RESOLUTION NO. 4836-2016

A RESOLUTION APPROVING THE CITY OF GRAND PRAIRIE'S CITY-WIDE DRAINAGE MASTER PLAN FOR BEAR CREEK AND DRY CREEK

WHEREAS, the "City-Wide Drainage Master Plan for Bear Creek and Dry Creek" (the Plan) provides comprehensive, updated technical data for the management of the Bear Creek and Dry Creek watersheds; and

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; and

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 Bear Creek and Dry Creek watersheds; and

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 Bear Creek and Dry Creek" to cost-effectively manage flood or storm waters within budgeting constraints, approves and adopts the "City-Wide Drainage Master Plan for Bear Creek and Dry 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 AUGUST, 2016.

APPROVED:

Ron Jensen, Mayor

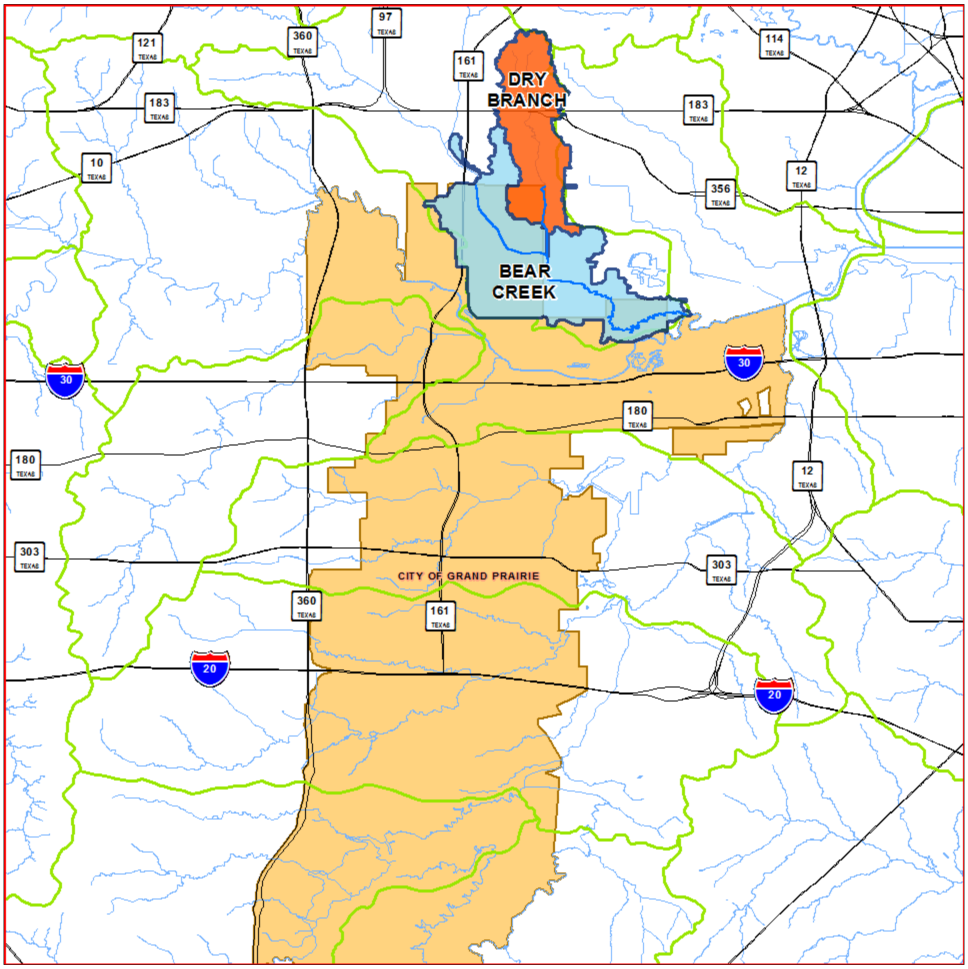
ATTEST:

Lydia M. Zuckerman

City Secretary

APPROVED AS TO FORM:

