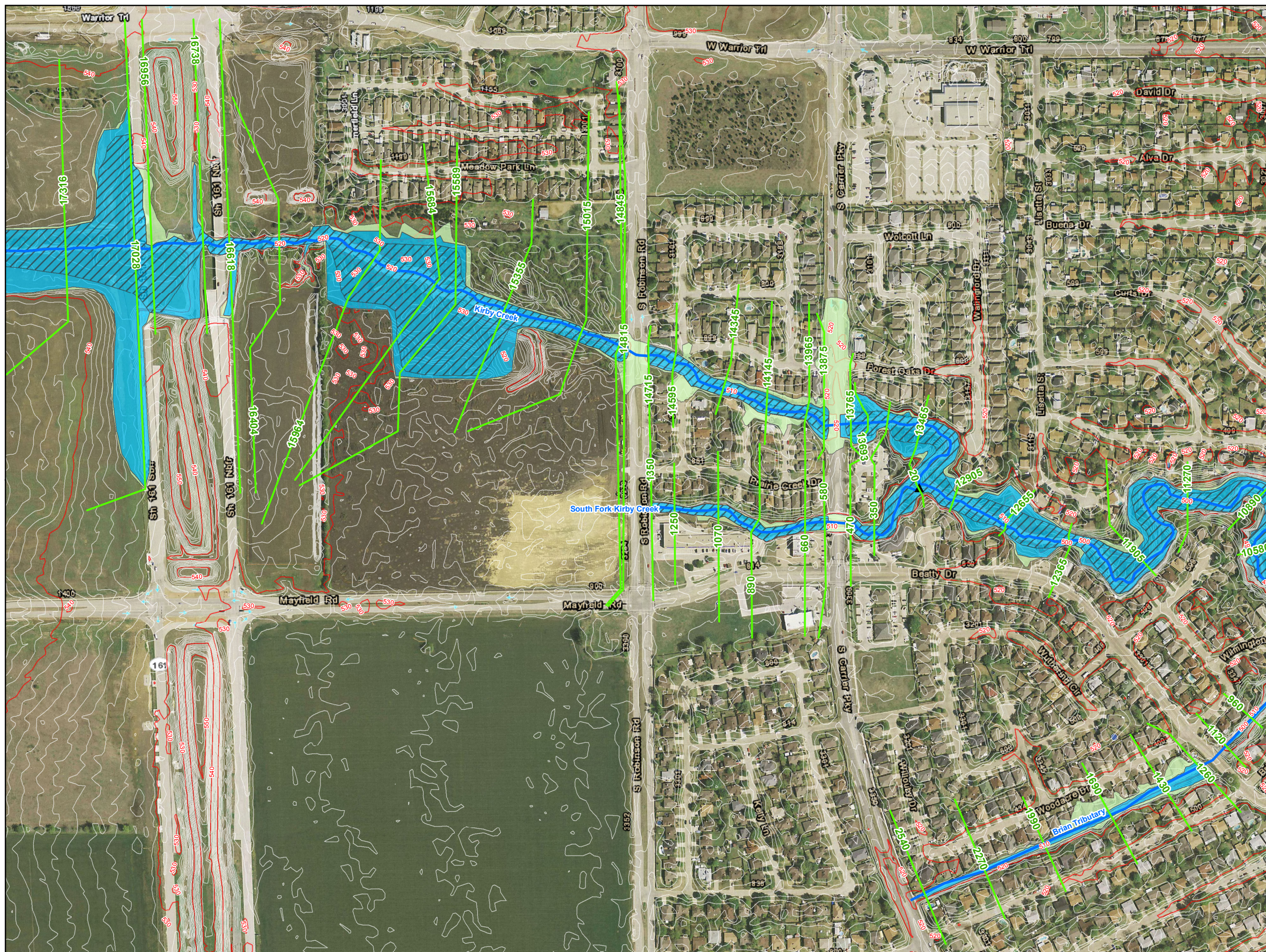
Notes:

- 1) Contours reflect the City of Grand Prairie 2009 Lidar Data.
- 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet



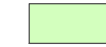




1 inch = 400 feet



Floodplain Workmap

KIRBY CREEK MAP 3

Legend

-  Floodway
-  Existing 100yr Floodplain
-  Existing 500yr Floodplain
-  BFE
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

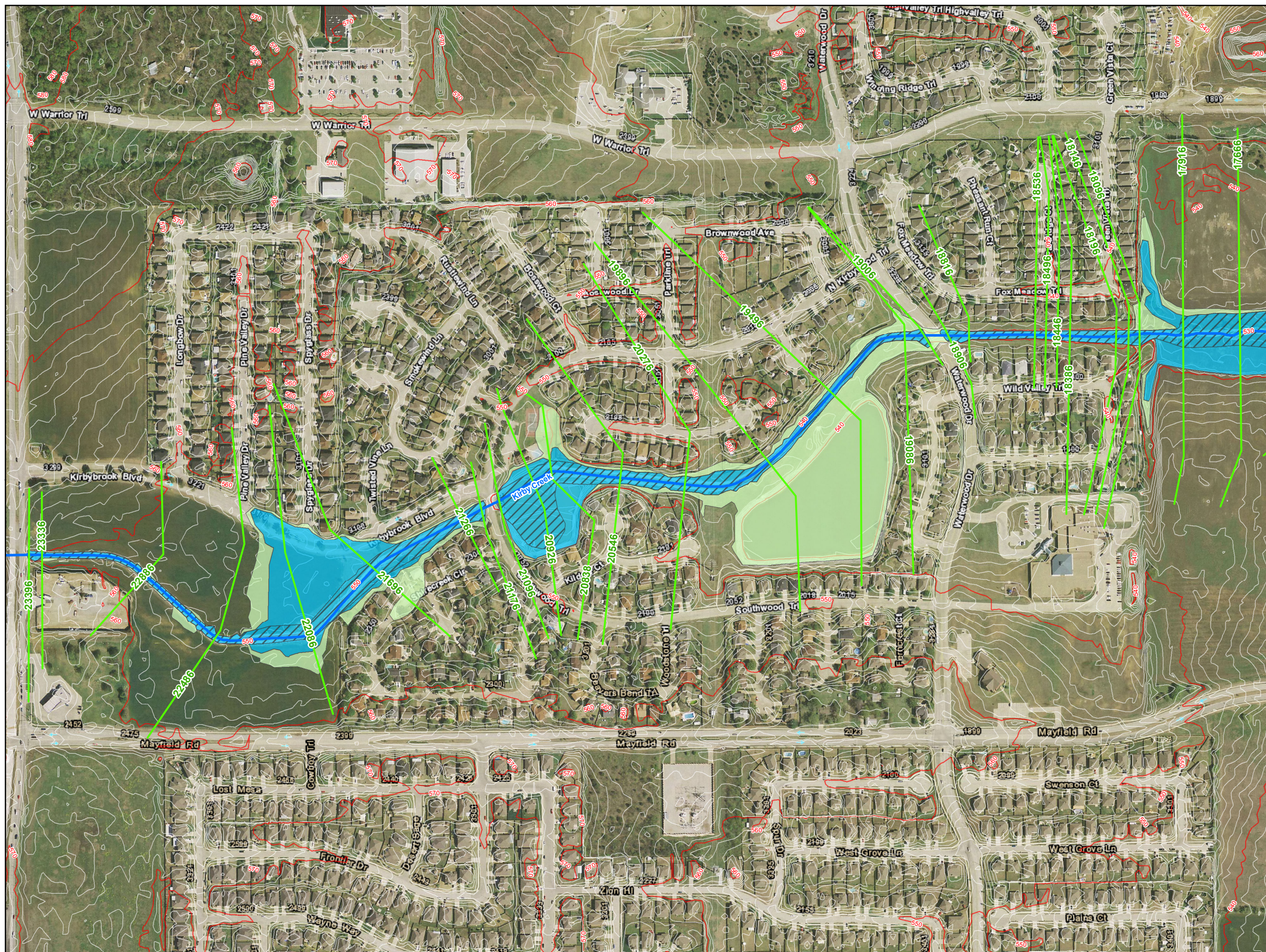
Notes:

- 1) Contours reflect the City of Grand Prairie 2009 Lidar Data.
- 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet








1 inch = 400 feet



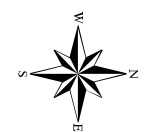
Floodplain Workmap

WILLIS BRANCH

Legend

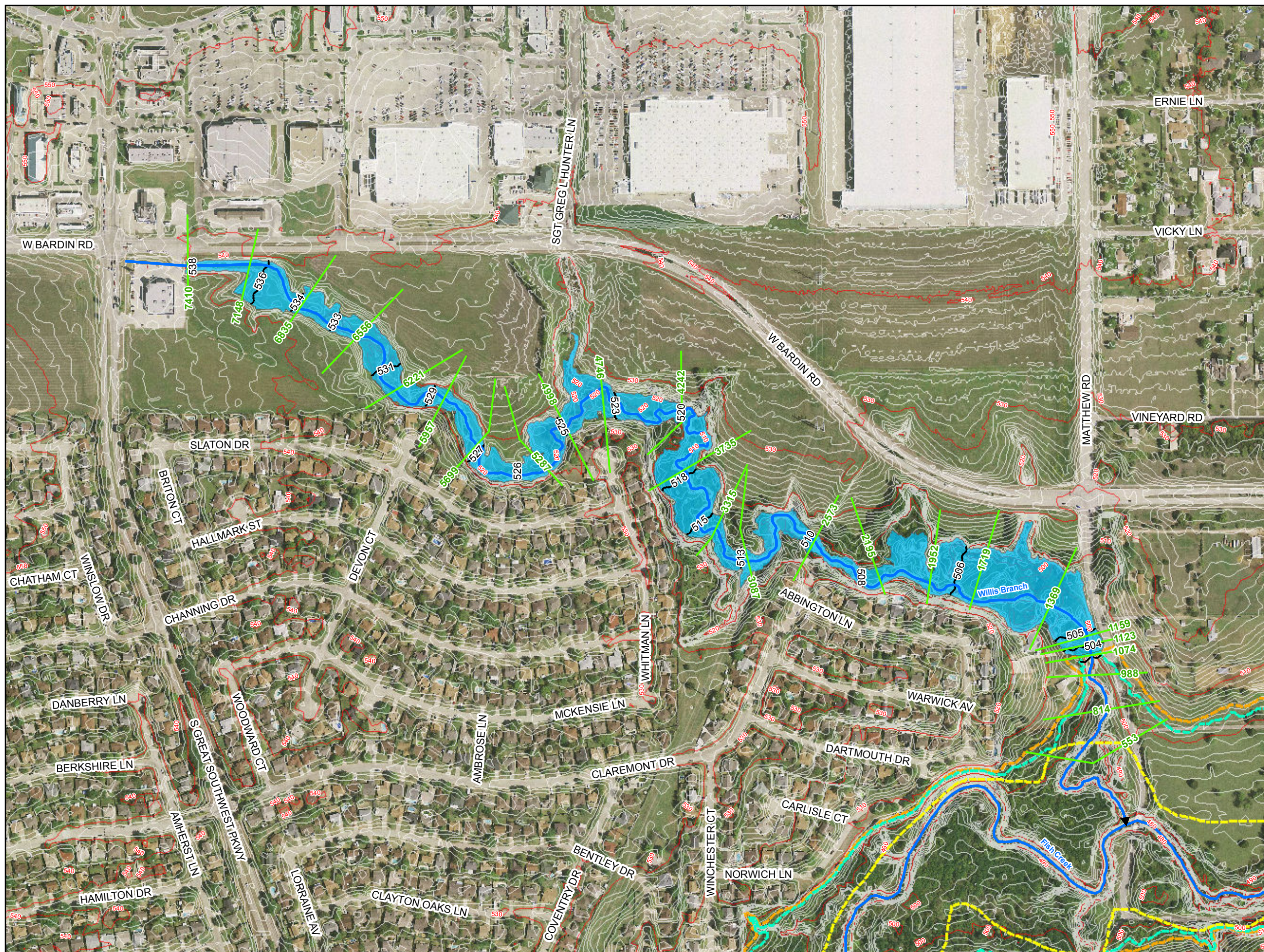
-  BFE
-  Floodway
-  Existing 100yr Floodplain
-  Existing 500yr Floodplain
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

- Notes:
- 1) Contours reflect the City of Grand Prairie 2009 Lidar Data.
 - 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet

1 inch = 400 feet



Ultimate Floodplain Workmaps




Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930

Ultimate Floodplain Workmap

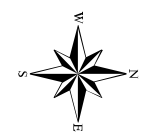
GARDEN BRANCH

Legend

-  Ultimate 100-yr BFE
-  Ultimate 100-yr Floodplain
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

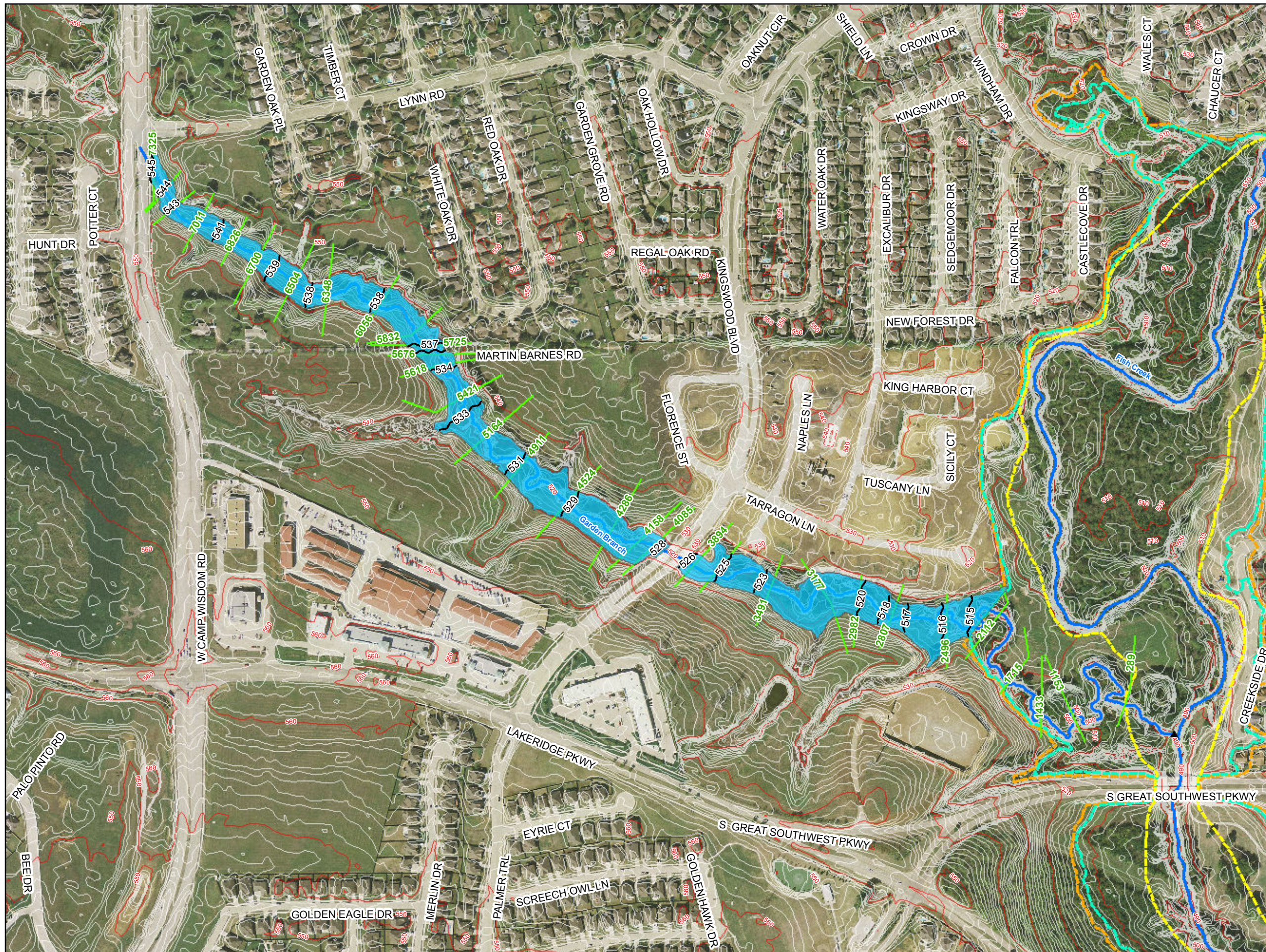
Notes:

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- 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet




1 inch = 400 feet



Ultimate Floodplain Workmap

WILLIS BRANCH

Legend

-  Ultimate 100-yr BFE
-  Ultimate 100-yr Floodplain
-  Fish CTP Floodway
-  Fish CTP 100yr Floodplain
-  Fish CTP 500yr Floodplain

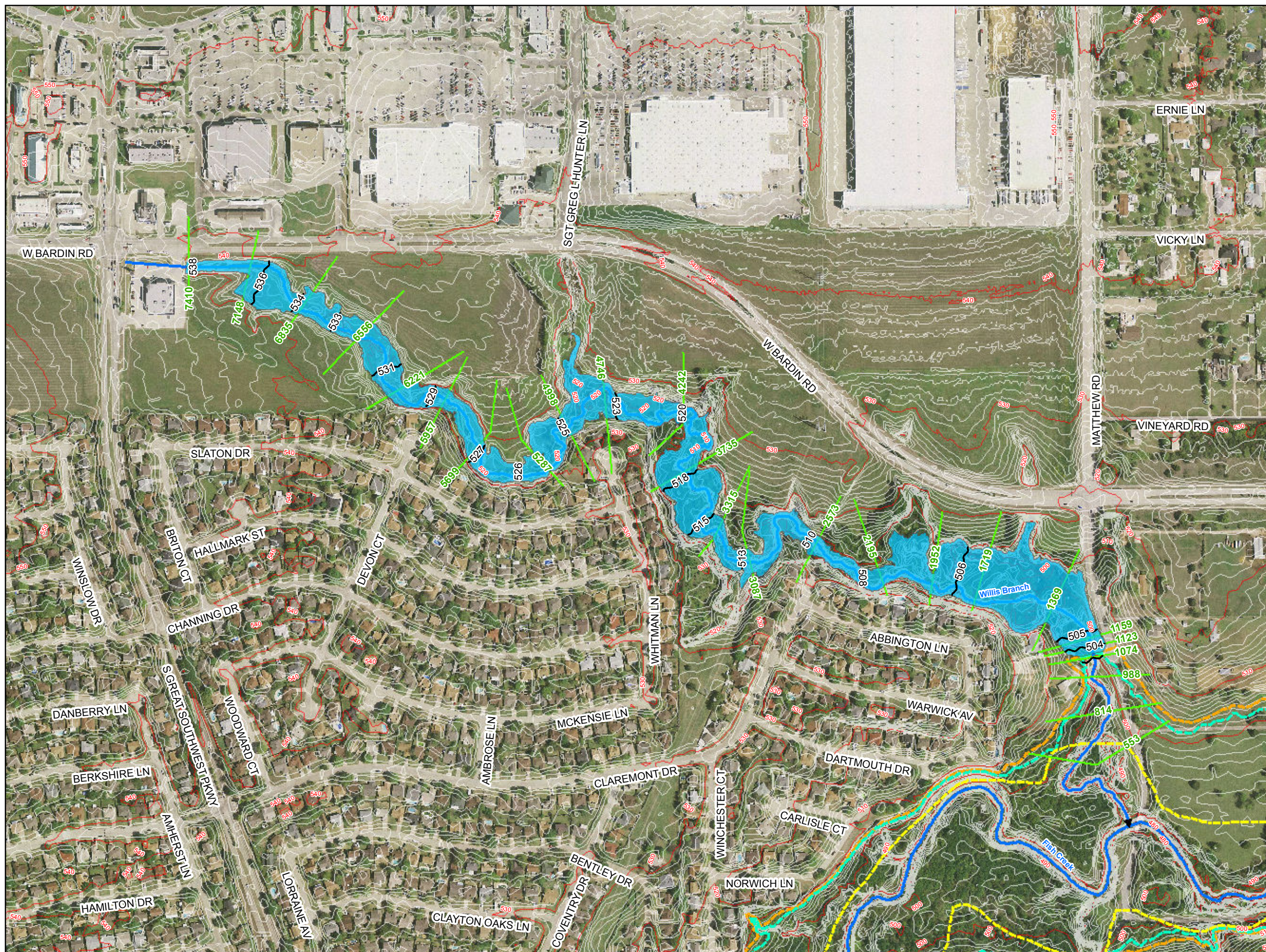
Notes:

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- 2) The Kirby Creek existing floodplains are also considered ultimate condition floodplains. See Section III.A of this report for an explanation.



0 200 400 800 Feet

1 inch = 400 feet










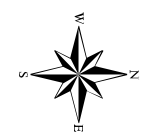
CIP Workmaps

CIP Workmap
GARDEN BRANCH

Legend

CIP Alternative

-  Bank Stabilization
-  Grade Stabilization
-  Channel Improvement
-  Roadway Improvement
-  Stream Centerline
-  Cross Section
-  Erosion Hazard Setback

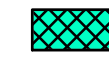








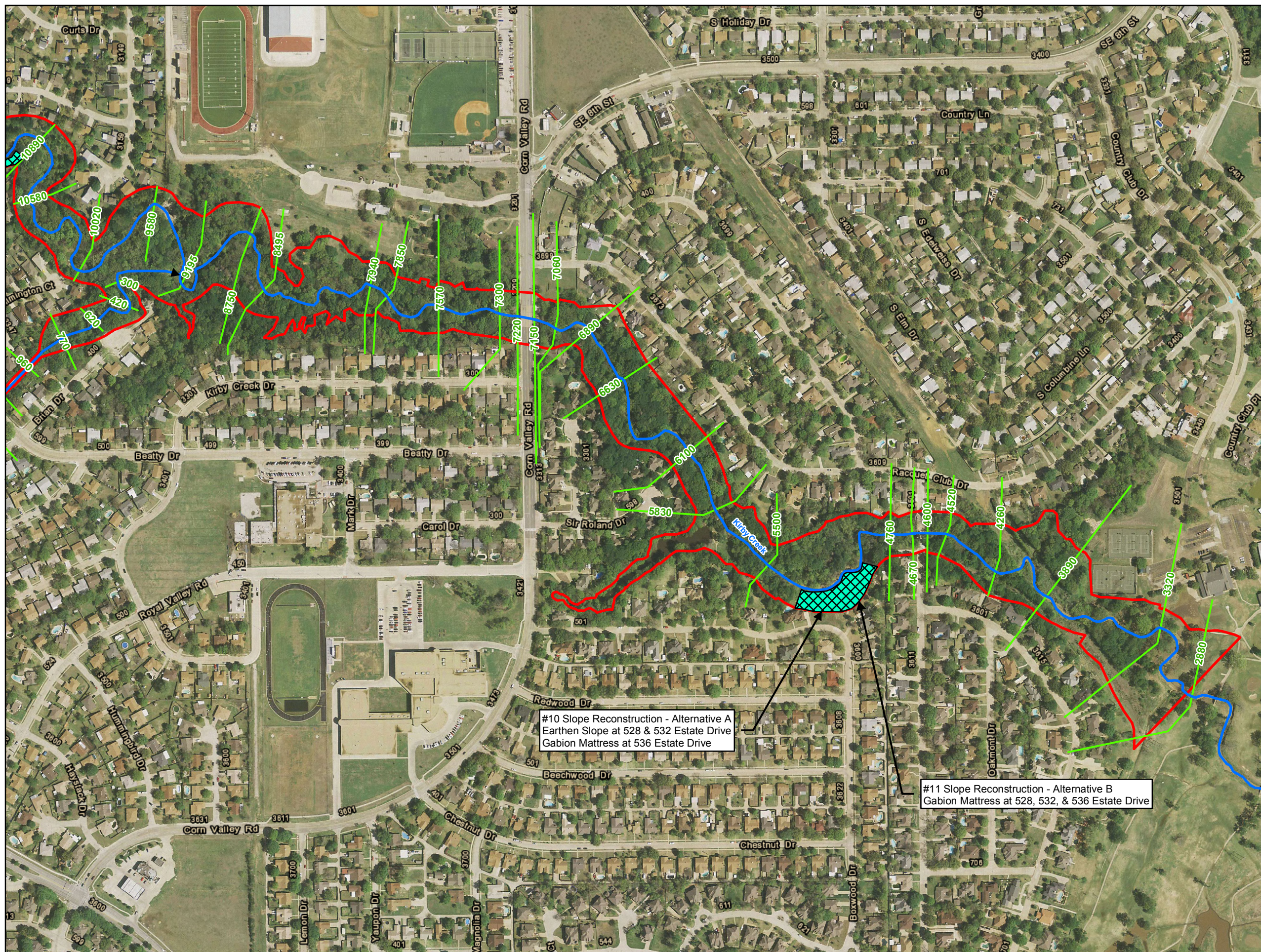
1 inch = 400 feet

CIP Workmap
KIRBY CREEK MAP 1

Legend

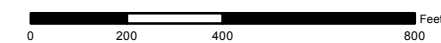
CIP Alternative

-  Bank Stabilization
-  Grade Stabilization
-  Channel Improvement
-  Roadway Improvement
-  Erosion Hazard Setback
-  Cross Section
-  Stream Centerline



#10 Slope Reconstruction - Alternative A
Earthen Slope at 528 & 532 Estate Drive
Gabion Mattress at 536 Estate Drive

#11 Slope Reconstruction - Alternative B
Gabion Mattress at 528, 532, & 536 Estate Drive

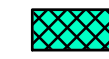








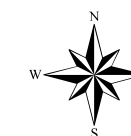
1 inch = 400 feet

CIP Workmap
KIRBY CREEK MAP 2

Legend

CIP Alternative

-  Bank Stabilization
-  Grade Stabilization
-  Channel Improvement
-  Roadway Improvement
-  Erosion Hazard Setback
-  Cross Section
-  Stream Centerline










0 200 400 800 Feet

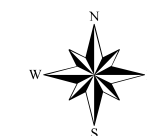
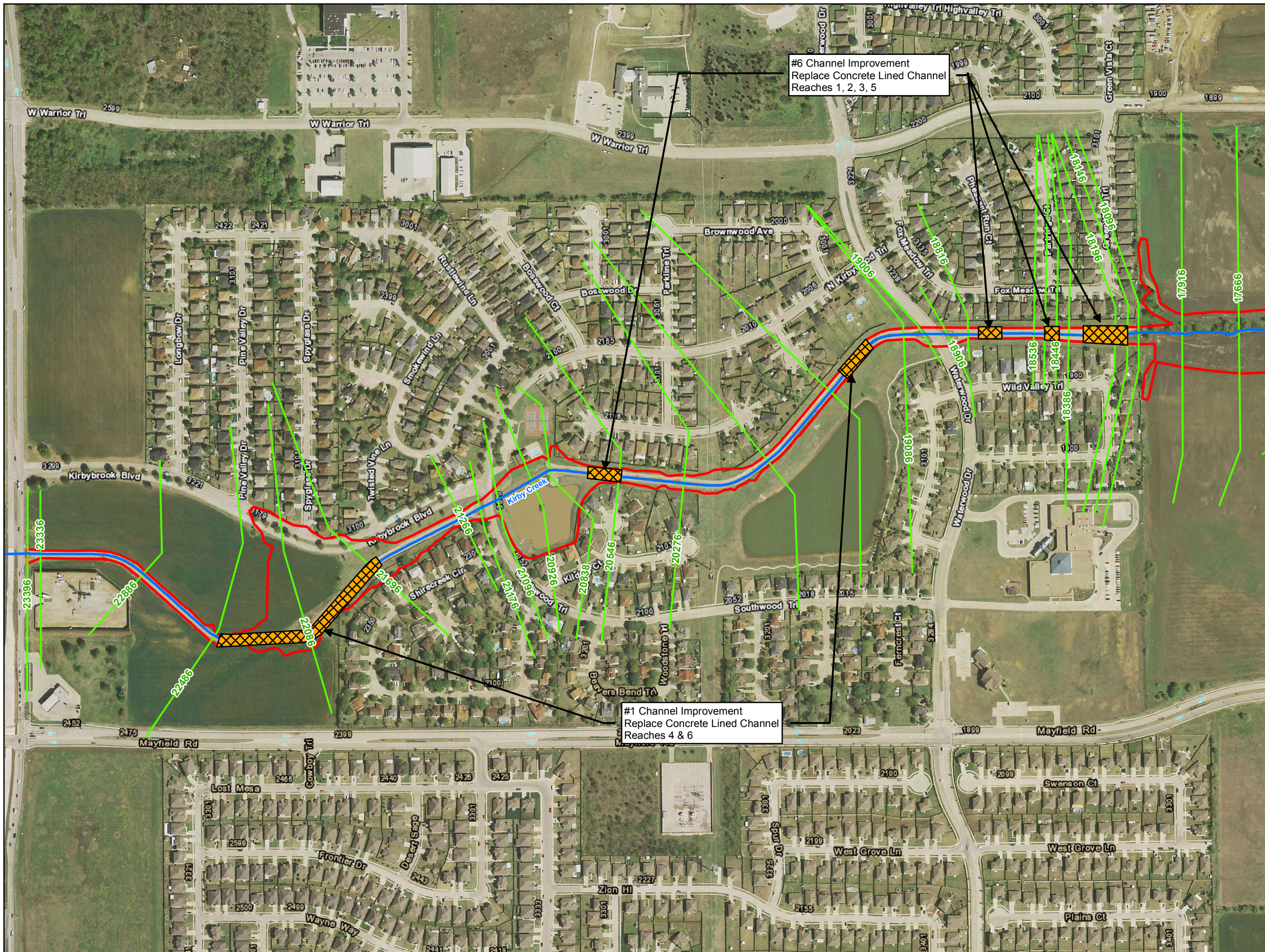
1 inch = 400 feet

CIP Workmap
KIRBY CREEK MAP 3

Legend

CIP Alternative

-  Bank Stabilization
-  Grade Stabilization
-  Channel Improvement
-  Roadway Improvement
-  Erosion Hazard Setback
-  Cross Section
-  Stream Centerline










0 200 400 800 Feet

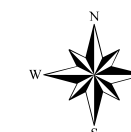
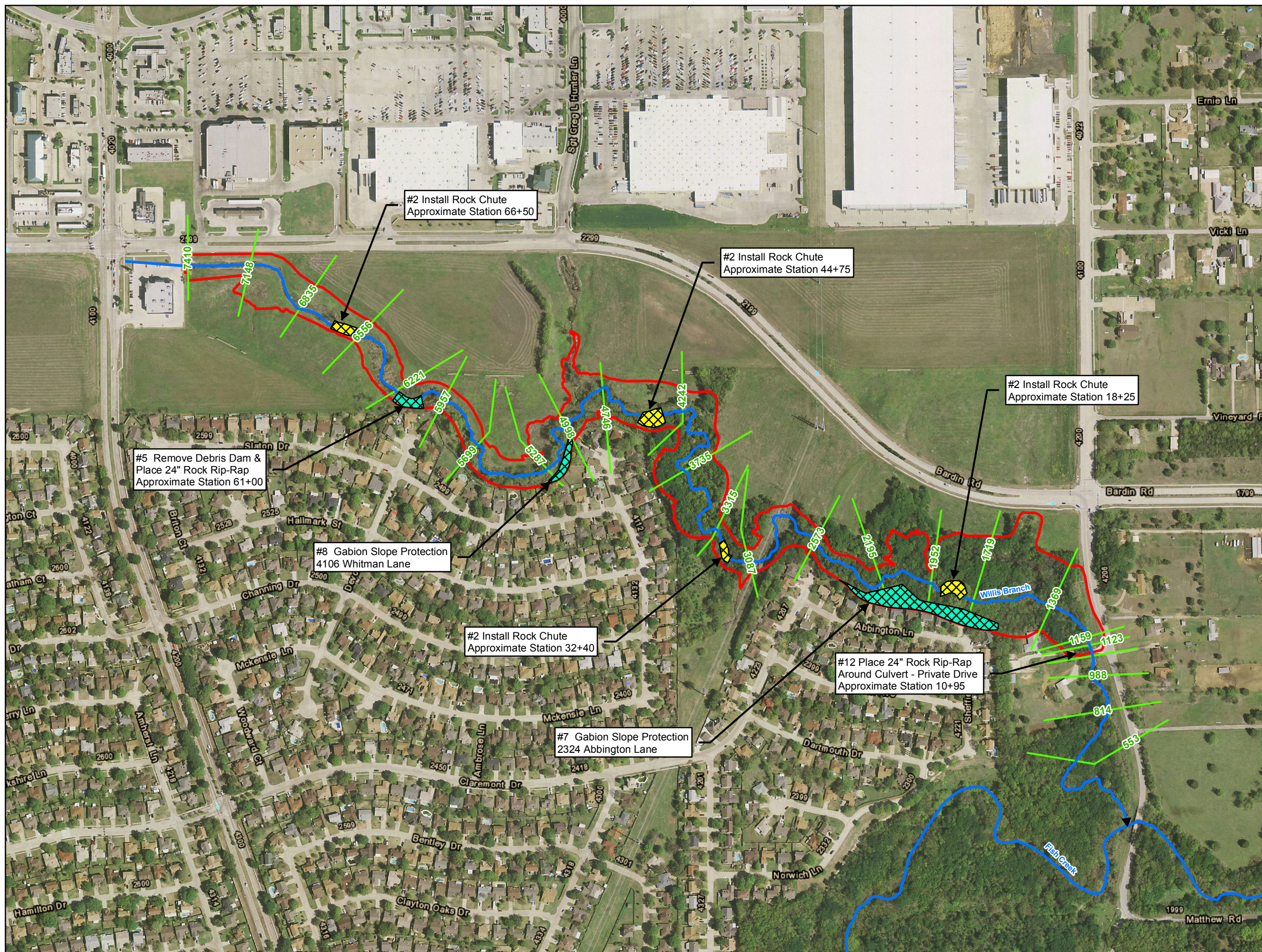
1 inch = 400 feet