City Attorney



Bear Creek and Dry Creek City-Wide Drainage Master Plan

City of Grand Prairie

May 2015

March 23, 2016
AVO 29283

Mr. Romin A. Khavari, P.E., CFM
City Engineer
Ms. Stephanie Griffin, P.E., CFM
Stormwater Utility Manager / Floodplain Administrator
City of Grand Prairie
206 W. Church Street
Grand Prairie, TX 75053-4045

Re: **City-wide Drainage Master Plan for Bear Creek and Dry Creek (Y#0948) Final Report**

Dear Mr. Khavari and Ms. Griffin:

Transmitted herewith is the Final Report for the City-wide Drainage Master Plan for Bear Creek and Dry Creek (Y#0948), including technical data and exhibits. This report compiles existing and newly developed technical data for the Bear Creek and Dry Creek watershed into a single comprehensive document. The report also includes a CD-ROM 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 if you have any questions or concerns regarding the CWDMP for the Bear Creek and Dry Creek watershed.

Sincerely,

HALFF ASSOCIATES, INC.

Stephen B. Crawford

Stephen Crawford, PE, CFM
Vice President

cc: Romin Khavari, P.E. CFM

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APPENDICES

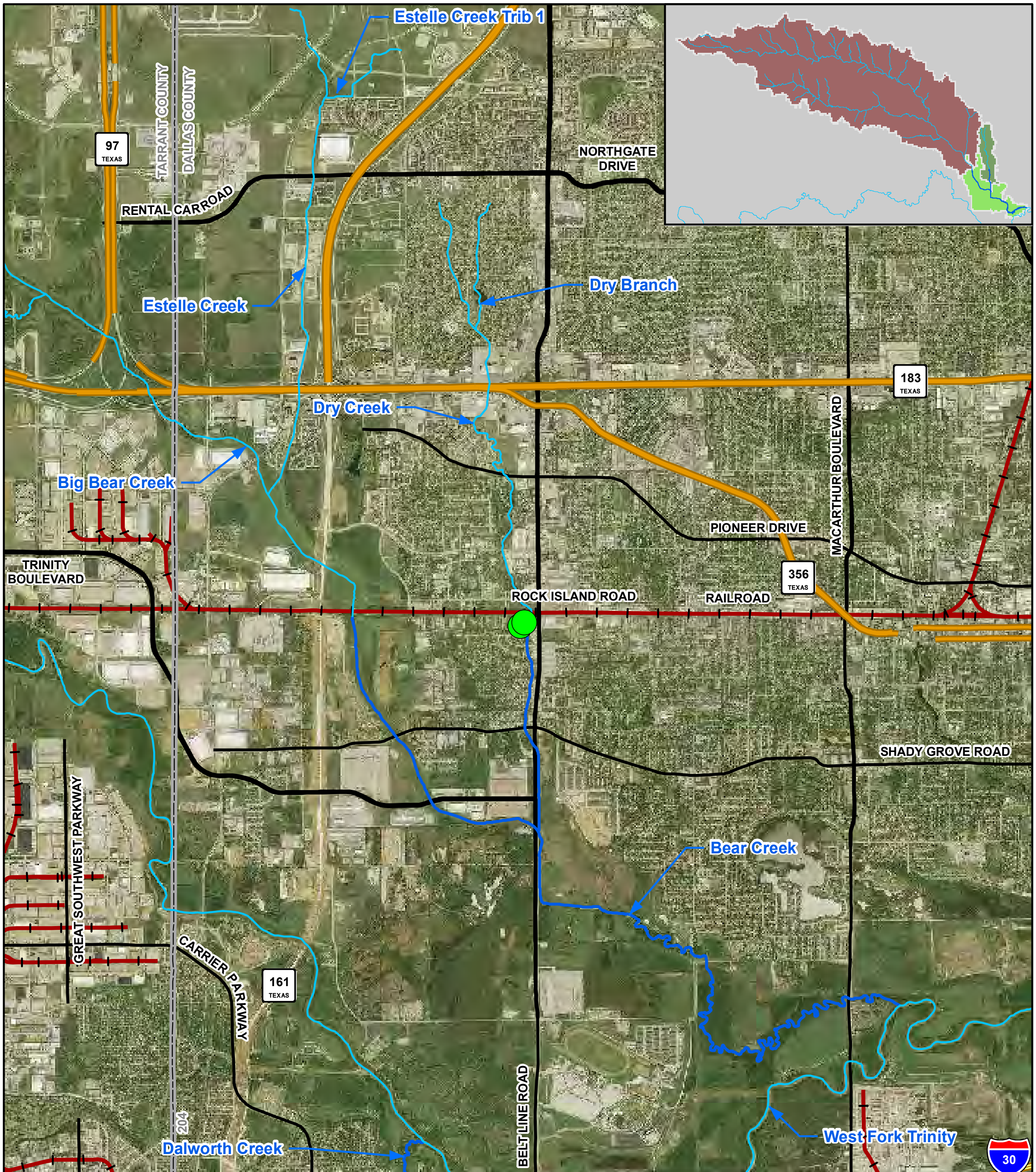
EXECUTIVE SUMMARY

The City-Wide Drainage Master Plan for Bear Creek and Dry Creek provides comprehensive, updated technical data for the management of the Bear Creek and Dry Creek watershed tributaries and storm water infrastructure. This report addresses flood dangers and erosion problems within the Bear Creek and Dry Creek 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 the Bear Creek and Dry Creek 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. ____________ approving this study on __________.

A total of one hundred and seven (107) structures were identified within the existing 100-year floodplain in the Bear Creek and Dry Creek watershed. The majority of the watershed in the City of Grand Prairie is currently undeveloped, except for some industrial development along Trinity Boulevard between S.H. 161 and Belt Line Road and some residential development north and east of the same intersection. The stream stability alternatives included in this report are considered short-term Capital Improvement Projects. See the following pages for the summary of the prioritization rankings and a location map.

This report includes structural stream stability alternatives that are recommended only on an "as-needed" basis. As development occurs, the Floodplain Workmaps should be utilized to determine whether a site is in a high risk area for bank erosion or channel degradation. If so, then stream bank stability alternatives should be considered.

This report is intended to be a living document that can be updated as additional information becomes available.



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KEY TO FEATURES

Studied Stream	County Boundary
Unstudied Stream	Interstate Highway
CIP Location	State Highway
	Major Road
	Railroad

* The upper portions of the Bear Creek watershed was not modeled in this study and are included only for hydrologic purposes.

0 2,500 5,000 10,000

Scale in Feet

N W E S

Title

CIP Location Map

Watershed

Bear-Dry Creek

Figure

1

Capital Improvement Project Summary

Preliminary Short-Term & Long-Term Implementation

Rank	Stream	Capital Improvement Project	Short-Term/Long-Term	Public/Private	Probable Cost
Stream Stability Alternatives					
1	Dry Creek	Rock Chutes	Short-Term	Public	$88,500

I. Introduction

I. INTRODUCTION

A. ACKNOWLEDGMENTS

Halff 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
Stephanie Griffin – Floodplain Administrators
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" (August 2010). The purpose of this City-Wide Drainage Master Plan for Bear Creek and Dry Creek is to provide comprehensive, updated technical data for the management of the Bear Creek and Dry Creek watershed. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood 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 damages within the Bear Creek and Dry Creek watershed.

This report compiles existing and newly developed data for the Bear Creek and Dry Creek watershed into one document. This report also provides a summary of the procedures used in the technical analyses, a summary of results, illustrative exhibits, and supporting technical data.

Specific objectives of this City-Wide Drainage Master Plan for the City of Grand Prairie, Texas for the management of the Bear Creek and Dry Creek watershed 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) and to delineate the ultimate 100-yr floodplain for Bear Creek and Dry Creek.

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’s Master Thoroughfare Plan.

5. Perform a Storm Water Infrastructure Analysis to identify potential urban flooding locations by providing converting record plans to StormCAD V8i.

6. Locate and provide detailed descriptions 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.

7. Utilize the City’s Storm Drain Outfall Assessment to provide detailed descriptions of locations where maintenance needs to occur.

8. Evaluate and Prioritize proposed alternative improvement projects and describe the methodology utilized to phase and implement the proposed alternative improvement projects.