CIP Workmap
WILLIS BRANCH

Legend

CIP Alternative

-  Bank Stabilization
-  Grade Stabilization
-  Channel Improvement
-  Roadway Improvement
-  Erosion Hazard Setback
-  Cross Section
-  Stream Centerline



0 200 400 800 Feet

1 inch = 400 feet

Appendix B

Hydrologic and Hydraulic Data

Hydrologic Parameters

Appendix B - Hydrologic Parameter Data

HEC-HMS Basin Name (1)	Area (ac) (2)	Area (mi ²) (3)	**Lag Time		% Soil Type A (6)	% Soil Type B (7)	% Soil Type C (8)	% Soil Type D (9)	Composite CN (10)	*Initial Abstraction (11)	% Impervious	
			Exist (min) (4)	Ultimate (min) (5)							Existing (12)	Ultimate (13)
Garden Branch												
0.801												
B_GAR_01	52	0.082	8	4	0	0	0	0	80	0.50	69	85
B_GAR_02	12	0.018	6	3	0	0	0	0	80	0.50	85	85
B_GAR_03	103	0.161	15	15	0	0	0	0	80	0.50	52	61
B_GAR_04	64	0.100	20	11	0	0	0	0	80	0.50	33	73
B_GAR_05	61	0.096	16	7	0	0	0	0	80	0.50	66	73
B_GAR_06	171	0.267	15	15	0	0	0	0	80	0.50	47	61
B_GAR_07	49	0.077	14	14	0	34	15	51	73	0.74	21	35
Kirby Creek												
3.384												
AP-1	33	0.052	-----	10	0.0	0.0	0.0	100.0	80	0.50	-----	7
AP-2	34	0.054	-----	20	0.0	0.0	0.0	100.0	80	0.50	-----	54
AP-3	16	0.025	-----	19	0.0	0.0	0.0	100.0	80	0.50	-----	31
AP-4	20	0.032	-----	6	0.0	0.0	0.0	100.0	80	0.50	-----	90
DA-1	43	0.067	-----	7	0.0	0.0	0.0	100.0	80	0.50	-----	90
DA-2	10	0.015	-----	7	0.0	0.0	0.0	100.0	80	0.50	-----	90
DA-3	48	0.075	-----	37	0.0	0.0	0.0	100.0	80	0.50	-----	12
KC-2	180	0.282	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	43
KC-3	97	0.152	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	34
KC-4	152	0.238	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	49
KC-5	159	0.249	-----	9	0.0	4.0	0.0	96.0	80	0.50	-----	62
KC-6	77	0.121	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	59
KC-7A	123	0.192	-----	9	0.0	0.0	0.0	100.0	80	0.50	-----	60
KC-7B	22	0.035	-----	5	0.0	0.0	0.0	100.0	80	0.50	-----	35
KC-8	69	0.108	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	32
KC-9a	86	0.134	-----	9	0.0	0.0	0.0	100.0	80	0.50	-----	34
KC-9b	37	0.058	-----	8	0.0	0.0	0.0	100.0	80	0.50	-----	34
KC-10A	228	0.357	-----	8	-----	-----	-----	-----	78	0.56	-----	51
KC-10B	128	0.200	-----	11	-----	-----	-----	-----	77	0.60	-----	35
KC-11	218	0.341	-----	13	0.0	0.0	0.0	100.0	80	0.50	-----	42
KC-12	134	0.209	-----	11	-----	-----	-----	-----	74	0.70	-----	35
KC-13	71	0.111	-----	7	-----	-----	-----	-----	62	1.23	-----	31
KC-14	35	0.055	-----	10	0.0	100.0	0.0	0.0	61	1.28	-----	20
TV-1	61	0.096	-----	7	0.0	0.0	0.0	100.0	80	0.50	-----	95
TV-2	30	0.047	-----	6	0.0	0.0	0.0	100.0	80	0.50	-----	95
TV-3	22	0.034	-----	6	0.0	0.0	0.0	100.0	80	0.50	-----	95
TV-4	29	0.046	-----	7	0.0	0.0	0.0	100.0	80	0.50	-----	95
Willis Branch												
0.723												
B_WIL_01	141	0.220	17	17	0.0	0.2	7.6	92.2	80	0.50	68	84
B_WIL_02	171	0.267	24	23	0.0	3.7	0.0	96.3	79	0.53	59	80
B_WIL_03	33	0.051	21	21	0.0	2.6	0.0	97.4	80	0.50	55	60
B_WIL_04	119	0.185	13	13	0.0	34.7	3.5	61.8	73	0.74	38	77

Times of Concentration Spreadsheets

TR 55 Existing Lag Time Calculations for Garden Branch

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow					Channel Flow				Total Time of Conc. (hr) (17)	Total Lag Time (hr) (18)	Total Lag Time (min) (19)	Time Step (min) (19)						
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T _O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T _S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Velocity (ft/s) (14)					Flow Type (15)	T _h (hr) (16)				
Garden Basins																										
GAR-01	1717	100	0.0205	Short Grass	0.19	0.15	0.146	288	0.0237	Paved	3.13	20.3	0.026	1329	0.0084	6.00	Stormdrain	0.062								
							T_O Total 0.146						T_S Total 0.026				T_C Total 0.062	0.233	0.140	8					2.4	
GAR-02	1094	100	0.0337	Short Grass	0.23	0.15	0.119	108	0.0081	Paved	1.83	20.3	0.016	886	0.0167	6.00	Stormdrain	0.041								
							T_O Total 0.119						T_S Total 0.016				T_C Total 0.041	0.177	0.106	6					1.8	
GAR-03	4036	71	0.0077	Short Grass	0.12	0.15	0.164	426	0.0048	Paved	1.41	20.3	0.084	3539	0.0053	6.00	Stormdrain	0.164								
							T_O Total 0.164						T_S Total 0.084				T_C Total 0.164	0.412	0.247	15					4.3	
GAR-04	2604	100	0.0050	Short Grass	0.11	0.15	0.256	732	0.0060	Unpaved	1.25	16.1	0.163	1302	0.0143	6.00	Stormdrain	0.060								
								470	0.0059	Paved	1.56	20.3	0.084													
							T_O Total 0.256						T_S Total 0.247				T_C Total 0.060	0.563	0.338	20					5.9	
GAR-05	3489	100	0.0048	Short Grass	0.11	0.15	0.260	48	0.0061	Unpaved	1.26	16.1	0.011	3243	0.0104	6.00	Stormdrain	0.150								
								98	0.0101	Paved	2.04	20.3	0.013													
							T_O Total 0.260						T_S Total 0.024				T_C Total 0.150	0.434	0.261	16					4.5	
GAR-06	4881	100	0.0532	Short Grass	0.28	0.15	0.099	95	0.0217	Unpaved	2.37	16.1	0.011	1980	0.0117	6.00	Stormdrain	0.092								
								828	0.0085	Paved	1.87	20.3	0.123	67	0.1232	8.37	Open Channel	0.002								
														1811	0.0048	5.08	Main Channel	0.099								
							T_O Total 0.099						T_S Total 0.134				T_C Total 0.193	0.426	0.256	15					4.5	
GAR-07	4724	100	0.0522	Short Grass	0.28	0.15	0.100	158	0.0372	Unpaved	3.11	16.1	0.014	363	0.0524	6.00	Stormdrain	0.017								
								497	0.0108	Paved	2.11	20.3	0.065	3606	0.0068	5.11	Main Channel	0.196								
							T_O Total 0.100						T_S Total 0.080				T_C Total 0.213	0.393	0.236	14					4.1	

Notes:
 (1) GeoHMS Longest Flowpath
 (2) Overland flow length (Maximum allowed in WinTR55 is 100 ft.)
 (3) Slope of the ground
 (4) WinTR55 surface type
 (5) WinTR55 Manning's n
 (6) WinTR55 Overland time of concentration: $T_O = 0.42(nL)^{0.8} / (3.95^{0.5} S^{0.4} 60)$
 (7) Shallow concentrated flow length
 (8) Slope of the ground
 (9) WinTR55 surface type
 (10) 16.1 for unpaved and 20.3 for paved soil cover
 (11) WinTR55 Shallow Concentrated time of concentration: $T_S = L / (60^2 K S^{0.5})$
 (12) Channelized flow length
 (13) Slope of the ground
 (14) Channel velocity taken from HECRAS model for main channel flow and Flowmaster was used to approximate velocities for open channel flow. Assumed 6 ft/s for all storm drains
 (15) Type of channel flow
 (16) Channelized time of concentration = Channel Length/Channel Velocity/3600
 (17) Total time of concentration: $T_C = T_O + T_S + T_h$
 (18) Total lag time: $T_L = 0.6 T_C$
 (19) Time Step : $T = 0.29 T_L$

TR 55 Existing Lag Time Calculations for Willis Branch

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow					Channel Flow					Total Time of Conc. (hr) (17)	Total Lag Time (hr) (18)	Total Lag Time (min) (19)	Time Step (min) (19)				
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T _O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T _S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Velocity (f/s) (14)	Flow Type (15)					T _h (hr) (16)			
Willis Basins																									
WIL-01	2510	100	0.019	Short Grass	0.18	0.15	0.152																		
							T_O Total				T_S Total							T_C Total		0.484	0.290	17			
WIL-02	1281	100	0.003	Short Grass	0.09	0.15	0.306	591	0.0109	Unpaved	1.68	16.1	0.098	590	0.0124	6.00	Stormdrain	0.027							5.1
														520	0.0071	3.37	Open Channel	0.043							
														1465	0.0109	6.00	Stormdrain	0.068							
														687	0.0143	5.89	Open Channel	0.032							
														1775	0.0083	5.38	Main Channel	0.092							
							T_O Total				T_S Total							T_C Total		0.666	0.399	24			6.9
WIL-03	827	100	0.009	Short Grass	0.14	0.15	0.204	186	0.0144	Unpaved	1.93	16.1	0.027	541	0.0149	6.00	Stormdrain	0.025							
								1565	0.0049	Paved	1.42	20.3	0.306	499	0.0395	8.96	Open Channel	0.015							
							T_O Total				T_S Total							T_C Total		0.577	0.346	21			6.0
WIL-04	2287	100	0.046	Short Grass	0.26	0.15	0.106	62	0.0190	Paved	2.80	20.3	0.006	2125	0.0158	6.00	Stormdrain	0.098							
														414	0.0336	6.01	Open Channel	0.019							
														1968	0.0079	4.23	Main Channel	0.129							
							T_O Total				T_S Total							T_C Total		0.359	0.215	13			3.7

Notes:

- (1) GeoHMS Longest Flowpath
- (2) Overland flow length (Maximum allowed in WinTR55 is 100 ft.)
- (3) Slope of the ground
- (4) WinTR55 surface type
- (5) WinTR55 Manning's n
- (6) WinTR55 Overland time of concentration: $T_o=0.42(nL)^{0.8}/(3.95^{0.5}S^{0.4}60)$
- (7) Shallow concentrated flow length
- (8) Slope of the ground
- (9) WinTR55 surface type
- (10) 16.1 for unpaved and 20.3 for paved soil cover
- (11) WinTR55 Shallow Concentrated time of concentration: $T_s=L/(60^2KS^{0.5})$
- (12) Channelized flow length
- (13) Slope of the ground
- (14) Channel velocity taken from HECRAS model for main channel flow and Flowmaster was used to approximate velocities for open channel flow. Assumed 6 ft/s for all storm drains
- (15) Type of channel flow
- (16) Channelized time of concentration = Channel Length/Channel Velocity/3600
- (17) Total time of concentration: $T_c=T_o+T_s+T_h$
- (18) Total lag time: $T_l=0.6T_c$
- (19) Time Step : $T=0.29T_l$

TR 55 Ultimate Lag Time Calculations for Garden Branch

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow						Channel Flow				Total Time of Conc. (hr) (17)	Total Lag Time (hr) (18)	Total Lag Time (min) (19)	Time Step (min) (19)							
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T _O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T _S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Channel Velocity (f/s) (14)	Flow Type (15)					T _b (hr) (16)						
GAR-01	1717	50	0.0205	Smooth Surface	1.34	0.011	0.010	338	0.0237	Paved	3.13	20.3	0.030	1329	0.0084	6.00	Stormdrain	0.062										
							T_O Total 0.010					T_S Total 0.030					T_C Total 0.062	0.102	0.061	4								
GAR-02	1094	50	0.0337	Smooth Surface	1.64	0.011	0.008	158	0.0081	Paved	1.83	20.3	0.024	886	0.0167	6.00	Stormdrain	0.041										
							T_O Total 0.008					T_S Total 0.024					T_C Total 0.041	0.074	0.044	3								
GAR-03	4036	71	0.0077	Short Grass	0.12	0.15	0.164	426	0.0048	Paved	1.41	20.3	0.084	3539	0.0053	6.00	Stormdrain	0.164										
							T_O Total 0.164					T_S Total 0.084					T_C Total 0.164	0.412	0.247	15								
GAR-04	2604	50	0.0050	Smooth Surface	0.76	0.011	0.018	782	0.0060	Paved	1.57	20.3	0.138	1302	0.0143	6.00	Stormdrain	0.060										
							T_O Total 0.018					T_S Total 0.222					T_C Total 0.060	0.300	0.180	11								
GAR-05	3489	50	0.0048	Smooth Surface	0.75	0.011	0.018	98	0.0061	Paved	1.59	20.3	0.017	3243	0.0104	6.00	Stormdrain	0.150										
							T_O Total 0.018					T_S Total 0.031					T_C Total 0.150	0.199	0.119	7								
GAR-06	4881	100	0.0532	Short Grass	0.28	0.15	0.099	95	0.0217	Paved	2.99	20.3	0.009	1980	0.0117	6.00	Stormdrain	0.092										
							T_O Total 0.099					T_S Total 0.132					T_C Total 0.193	0.424	0.254	15								
GAR-07	4724	100	0.0522	Short Grass	0.28	0.15	0.100	158	0.0372	Paved	3.92	20.3	0.011	363	0.0524	6.00	Stormdrain	0.017										
							T_O Total 0.100					T_S Total 0.077					T_C Total 0.213	0.390	0.234	14								

Notes:
 (1) GeoHMS Longest Flowpath
 (2) Overland flow length (Maximum allowed in WinTR55 is 100 ft.)
 (3) Slope of the ground
 (4) WinTR55 surface type
 (5) WinTR55 Manning's n
 (6) WinTR55 Overland time of concentration: $T_o = 0.42(nL)^{0.8} / (3.95^{0.5} S^{0.4} 60)$
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 (11) WinTR55 Shallow Concentrated time of concentration: $T_s = L / (60^2 K S^{0.5})$
 (12) Channelized flow length
 (13) Slope of the ground
 (14) Channel velocity taken from HECRAS model for main channel flow and Flowmaster was used to approximate velocities for open channel flow. Assumed 6 ft/s for all storm drains
 (15) Type of channel flow
 (16) Channelized time of concentration = Channel Length/Channel Velocity/3600
 (17) Total time of concentration: $T_c = T_o + T_s + T_b$
 (18) Total lag time: $T_l = 0.6 T_c$
 (19) Time Step : $T = 0.29 T_l$

TR 55 Ultimate Lag Time Calculations for Willis Branch

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow						Channel Flow					Total Time of Conc. (hr) (17)	Total Lag Time (hr) (18)	Total Lag Time (min) (19)	Time Step (min) (19)				
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s) (5)	Manning's n (6)	T _O (hr) (7)	Length (ft) (8)	Slope (ft/ft) (9)	Surface Type (10)	Velocity (ft/s) (11)	K (12)	T _S (hr) (13)	Length (ft) (14)	Slope (ft/ft) (15)	Channel Velocity (ft/s) (16)	Flow Type (17)	T _h (hr) (18)								
Willis Basins																										
WIL-01	2510	100	0.019	Short Grass	0.18	0.15	0.152																			
							T_O Total																			
							0.152																			

Technical Release 55, Table 2-2c

Table 2-2c Runoff curve numbers for other agricultural lands ^{1/}

Cover type	Cover description	Hydrologic condition	Curve numbers for hydrologic soil group			
			A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. ^{2/}		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.		—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. ^{3/}		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 ^{4/}	48	65	73
Woods—grass combination (orchard or tree farm). ^{5/}		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods. ^{6/}		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30 ^{4/}	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.		—	59	74	82	86

^{1/} Average runoff condition, and $I_a = 0.2S$.

^{2/} *Poor*: <50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: > 75% ground cover and lightly or only occasionally grazed.

^{3/} *Poor*: <50% ground cover.

Fair: 50 to 75% ground cover.

Good: >75% ground cover.

^{4/} Actual curve number is less than 30; use CN = 30 for runoff computations.

^{5/} CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

^{6/} *Poor*: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

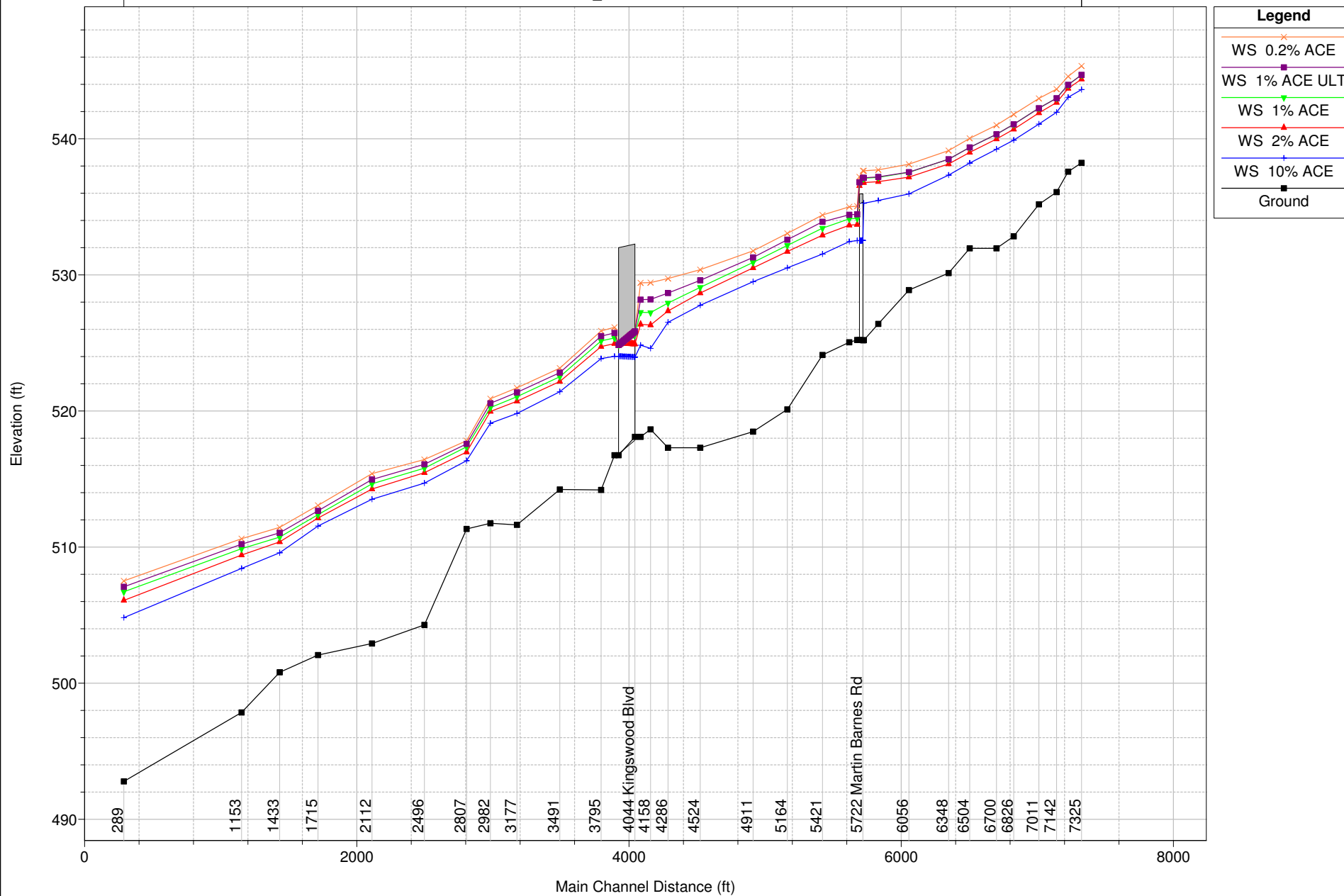
Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Profiles

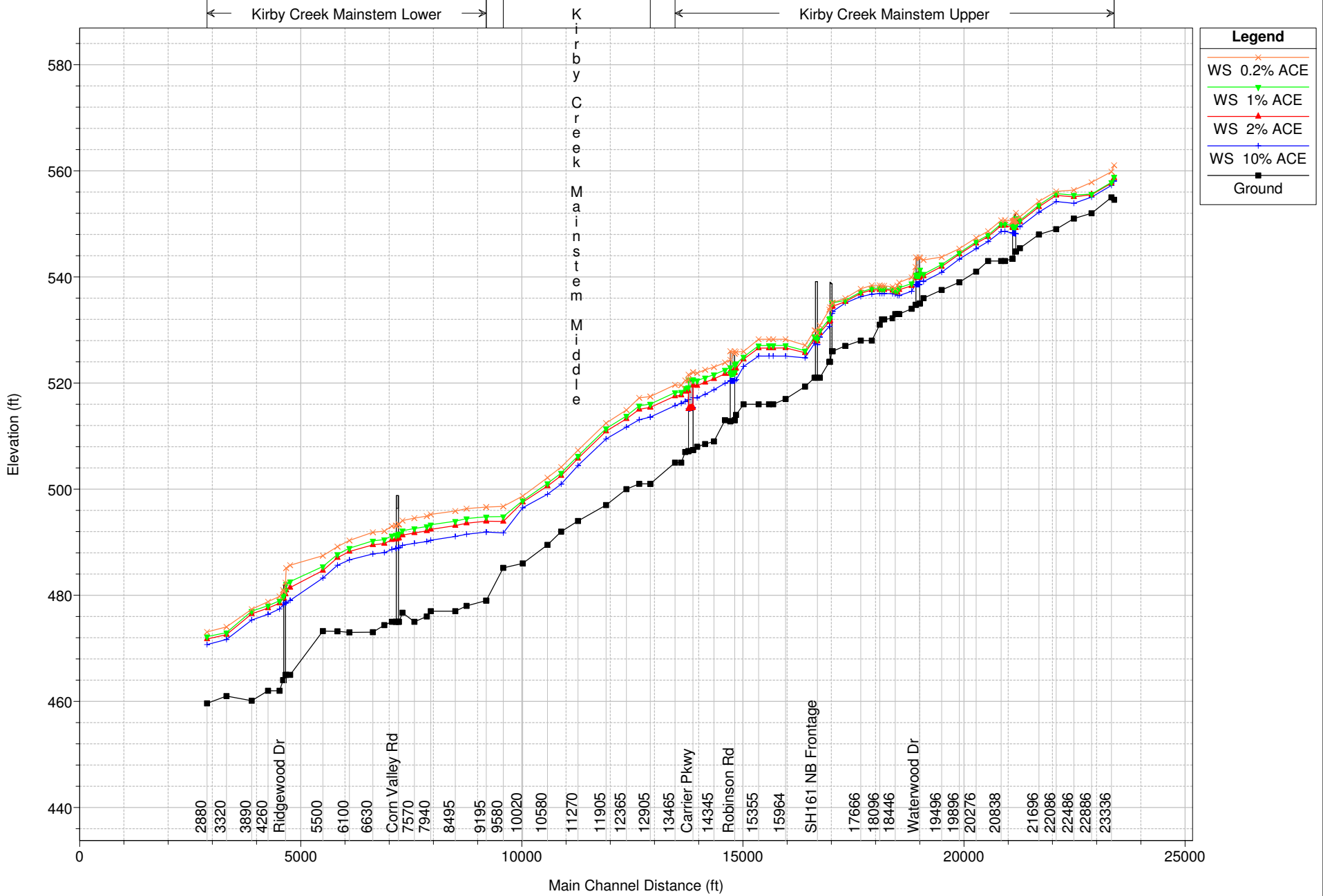
Garden_Branch_Final

Garden_Branch 1

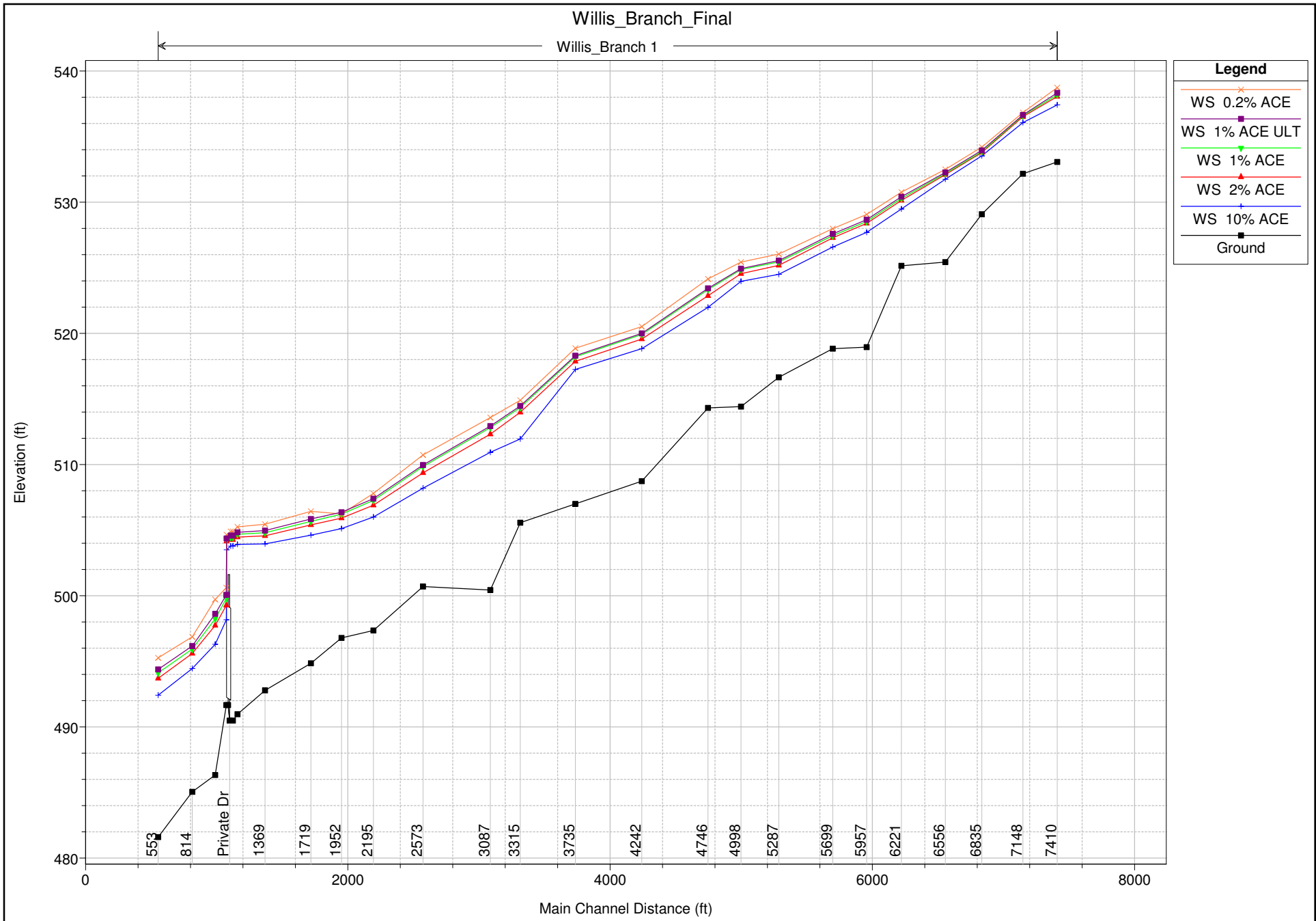


1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

Kirby_Creek_Final



1 in Horiz. = 3000 ft 1 in Vert. = 25 ft



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

Appendix C

Geomorphic Stream Assessment



Innovative approaches
Practical results
Outstanding service



Garden Branch Stream Condition Assessment

Prepared for:

City of Grand Prairie

August 6, 2012

Prepared by:

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HAF12272



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Appendix A – Representative Photographs from Garden Branch

Appendix B – Field Assessment Sketches

Appendix C – Areas of Interest Location Map

Appendix D – Channel Erosion Rating Location Map

ATTACHMENT

Attachment 1 – DVD with digital photographs, GPS tagged and image direction shapefile.

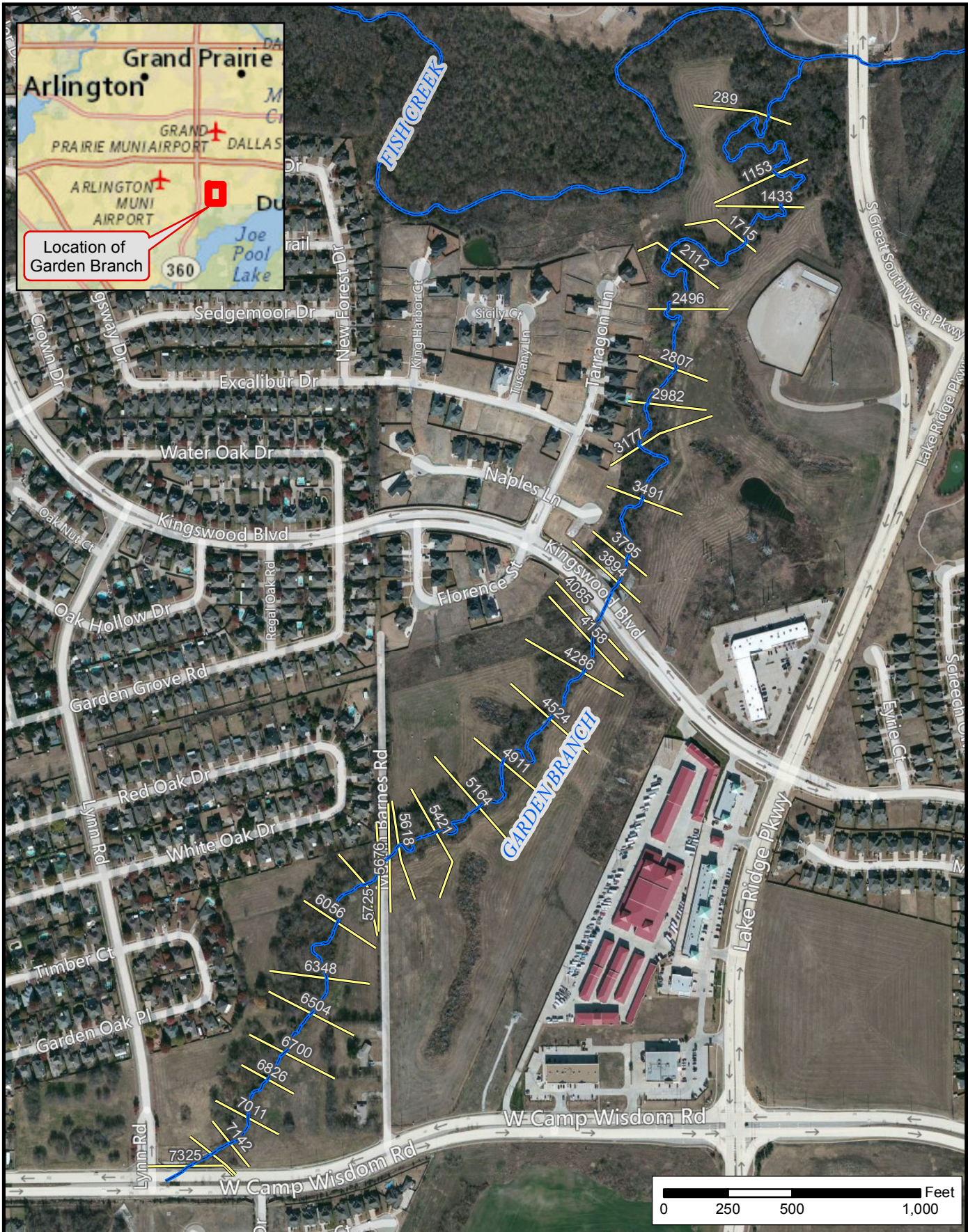
EXECUTIVE SUMMARY

Bed	Upstream of Kingswood Boulevard, the channel bed and banks of Garden Branch were composed of soil and Quaternary Alluvium deposits of gravel, sand, silt and clay. Downstream of Kingswood Boulevard, the channel of Garden Branch had downcut into the Eagle Ford Shale, and shale outcrops were periodically exposed on the channel bed. Gravel-size particles of shale were present in the alluvial deposits on the channel bed downstream of Kingswood Boulevard.
Bed Stability	Knickpoints were observed at three locations in Garden Branch. Knickpoints suggest channel instability. Table 4.1 provides locations and descriptions of the knickpoints observed in Garden Branch during the stream condition assessment. It is recommended that the knickpoints be stabilized to decrease future channel degradation and/or monitored (surveyed) to identify actual migration rates in order to prioritize stabilization efforts. The channel was stable between Camp Wisdom Road and Martin Barnes Road. The downstream segments of Garden Branch appeared to be downcutting to reach the base level of Fish Creek. The concrete low-water crossing near cross section 2496 was halting headward channel incision, but may become unstable in the future due to local scour and undercutting of the structure.
Banks	The alluvial soils that formed the channel banks of Garden Branch consisted of clay, silty clay, and clay loam soils mapped as the Ferris Clay, Frio Silty Clay, and Sunev Clay Loam by the Natural Resources Conservation Service (NRCS). Downstream of Kingswood Boulevard, shale of the Eagle Ford formation was exposed in some banks.
Bank Stability	The majority of the channel of Garden Branch was stable. The most unstable areas were noted in areas where channel hydraulics were affected by existing infrastructure (bridges, culverts, and a low-water crossing). These locations showed severe erosion, exposed tree roots, and were threatening infrastructure. In areas where the Eagle Ford Shale was exposed in the channel banks, the shale was undergoing slaking. The slaked shale is susceptible to severe erosion. Bank failures in the form of slumps were noted downstream of the concrete low-water crossing near cross section 2496. Along with bank scour, this appeared to be a primary mode of channel widening.
Channel Evolution	The Garden Branch study reach has been disturbed by increased development in the watershed that started in the 1990's. The channel has downcut and widened downstream of the concrete low-water crossing near cross section 2496. This appears to be the result of channel incision to reach the base level elevation of Fish Creek. The channel of Garden Branch was stable between Camp Wisdom Road and Martin Barnes Road. If flows increase due to future watershed disturbances, it can be expected that the channel of Garden Branch will respond with increased instability.

1.0 INTRODUCTION

Fluvial Geomorphology is the study of river related landforms. It investigates how the complex behaviors of streams respond to land use change in a watershed. This dynamic relationship determines the shape of a stream channel. Fluvial Geomorphologists are trained to identify how a stream channel will adjust its physical characteristics in response to land use changes; and consequently, how these adjustments will affect the physical stream system, habitat availability/function, and infrastructure.

On June 4, 2012, FNI Hydrologists/Fluvial Geomorphologists performed a stream condition assessment on the channel of Garden Branch in the City of Grand Prairie (Figure 1.1). The City of Grand Prairie selected this assessment study area to evaluate and document the locations of erosive conditions, channel instability issues, and potential erosion threats to private property and infrastructure adjacent to the channel. Existing conditions of Garden Branch were observed and recorded. This report documents the data collected during the field visit, locations of erosive channel conditions, and channel instabilities. The locations may be considered for channel protection, stabilization, and improvement projects.



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**City of Grand Prairie
 Garden Branch Stream Condition Assessment**

Location Map

FN JOB NO	HAF12272
FILE	location.mxd
DATE	July 06 2012
SCALE	1:6,246
DESIGNED	SVC
DRAFTED	DKC

**1.1
 FIGURE**

2.0 FIELD ASSESSMENT METHODOLOGY

The stream condition assessment entailed a walking survey of the study reach of Garden Branch, making detailed field notes that included a visual summary of channel conditions and identification of definitive characteristics of channel erosion. For convenience in referencing locations, the study reach was divided into segments and numbered the same as the cross sections in the hydrologic and hydraulic model of Garden Branch (Halff Associates, 2012). Channel geometry was measured with a survey rod and digital range finder at each cross section. All locations were photographed with a GPS-enabled digital camera. Representative photographs are provided in Appendix A. All digital photographs contain a GPS tag and image direction and are included on a DVD as Attachment 1. The entire reach was sketched on an aerial photograph mapbook to capture the channel morphology. Copies of the sketches are provided in Appendix B. The geology of the reach was noted considering rock type, degree of weathering, and thickness of alluvial soils. Bank stability and degree of erosion were recorded. Bed and bank geomorphic processes were noted using the methodologies developed by Thorne, 1998; Montgomery and Buffington, 1998; Henshaw and Booth, 2000; Rosgen and Silvey, 1995; and Johnson et al., 1999. Streambank stability and bank erosion characteristics used in this evaluation are shown in Table 2.1. This fluvial geomorphologic study also included a review of the Channel Evolution Model (CEM) (Schumm, 1977) and the potential for change over time.

Table 2.1 Factors affecting stream bank stability**VARIABLES**

- Top width, bottom width, active channel depth and width
- Bed material, bedload size, and depositional features
- Knickpoints and log jams (drops in elevation)
- Gullies and tributaries
- Pools, runs, riffles, and glides
- Channel type (alluvium or rock) and height of soil or rock

STABLE

- Perennial vegetation to waterline
- No raw or undercut banks (some erosion on outside of meander bends OK)
- No recently exposed roots
- No recent tree falls

SLIGHTLY UNSTABLE

- Perennial vegetation to waterline in most places
- Some scalloping of banks
- Minor erosion and/or bank undercutting
- Recently exposed tree roots rare but present
- Minimal scour less than 50 percent of the bank

MODERATELY UNSTABLE

- Perennial vegetation to waterline sparse (mainly scoured or stripped by lateral erosion)
- Bank held by hard points (trees, boulders) and eroded back elsewhere
- Extensive erosion and bank undercutting
- Recently exposed tree roots and fine root hairs common
- Moderate erosion scour from 50 to 75 percent of the bank

SEVERELY UNSTABLE

- No perennial vegetation at waterline
- Banks held by hard points
- Banks are near vertical
- Recently exposed tree roots common
- Tree falls and/or severely undercut banks common
- High erosion greater than 75 percent of the active channel is scoured

3.0 WATERSHED CHARACTERISTICS

The following sections describe the existing conditions of the study area including the geographic setting, climate, topography, geology and soils, and channel morphology. The information was developed from a desktop analysis of available data including topographic maps, aerial photographs, soil survey reports, and geologic maps and reports. Additional information was obtained from the field investigation, where visual observations, photographs and field measurements were collected. Appendix C shows areas of concern and items of interest along the channel of the study reach on a 2011 aerial photograph. Appendix D shows the channel erosion rating given to the channel banks throughout the study reach on a 2011 aerial photograph.

3.1 GEOGRAPHIC SETTING

The stream condition assessment was conducted on the channel of Garden Branch in the City of Grand Prairie in Tarrant County, Texas (Figure 1.1). The study reach of Garden Branch is in the Fish Creek watershed. Garden Branch confluences with Fish Creek upstream of the Great Southwest Parkway bridge crossing on Fish Creek. The assessment reach extended from the Camp Wisdom Road bridge crossing downstream to the confluence with Fish Creek.

The Garden Branch watershed was mostly developed and land use types included agriculture, single family residential, and industrial. The watershed of Garden Branch contains agricultural lands which are adjacent to the channel along the entire study reach. Land use in the watershed was primarily agriculture until development started in the 1990's. Development has continued until present. See section 4.1 for Historical Watershed Development.

3.2 CLIMATE

The study reach of Garden Branch occupies the extreme northern part of the humid subtropical belt which extends inland from the Gulf of Mexico. Average annual temperatures range from 52°F to 77°F. Annual precipitation averages 36 inches. Rainfall in October to March is triggered by southward moving continental polar fronts, which produce low intensity, long duration storms (National Weather Service, 2012). The most common storms in April to September are thunderstorms which are responsible for most of the serious flooding (100- year peak flows) in small watersheds (1-10 square miles).

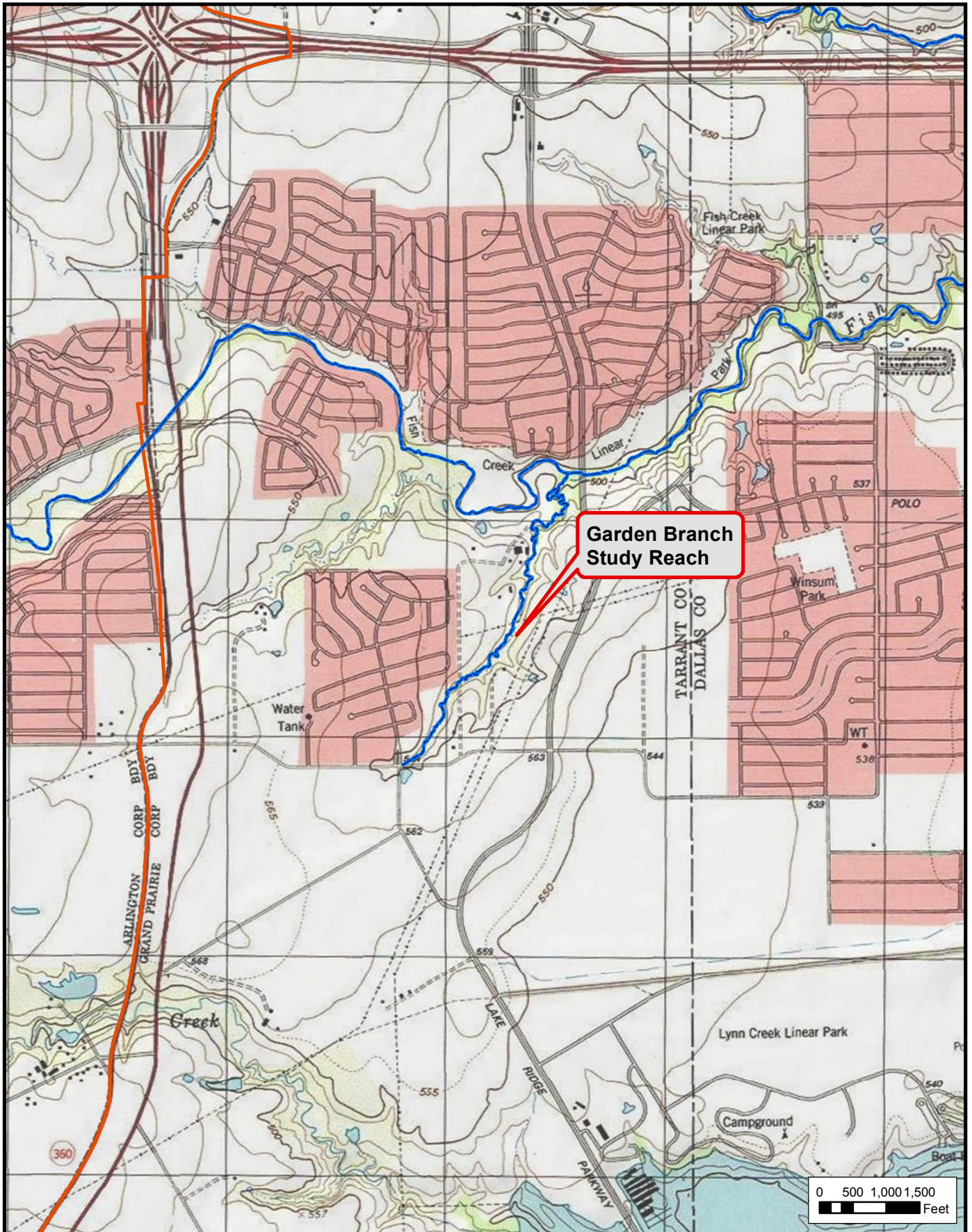
3.3 TOPOGRAPHY

Elevations in the Garden Branch study area ranged from 540 feet (ft.) above mean sea level (msl) to 490 ft. msl (Figure 3.1). The average study reach channel slope was 0.007 ft./ft. The drainage area of Garden Branch upstream of the confluence with Fish Creek was approximately 0.6 square mile.

3.4 GEOLOGY AND SOILS

The study area is located in the Blackland Prairie physiographic subprovince of the Texas Gulf Coastal Plain. The Blackland Prairie is underlain by Cretaceous age limestones, shales, and sandstones, which dip gently to the southeast at 0.54 degrees (Allen and Flannigan, 1985). Stream valleys contain Quaternary Alluvium deposits (Figure 3.2). Upstream of Kingswood Boulevard, the channel bed and banks of Garden Branch were composed of soil and Quaternary Alluvium deposits of gravel, sand, silt and clay. Downstream of Kingswood Boulevard, the channel of Garden Branch had downcut into the Eagle Ford Shale, and shale outcrops were periodically exposed on the channel bed and lower banks. The shale was undergoing slaking, making it susceptible to severe erosion. Gravel-size particles of shale were present in the alluvial deposits on the channel bed downstream of Kingswood Boulevard. The Eagle Ford is a shale formation that consists largely of fissile, dark gray calcareous to noncalcareous clay with thin limestone beds and ashy bentonite seams in the lower unit (Bureau of Economic Geology, 1988).

The alluvial soils that formed the channel banks of Garden Branch consisted of clay, silty clay, and clay loam soils mapped as the Ferris Clay, Frio Silty Clay, and Sunev Clay Loam by the Natural Resources Conservation Service (NRCS) (Figure 3.3). These soils formed in weakly consolidated calcareous marine shales and clays. They are characterized as well drained with moderate to slow permeability and high available water capacity. Runoff in these areas is rapid, and the Ferris Clay has is highly erodible. The hazard of surface erosion of the Frio and Sunev is slight and moderate, respectively.



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Topographic Map

FN JOB NO	HAF12272
FILE	topo.mxd
DATE	July 06 2012
SCALE	1:24,000
DESIGNED	SVC
DRAFTED	DKC

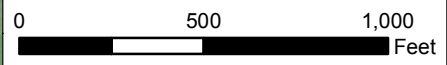
3.1

FIGURE



Geology

- Terrace deposits
- Eagle Ford Formation



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Geologic Map

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FILE	geology.mxd
DATE	July 06 2012
SCALE	1:6,246
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3.2
FIGURE



Soils	
	FERRIS CLAY, 5 TO 12 PERCENT SLOPES, ERODED
	FRIO SILTY CLAY, FREQUENTLY FLOODED
	SUNEV CLAY LOAM, 1 TO 3 PERCENT SLOPES
	SUNEV CLAY LOAM, 3 TO 8 PERCENT SLOPES



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Soils Map

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FILE	soils.mxd
DATE	July 06 2012
SCALE	1:6,246
DESIGNED	SVC
DRAFTED	DKC

3.3
FIGURE

3.5 STREAM MORPHOLOGY

The channel of Garden Branch had high sinuosity (ratio of channel length to valley length was 1.5), was slightly entrenched (ratio of flood-prone width to bankfull width greater than 2.2), and had a low width/depth ratio (less than 12).

Historical aerial photographs show that the channel of Garden Branch has been impacted by agricultural practices. In the 1950, little vegetative cover was present adjacent to the channel. Over time, a dense riparian corridor became established along the entire study reach, and it was present at the time of the field assessment. The riparian corridor also acts as a filter that removes sediment eroded by overland runoff from the surrounding agricultural fields. The majority of the study reach contained multiple geomorphic units including scour pools, pools, runs, riffles, bars, stable undercut banks, knickpoints, benches, and large woody debris. Segments of Garden Branch had floodplain connectivity, which allows flows to spread out and dissipate during high flow events.

Downstream of a large concrete low water crossing, the channel of Garden Branch became more deeply incised. It appeared that the channel was downcutting in response to the lower base level of Fish Creek. The over-steepened banks that resulted from the channel incision contained numerous bank failures. It appeared that the bank failures were the primary mode of channel widening. The channel meandered through this reach and had little to no floodplain connectivity.

4.0 RESULTS

4.1 HISTORICAL WATERSHED DEVELOPMENT

A historical aerial photograph analysis was performed to assess channel conditions prior to urban development. Historical aerial photographs from 1942, 1958, and 1964 were obtained from the Texas Natural Resources Information System (TNRIS). Historical aerial photographs from 2004, 2009, and 2011 were obtained from North Central Texas Council of Governments, Landiscor, and Bing, respectively. The following photographs are examples from the Garden Branch watersheds at 1:10,000 scale (Figures 4.1).

In 1942 (Figure 4.1), the surrounding land adjacent to Garden Branch was rural pasture land. The photograph shows a non-developed buffer containing the tributary channel. In 1996, the historical photograph showed development within the watershed. In 2011, the portion of the watershed immediately adjacent to the channel had remained agricultural. Since the 1940's Garden Branch has had a riparian corridor that has continued to mature.

Figure 4.1 Historical aerial photographs from 1942 and 2011



4.2 KNICKPOINT MIGRATION

As part of the stream condition assessment, knickpoints (headcuts) in the channel bed were identified. A knickpoint is a break in slope in the long profile of the stream which is marked by a sharp change in channel slope (drop in elevation) resulting in a waterfall. Figure 4.2 through Figure 4.4 show the knickpoints observed during the stream condition assessment of Garden Branch. Table 4.1 provides descriptions and locations of the knickpoints identified during the stream condition assessment. None of the knickpoints observed during the stream condition assessment were a direct threat to infrastructure. They indicated instability within the reach. Urban development in the watershed likely triggered the upstream migration of the knickpoints, as the stream downcut to adjust its slope to the increase in flow.

Figure 4.2 Looking downstream near cross section 6056 at a knickpoint with a 1.5-foot drop in elevation.



Figure 4.3 Looking downstream near cross section 3491 at a knickpoint with a 2-foot drop in elevation.



Figure 4.4 Looking downstream near cross section 1433 at a series of knickpoints. Total drop in elevation was 4 feet.



Table 4.1 Locations of knickpoints and movement

Knickpoint Location	Description and Movement
Between XS 6348 and 6056	The knickpoint had a total drop in elevation measuring approximately 1.5 feet. Field observations suggest minimal migration exposing tree roots.
Between XS 3491 and 3177	Near cross section 3491, there was a knickpoint with a two-foot drop in elevation. The location contained a debris jam. Field observations suggest that this knickpoint has the potential migrate upstream with higher flows. The second knickpoint was located approximately half way between cross section 3491 and 3177. The knickpoint had an approximately one-foot drop in elevation.
Downstream of XS 1433	There were two knickpoints spaced eight feet apart. The total drop in elevation measured about 4 feet. The knickpoints were directly downstream of a beaver dam. Observations suggested that beaver dams existed at the locations of the knickpoints, but were undercut as the knickpoint migrated upstream. Field observations also indicated active knickpoint migration at this location.

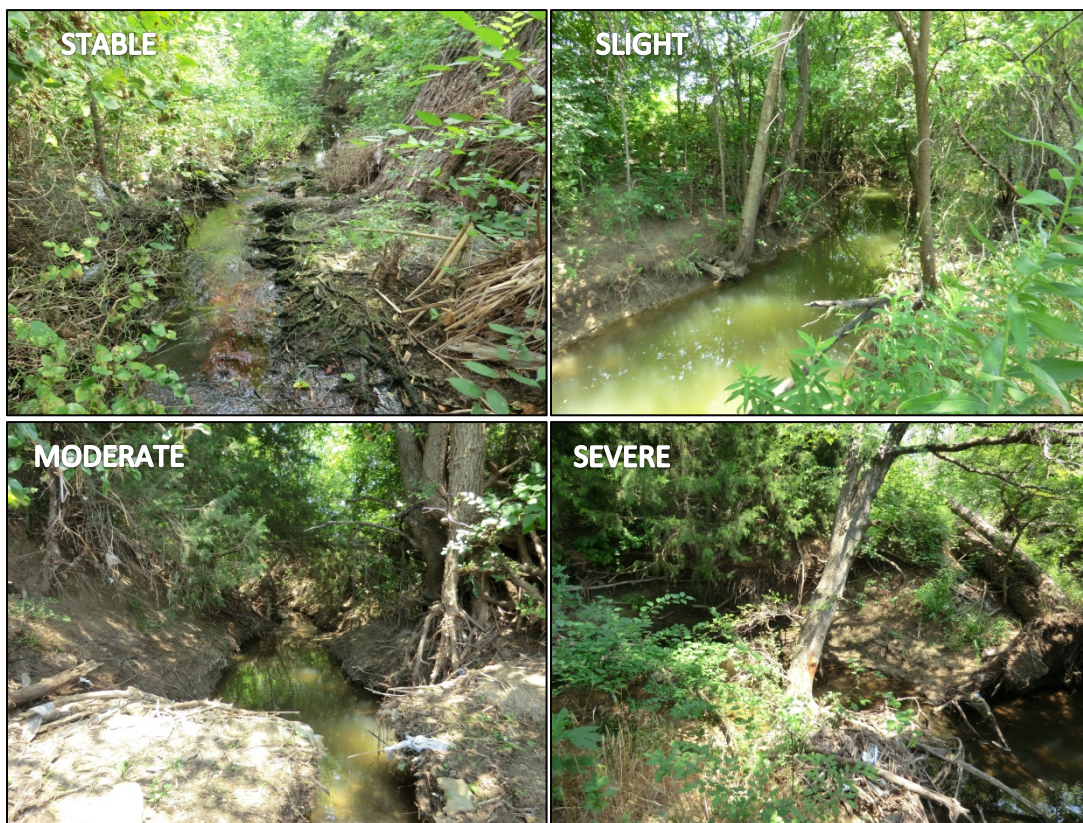
XS is the abbreviation for cross section. Cross section numbers reference the cross sections used in the HECRAS modeling.

4.3 CHANNEL EROSION AND INSTABILITY

The stream condition assessment documented the existing channel processes of bank erosion and channel instability. Channel segments were rated “stable”, “slight”, “moderate”, and “severe” using the criteria in Table 2.1. Examples are shown in Figure 4.5. In addition, the following channel processes were observed and recorded:

- bank undercutting by flowing water
- ratio of bankfull height to bank height (incised channel and steep bank angles)
- rooting depth
- channel scour and collapsed banks (failures)
- newly-fallen large woody debris
- human-induced alteration (retaining walls, culverts, and retention ponds)

Figure 4.5 Example of channel condition ranking



The following sections describe the erosion and instabilities observed in the study reach. Example photographs are provided. Please note that left and right bank views assume downstream direction. Garden Branch was a small channel set within a riparian buffer. The surrounding watershed was experiencing increased urban development. The majority of the channel ranked stable with short segments that ranked as having moderate and severe erosion. This section of the report highlights the moderate and severe erosion segments observed during the stream assessment. Appendix D illustrates the channel erosion ranking for Garden Branch. The channel of Garden Branch was stable between Camp Wisdom Road and Martin Barnes Road.

The first moderate erosion location was downstream of an outfall on the left bank near cross section 3491. The left bank was scoured by the erosive flows from the outfall. The bank lacked sufficient erosion control (Figure 4.6). The eroding bank was not threatening infrastructure, but was contributing sediment from erosion.

Figure 4.6 Looking upstream at bank erosion near cross section 3491



The first severe erosion location was near cross section 3177. The severe erosion was located on a meander bend downstream of an outfall. The combination of stream flow and flow from the outfall induced bank erosion. The bank was near-vertical with exposed roots and tree falls (Figure 4.7). The bank lacked sufficient erosion control. The eroding bank was not threatening infrastructure, but was contributing sediment from erosion.

Figure 4.7 Looking downstream at severe bend scour near cross section 3177



The second severe erosion location was near cross section 2496. This segment of channel contained a concrete low water crossing that protected a pipeline. The concrete crossing had a low flow outlet that was completely clogged. The blockage caused the water to pond upstream. Downstream of the concrete crossing the channel was severely scoured. The banks were collapsing, trees were falling, roots were exposed and the concrete structure was undermined from local scour (Figure 4.8). Water was flowing underneath the concrete structure.

Figure 4.8 Looking upstream at the undercut concrete crossing and severe erosion near cross section 2496



Specific areas of concern, severe instability, and items of interest observed during the Garden Branch field assessment are called out and described on a 2011 aerial photograph in Appendix C. Digital photographs representing each cross section location are shown in Appendix A. Copies of digital photographs taken during the field assessment along with image direction are provided on a DVD (Attachment 1). The areas experiencing channel erosion along the study reach are shown on a 2011 aerial photograph of the study area in Appendix D.

Processes of bank erosion and instability are important in the development and natural evolution of channel forms. The migration of a channel across floodplains involves a combination of bank erosion and deposition. Bank erosion however, can also create management problems when bridges, buildings and roads are undermined or destroyed. Excess sediment deposition can cause problems by filling channels and culverts with sediment, potentially increasing flood risk. Sediment that is not deposited in the channel may be carried downstream to a detention structure, reducing its total capacity over time.

Bank failures occur when bank material becomes unstable and falls or slides to the base of the bank. Several types of failures and different failure mechanisms were observed for cohesive bank materials. In addition, bank height, bank angle, moisture content, groundwater, vegetation, climatic cycles, and duration of stream flow affects bank stability.

In the study reach, slumps occurred in the soil material on the upper banks of the channels (Figure 4.9). In locations where soil material extended the entire bank height and the channel bed was comprised of clay, scouring of the base of the slope (channel toe) resulted in slumps. Slump failures can also result from high pore pressures related to floods and intense rain storms which can fill soil cracks and induce bank failure (Kuhn and Zornberg, 2006).

Note that bank stability is a complex process; geotechnical engineers should be consulted and a detailed geotechnical analysis should be conducted to provide data for any bank stabilization designs.

Figure 4.9 Looking downstream at a slump failure on the right bank downstream of the scoured concrete crossing near cross section 2496



4.4 CHANNEL FORMING FLOW

Research has shown that in many streams and rivers a single discharge can be used to estimate stable channel geometry (Copeland et al, 2000). This single representative discharge is known as the channel forming or effective discharge. The channel forming discharge has been defined as the flow that determines particular channel parameters, such as cross-sectional capacity (Wolman and Leopold, 1957) and performs most of the work, where work is defined in terms of sediment transport (Wolman and Miller, 1960). Theoretically, it is the discharge that if maintained indefinitely would produce the same channel geometry as the natural long-term hydrograph in an undisturbed watershed. The channel-forming discharge is a function of both the magnitude of the event and its frequency of occurrence (Wolman and Miller, 1960). Leopold and Wolman (1957) suggest that the channel forming discharge has an approximate return period between one and two years. In stable perennial alluvial channels, the channel-forming discharge typically reflects the 2-year frequency peak discharge (Thomas et al., 1996;

NRCS, 2007). Allen et al. (2002) suggest that the channel forming discharge in urbanized watersheds of the Dallas-Fort Worth area corresponds to a recurrence interval less than the 1.25-year frequency flow.

Based on field observations and review of the Garden Branch hydrologic and hydraulic model (Halff, 2012), the modeled 2-year peak discharge appeared to be greater than the channel forming flow for the majority of Garden Branch.

4.5 CHANNEL EVOLUTION

There is an important balance between the supply of bedload at the upstream end of a channel reach and the stream power available to transport it. This is known as Lane's Balance. Based on extensive field observations, E.W. Lane formulated a qualitative expression for stream equilibrium (Lane, 1955):

$$Q_w S \propto Q_s D_{50}$$

where Q_w is the water discharge (ft³/s), S is the channel slope (ft./ft.), Q_s is the bed material discharge (tons/day), and D_{50} is the average particle size (50 percent) of the bed material (inches).

An imbalance will occur if there is an increase in the volume of sediment load in relation to the available stream power. If the stream power is insufficient to transport all of the sediment in the reach, then the balance tips towards aggradation, with net deposition occurring along the reach. Aggradation occurs when sediment supply is increased by upstream channel erosion, mass movement, or human activities. Deposition in the channel may lead to the channel bed becoming elevated above the floodplain surface, and reduced channel capacity due to deposition increases flooding and promotes channel migration (Charlton, 2008).

If the water discharge is increased, over time the channel slope would increase by degrading. Harvey and Watson (1986) showed that channel evolution occurs as a result of increased discharge and can be assessed in terms of the Channel Evolution Model (CEM) (Schumm, 1977, Figure 4.10). The following is a synopsis of the channel evolution of Garden Branch.

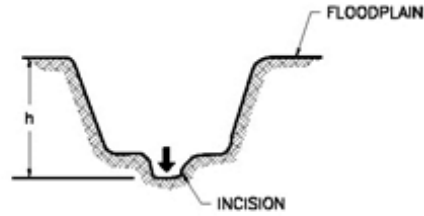
- Between Camp Wisdom Road and Martin Barnes Road, the channel was flowing through a stable (Stage I) segment with a riparian corridor.

- Martin Barnes Road to Kingswood Boulevard was relatively stable to slightly unstable. Much of the channel was significantly ponded by beaver dams. There were few areas that showed signs of slight incision (Stage I to II). Immediately downstream of Kingswood Boulevard the channel became incised and the channel banks were steep (Stage II). The channel continued to flow through a protected riparian buffer.
- Upstream of the concrete low water crossing near cross section 2496, the channel was channelized and ponded. Downstream of the concrete low water crossing the channel was incised and showed signs of widening (Stage II to III). Diagnostic indicators were undercut banks and bank failures. Meander bends were eroded and contained exposed shale (Figure 4.11). There were knickpoints located in this segments that suggested channel instability and active downcutting (Figure 4.12). Upstream of the confluence with Fish Creek the channel was very narrow and was likely lowering the channel bed to the lower bed elevation of Fish Creek.