9. Determine Short-Term and Long-Term Plan to prioritize proposed alternative improvement projects including benefit-cost analysis ratios.

C. CITY ORDINANCES AND DEVELOPMENT REQUIREMENTS

As part of this City-wide Drainage Master Plan study, the City Drainage Design Manual and existing development requirements were reviewed to determine their adequacy to prevent future flooding issues. The Bear Creek and Dry Creek watershed is approximately 60% developed at this time and proper drainage and continued responsible development of the watershed will help prevent future flood damage and unnecessary capital improvement costs.

The City of Grand Prairie is especially progressive in their storm water management program. The City's Drainage Design Manual was updated as recently as June of 2015 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 Bear Creek and Dry Creek watersheds stretches through a number of cities from the City of Fort Worth to City of Grand Prairie to a point it discharges into West Fork Trinity River. The watershed is approximately 60% urbanized and is characterized by a mix of industrial, commercial, and residential use though it is mostly residential use. The area within the City of Grand Prairie’s is built out in the developable areas. Much of the watershed in the City of Grand Prairie is within the 100-year floodplain and has not been developed and most likely will not be developed. This City-wide Drainage Master Plan will focus on the Bear Creek and Dry Creek watershed. A detailed description of the Bear Creek and Dry Creek watershed can be found in Section II.B of this report.

1. Major Streams and Tributaries

Dry Creek is a tributary of Bear Creek. These watersheds do not contain any other major tributaries. Table I-1 lists this stream’s downstream limit, upstream limit, Federal Emergency Management Agency (FEMA) designation, and length.

Table I-1 – Study Streams

Stream Name	Downstream Limit	Upstream Limit (within Grand Prairie)	FEMA Designation	Length (ft)*
Bear Creek and Dry Creek	Confluence with West Fork Trinity	Rock Island Road	Zone AE	46,500
* Note: Length was taken from centerline data in GIS from Rock Island Road to the confluence with West Fork Trinity River.				

2. Unique Attributes of Watershed

The most unique attribute of the Bear Creek and Dry Creek watershed is the presence of Lone Star Park, Quick Trip Park and Verizon Theatre. A levee maintained by the Grand Prairie Metropolitan Utility and Reclamation District protects these event venues from the 100 year storm event.

E. PRINCIPAL FLOODING PROBLEMS

The City of Grand Prairie's floodplain management has helped prevent problems for much of the new development within the Bear Creek and Dry Creek watershed. Storm drain systems designed according to the standards detailed in the City's Drainage Criteria Manual have minimized drainage complaints to only a few localized areas. Some flooding issues exist in the rural areas of the watershed; specifically, many of the roads are undersized and will be overtopped by nearly any significant rainfall event.

1. Drainage Complaint Database

Halff Associates, Inc. obtained the latest information from the City of Grand Prairie's Drainage Complaint Database for the Bear Creek and Dry Creek watershed. One hundred and eighteen (118) drainage complaints at eighty four (84) different locations have been filed with the City of Grand Prairie within the Bear Creek and Dry Creek watershed. Of these complaints, thirty-six (36) were structure flooding problems related to streets or storm drains, thirty-six (36) were yard flooding problems, twelve (12) were street ponding problems, two (2) were a lot-to-lot property flooding problem, two (2) were ponding problems in park areas, and six (6) were complaints about debris obstructing flow in the channel. Twenty-four (24) complaints have other categorizations. There were twenty (20) complaints coinciding with riverine flooding locations. Other complaints in the watershed primarily involved storm drainage system performance or local flooding due to grading issues.