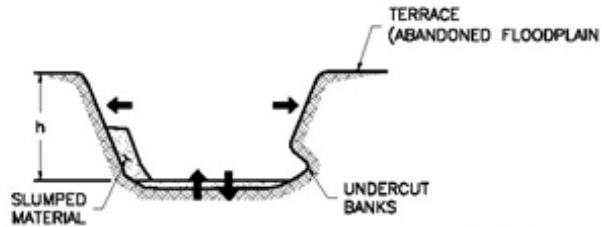
TYPE I ($h < h_c$)
CHANNELIZED



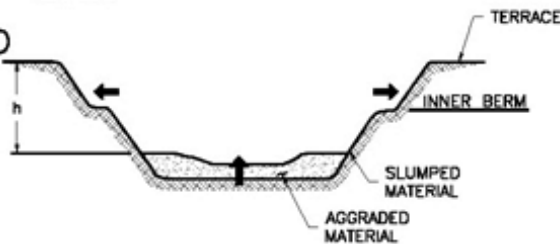
TYPE II ($h < h_c$)
DEGRADATION



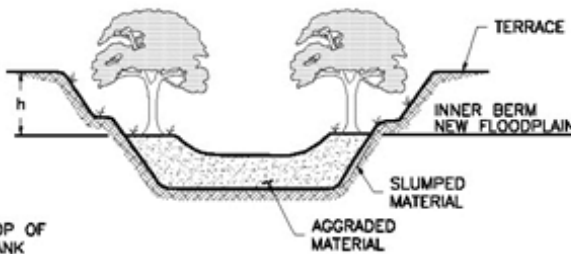
TYPE III ($h > h_c$)
WIDENING



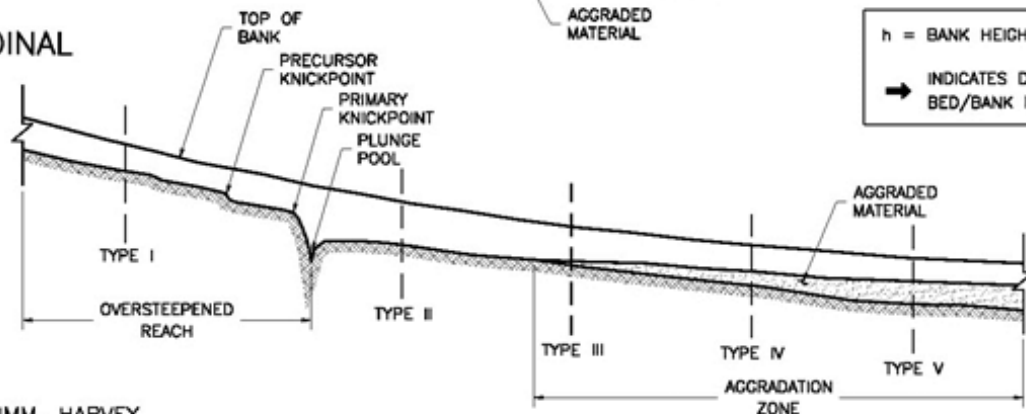
TYPE IV ($h > h_c$)
WIDENING AND
AGGRADATION



TYPE V ($h < h_c$)
DYNAMIC
EQUILIBRIUM



LONGITUDINAL
PROFILE



REFERENCE: SCHUMM, HARVEY
AND WATSON (1984)



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City of Grand Prairie
Garden Branch Stream Condition Assessment

Channel Evolution Model

FN JOB NO	HAF12272
FILE	CEM.mxd
DATE	July 24 2012
SCALE	1:0
DESIGNED	SVC
DRAFTED	DKC

4.10

FIGURE

Figure 4.11 Looking Upstream at exposed shale on a meander in Garden Branch



**Figure 4.12 Garden Branch was incised near cross section 289
(looking upstream)**

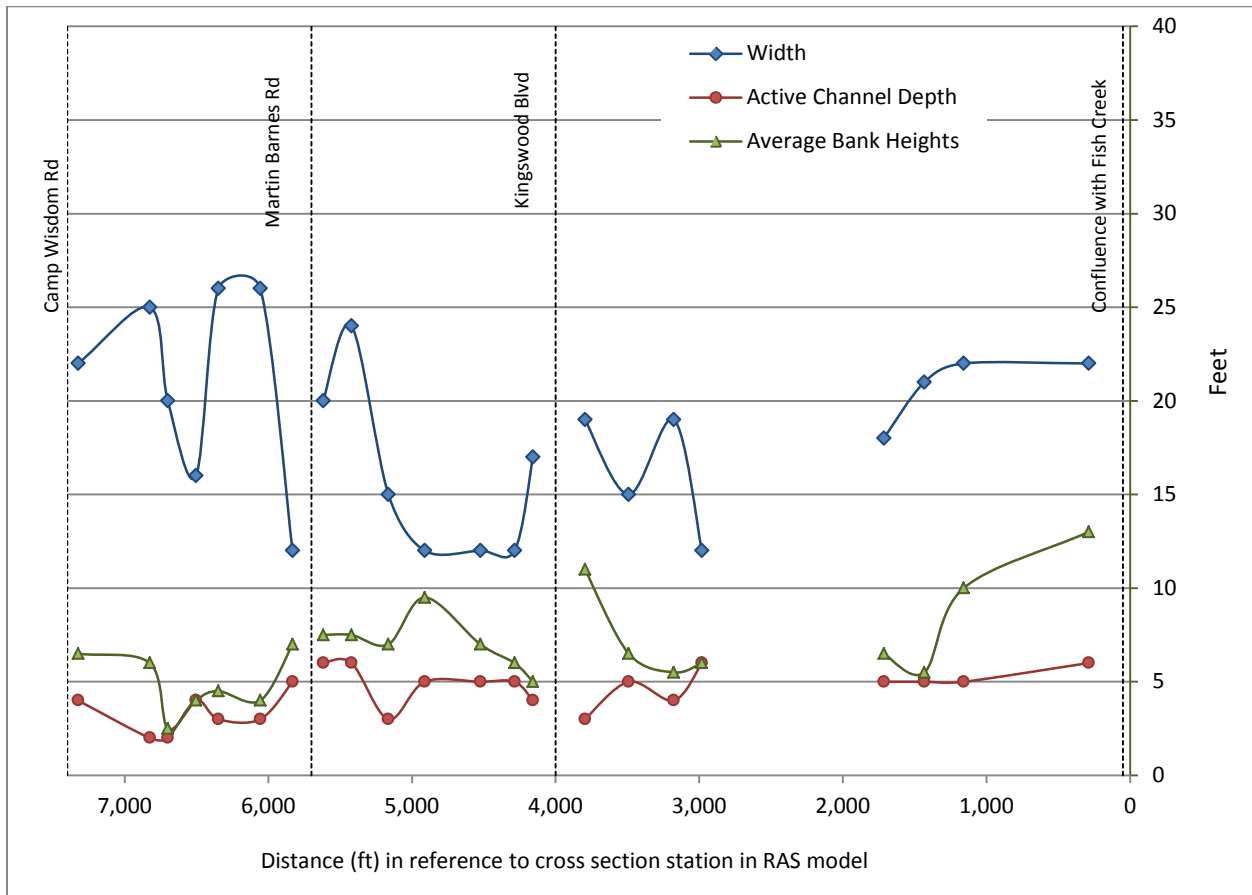


4.6 EXISTING CONDITION CHANNEL GEOMETRY

The existing condition geometry assessment included measurement and evaluation of the channel morphology of the study reach at each cross section location. The bottom width, active channel width, active channel depth, left bank height and right bank heights were analyzed based on field measurements to identify where possible changes were occurring in the channel. The active channel contains the flow that is responsible for forming the channel of the study reach. The active channel is defined as the portion of the channel in which flows occur frequently enough to keep vegetation from becoming established (Wood-Smith and Buffington 1996). Another active channel indicator was the top of depositional bars, which is indicative of the bankfull elevation in incised channels (Simon and Castro, 2003).

Channel dimensions varied throughout the study reach. Variation was likely due to local scour caused by existing infrastructure (bridges, culverts, and a low-water crossing). Valley morphology also affected channel dimensions. Generally, channel-floodplain connectivity was noted when the valley was wide and channel depth was relatively shallow. High flows are able to spread onto a floodplain, decreasing the erosive power of the stream. If discharges are increased as a result of future urbanization, the erosive power of the stream will increase and the channel may become larger. Results of measurements taken in the study area are shown in Figure 4.13. The blank areas on the graph signify areas where channel dimensions have been altered. The channel of Garden Branch was lined with riprap downstream of Kingswood Boulevard between cross sections 4158 and 3795. Water was channelized behind a residential development and water was ponded upstream of the concrete low-water crossing between cross sections 2982 and 1715.

Figure 4.13 Channel geometry of Garden Branch



5.0 CONCLUSIONS

5.1 HISTORICAL WATERSHED DEVELOPMENT

The historical aerial photograph analysis showed that the Garden Branch watershed was largely undeveloped until the 1990's, when residential development began. The majority of the watershed was still agricultural the time of the field assessment, and there was a vegetated riparian buffer that bordered the channel throughout the study reach. If the amount of impervious cover in the watershed increases, or the riparian buffer is removed, the channel will likely become unstable. Increased instability will lead to increased erosion, downstream sedimentation, and threats to infrastructure.

5.2 KNICKPOINT MIGRATION

As part of the stream condition assessment, knickpoints (headcuts) in the streambed were identified. Table 4.1 provides locations and descriptions of the knickpoints observed in Garden Branch during the stream condition assessment. It is recommended that the knickpoints be stabilized to decrease future channel degradation and/or monitored (surveyed) to identify actual migration rates in order to prioritize stabilization efforts.

5.3 CHANNEL EROSION AND INSTABILITY

Stream bank protection and bank stabilization should be considered at all locations categorized as severely unstable and priority should be given to the areas in closest proximity to homes and infrastructure. Locations with severe erosion and actively migrating knickpoints should be addressed to decrease excess sediment loading. Appendix C provides maps describing specific areas of concern, items of interest and severe instability along the study reach of Garden Branch. Erosion severity along the study reach is categorized in Appendix D.

5.4 CHANNEL FORMING FLOW

Based on field observations and review of the Garden Branch hydrologic and hydraulic model (Halff Associates, 2012), the modeled 2-year peak discharge appeared to be greater than the channel forming flow in the majority of the modeled cross-sections in the study area.

5.5 CHANNEL EVOLUTION

The majority of Garden Branch is stable and flows through a riparian buffer. Portions of the study reach have been disturbed by development in the watershed. Downstream of Kingswood Boulevard the channel has downcut and widened as a result of the increased flows resulting from urbanization. If flows continue to increase due to future watershed disturbances, it can be expected that the channel of Garden Branch will respond with increased instability.

6.0 REFERENCES

- Allen, P.M., Arnold, J.G., Skipwith, W., 2002. Erodibility of Urban Bedrock and Alluvial Channel, North Texas. *Journal of American Water Resources Association*, Vol. 38, No. 5, pp 147-149.
- Allen, P. M. and B. Flannigan, 1985. Geology of Dallas, Texas. In: *Cities of the World*, A. Hathaway (Editor). *Bulletin of the Association of Engineering Geologists* 23:363-416.
- Charlton, R., 2008, *Fundamentals of Fluvial Geomorphology*: Routledge, New York, NY, 234 p.
- Copeland, R.R., Biedenharn, D.S., and Fischenich, J.C., 2000, Channel-forming discharge: United States Corps of Engineers, ERDC/CHL CHETN-VIII-5, accessed at <http://chl.ercd.usace.army.mil/library/publications/chetn/pdf/chetn-viii-5.pdf>
- Henshaw, P.C. and Booth, D.B., 2000. Natural restabilization of stream channels in urban watersheds: *Journal of the American Water Resources Association*, v. 36, p. 1219-1236.
- Lane, E.W., 1955, Design of Stable Channels. *Trans. Amer. Soc. Civil Engineers*, v. 120, p. 1234-1279.
- Montgomery, D.R. and Buffington, J.M., 1998, Channel processes, classification and response: in *River ecology and management*, Naiman, R. and Bilby, R., eds., Springer-Verlag New York, Inc., p. 13-42.
- National Weather Service, 2012, Dallas/Fort Worth Climatology, accessed at: <http://www.srh.noaa.gov/fwd/?n=dfwclimo>
- NRCS, 2007, Stream restoration Design, *National Engineering Handbook*, Part 654, August 2007, U.S. Department of Agriculture and Natural Resources Conservation Services.
- Rosgen, D.L. and Silvey, H.L., 2005. *The Reference Reach Field Book*. Wildland Hydrology Books, Fort Collins, CO, p. 256
- Schumm, S.A., 1977, *The fluvial system*: Wiley-Interscience, New York, NY, 338 p.
- Thorne, C.R., 1982. Processes and mechanisms of riverbank erosion. In Hey, R.D., J.C. Bathurst, and C.R. Thorne, eds.: *Gravel-bed Rivers*, John Wiley & Sons: Chichester, UK, p. 125-144.

Thorne, C. R., 1998. Stream Reconnaissance Handbook. John Wiley and Sons, Chichester, England, 133 pp.

Wolman, M.G., 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union, v. 35, no, 6, p. 951-956.

Wolman, M.G., and Leopold, L.B., 1957. Bankfull discharge of rivers. Water Resources Research, v. 14, p. 1141-1154.

Wolman, M.G., and Miller, J.P., 1960. Magnitude and frequency of forces in geomorphic processes, Journal of geology, v. 68, p. 54-74.

Wood-Smith, R.D., and Buffington, J.M., 1996, Multivariate Geomorphic Analysis of Forest Streams: Implications for Assessment of Land Use Impacts of Channel Condition: Earth Surface Processes and Landforms, v. 21, p. 377-393

APPENDIX A
Representative Photographs of Garden Branch

	
<p>Downstream view from 7325 at Camp Wisdom Rd. The banks are armored with riprap and shotcrete.</p>	<p>Downstream of 7011 the channel has a riparian buffer and the channel is ponded by a beaver dam.</p>
	
<p>Downstream of 6826 looking at a debris jam of plant material and trash, not a threat.</p>	<p>Upstream view from 6700, stable channel.</p>
	
<p>Downstream view from 6504, stable stream, great habitat.</p>	<p>Upstream view from 6384, stable low flow channel.</p>

Garden Branch: downstream of Camp Wisdom (cross sections 7325 – 6384)

Left and right bank views assume downstream direction

<p>Downstream of 6384, looking downstream at a riffle/pool sequence, stable channel.</p>	<p>Downstream of 6384, looking downstream at a knickpoint location, arrested by dense tree roots.</p>
<p>Downstream from 6056, looking downstream at a black willow growing in the center of the channel, the roots are acting as grade control.</p>	<p>Downstream from 6056, looking downstream at a pool. The pool location was downstream of the tree in the center of the channel.</p>
<p>Left bank at 5823, well vegetated, stable channel.</p>	<p>Upstream view from 5725 at Martin Barnes Rd. The left bank is armored with concrete rubble, protection for an outfall upslope.</p>

Garden Branch: Between Camp Wisdom Rd and Martin Barnes Rd (cross sections 6384 – 5725)

Left and right bank views assume downstream direction

	
<p>Downstream view from 5676 at Martin Barnes. The meander on the left bank was eroding.</p>	<p>Downstream view from 5618, eroding meander.</p>
	
<p>Upstream view from 5412, stream is ponded by a beaver dam downstream, good habitat.</p>	<p>Upstream of 5164, looking upstream at a beaver dam built on top of riprap from an old creek crossing.</p>
	
<p>Upstream of 5164, looking downstream at an old riprap creek crossing acting as grade control.</p>	<p>Looking downstream from 5164 at gravels and cobbles from the creek crossing stabilized downstream as bar formation.</p>

Garden Branch: Downstream of Martin Barnes (cross sections 6576 – 5164)

Left and right bank views assume downstream direction

	
<p>Downstream from 4911, looking upstream at large woody debris.</p>	<p>Downstream of 4911, the left bank has failed from seepage.</p>
	
<p>Right bank 4524 there is an outfall. The left bank is protected with riprap</p>	<p>Downstream from 4524 showing the left bank protected by</p>
	
<p>Downstream of 4286 showing a beaver dam, ponding the water upstream.</p>	<p>Looking upstream from 4158, notice the beaver dam and the large woody debris.</p>

Garden Branch: Between Martin Barnes Rd and Kingswood Blvd (4911 – 4158)

Left and right bank views assume downstream direction

	
<p>Downstream from 4158, water is ponded.</p>	<p>Upstream from 4085 towards vegetation in the center line of the channel. The channel bed at this location is concrete.</p>
	
<p>Downstream from 4085, culverts had little to no sediment deposition.</p>	<p>Downstream from 3894, vegetated channel.</p>
	
<p>Downstream from 3795, incised channel, has a riparian buffer.</p>	<p>Upstream of 3491 left bank shows local scour from the outfall.</p>

Garden Branch: Downstream of Kingswood Blvd (4158 – 3491)

Left and right bank views assume downstream direction

	
<p>Downstream of 3491 incised channel</p>	<p>Downstream of 3491, 2-foot knickpoint and debris jam on the downstream side.</p>
	
<p>Upstream of 3177, 1-foot knickpoint</p>	<p>Downstream of 3177, left bank was eroding from local scour induced from an outfall, in addition to the location being on a cutbank.</p>
	
<p>Upstream of 2982, looking upstream where the narrow channel becomes wider, channelized.</p>	<p>Upstream of 2982 on the left over bank, there was a drainage channel filled in with debris.</p>


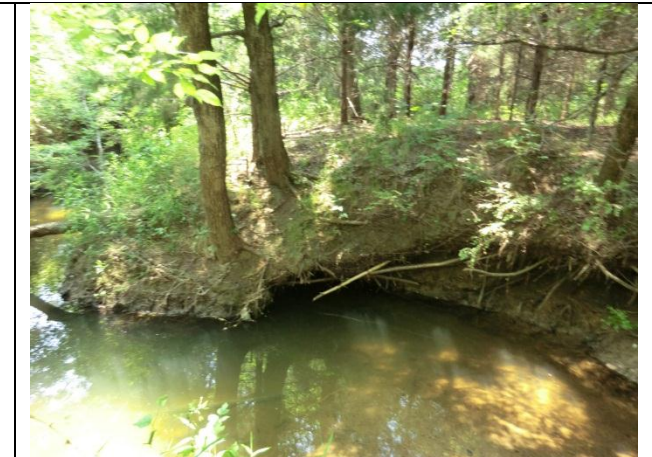




Garden Branch: Downstream of Kingswood Blvd (3491 – 2982)

Left and right bank views assume downstream direction

<p>Downstream of 2807 was a concrete structure in the channel.</p>	<p>Upstream of 2496 that was a concrete low water crossing (LWC) that also served as pipeline protection. Low flow culvert was blocked, no flow.</p>
<p>Upstream of 2496, the LWC blocked ponded the flow upstream,</p>	<p>Upstream of 2496, looking downstream from the LWC notice large scour and undercutting to the banks and concrete.</p>
<p>At 2496 aerial view, downstream of the LWC there was serve scour to the channel.</p>	<p>Upstream of 2112, looking in the downstream direction, wider channel.</p>

Garden Branch: Downstream of Kingswood Blvd (2807 – 2112)

Left and right bank views assume downstream direction

	
<p>Downstream of 2112, there was a metal culvert blocking the channel; it eroded out from a water crossing location.</p>	<p>Upstream of 2112, the right bank was slumping and showed soil creep.</p>
	
<p>Upstream from 1715, eroded right bank exposing shale.</p>	<p>Right bank at 1715, shows the e</p>
	
<p>Upstream of 1433, incised channel.</p>	<p>Left bank at 1433 shows a stable cutbank.</p>

Garden Branch: Downstream of Kingswood Blvd (2112 – 1443)

Left and right bank views assume downstream direction



Downstream of 1433 there was a series of knickpoints migrating in the upstream direction.



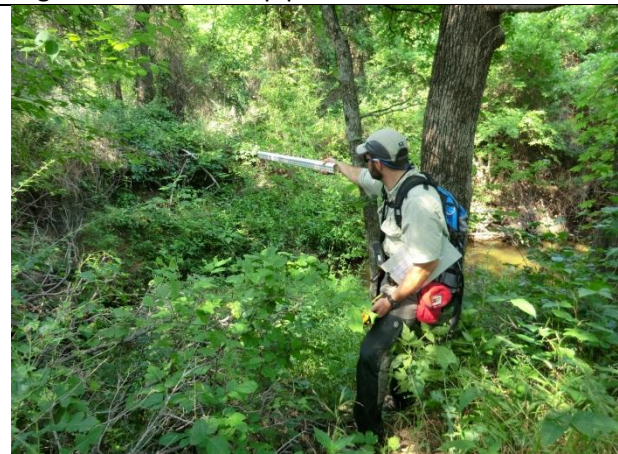
Downstream of 1433, looking downstream at the series of knickpoints, total drop was about 4 feet.



Upstream of 1153 there was a debris jam around a segment of concrete pipe.



Looking upstream from 1153 there was a second segment of concrete pipe.



Looking to the east towards a potential meander cutoff near 1153.



Right bank downstream of 1153 the banks are actively eroding.

Garden Branch: Downstream of Kingswood Blvd (1443 – 1153)

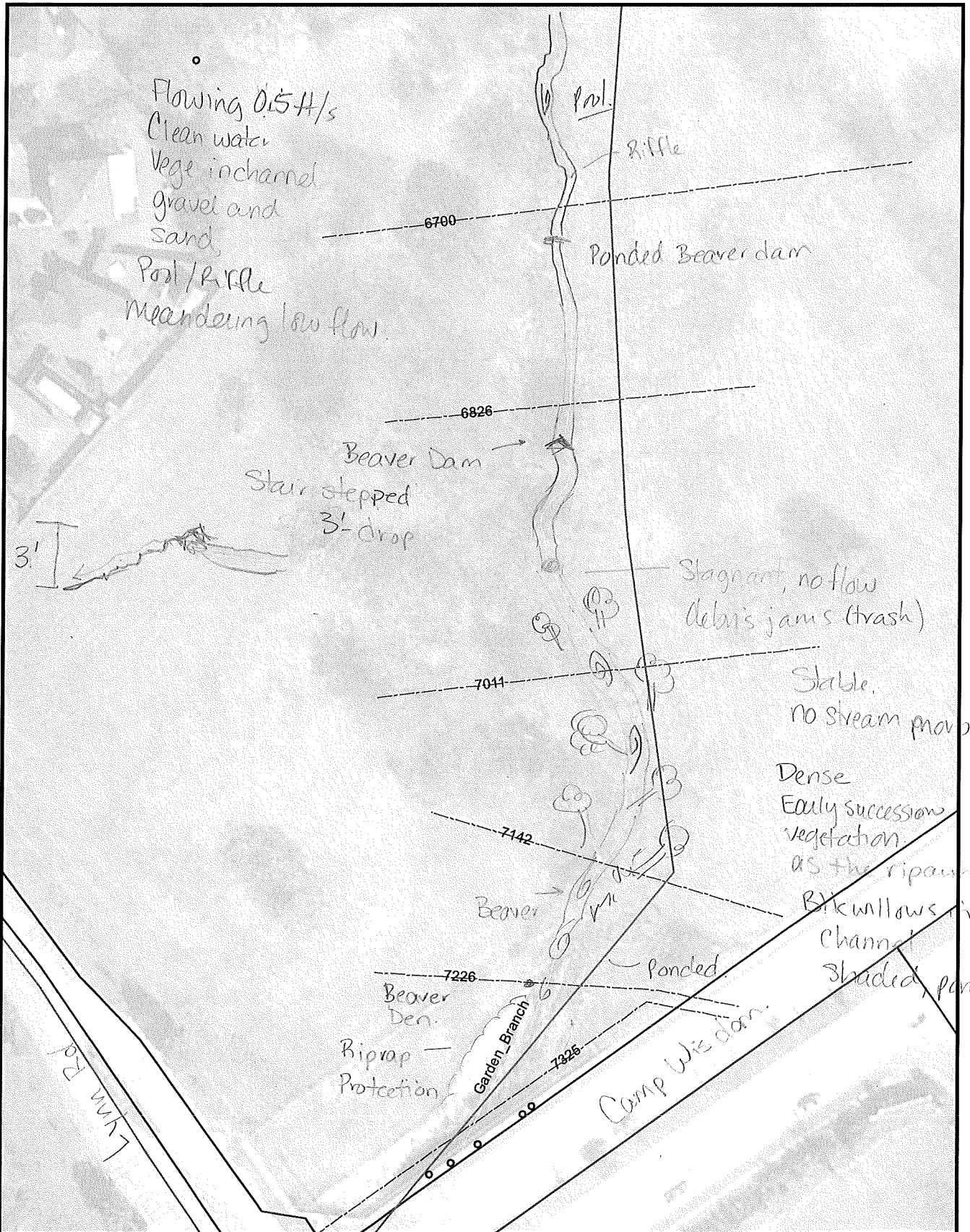
Left and right bank views assume downstream direction



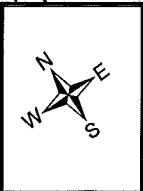
Garden Branch: Upstream of Great Southwest Pkwy (289)

Left and right bank views assume downstream direction

APPENDIX B
Stream Assessment Field Sketches




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Garden Branch Stream Condition Assessment
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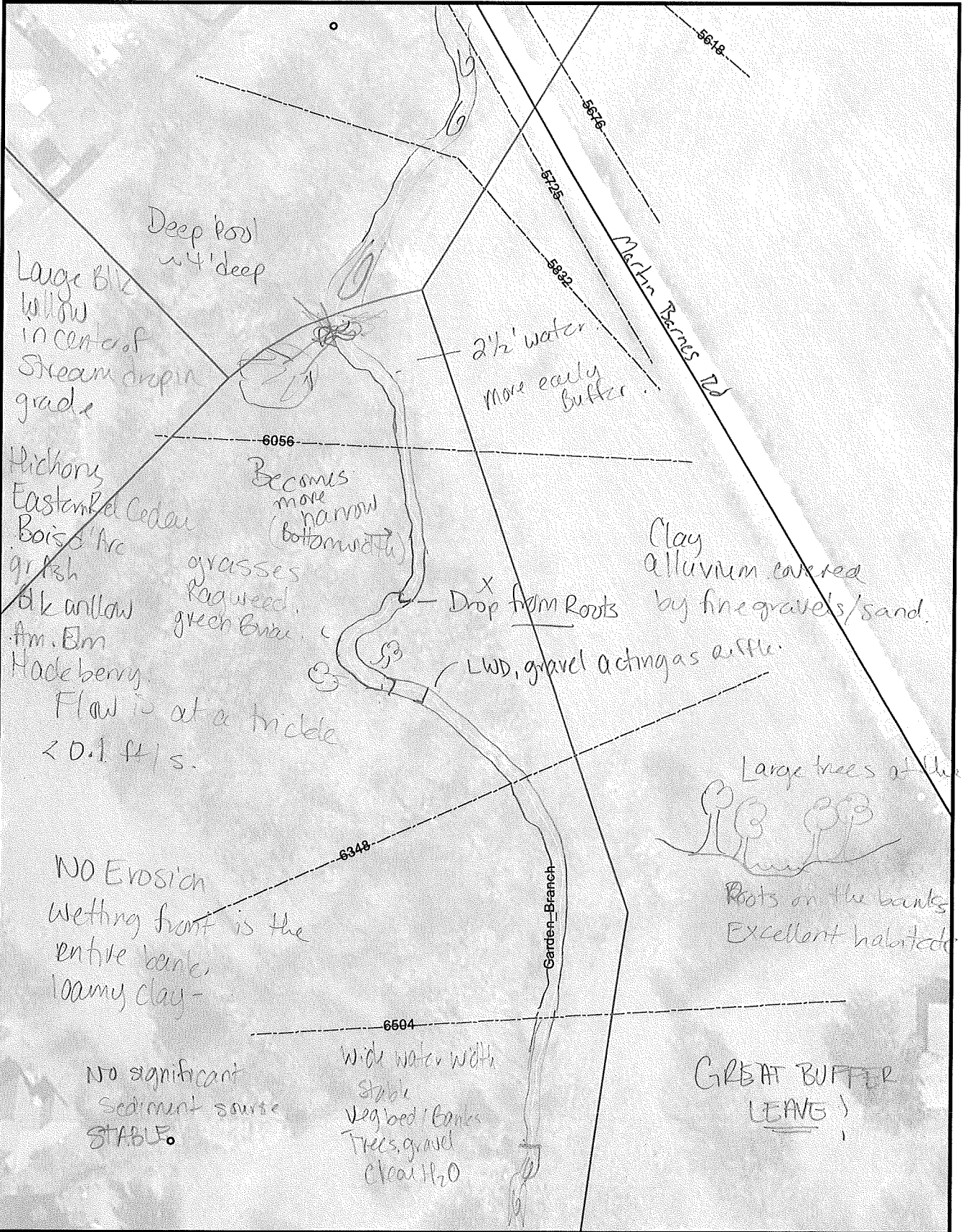
Field Assessment

FN JOB NO	HAF12272
FILE	garden_field.mxd
DATE	6-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

1
FIGURE

* No Sign of Pipeline

Mix of ~~low~~ clay, mid and late



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 Fort Worth, TX 76109 - 4895
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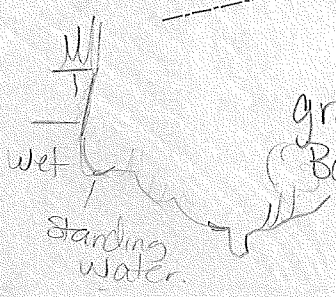
Garden Branch Stream Condition Assessment
 City of Grand Prairie

Field Assessment

FN JOB NO	HAF-12272
FILE	garden_field.mxd
DATE	6-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

2
FIGURE

groundwater
Recharge?



4944

-3' Beaverdam (not actively eroding - slow)

groundwater seep
Bank failure

Narrow, shaded
Ponded
Stable

5164

Garden Branch

* Old Creek Crossing/Beaver dam
Stabilized.
Some gravel downstream
Self forming the banks.
Stabilized w/ Riprap.

* GREAT BUFFER
Ag on upland
Buffer for erosion
control, well kept.

6421

Alice Longfellow

Ponded duckweed

Trees growing
in the center.

Slight erosion

Water is ponded
3-4' deep

5618

Trees leaning
Roots exposed.

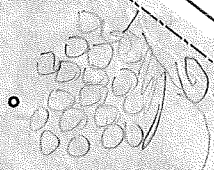
5676

Martha Barnes

Trees in the
water, same as up
just wider.

5725

Concrete rubble
on outfall
location



Garden Branch Stream Condition Assessment
City of Grand Prairie

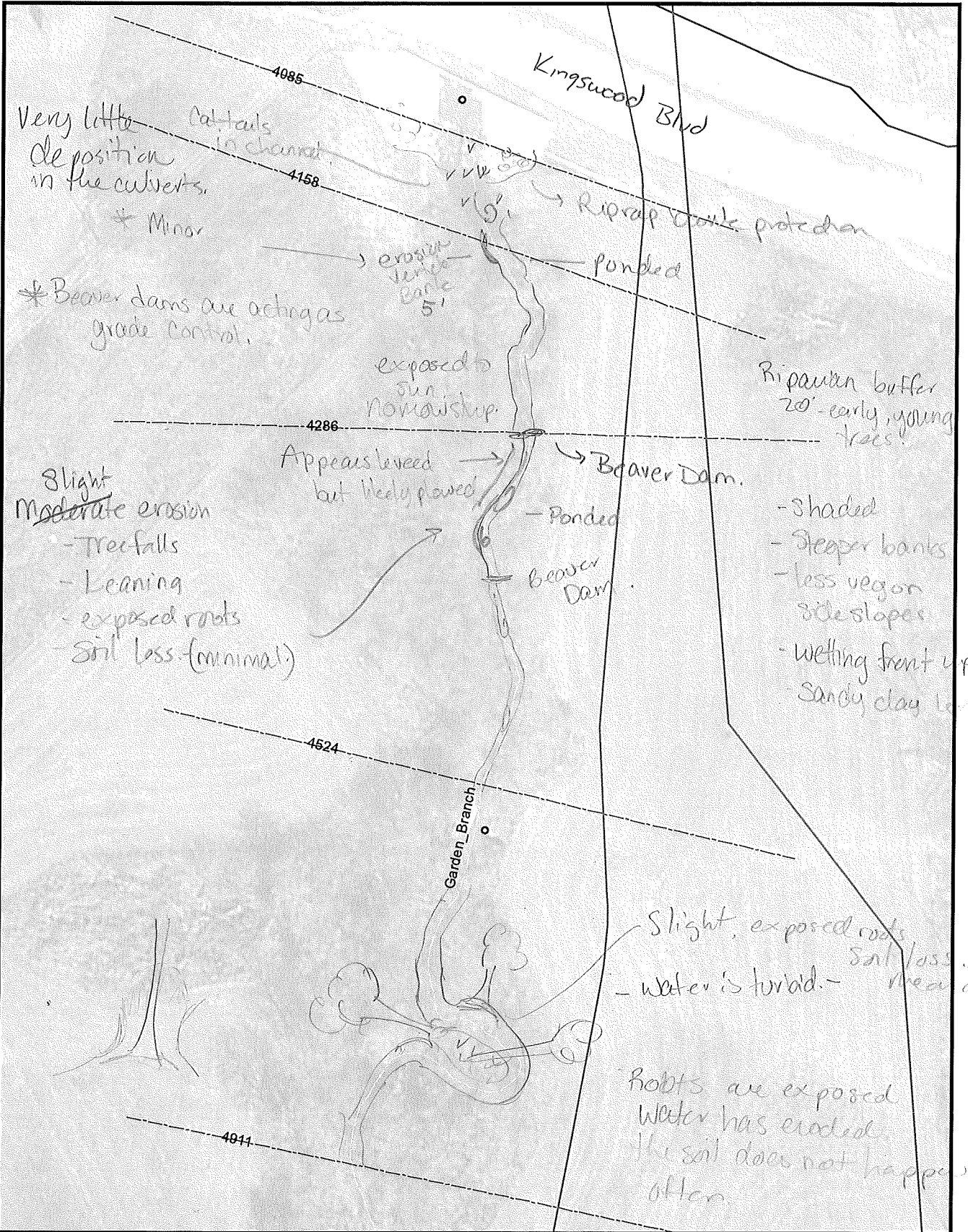
Field Assessment

FN JOB NO	HAF12272
FILE	garden_field.mxd
DATE	6-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

3

FIGURE

3
9/10/20



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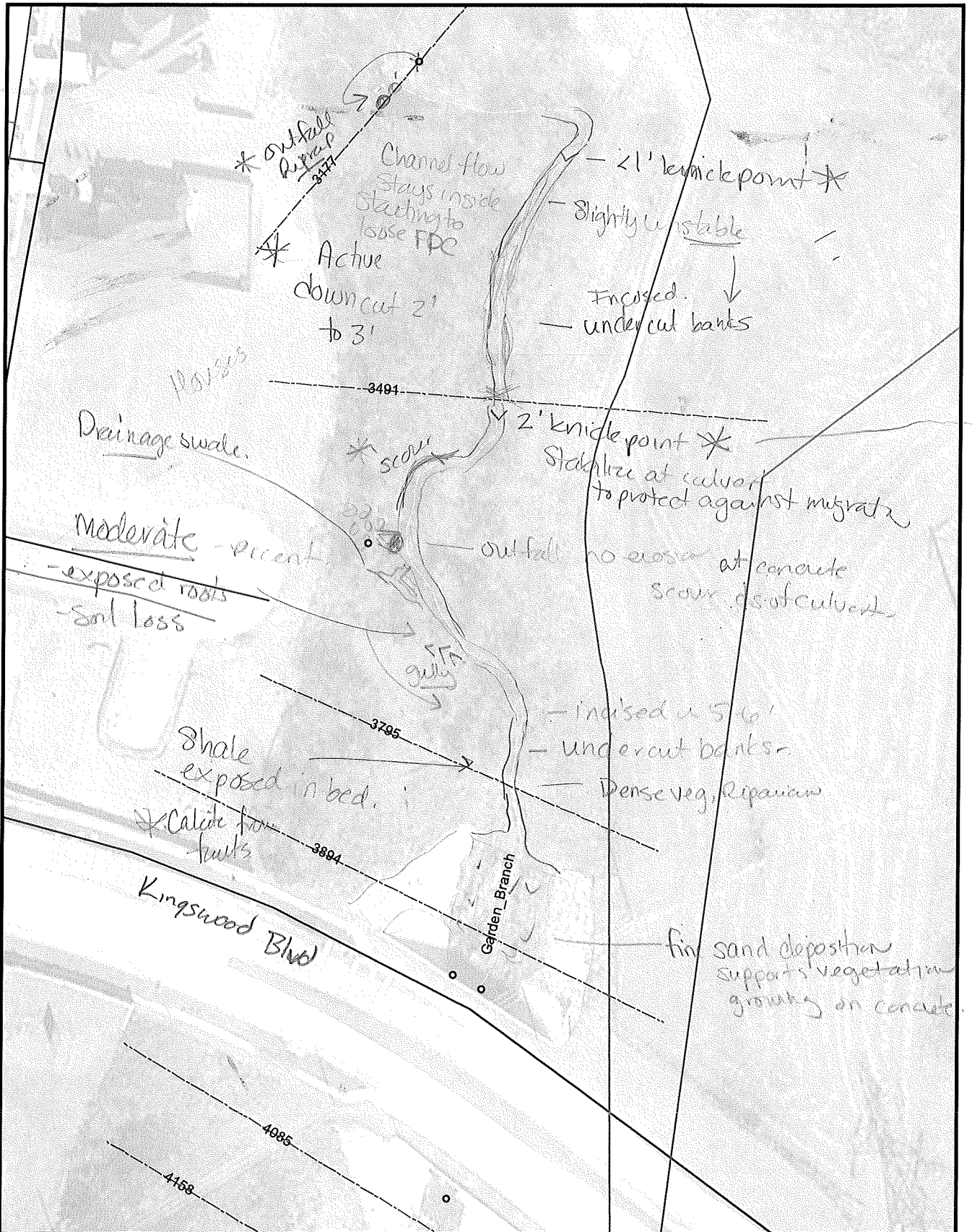