F. Pertinent Study and Technical Data Related to Watershed Prior to Bear Creek and Dry Creek Master Plan Preparation

1. Existing Data

i. *Belt Line Corridor Reclamation Master Plan (Nathan D. Maier, April 1999 & October 2004 update)*

ii. *Bear Creek Map Modernization – Hydrology – FEMA – Halff Associates*

iii. *Bear Creek/Hunter Ferrell Road Study – Halff Associates*

iv. *Bear Creek – Fully Urbanized H&H (100-year) – Halff Associates (prepared for NCTCOG communities)*

v. *Big Bear Creek – Engineering Analysis – Hydraulics – Halff Associates (October 2005)*

vi. *Dry Branch LOMR – Halff Associates (1998)*

vii. *Dry Branch Study for the City of Irving – Freese and Nichols (2008)*

viii. *Post Oak Drainage Study and Preliminary Plan*

ix. *City Wide Internal Storm Drain Master Plan Study – Halff Associates (2015)*

Halff Associates was contracted in July 2013 by the City of Grand Prairie to analyze the limitations and deficiencies of the drainage system for portions of City watersheds, including: Alspaugh Branch, Arbor Creek, Bear Creek, Cedar Creek, Cottonwood Creek, Dalworth Creek, Dry Branch, Fish Creek, Gopher Branch, Johnson Creek, Kirby Creek, Mountain Creek, Prairie Creek, Turner Branch, and West Fork Trinity River, through the use of detailed hydraulic analysis and to provide improvement recommendations that are effective both functionally and financially. Analysis for this master plan was performed using the StormCAD v8i modeling package with available patches, and focused on the storm drain trunk lines (24" and larger) with limited open channel evaluation.

II. Hydrologic Studies

II. HYDROLOGIC STUDIES

A. GENERAL

Hydrologic analyses were conducted by Halff Associates for the Bear Creek and Dry Creek watershed. In the study area it is bordered by the West Fork Irving Branch basin to the east and northeast, Kieth Branch and Robertson Branch to the west, West Fork Trinity River basin to the southwest, south, and southeast. Bear Creek and Dry Creek is located within the Lower West Fork Trinity hydrologic region which is characterized by generally flat terrain and impermeable soils.

The USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS, Version 3.5) was utilized to develop the following hydrologic scenarios:

1. Existing (2013) Land Use Conditions
2. Ultimate Land Use Conditions

Significant rainfall events considered for the hydrologic model were the 2-, 5-, 10-, 25-, 50-, 100- and 500-year frequency floods. Detailed watershed delineation, existing and ultimate land use determinations, and the hydrologic soil coverage were used to develop the HEC-HMS hydrologic computer model for the Bear Creek and Dry Creek watershed. The City's Drainage Design Manual (June 2015) along with Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55) Second Edition were used as guidelines for the new hydrologic analyses in 2013.