Garden Branch Stream Condition Assessment
 City of Grand Prairie

Field Assessment

FN JOB NO	HAF12272
FILE	garden_field.mxd
DATE	10-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

4
FIGURE



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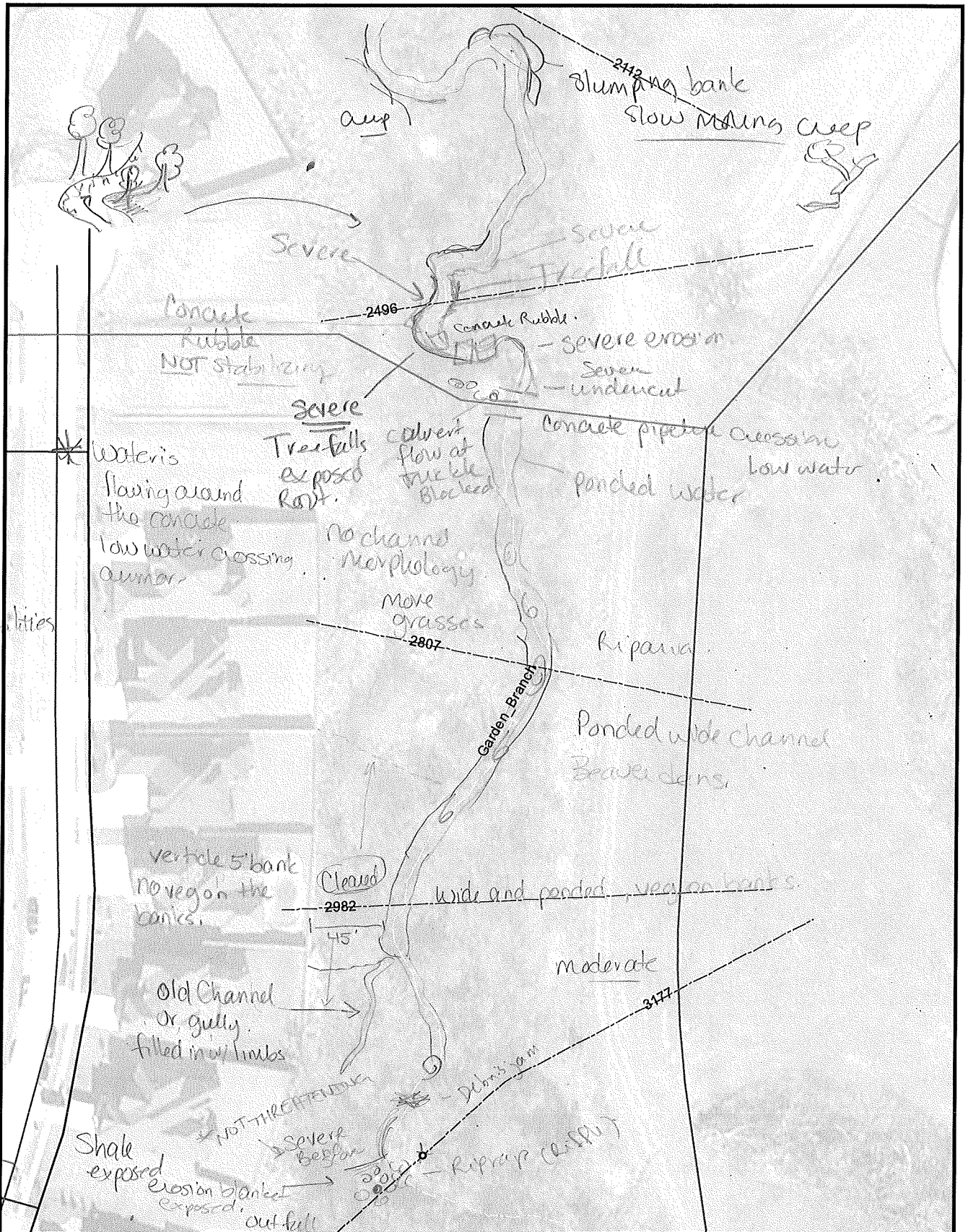
Garden Branch Stream Condition Assessment
 City of Grand Prairie

Field Assessment

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SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

5
FIGURE

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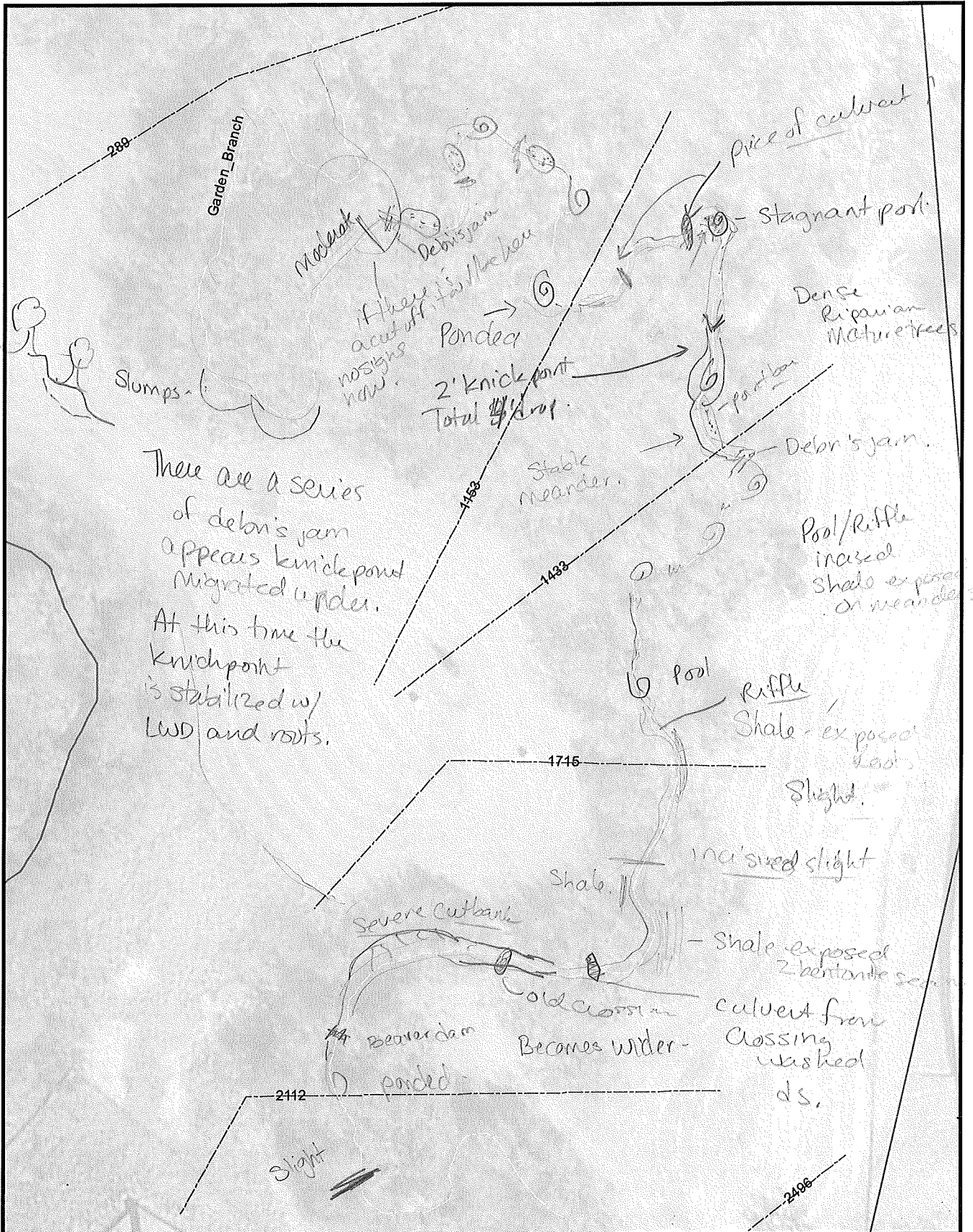


Garden Branch Stream Condition Assessment
City of Grand Prairie

Field Assessment

FN JOB NO	HAF12272
FILE	garden_field.mxd
DATE	6-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

6
FIGURE



There are a series of debris jam appears knick point migrated updr. At this time the knick point is stabilized w/ LWD and roots.



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 City of Grand Prairie

Field Assessment

FN JOB NO	HAF12272
FILE	garden field.mxd
DATE	10-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

7

FIGURE



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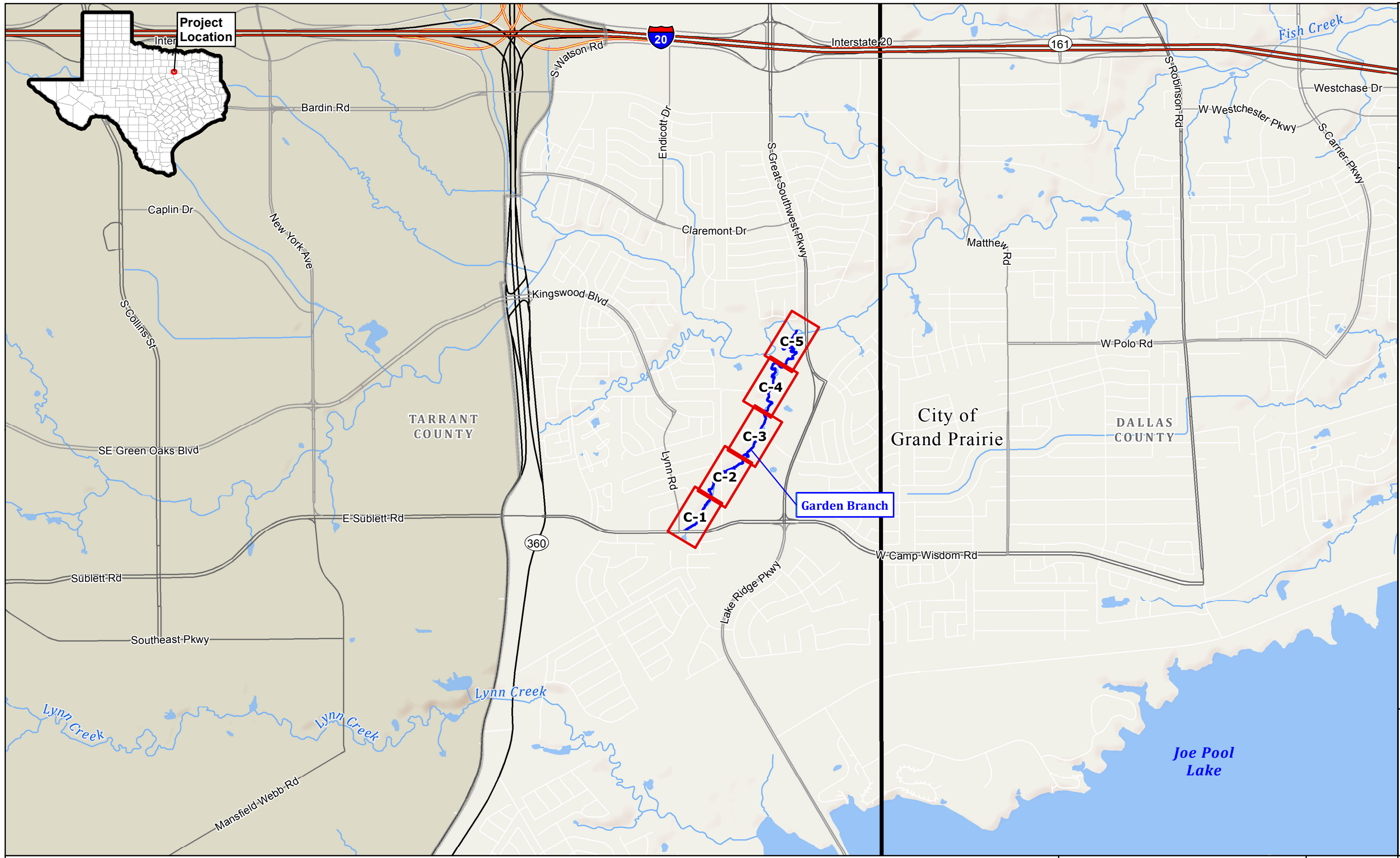
Garden Branch Stream Condition Assessment
 City of Grand Prairie

Field Assessment

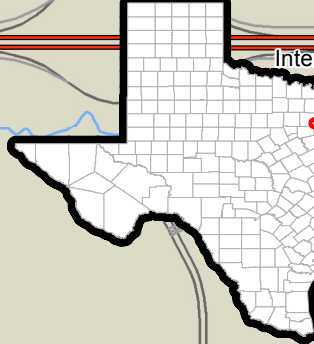
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FILE	garden_field.mxd
DATE	6-4-12
SCALE	1:1,000
Team	SVC, DKC
DRAFTED	SVC

8
FIGURE

APPENDIX C
Areas of Interest



Project Location



FN PROJECT NO.	HA112272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden_Branch_AOI_Index
PREPARED BY	SSJ

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Areas of Interest - Index

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Grand Prairie

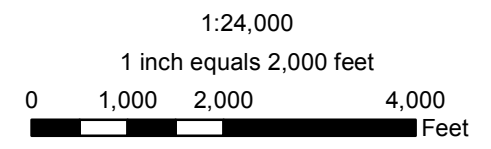
Index

County Boundary

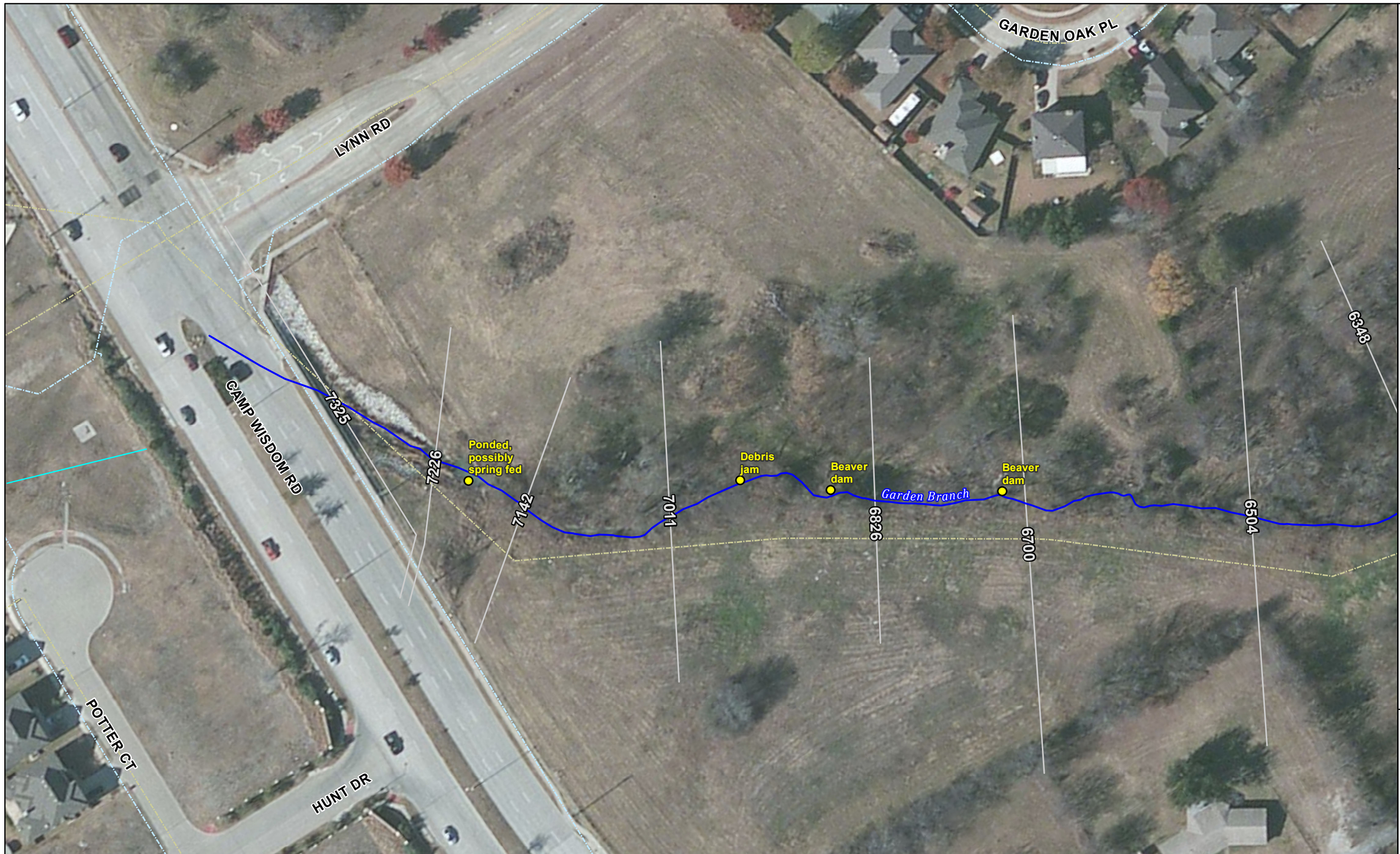
Garden Branch

NHD Flowline

NHD Waterbody



C
FIGURE

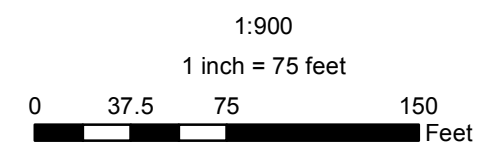
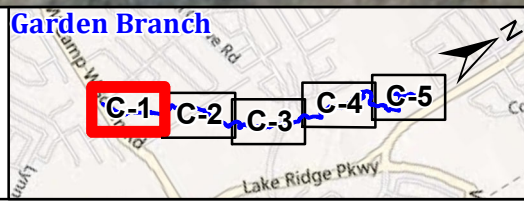


PROJECT NO.	HA12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden Branch AOI
PREPARED BY	SSJ

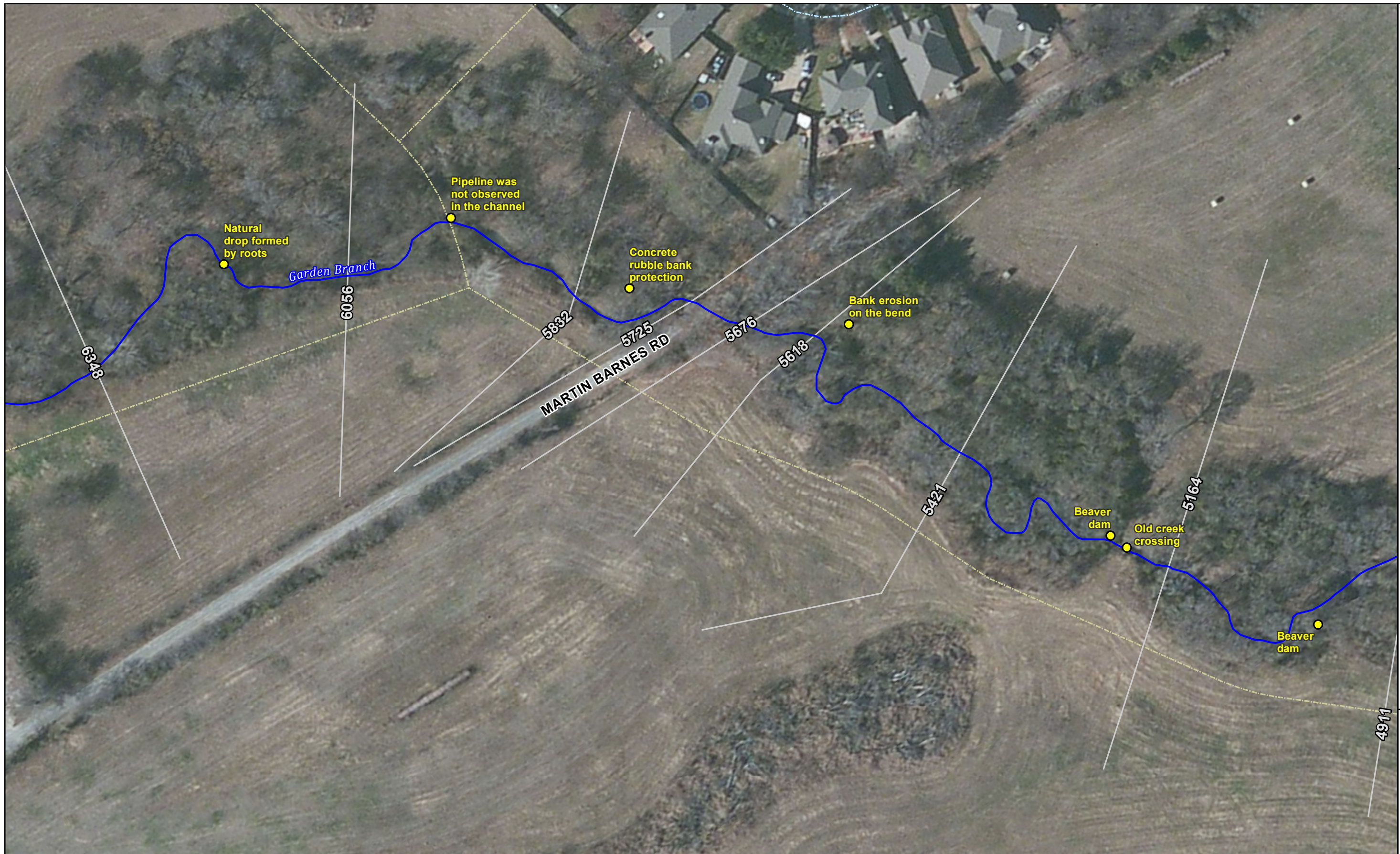
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Areas of Interest

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- Garden Branch Areas of Interest
- ~ Garden Branch
- ~ NHD Flowline
- Cross Section
- Water Line
- Wastewater Line



C-1
FIGURE

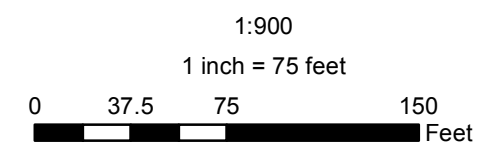
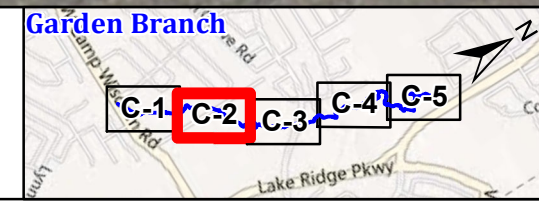


PROJECT NO.	HAF12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden Branch AOI
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- Garden Branch Areas of Interest
- ~ Garden Branch
- ~ NHD Flowline
- Cross Section
- Water Line
- Wastewater Line



C-2
FIGURE

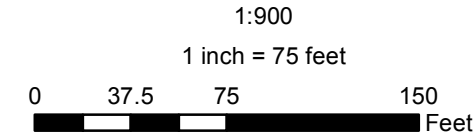
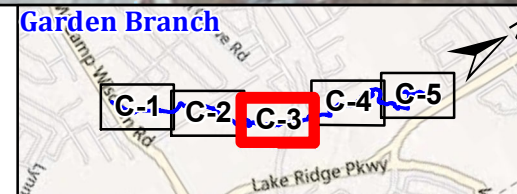


PROJECT NO.	HAF12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden Branch AOI
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- Garden Branch Areas of Interest
- ~ Garden Branch
- ~ NHD Flowline
- Cross Section
- - - Water Line
- - - Wastewater Line



C-3
FIGURE

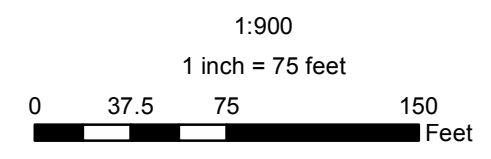
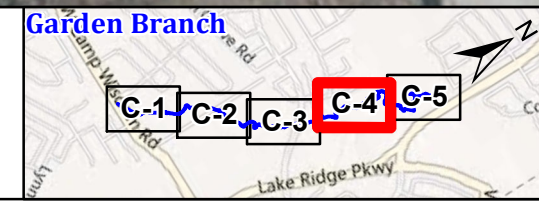


PROJECT NO.	HA12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden Branch AOI
PREPARED BY	SSJ

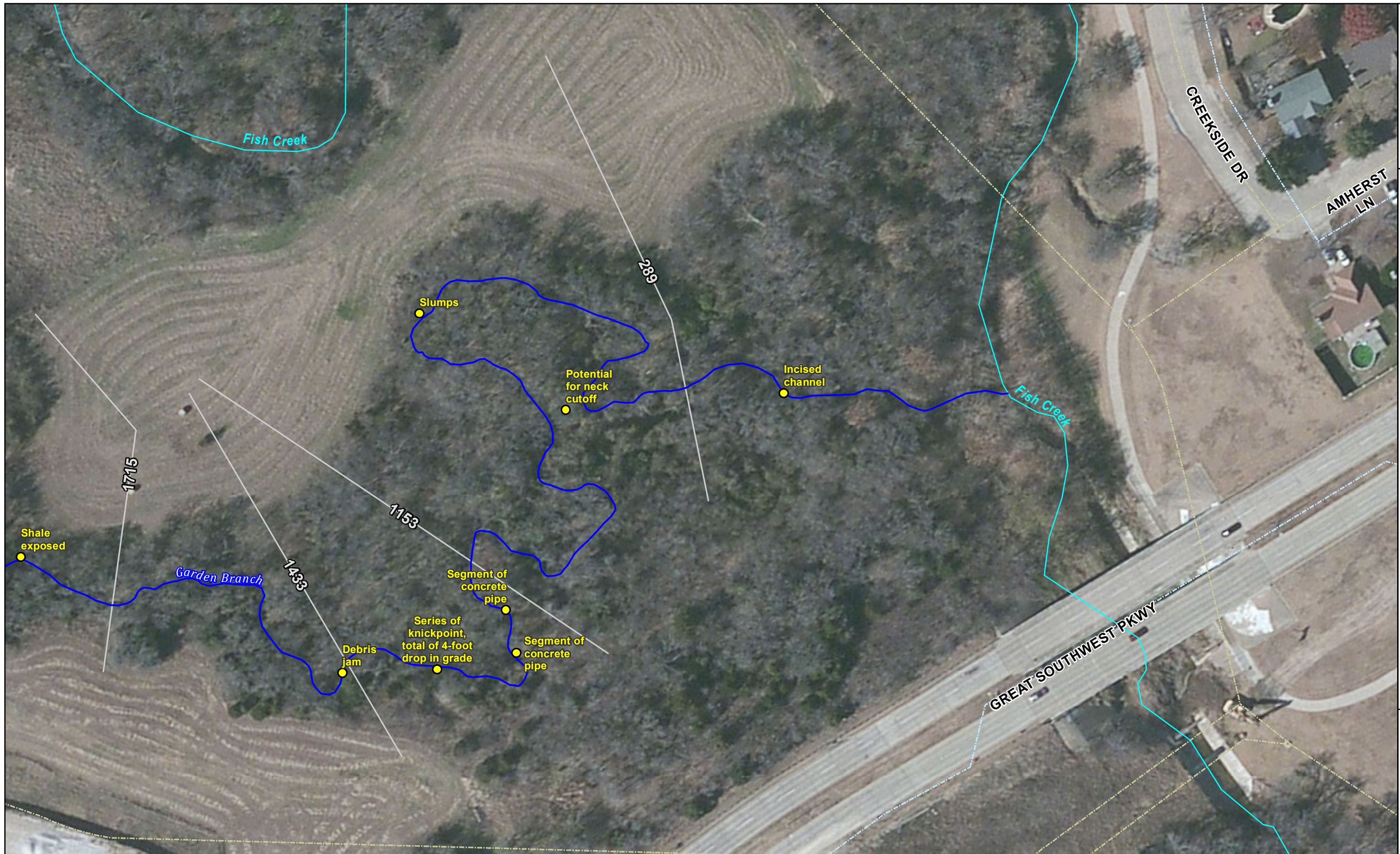
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Areas of Interest

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- Garden Branch Areas of Interest
- ~ Garden Branch
- ~ NHD Flowline
- Cross Section
- Water Line
- Wastewater Line



C-4
FIGURE

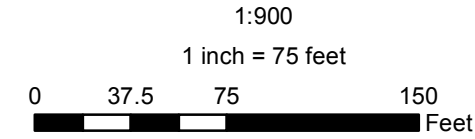
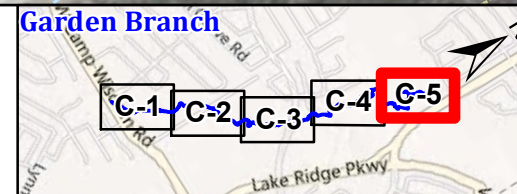


PROJECT NO.	HAF12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden Branch AOI
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Garden Branch Stream Condition Assessment
Areas of Interest

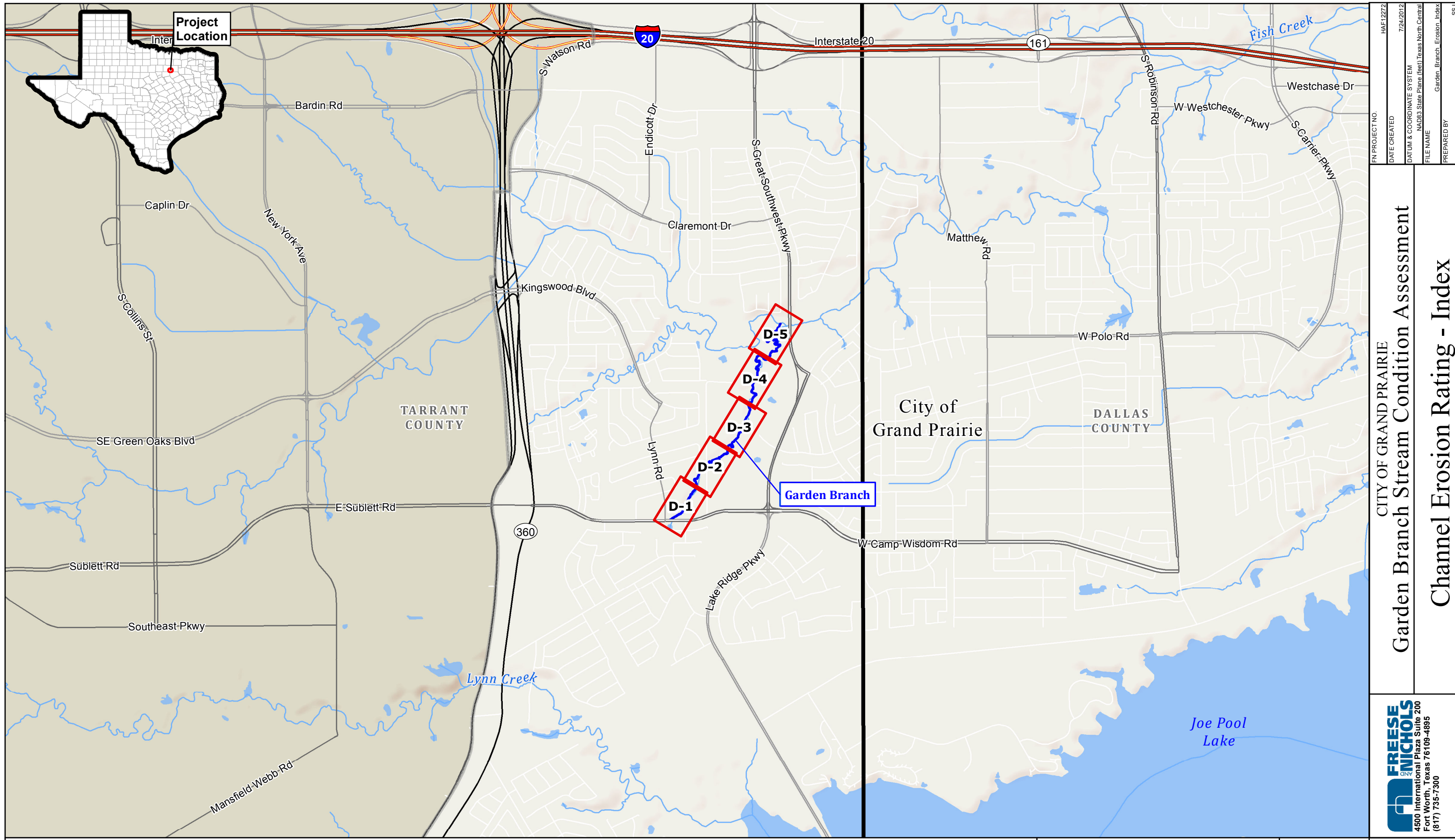
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- Garden Branch Areas of Interest
- ~ Garden Branch
- ~ NHD Flowline
- Cross Section
- - - Water Line
- - - Wastewater Line



C-5
FIGURE

APPENDIX D
Channel Erosion Rating

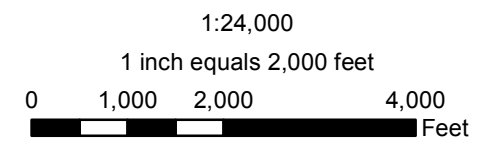


FN PROJECT NO.	HA112272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden_Branch_Erosion_Index
PREPARED BY	SSJ

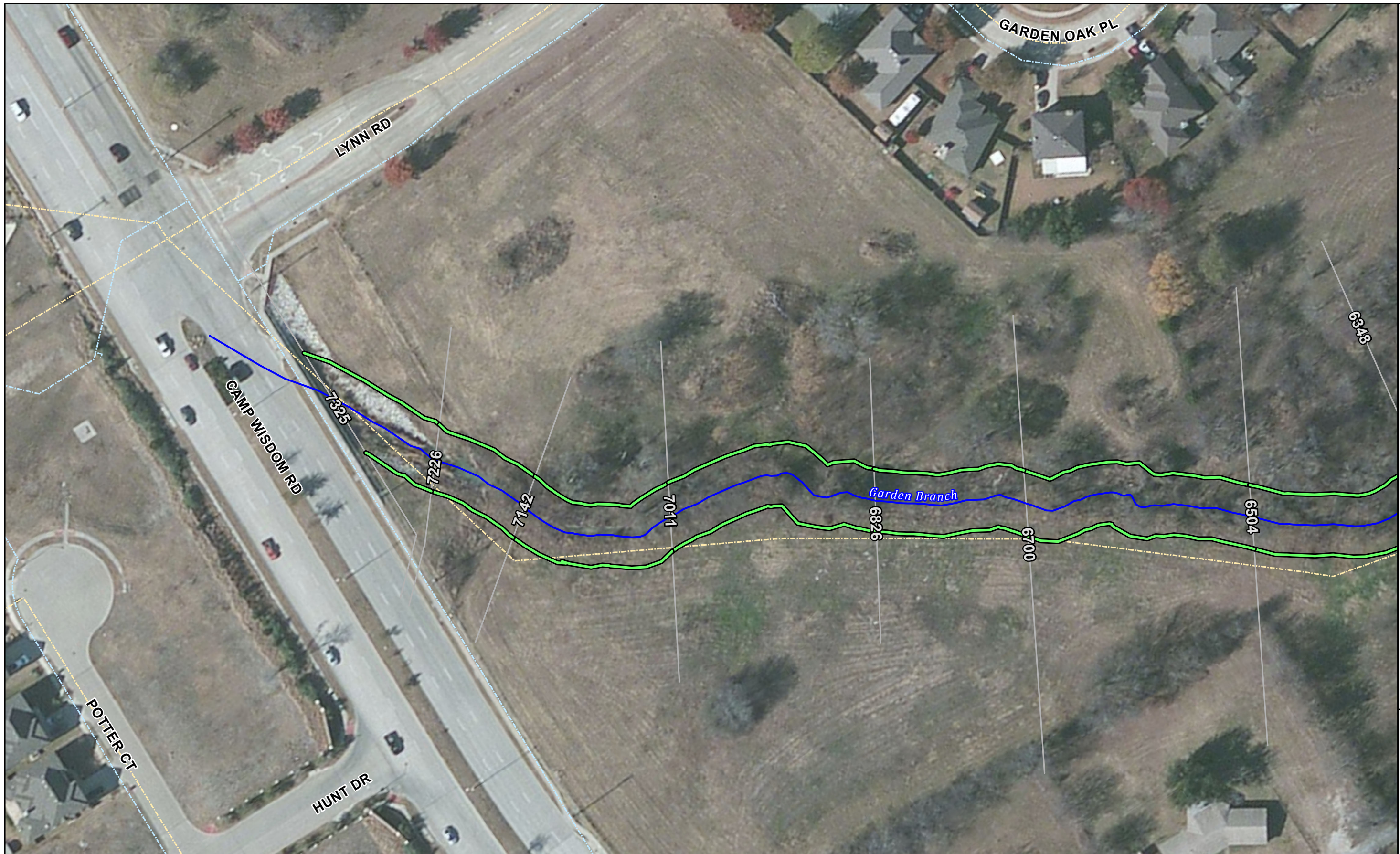
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Garden Branch Stream Condition Assessment
Channel Erosion Rating - Index

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- Grand Prairie
- Index
- County Boundary
- Garden Branch
- NHD Flowline
- NHD Waterbody



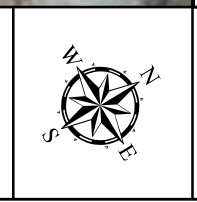
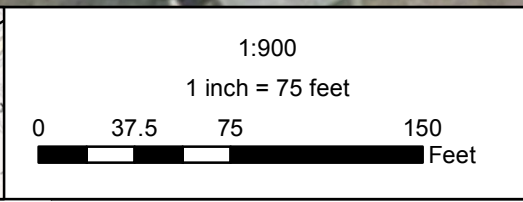
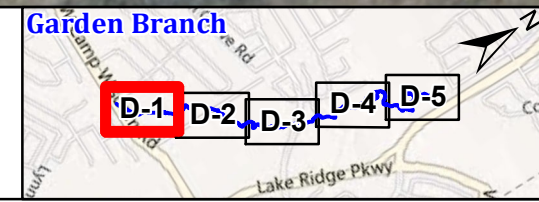
D
FIGURE



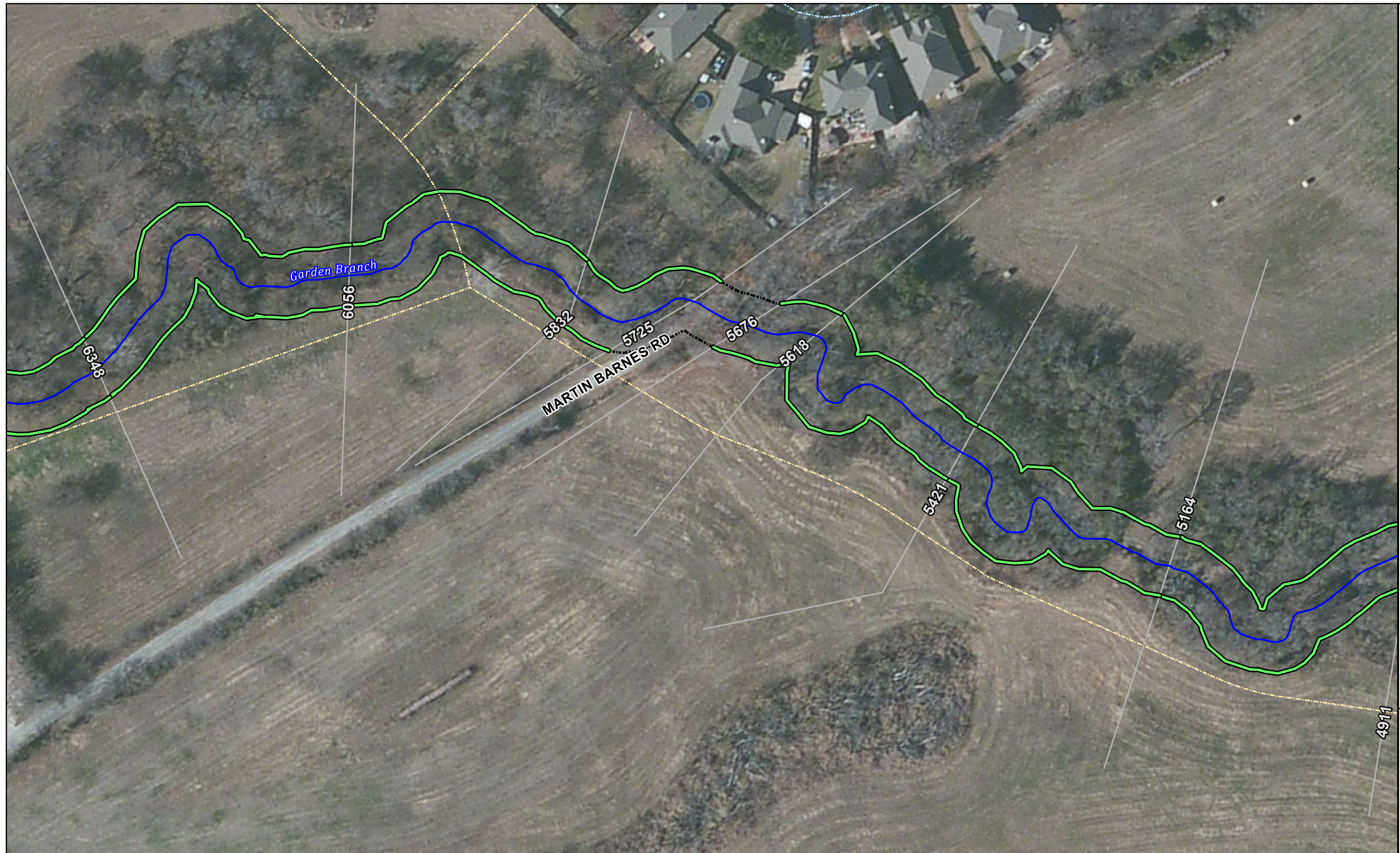
PROJECT NO.	HAF12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden_Branch_Erosion
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Garden Branch Stream Condition Assessment
Channel Erosion Rating

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D-1
FIGURE

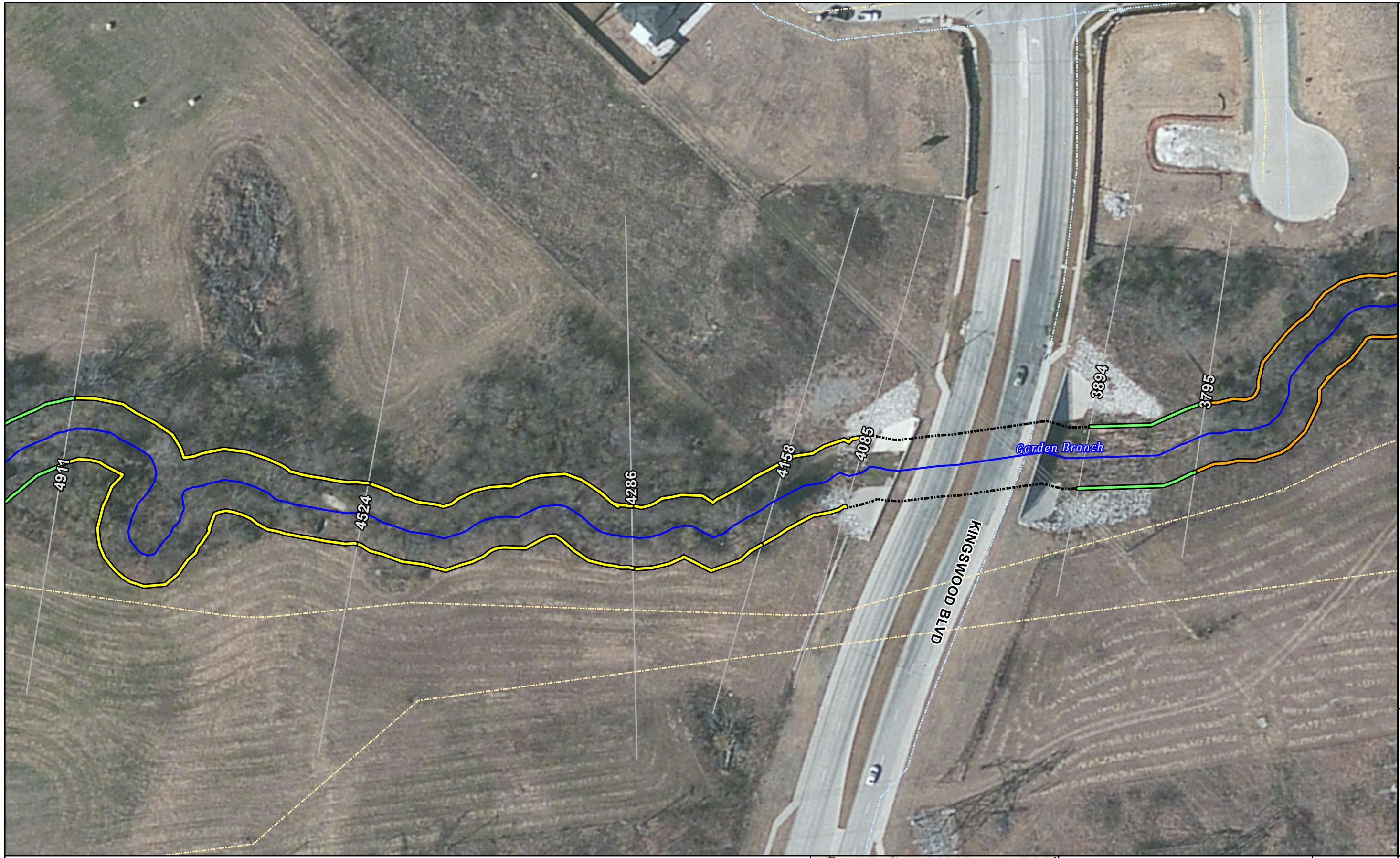


PROJECT NO.	HAF12272
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FILE NAME	Garden_Branch_Erosion
PREPARED BY	SSJ

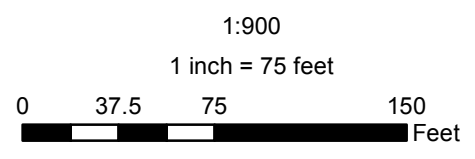
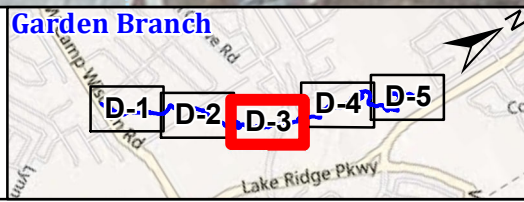
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Garden Branch Stream Condition Assessment
Channel Erosion Rating

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<ul style="list-style-type: none"> Concrete Road Stable Slight Moderate Severe Garden Branch Stream/River Cross Section Water Line Wastewater Line 	<p>Garden Branch</p>	<p>1:900 1 inch = 75 feet</p>		<p>D-2</p> <p>FIGURE</p>
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- | | | | |
|----------|----------|---------------|-----------------|
| Concrete | Slight | Garden Branch | Water Line |
| Road | Moderate | Stream/River | Wastewater Line |
| Stable | Severe | Cross Section | |



PROJECT NO.	HAF12272
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DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
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Garden Branch Stream Condition Assessment
Channel Erosion Rating

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D-3
FIGURE

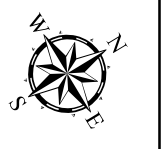
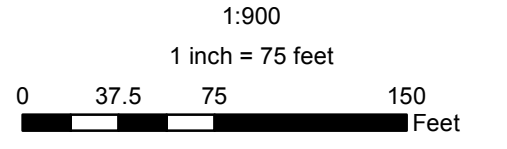
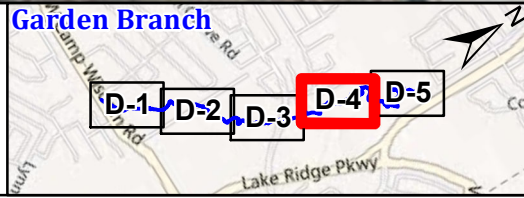


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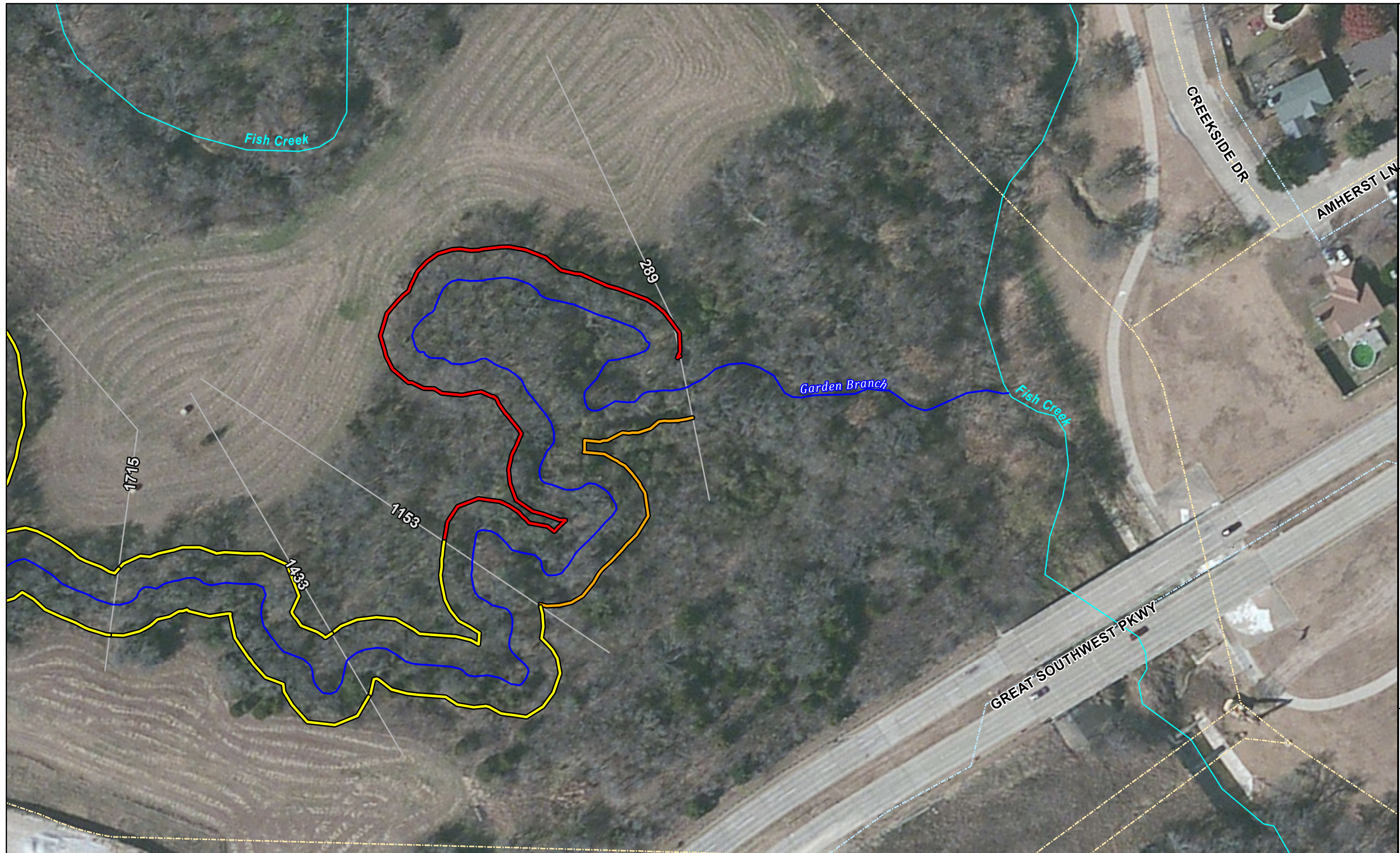
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Garden Branch Stream Condition Assessment
Channel Erosion Rating

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- Concrete
- Road
- Stable
- Slight
- Moderate
- Severe
- Garden Branch
- Stream/River
- Cross Section
- Water Line
- Wastewater Line



D-4
FIGURE



PROJECT NO.	HAF12272
DATE CREATED	7/24/2012
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Garden_Branch_Erosion
PREPARED BY	SSJ

CITY OF GRAND PRAIRIE
Garden Branch Stream Condition Assessment
Channel Erosion Rating

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<ul style="list-style-type: none"> Concrete Road Stable 	<ul style="list-style-type: none"> Slight Moderate Severe 	<ul style="list-style-type: none"> Garden Branch Stream/River Cross Section 	<ul style="list-style-type: none"> Water Line Wastewater Line 	<p>Garden Branch</p>	<p>1:900 1 inch = 75 feet</p>		<p>D-5</p> <p>FIGURE</p>
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ATTACHMENT 1
Digital photographs, GPS and image direction shapefile

Appendix D
Channel Stability Alternatives

Design Considerations for Siting Grade Control Structures

Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930



**US Army Corps
of Engineers®**

Design Considerations for Siting Grade Control Structures

by David S. Biedenbarn and Lisa C. Hubbard

PURPOSE: The purpose of this Coastal and Hydraulics Engineering Technical Note (CHETN) is to provide guidance and highlight possible areas of concern that may require consideration before siting grade control structures.

INTRODUCTION: In the widest sense, the term grade control can be applied to any alteration in the watershed which provides stability to the streambed. By far the most common method of establishing grade control is the construction of in-channel grade control structures. There are two basic types of grade control structures. One type can be referred to as a bed control structure as it is designed to provide a hard point in the streambed that is capable of resisting the erosive forces of the degradational zone. The second type can be referred to as a hydraulic control structure as it is designed to function by reducing the energy slope along the degradational zone to the point that the stream is no longer capable of scouring the bed. The distinction between the operating processes of these two types is important whenever grade control structures are considered.

Design considerations for siting grade control structures include determination of the type, location, and spacing of structures along the stream, along with the elevation and dimensions of structures. Siting grade control structures is often considered a simple optimization of hydraulics and economics. However, these factors alone are usually not sufficient to define the optimum siting conditions for grade control structures. In practice, hydraulic considerations must be integrated with a host of other factors, which vary from site to site, to determine the final structure plan. Some of the more important factors to be considered when siting grade control structures are discussed in the following paragraphs.

HYDRAULIC CONSIDERATIONS: One of the most important steps in the siting of a grade control structure or a series of structures is the determination of the anticipated drop at the structure. This requires some knowledge of the ultimate channel morphology, both upstream and downstream of the structure, which involves assessment of sediment transport and channel morphologic processes.

The hydraulic siting of grade control structures is a critical element of the design process, particularly when a series of structures is planned. The design of each structure is based on the anticipated tailwater or downstream bed elevation which, in turn, is a function of the next structure downstream. Heede and Mulich (1973) suggested that the optimum spacing of structures is such that the upstream structure does not interfere with the deposition zone of the next downstream structure. Mussetter (1982) showed that the optimum spacing should be the length of the deposition above the structure, which is a function of the deposition slope (Figure 1). Figure 1 also illustrates the recommendations of Johnson and Minaker (1944) that the most desirable spacing can be determined by extending a line from the top of the first

structure at a slope equal to the maximum equilibrium slope of sediment upstream until it intersects the original streambed.

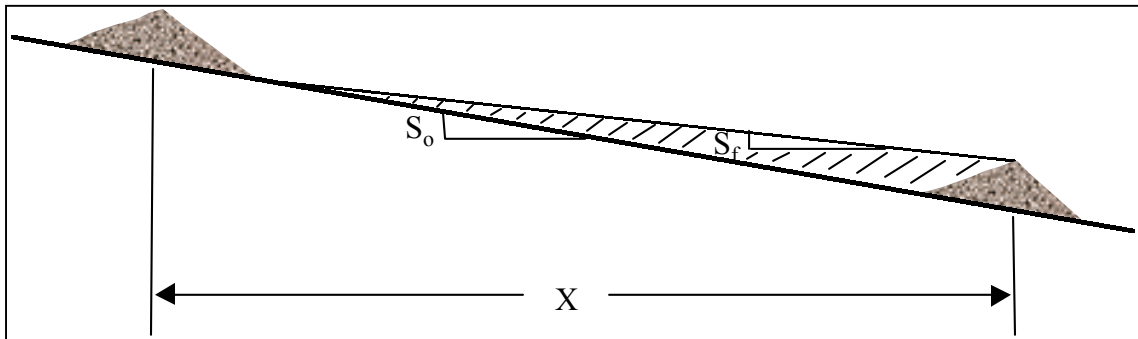


Figure 1. Spacing of grade control structure (adapted from Mussetter 1982)

Theoretically, the hydraulic siting of grade control structures is straightforward and can be determined by:

$$H = (S_o - S_f)X \quad (1)$$

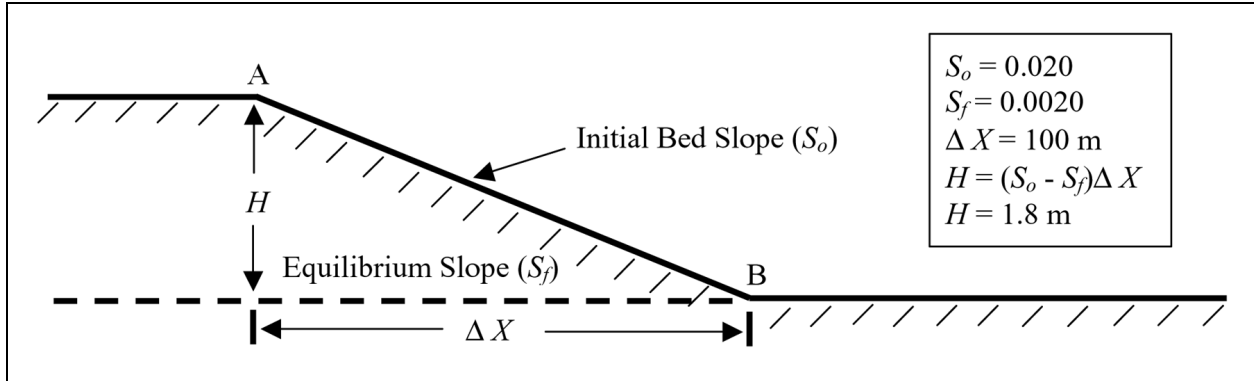
where H is the amount of drop to be removed from the reach, S_o is the original bed slope, S_f is the final, or equilibrium slope, and X is the length of the reach (Goitom and Zeller 1989). The number of structures (N) required for a given reach can then be determined by:

$$N = H/h \quad (2)$$

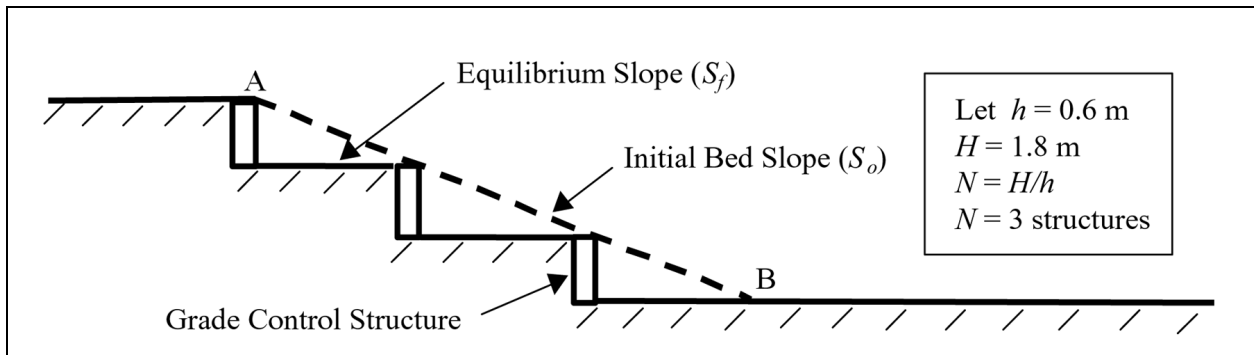
where h is the selected drop height of the structure.

The hydraulic siting of a series of bed control structures using the preceding procedure is illustrated in Figure 2. In contrast to bed control structures which are built at grade and the bed allowed to degrade between them (Figure 2b), hydraulic control structures are constructed with a raised and possibly constricted weir crest that drowns out the degradational zone (Figure 3b). It follows from Equation 1 that one of the most important factors to consider when siting grade control structures is the determination of the equilibrium slope (S_f). Unfortunately, this is also one of the most difficult parameters to define with any reliability. Failure to properly define the equilibrium slope can lead to costly, overly conservative designs, or inadequate design resulting in continued maintenance problems and possible complete failure of the structures.

The primary factors affecting the final equilibrium slope upstream of a structure include the incoming sediment concentration and load, the channel characteristics (slope, width, depth, roughness, etc.), and the hydraulic effect of the structure. Another complicating factor is the amount of time it takes for the equilibrium slope to develop. In some instances, the equilibrium slope may develop over a period of a few hydrographs while in others, it may take many years.



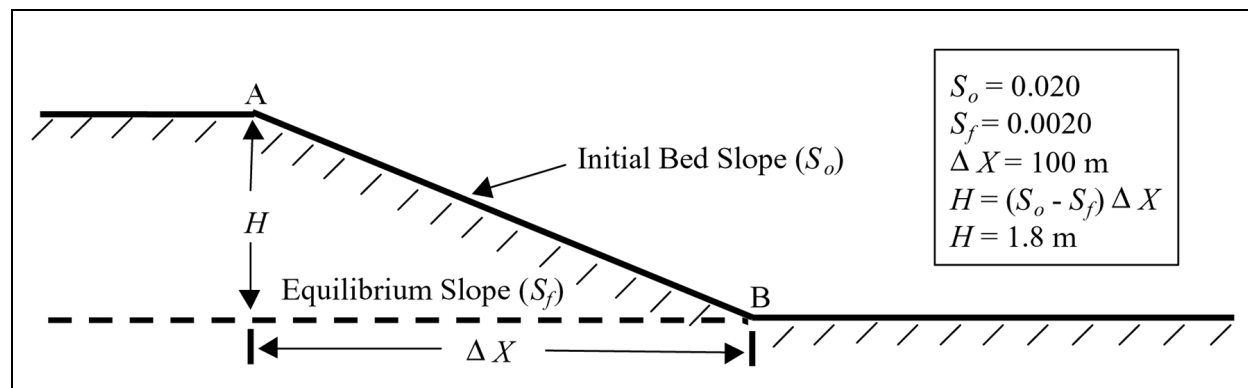
a. Initial condition of streambed showing degradational zone between points A and B.
Total anticipated drop in reach is calculated to be 1.8 m



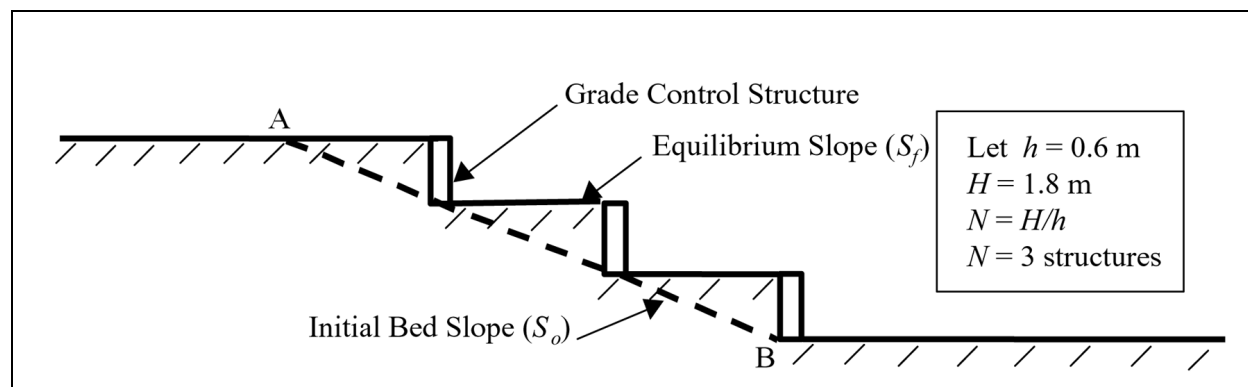
b. Stabilization of degradational zone using three bed control structures.
Each structure has a design drop of 0.6 m

Figure 2. Hydraulic siting of bed control structures

There are many different methods for determining the equilibrium slope in a channel (Mussetter 1982; Federal Interagency Stream Restoration Working Group 1988; Watson, Biedenharn, and Scott 1999). These can range from detailed sediment transport modeling (Thomas et al. 1994; HQUSACE 1993) to less elaborate procedures involving empirical or process-based relationships such as regime analysis (Lacey 1931; Simons and Albertson 1963), tractive stress (Lane 1953a,b; Simons 1957; Simons and Sentürk 1992; HQUSACE 1994), or minimum permissible velocity (USDA 1977). In some cases, the equilibrium slope may be based solely on field experience with similar channels in the area. Regardless of the procedure used, the engineer must recognize the uses and limitations of that procedure before applying it to a specific situation. The decision to use one method or another depends upon several factors such as the level of study (reconnaissance or detail design), availability and reliability of data, project objectives, and time and cost constraints.



a. Initial condition of streambed showing degradational zone between points A and B.
Total anticipated drop in reach is calculated to be 1.8 m



b. Stabilization of degradational zone using three hydraulic control structures.
Each structure has a design drop of 0.6 m

Figure 3. Hydraulic siting of hydraulic control structures

GEOTECHNICAL CONSIDERATIONS: The preceding discussion focused only on the hydraulic aspects of siting grade control structures. However, in some cases, the geotechnical stability of the reach may be an important or even the primary factor to consider when siting grade control structures. This is often the case where channel degradation has caused, or is anticipated to cause, severe bank instability due to exceedance of the critical bank height (Thorne and Osman 1988). When this occurs, bank instability may be widespread throughout the system rather than restricted to the concave banks in bendways. Traditional bank stabilization measures may not be feasible in situations where system-wide bank instabilities exist. In these instances, grade control may be the more appropriate solution.

Grade control structures can enhance the bank stability of a channel in several ways. Bed control structures indirectly affect the bank stability by stabilizing the bed, thereby reducing the length of bank line that achieves an unstable height. With hydraulic control structures, two additional advantages with respect to bank stability are: (a) bank heights are reduced due to sediment deposition, which increases the stability of the banks with regard to mass failure; and (b) by

creating a backwater situation, velocities and scouring potential are reduced, which reduces or eliminates the severity and extent of basal cleanout of the failed bank material, thereby promoting self-healing of the banks.

FLOOD CONTROL IMPACTS: Channel improvements for flood control and channel stability often appear to be mutually exclusive objectives. For this reason, it is important to ensure that any increased postproject flood potential is identified. This is particularly important when hydraulic control structures are considered. In these instances, the potential for causing overbank flooding may be the limiting factor with respect to the height and amount of constriction at the structure. Grade control structures are often designed to be hydraulically submerged at flows less than bank-full so that the frequency of overbank flooding is not affected. However, if the structure exerts control through a wider range of flows including overbank, then the frequency and duration of overbank flows may be impacted. When this occurs, the impacts must be quantified and appropriate provisions such as acquiring flowage easements or modifying structure plans should be implemented.

Another factor that must be considered is the safe return of overbank flows back into the channel. This is particularly a problem when the flows are out of bank upstream of the structure but still within bank downstream. The resulting head differential can cause damage to the structure as well as severe erosion of the channel banks depending upon where the flow re-enters the channel. Some means of controlling the overbank return flows must be incorporated into the structure design. One method is simply to design the structure to be submerged below the top bank elevation, thereby reducing the potential for a head differential to develop across the structure during overbank flows. If the structure exerts hydraulic control throughout a wider range of flows including overbank, then a more direct means of controlling the overbank return flows must be provided. One method is to ensure that all flows pass only through the structure. This may be accomplished by building an earthen dike or berm extending from the structure to the valley walls which prevents any overbank flows from passing around the structure (Forsythe 1985). Another means of controlling overbank flows is to provide an auxiliary high-flow structure which will pass the overbank flows to a specified downstream location where the flows can re-enter the channel without causing significant damage (Hite and Pickering 1982).

ENVIRONMENTAL CONSIDERATIONS: In today's environment, projects must work in harmony with the natural system to meet the needs of the present without compromising the ability of future generations to meet their needs. Engineers and geomorphologists are responding to this challenge by trying to develop new and innovative methods for incorporating environmental features into channel projects. The final siting and design of a grade control structure is often modified to minimize adverse environmental impacts to the system.

Grade control structures can produce positive environmental impacts on a channel system in a number of ways. Grade control structures are typically placed in severely unstable stream reaches. By preventing the headward migration of zones of degradation, grade control structures provide vertical stability to the stream and reduce the amount of sediment eroded from the streambed and banks. This not only protects the upstream reaches from the destabilizing effects of bed lowering, but can also minimize sedimentation problems in the downstream reaches.

Therefore, the impacts of grade control structures are not restricted to a local area around the structure, but can have far-reaching impacts on the whole channel system.

Grade control structures can provide direct environmental benefits to a stream. Cooper and Knight (1987) conducted a study of fisheries resources below natural scour holes and man-made pools below grade control structures in north Mississippi. They concluded that, although there was greater species diversity in the natural pools, there was increased growth of game fish and a larger percentage of harvestable-size fish in the man-made pools. They also observed that the man-made pools provided greater stability of reproductive habitat. Shields et al. (1990) reported that the physical aquatic habitat diversity was higher in stabilized reaches of Twentymile Creek, MS, than in reaches without grade control structures. They attributed the higher diversity values to the scour holes and low-flow channels created by the grade control structures. The use of grade control structures as environmental features is not limited to the low-gradient sand bed streams of the southeastern United States. Jackson (1974) documented the use of gabion grade control structures to stabilize a high-gradient trout stream in New York. She observed that, following construction of a series of bed sills, there was a significant increase in the density of trout. The increase in trout density was attributed to the accumulation of gravel between the sills which improved the spawning habitat for various species of trout.

Adverse environmental impacts can also be associated with grade control structures. During the construction of any structure there is always the potential for the destruction of riparian habitat. However, with grade control structures, these impacts are usually limited to a localized area at the structure as opposed to other types of channel improvement features (levees, bank stabilization, or channelization) where habitat destruction may occur continuously over long reaches of stream.

Perhaps the most serious negative environmental impact of grade control structures is the obstruction to fish passage. In many instances, fish passage is one of the primary considerations and may lead the engineer to select several small fish passable structures in lieu of one or more high drops that would restrict fish passage. In some cases, particularly when drop heights are small, fish are able to migrate upstream past a structure during high flows (Cooper and Knight 1987). However, in situations where structures are impassable, and where the migration of fish is an important concern, openings, fish ladders, or other passageways must be incorporated into the design of the structure to address the fish movement problems (Nunnally and Shields 1985). The various methods of accomplishing fish movement through structures are not discussed here. Interested readers are referred to Nunnally and Shields (1985); Clay (1961); and Smith (1985) for a more detailed discussion.

Other potentially adverse impacts associated with grade control structures include changed substrate character due to sediment deposition, increased water temperature, altered energy and transport characteristics, general habitat modification, and reduction in stream dynamics including riparian succession. There may also be social considerations that should be considered, especially safety.

The environmental aspects of the project must be an integral component of the design process when siting grade control structures. A detailed study of all environmental features in the project

area should be conducted early in the design process. This will allow these factors to be incorporated into the initial plan rather than having to make costly and often less environmentally effective last minute modifications to the final design. Unfortunately, there is very little published guidance concerning the incorporation of environmental features into the design of grade control structures. One source of useful information can be found in the following technical reports published by the U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory: Shields and Palermo (1982); Henderson and Shields (1984); and Nunnally and Shields (1985).

EXISTING STRUCTURES: Bed degradation can cause significant damage to bridges, culverts, pipelines, utility lines, and other structures along the channel perimeter. Grade control structures can prevent this degradation and thereby provide protection to these structures. For this reason, it is important to locate all potentially impacted structures when siting grade control structures. The final siting should be modified, as needed, within project restraints, to ensure protection of existing structures.

It must also be recognized that grade control structures can have adverse as well as beneficial effects on existing structures. This is a concern upstream of hydraulic control structures due to the potential for increased stages and sediment deposition. In these instances, the possibility of submerging upstream structures such as water intakes or drainage structures may become a deciding factor in the siting of grade control structures.

Whenever possible, the designer should take advantage of any existing structures which may already be providing some measure of grade control. This usually involves culverts or other structures that provide a nonerodible surface across the streambed. Unfortunately, these structures are usually not initially designed to accommodate any significant bed lowering and, therefore, cannot be relied on to provide long-term grade control. However, it may be possible to modify these structures to protect against the anticipated degradation. These modifications may be accomplished by simply adding some additional riprap with launching capability at the downstream end of the structure. In other situations, more elaborate modifications such as providing a sheet pile cutoff wall or energy dissipation devices may be required. Damage to and failure of bridges is the natural consequence of channel degradation. Consequently, it is not uncommon in a channel stabilization project to have several bridges that are in need of repair or replacement. In these situations it is often advantageous to integrate the grade control structure into the planned improvements at the bridge. If the bridge is not in immediate danger of failing and only needs some additional erosion protection, the grade control structure can be built at or immediately downstream of the bridge with the riprap from the structure tied into the bridge for protection. If the bridge is to be replaced, then it may be possible to construct the grade control structure concurrently with the road crossing.

LOCAL SITE CONDITIONS: When planning grade control structures, the final siting is often adjusted to accommodate local site conditions, such as the planform of the stream or local drainage. A stable upstream alignment that provides a straight approach into the structure is critical. Since failure to stabilize the upstream approach may lead to excessive scour and possible flanking of the structure, it is desirable to locate the structure in a straight reach. If this is not possible (as in the case in a very sinuous channel), it may be necessary to realign the

channel to provide an adequate approach. Stabilization of the realigned channel may be required to ensure that the approach is maintained. Even if the structure is built in a straight reach, the possibility of upstream meanders migrating into the structure must be considered. In this case, the upstream meanders should be stabilized prior to, or concurrent with, the construction of the grade control structure.

Local inflows from tributaries, field drains, roadside ditches, or other sources often play an important part in the siting of grade control structures. Failure to provide protection from local drainage can result in severe damage to a structure (U.S. Army Corps of Engineers 1981). During the initial siting of the structure, all local drainage should be identified. Ideally, the structure should be located to avoid local drainage problems. However, there may be some situations where this is not possible. In these instances, the local drainage should either be redirected away from the structure or incorporated into the structure design in such a manner that there will be no damage to the structure.

DOWNSTREAM CHANNEL RESPONSE: Since grade control structures affect the sediment delivery to downstream reaches, it is necessary to consider the potential impacts to the downstream channel when grade control structures are planned. Bed control structures reduce the downstream sediment loading by preventing the erosion of the bed and banks, while hydraulic control structures have the added effect of trapping sediments. The ultimate response of the channel to the reduction in sediment supply will vary from site to site. In some instances, the effects of grade control structures on sediment loading may be so small that downstream degradational problems may not be encountered. However, in some situations such as when a series of hydraulic control structures is planned, the cumulative effects of sediment trapping may become significant. In these instances, it may be necessary to modify the plan to reduce the amount of sediment being trapped or to consider placing additional grade control structures in the downstream reach to protect against the induced degradation.

GEOLOGIC CONTROLS: Geologic controls often provide grade control in a similar manner to a bed control structure. In some cases, a grade control structure can actually be eliminated from the plan if an existing geologic control can be utilized to provide a similar level of bed stability. However, caution must always be used when relying on geologic outcrops to provide long-term grade control. In situations where geologic controls are to be used as permanent grade control structures, a detailed geotechnical investigation of the outcrop is needed to determine its vertical and lateral extent. This is necessary to ensure that the outcrop will neither be eroded, undermined, or flanked during the project life.

EFFECTS ON TRIBUTARIES: The effect of main stem structures on tributaries should be considered when siting grade control structures. As degradation on a main stem channel migrates upstream it may branch up into the tributaries. Therefore, the siting of grade control structures should consider effects on the tributaries. If possible, main stem structures should be placed downstream of tributary confluences. This will allow one structure to provide grade control to both the main stem and the tributary. This is generally a more cost-effective procedure than having separate structures on each channel.

SUMMARY: The preceding discussion illustrates that the siting of grade control structures is not simply a hydraulic exercise, and there are many other factors that must be included in the design process. For any specific situation, some or all of the factors discussed in this section may be critical elements in the final siting of grade control structures. It is recognized that this does not represent an all inclusive list since there may be other factors not discussed here that may be locally important. For example, in some cases, maintenance requirements, debris passage, ice conditions, esthetics or safety considerations may be controlling factors. Consequently, there is no definitive cookbook procedure for siting grade control structures that can be applied universally. Rather, each situation must be assessed on an individual basis.

ADDITIONAL INFORMATION: Questions about this CHETN can be addressed to David S. Biedenbarn (601-634-4653), e-mail: David.S.Biedenbarn@erdc.usace.army.mil or Lisa C. Hubbard (601-634-4150), e-mail: Lisa.C.Hubbard@erdc.usace.army.mil. This CHETN should be referenced as follows:

Biedenbarn, D. S., and Hubbard, L. C. (2001). "Design considerations for siting grade control structures," Coastal and Hydraulics Engineering Technical Note CHETN-VII-3 U.S. Army Engineer Research and Development Center, Vicksburg, MS.
<http://chl.wes.army.mil/library/publications/chetn/>

REFERENCES

- Clay, C. H. (1961). "Design of fishways and other fish facilities," Department of Fisheries and Oceans, Canada, Queen's Printer, Ottawa.
- Cooper, C. M., and Knight, S. S. (1987). "Fisheries in man-made pools below grade control structures and in naturally occurring scour holes of unstable streams," *Journal of Soil and Water Conservation*, 42, 370-373.
- Federal Interagency Stream Restoration Working Group. (1998). "Stream corridor restoration: Principles, processes, and practices."
- Forsythe, P. (1985). "Performance of a grade control structure system during extreme floods," American Society of Agricultural Engineers Winter Meeting, Chicago IL.
- Goitom, T. G., and Zeller, M. E. (1989). "Design procedures for soil-cement grade control structures," Proceedings of the National Conference on Hydraulic Engineering, American Society of Civil Engineers, New Orleans, LA.
- Headquarters, U.S. Army Corps of Engineers. (1981). "Final Report to Congress, Streambank Erosion Control and Demonstration Project (Section 32), Appendix F, Yazoo River Basin Demonstration Projects," Washington, DC.
- _____. (1993). "Scour and deposition in rivers and reservoirs (HEC-6)," Washington, DC.
- _____. (1994). "Channel stability assessment for flood control projects," EM 1110-2-1418, Washington, DC.
- Heed, B. H., and Mulich, J. G. (1973). "Functional relationships and a computer program for structural gully control," *Journal of Environmental Management*, Vol.1.

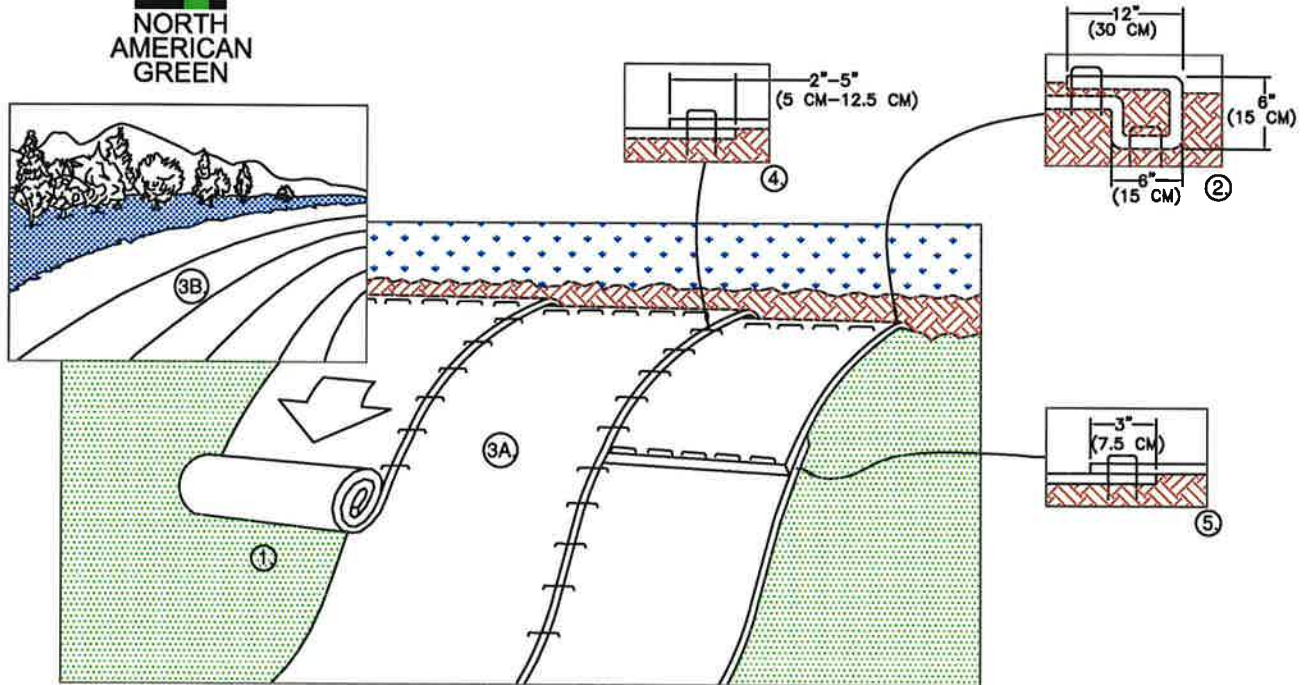
- Henderson, J. E., and Shields, F. D. (1984). "Environmental features for streambank protection projects," Technical Report E-84-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Hite, J. W., and Pickering, G. A. (1982). "South Fork Tillatoba Creek drop structures, Mississippi; Hydraulic model investigation," Technical Report HL-82-22, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Jackson, B. J. (1974). "Stream bed stabilization in Enfield Creek, New York," *New York Fish and Game Journal*, 21(10), 32-46.
- Johnson, J. W., and Minaker, W. L. (1944). "Movement and deposition of sediment in the vicinity of debris-barriers," Transactions, American Geophysical Union, Part VI, 901-905.
- Lacey, G. (1931). "Regime diagrams for the design of canals and distributaries," Technical Paper No. 1, United Provinces: P.W.D. Irrigation Branch.
- Lane, E. W. (1953a). "Progress report on studies on the design of stable channels by the bureau of reclamation," Proceedings, American Society of Civil Engineers, 79, Separate No. 280, 1-31.
- _____. (1953b). "Design of stable channels," Transactions, American Society of Civil Engineers, 120, 1234-1260.
- Mussetter, R. A. (1982). "Equilibrium slopes above channel control structures," Colorado State University, Civil Engineering Department, M.S. thesis, Fort Collins, CO.
- Nunnally, N. R., and Shields, F. D. (1985). "Incorporation of environmental features in flood control channel projects," Technical Report E-85-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Shields, F. D., and Palermo, M. R. (1982). "Assessment of environmental considerations in the design and construction of waterways projects," Technical Report E-82-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Shields, F. D., Jr., Hoover, J. J., Nunnally, N. R., Kilgore, K. J., Schaefer, T. E., and Waller, T. N. (1990). "Hydraulic and environmental effects of channel stabilization Twentymile Creek, Mississippi," Technical Report EL-90-14, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Simons, D. B. (1957). "Theory and design of stable channels in alluvial materials," Ph.D. diss., Colorado State University, Fort Collins, CO.
- Simons, D. B., and Albertson, M. L. (1963). "Uniform water conveyance channels in alluvial material," Transactions, American Society of Civil Engineers, 128, 65-167.
- Simons, D. B., and Sentürk, F. (1992). "Sediment transfer technology," Water Resources Publication, Littleton, CO.
- Smith, C. D. (1985). "Hydraulic structures," University of Saskatchewan Printing Services, Saskatoon, Canada.
- Thomas, W. A., Copeland, R. R., Raphelt, N. K., and McComas, D. N. (1994). "User's manual for the hydraulic design package for channels (SAM)," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Thorne, C. R., and Osman, A. M. (1988). "Riverbank stability analysis II: Applications," *Journal of Hydraulic Engineering*, ASCE, 114(2), 151-172.
- U.S. Department of Agriculture. (1977). "Design of open channels," Technical Release No. 25.

Watson, C. C., Biedenharn, D. S., and Scott, S. H. (1999). "Draft – channel rehabilitation: Processes, design and implementation," U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Slope Installation



SLOPE INSTALLATION APLICACIONES PARA TALUDES



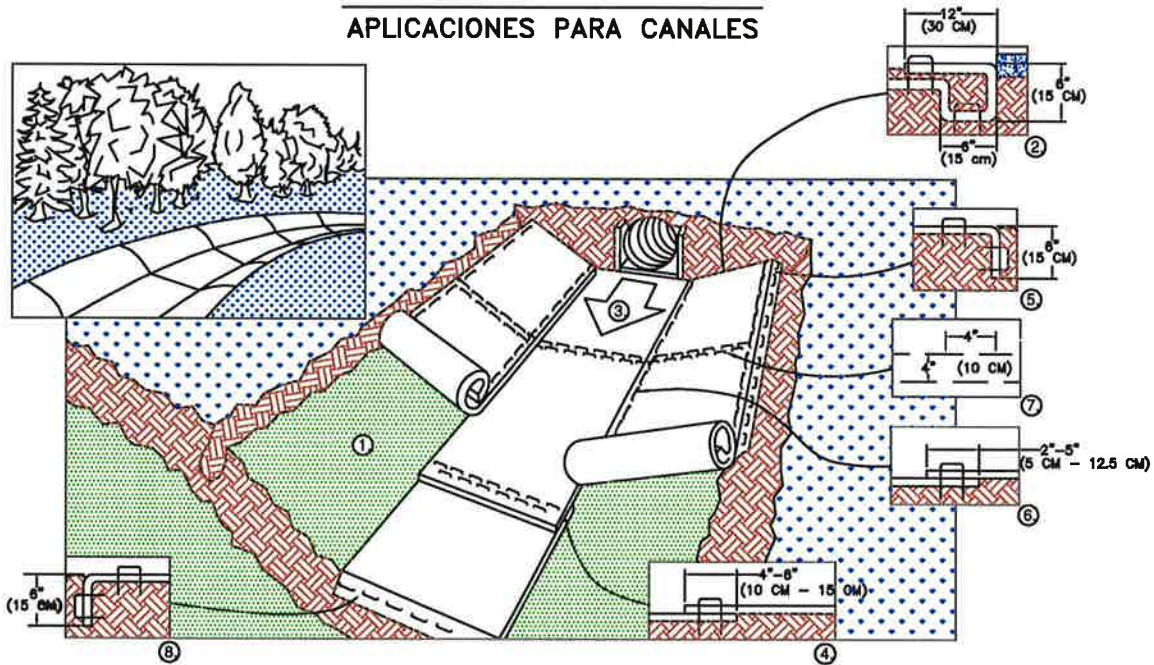
1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE BLANKET.
3. ROLL THE BLANKETS (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. THE EDGES OF PARALLEL BLANKETS MUST BE STAPLED WITH APPROXIMATELY 2" – 5" (5 CM – 12.5 CM) OVERLAP DEPENDING ON BLANKET TYPE.
5. CONSECUTIVE BLANKETS SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE BLANKET WIDTH.
NOTE:
*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE BLANKETS.

1. PREPARE EL TERRENO ANTES DE INSTALAR LAS MANTAS, INCLUYENDO LA APLICACION DE CAL, FERTILIZANTE Y SEMILLA.
NOTA: CUANDO ESTE USANDO CELL-O-SEED NO SIEMBRE EL AREA PREPARADA. CELL-O-SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
2. COMIENCE EN LA CABECERA DEL TALUD SUJETANDO LA MANTA EN UNA ZANJA DE 6' (15 CM) DE PROFUNDIDAD POR 6' (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE LA MANTA AL FONDO DE LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE. RIEGE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENROLLE LAS MANTAS (3A) HACIA ABAJO U (3B) HORIZONTAMENTE A TRAVES DEL TALUD CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™. LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADU UNDO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. LOS BORDES DE LAS MANTAS PARALELAS TIENEN QUE ENGRAPARSE CON UN TRASLAPE DE APROXIMADAMENTE 2" – 5" (5 CM – 12.5 CM) DEPENDIENDO DEL TIPO DE MANTA.
5. MANTAS CONSECUTIVAS UNIDAS EN LA BAJADA DE LOS TALUDES, DEBEN COLOCARSE ORILLA SOBRE ORILLA (TIPO EXCALONADO) CON UN TRASLAPE DE APROXIMADAMENTE 3" (7.5 CM). ENGRAPE EL AREA TRASLAPADA CON UNA SEPARACION DE APROXIMADAMENTE 12" (30 CM) A TRAVES DE TODO EL ANCHO DE LA MANTA.

NOTA:

* EN CONDICIONES DE SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

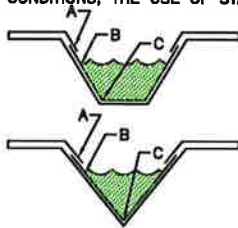
CHANNEL INSTALLATION APLICACIONES PARA CANALES



1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE CHANNEL BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) ACROSS THE WIDTH OF THE BLANKET.
3. ROLL CENTER BLANKET IN DIRECTION OF WATER FLOW IN BOTTOM OF CHANNEL. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. PLACE CONSECUTIVE BLANKETS END OVER END (SHINGLE STYLE) WITH A 4" - 6" (10 CM - 15 CM) OVERLAP. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER TO SECURE BLANKETS.
5. FULL LENGTH EDGE OF BLANKETS AT TOP OF SIDE SLOPES MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
6. ADJACENT BLANKETS MUST BE OVERLAPPED APPROXIMATELY 2" - 5" (5 CM - 12.5 CM) (DEPENDING ON BLANKET TYPE) AND STAPLED.
7. IN HIGH FLOW CHANNEL APPLICATIONS, A STAPLE CHECK SLOT IS RECOMMENDED AT 30 TO 40 FOOT (9 M - 12 M) INTERVALS. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER OVER ENTIRE WIDTH OF THE CHANNEL.
8. THE TERMINAL END OF THE BLANKETS MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.

NOTE:

* IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.



CRITICAL POINTS

- A. OVERLAPS AND SEAMS
- B. PROJECTED WATER LINE
- C. CHANNEL BOTTOM/SIDE SLOPE VERTICES

NOTE:

* HORIZONTAL STAPLE SPACING SHOULD BE ALTERED IF NECESSARY TO ALLOW STAPLES TO SECURE THE CRITICAL POINTS ALONG THE CHANNEL SURFACE.

** IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

PUNTOS CRITICOS

- A. TRASLAPES Y JUNTAS
- B. LINEAS DE AGUA PROYECTADA
- C. FONDO DEL CANAL/VERTICES DE LAS PENDIENTES LATERALES

NOTA:

* LA SEPARACION HORIZONTAL DE LAS GRAPAS SE DEBE ALTERAR SI SE NECESITA, PARA PERMITIR QUE LAS GRAPAS ASEGUEN LOS PUNTOS CRITICOS A LO LARGO DE LA SUPERFICIE DEL CANAL.

** EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGUAR LAS MANTAS CORRECTAMENTE.

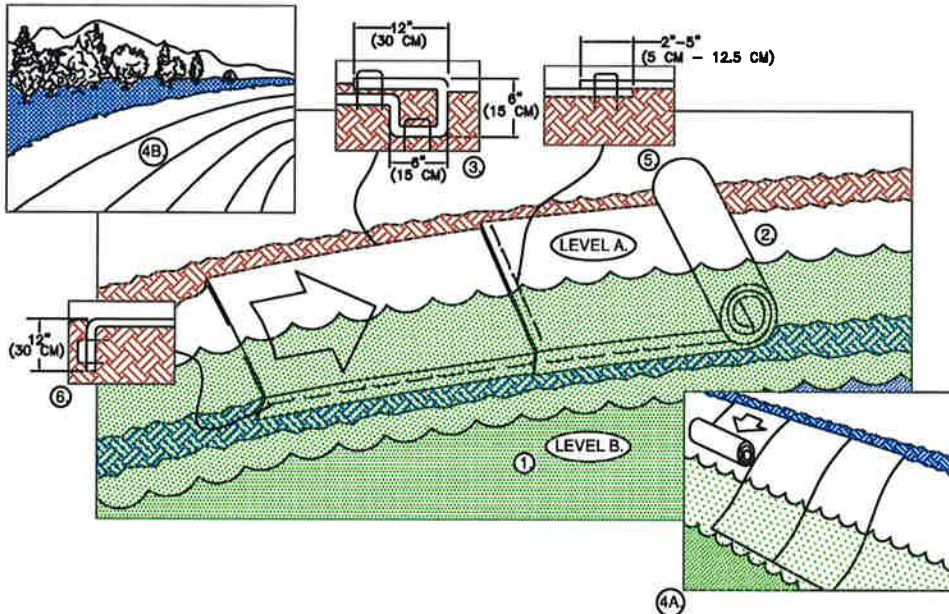
1. PREPARE EL SUELO DE COLOCAR LAS MANTAS, INCLUYENDO LA APLICACION DE CAL, FERTILIZANTE SEMILLA. NOTA: CUANDO ESTE USANDO CELL-O-SEED NO SIEMBRAR EL AREA PREPARADA. CELL-O-SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
2. COMIENCE EN LA CABECERA DEL CANAL SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPADO. RIEGUE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA Y EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENLLE LA MANTA DEL MEDIO EN EL FONDO DEL CANAL Y EN LA DIRECCION DEL FLUJO DE AGUA CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGUARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™, LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADA UNO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. COLOQUE LAS MANTAS CONSECUTIVAS BORDE SOBRE BORDE (TIPO ESCALONADO) CON UN TRASLAPE DE 4" - 6" (10 CM - 15 CM). USE UNA LINEA DOBLE DE GRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO PARA ASEGUAR LAS MANTAS.
5. EN EL TOPE DE LAS DOS PENDIENTES LATERALES DEL CANAL, SE DEBE SUJETAR TODO EL LARGO DE LA ORILLA DE LAS MANTAS CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" (30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPADO.
6. LAS MANTAS ADYACENTES DEBEN TRASLAPARSE APROXIMADAMENTE DE 2" - 5" (5 CM - 12.5 CM) (DEPENDIENDO DEL TIPO DE MANTA) Y ENGRAPPARSE.
7. EN APLICACIONES PARA CANALES DE FLUJO ALTO, SE RECOMIENDA DEJAR UNA RANURA PARA EL CHEQUEO DE LAS GRAPAS A INTERVALOS DE 30 A 40 PIES (9 M - 12 M). USE UNA LINEA DOBLE DE GRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO A TRAVES DE TODO EL ANCHO DEL CANAL.
8. LOS BORDOS FINALES DE LAS MANTAS DEBEN SUJETARSE CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" (30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE DESPUES DEL ENGRAPADO.

NOTA:

* EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGUAR LAS MANTAS CORRECTAMENTE.

SHORELINE INSTALLATION

APLICACIONES PARA LAS LINEAS COSTERAS



- FOR EASIER INSTALLATION, LOWER WATER FROM LEVEL A TO LEVEL B BEFORE INSTALLATION.
- PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED
NOTE: WHEN USING CELL-O-SEED, DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
- BEGIN AT THE TOP OF THE SHORELINE BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE BLANKET.
- ROLL BLANKETS EITHER (A.) DOWN THE SHORELINE FOR LONG BANKS, (TOP TO BOTTOM) OR (B.) HORIZONTALLY ACROSS THE SHORELINE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEMSM, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
- THE EDGES OF ALL HORIZONTAL AND VERTICAL BLANKET SEAMS MUST BE STAPLED WITH APPROXIMATELY 2" - 5" (5 CM - 12.5 CM) OVERLAP.
NOTE:
* SEAM OVERLAP SHOULD BE SHINGLED ACCORDING TO PREDOMINANT EROSION ACTION.
- THE EDGE OF THE BLANKET AT OR BELOW NORMAL WATER LEVEL MUST BE ANCHORED BY PLACING THE BLANKET IN A 12" (30 CM) DEEP X 6" (15 CM) WIDE ANCHOR TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART IN THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING (STONE OR SOIL MAY BE USED AS BACKFILL)
NOTE:
* IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

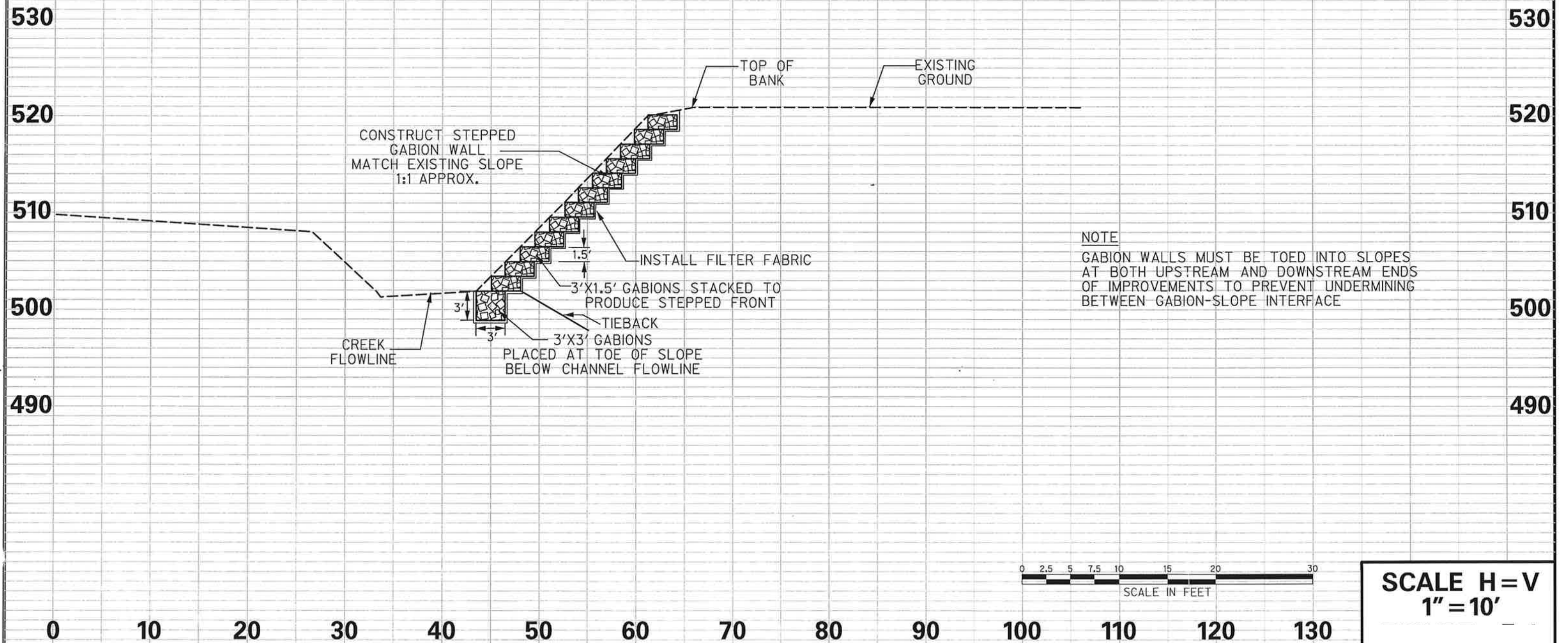
- PARA UNA INSTALACION MAS FACIL, BAJE EL NIVEL DEL AGUA DEL PUNTO A AL PUNTO B, ANTES DE LA INSTALACION.
- PREPARE EL TERRENO ANTES DE LA INSTALACION DE LAS MANTAS, INCLUYENDO APLICACION DE CAL, FERTILIZANTE Y SEMILLA.
NOTA: CUANDO ESTE USANDO CELL-O-SEED NO SIEMBRE EL AREA PREPARADA. CELL-O-SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
- COMIENCIE EN LA CABECERA DE LA LINEA COSTERA SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE LA MANTA AL FONDO DE LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30cm) UNA BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) DE LA ORTA. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPADO. RIEGUE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA Y EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA ORTA A TRAVES DEL ANCHO DE LA MANTA.
- DESENNOLLE LAS MANTAS (4A) HACIA ABAJO EN LA LINEA COSTERA PARA RIBERAS LARGAS U (4B) HORIZONTALMENTE A TRAVES DE LA PENDIENTE DE ESTA CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEMSM, LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADA UNO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
- LOS BORDES DE LAS COSTURAS DE LAS MANTAS HORIZONTALES Y VERTICALES DEBEN ENGRAPARSE CON UN TRASLAPE DE APROXIMADAMENTE 2" - 5" (5 CM - 12.5 CM).
NOTE:
* LA COSTURA DEL TRASLAPE DEBE CUBRIRSE DE ACUERDO A LA ACCION PREDOMINANTE DE EROSION.
- EL BORDE DE LA MANTA QUE ESTA AL O POR DEBAJO DEL NIVEL DE AGUA NORMAL DEBE ASEGURARSE COLOCANDOLO EN UNA ZANJA DE ANLAJE DE 12" (30 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. ASEGURE LA MANTA EN LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE A 12" (30 CM) UNA DE LA OTRA. RELLENE Y COMPACTE LA ZANJA DESPUES DE ENGRAPAR (PIEDRAS O SUELO PUEDE USARSE COMO RELLENO).
NOTE:
* EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

Hard Armor Solutions

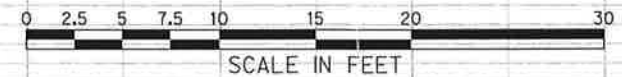
Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930

TYPICAL SECTION STEPPED GABION WALL



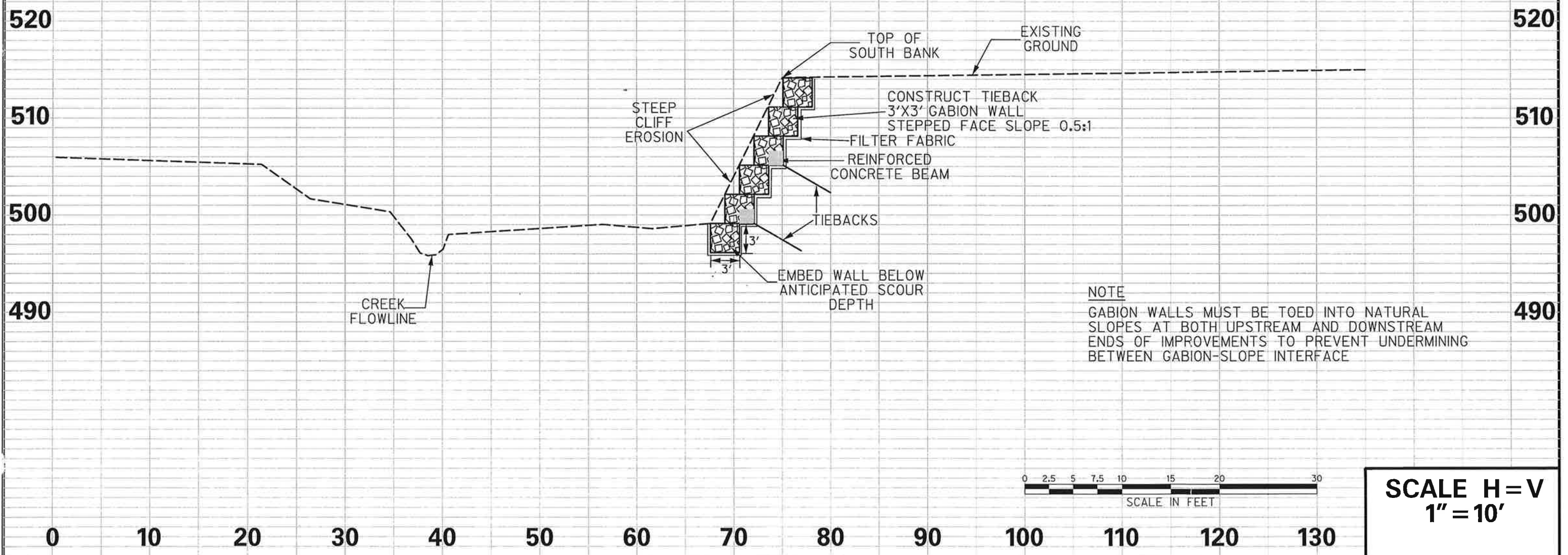
NOTE
GABION WALLS MUST BE TOED INTO SLOPES
AT BOTH UPSTREAM AND DOWNSTREAM ENDS
OF IMPROVEMENTS TO PREVENT UNDERMINING
BETWEEN GABION-SLOPE INTERFACE



SCALE H=V
1" = 10'

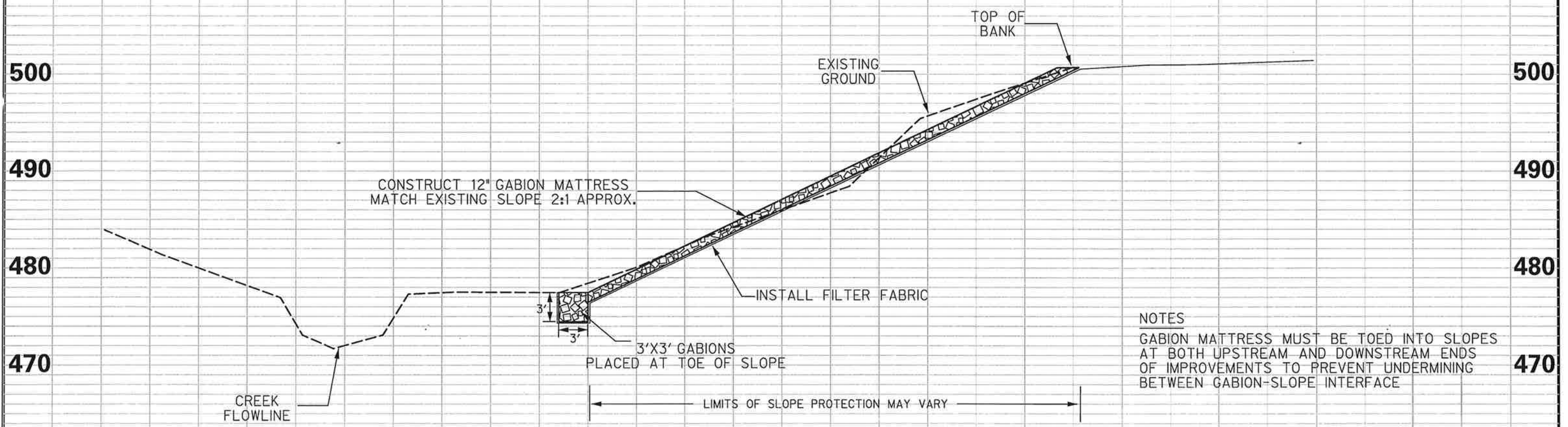
STREAM BANK STABILITY

TYPICAL SECTION
TIEBACK GABION WALL



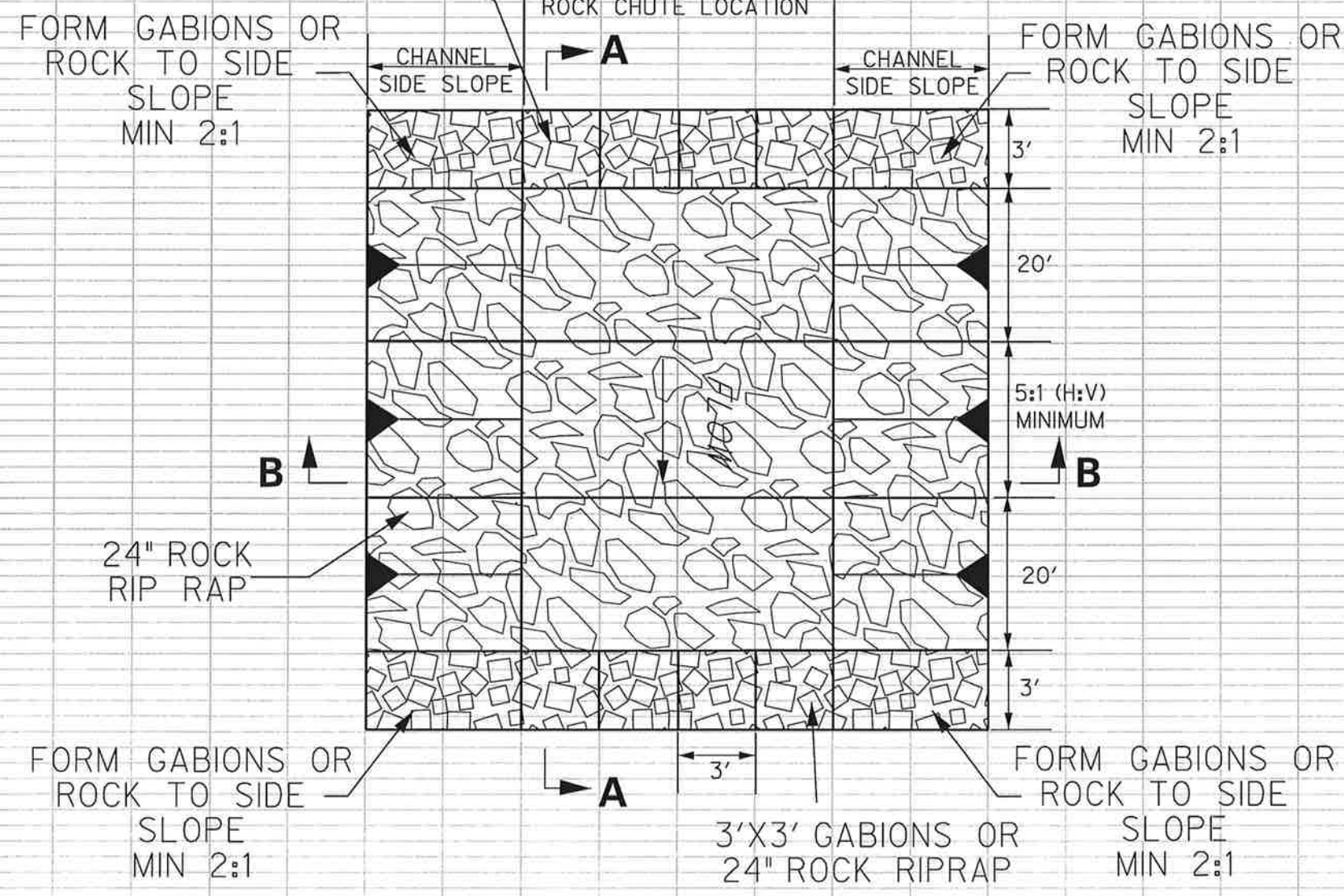
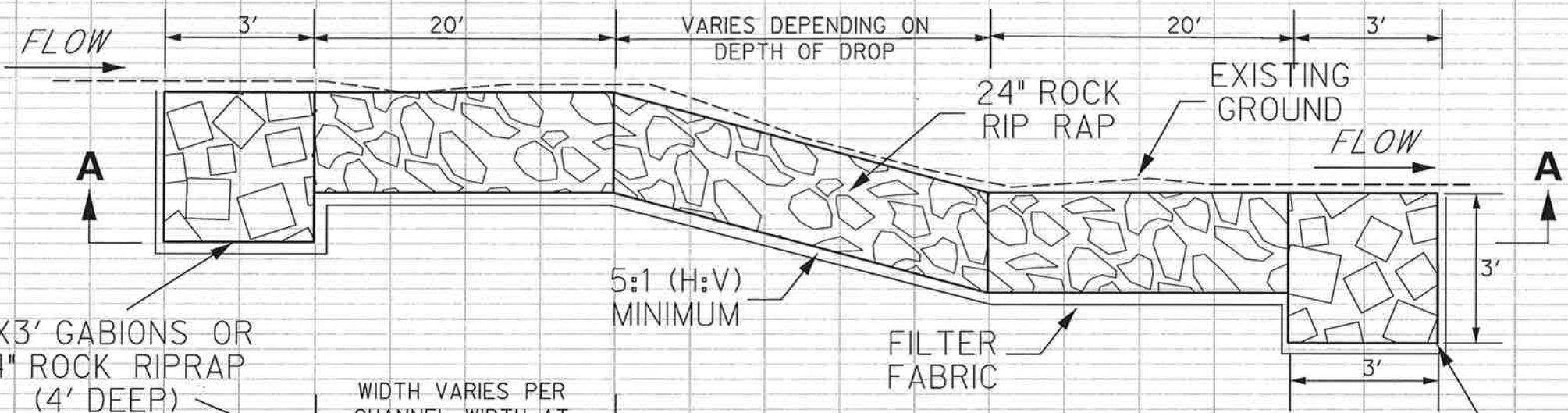
STREAM BANK STABILITY

TYPICAL SECTION GABION MATTRESS



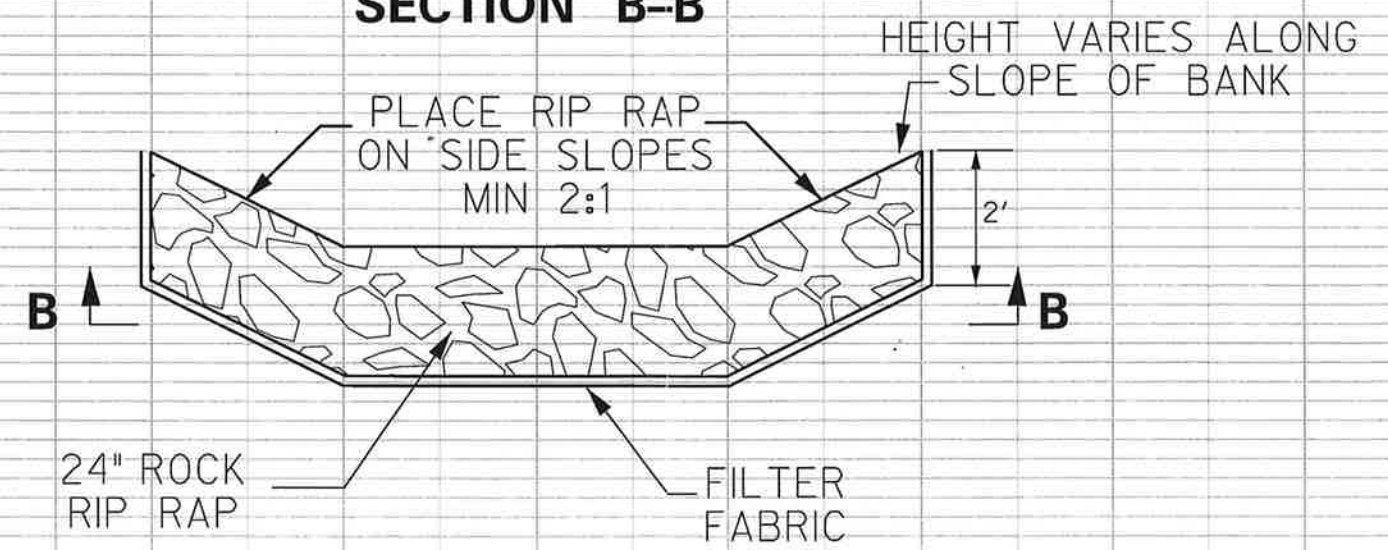
ROCK CHUTE TYPICAL SECTION

PROFILE VIEW SECTION A-A



PLAN VIEW

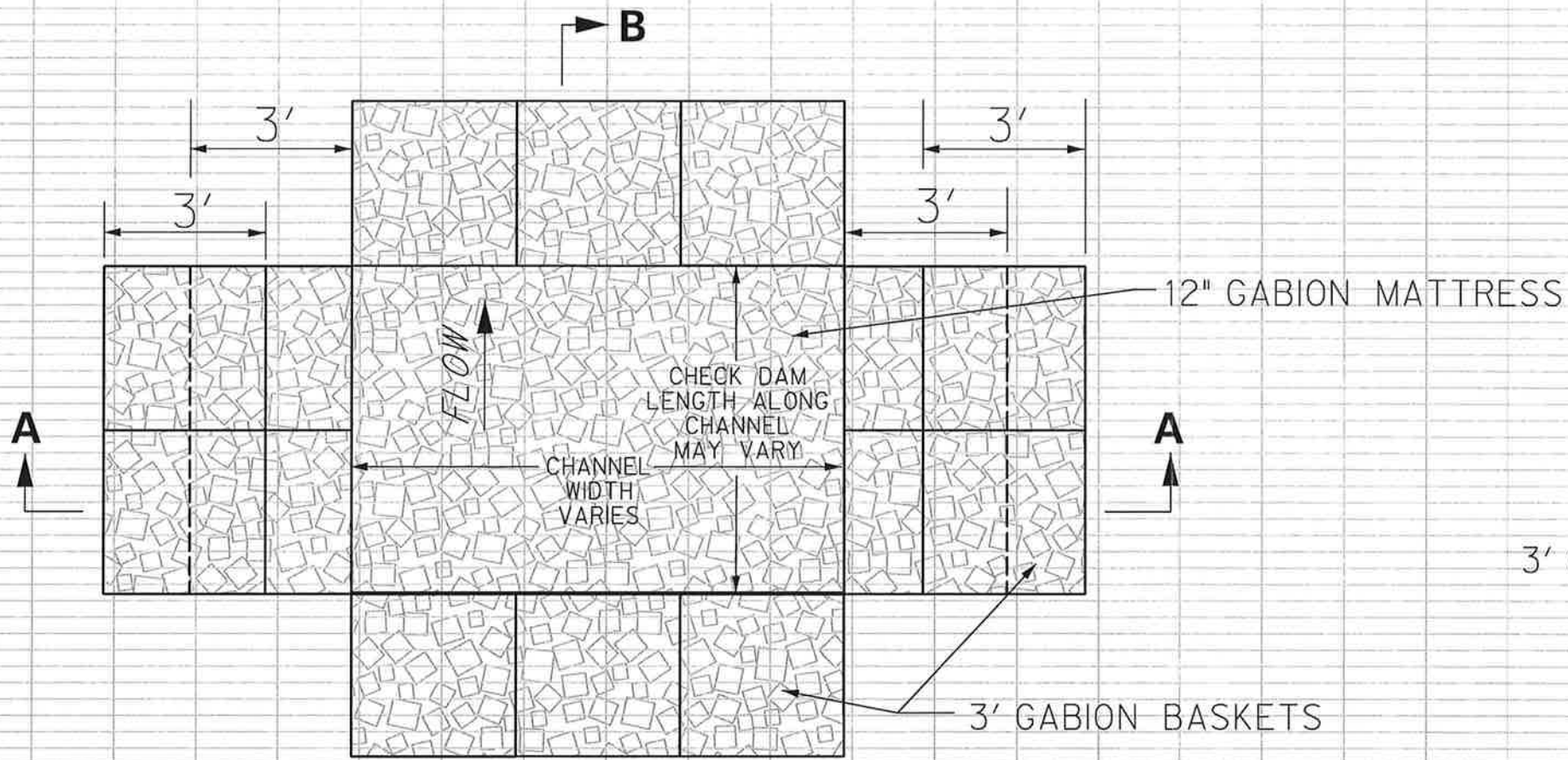
FRONT VIEW SECTION B-B



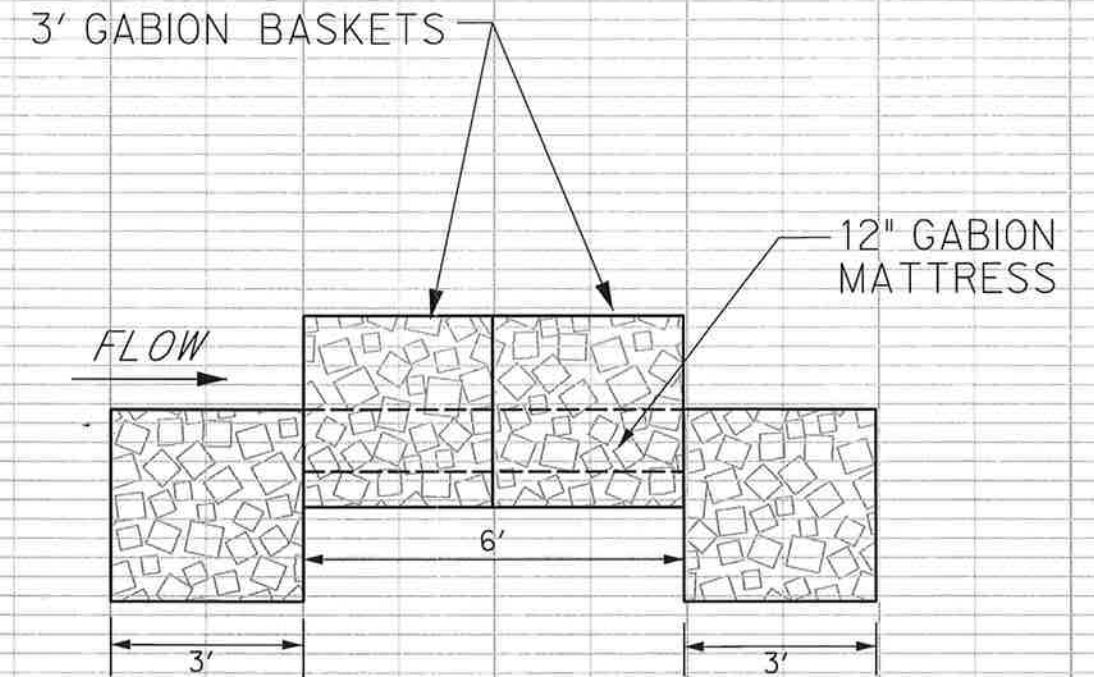
NOTE:
 1. HEIGHT OF ROCK CHUTES WILL VARY ACCORDING TO BANKFULL ELEVATION AT SPECIFIC LOCATIONS.
 2. IF NO GRADE CHANGE EXISTS, "DROP" PORTION OF CHUTE CAN BE REMOVED.

**SCALE H=V
1"=3'**

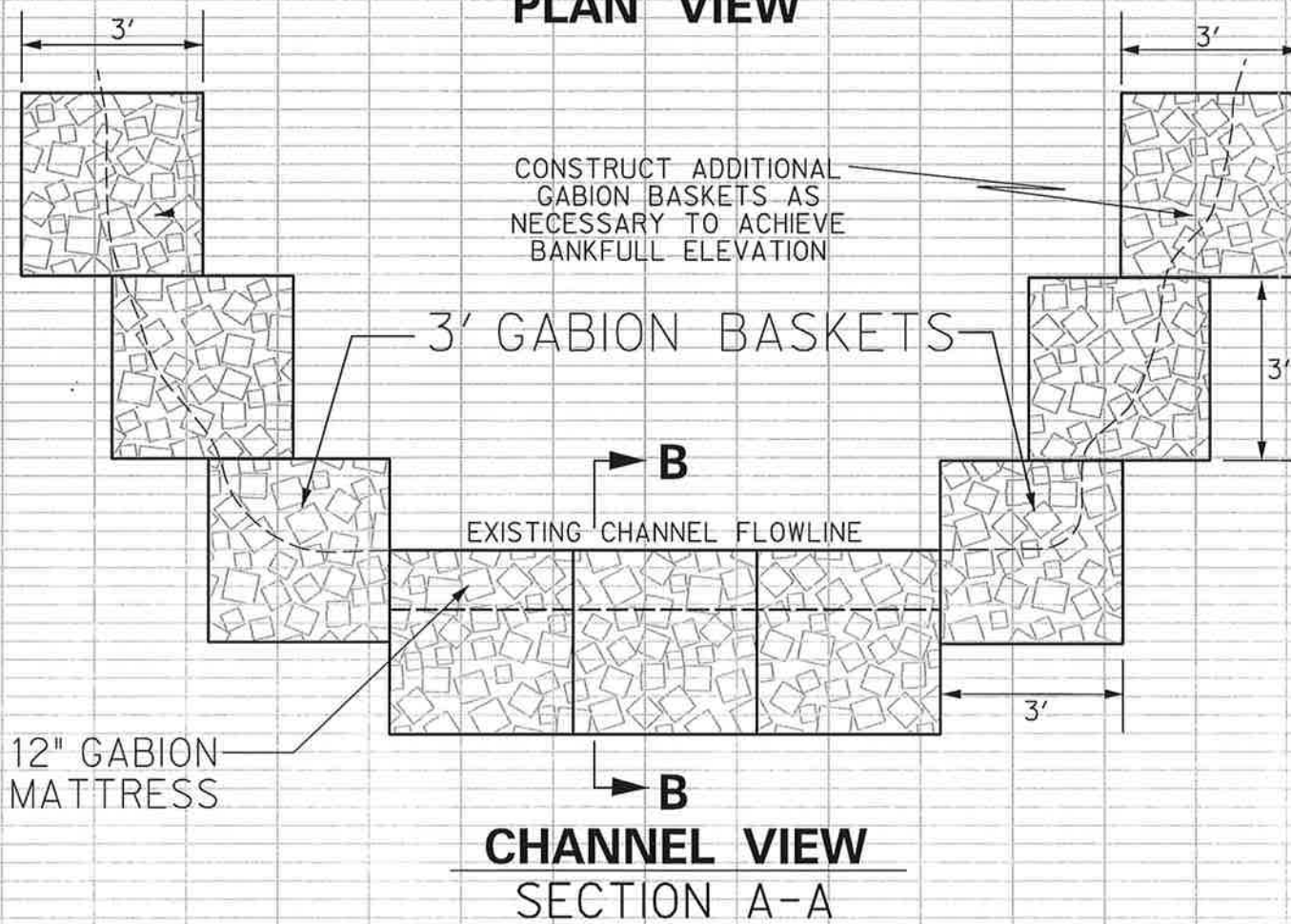
GABION CHECK DAM DAM TYPICAL SECTION



PLAN VIEW



**SIDE VIEW
SECTION B-B**



**CHANNEL VIEW
SECTION A-A**

**SCALE H=V
1"=3'**

Appendix E
Miscellaneous

City Resolution No. 3919

Half Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930

A RESOLUTION ESTABLISHING A POLICY CONCERNING EROSION AND OTHER DRAINAGE PROBLEMS RELATING TO WATERWAYS.

WHEREAS, the City Council has determined that Erosion problems along the Trinity River and Creeks in the city are of concern to the City.

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

SECTION 1. That it is hereby determined to be in the best interests of the City of Grand Prairie, Texas and its inhabitants to adopt the following drainage policy:

Erosion and/or flooding problems on private property will be investigated on a case-by-case basis. The City will focus on improvements to the waterways that will result in a general public benefit, such as lowering erosive velocities and increasing flow capacities in proximate streams for the general prevention of erosion and flooding.


Remedy of private property issues, such as flooding due to lot-to-lot drainage (no involvement of City property) and construction projects to protect specific private property due to proximate stream erosion, will not be undertaken by the City unless a general public benefit or public safety concern can be demonstrated, and the undertaking of such are approved by the City Council. Individual projects will be evaluated and prioritized based on available funding.

SECTION 2. That this resolution shall become effective immediately upon its passage and approval.

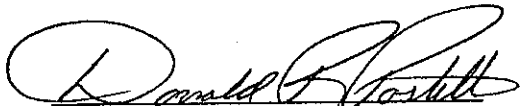
PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS, this 17th day of June, 2003.


Mayor, Grand Prairie, Texas

ATTEST:

for 
Catherine E. DiMaggio, City Secretary

APPROVED AS TO FORM:


Donald R. Postell, City Attorney

**U.S. Army Corps of Engineers
Nationwide Permits
Individual Permit Application**

Halff Associates, Inc.
Supplemental CWDMP for Fish Creek (Y#0882)

AVO 27930



US Army Corps
of Engineers

Regulatory Program Information



- National Regulatory Program Home Page:
<http://www.usace.army.mil/inet/functions/cw/cecwo/reg/>
- Fort Worth District Regulatory Home Page:
<http://www.swf.usace.army.mil/pubdata/environ/regulatory/index.asp>
- Galveston District Regulatory Home Page:
www.swg.usace.army.mil/reg/
- Tulsa District Regulatory Home Page:
www.swt.usace.army.mil/permits/permits.cfm
- Albuquerque District Regulatory Home Page:
www.spa.usace.army.mil/reg/

One Corps Serving The Army and the Nation



US Army Corps
of Engineers

Corps Contacts in Texas and Southwestern Division



Fort Worth District	(817) 886-1731
Little Rock District	(501) 324-5296
Galveston District	(409) 766-3930
Tulsa District	(918) 669-7400
Albuquerque District	(915) 568-1359

One Corps Serving The Army and the Nation

**Geotechnical Investigation by CMJ Engineering,
Inc. (Along Kirby Creek at Estate Drive)**

4.3.8 General Recommendations

4.3.8.1 Sites at Borings B-1 through B-5 (Note: Includes Gabion Slope Protection Areas)

The sites at Borings B-1 through B-5 possess satisfactory long-term slope stability characteristics and generally soils with good to excellent strength characteristics. Remediation at these sites should be available via providing adequate erosion control along the creek banks of Kirby Creek and/or provide adequate lateral confinement of fence posts and fence supports. The combination of erosion control and appropriate lateral confinement of fence structures is anticipated to eliminate problems associated with soil creep movements. That specific area at Boring B-4 likely will require removal of a section of concrete wall and replacement with appropriate doweling and supports. It also would be highly recommended that weep holes be provided in the wall to allow elimination of potential hydrostatic pressures from building up behind the wall structure.

4.3.8.2 Sites at Boring B-6

It is our opinion that the area of Boring B-6 needs to be completely reconstructed. Failure plane soils should be removed and the slope reconstructed with the minimum thickness of higher quality material in the lower portion of the reconstructed slope. Plate A.20c depicts slope stability analyses in which the failed slope soils have been removed, a 10-foot thick zone of more granular, competent soils placed initially from the base of the excavation upwards (see Soil Type 3), and competent clay soil placed above the offsite granular material in an engineered fashion. The entire slope can consist of the more granular soil, if desired. The following specific earthwork procedure is recommended at the area of Boring B-6:

- Excavate/remove failed soils, stockpile on site or discard at on offsite location
- As excavation proceeds, slope the satisfactory, natural soils in a temporary 1 horizontal to 1 vertical slope or flatter, if possible
- Re-divert channel water, as necessary, to prevent near surface water from affecting the general area for new soil placement
- After final removal of failed soils, proof roll the existing subgrade to observe any soft/loose materials that require removal and replacement
- Obtain offsite granular material to consist of flexible base (TxDOT Item 247, Type A, Grade 1 or 2 material in accordance with the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highway, Streets, and Bridges), or place an offsite select fill, consisting of clayey sand with a liquid limit less than 35 and plasticity index between 4 and 12
- Place new granular fill in approximate 9-inch loose lifts and compact this material to at least 95 percent of Standard Proctor Compaction (ASTM D 698) at a moisture content between - 2 and +5 percentage points of the optimum moisture value (it may be necessary to place

Appendix F
DVD