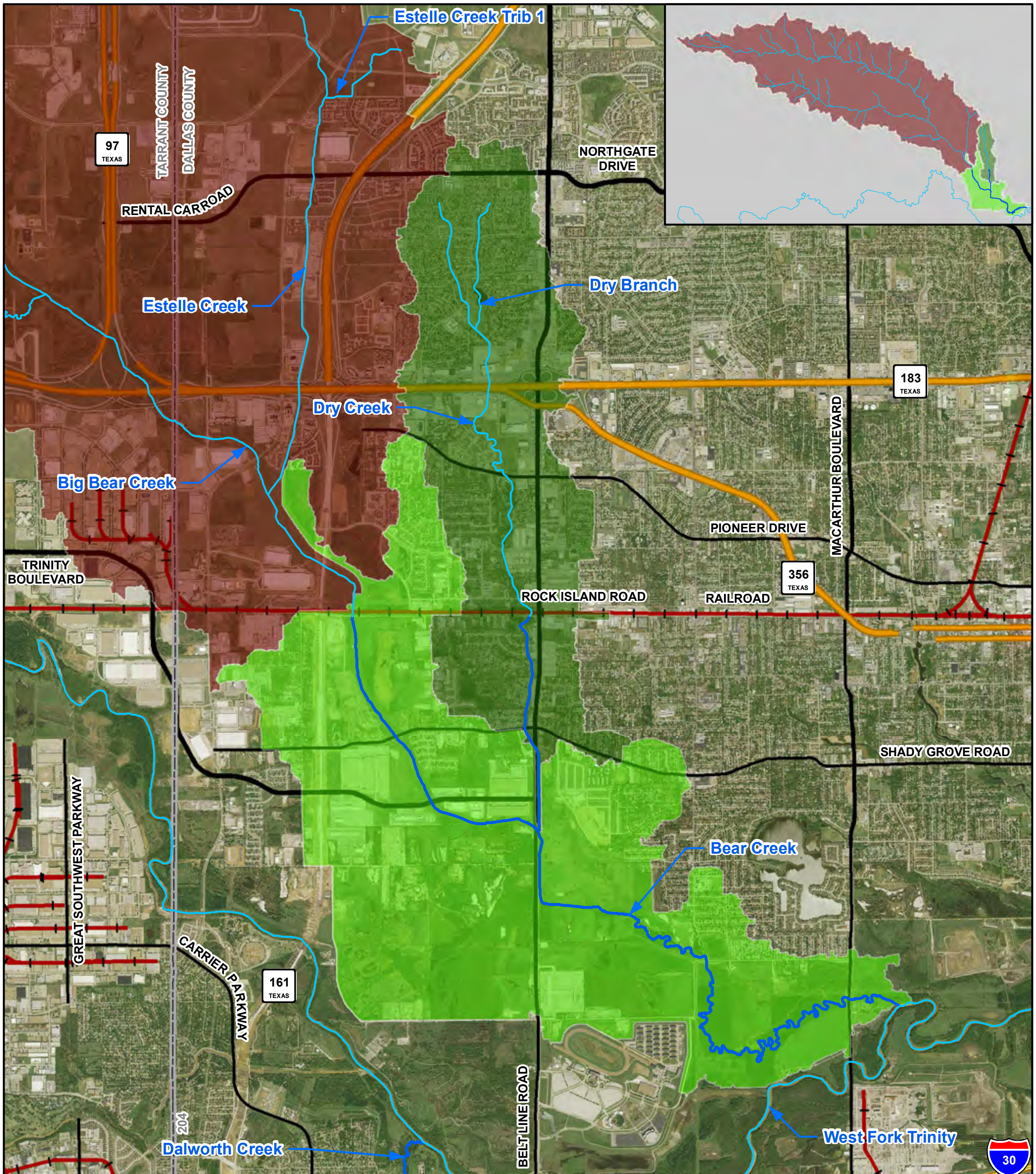
B. WATERSHEDS

The following is a brief description of the Bear Creek and Dry Creek watershed.

The Bear Creek and Dry Creek watershed is located north of Interstate 30 and the Trinity River, and mostly west of MacArthur Boulevard in the northern portion of the City of Grand Prairie. The total contributing watershed area draining to Bear Creek and Dry Creek is about 93.47 square miles or approximately 59,820 acres with an estimated affected population of 28,620 people (U.S. Census Bureau, 2010). Bear Creek stretches 7.36 miles within the study limits from the confluence with the West Fork Trinity River to just downstream of Rock Island Road. Dry Creek is a tributary to Bear Creek and stretches 1.47 miles from its confluence with Bear Creek to just downstream of Rock Island Road.

The watershed is currently about 60% urbanized, shown in Figure II-2. The upper watershed is heavily developed with industrial, commercial, and residential property with a large percentage of impervious area. The lower portion of the watershed closest to the West Fork Trinity River is mostly undeveloped because it is mainly in the 100 year floodplain. The Overall Watershed Map, Figure II-1, found on the following page and in Appendix A of this report shows the Bear Creek and Dry Creek watershed in regards to the City of Grand Prairie and adjacent communities.

The Bear Creek and Dry Creek watershed within the study area was sub-divided into twenty-nine (29) sub-basins. Sub-basin delineations were generated in ESRI's ArcGIS Version 9.3 based on the City of Grand Prairie 2009 Light Detection and Ranging (LiDAR) Terrain Data. Digital storm sewer lines supplied by the City of Grand Prairie, supported by current aerial photography, aided in the basin delineation process.



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KEY TO FEATURES

Bear Creek Watershed	County Boundary
Dry Branch Watershed	Interstate Highway
Upper Bear Creek Watershed*	State Highway
Studied Stream	Major Road
Unstudied Stream	Railroad

* The upper portions of the Bear Creek watershed was not modeled in this study and are included only for hydrologic purposes.

0 2,500 5,000 10,000

Scale in Feet

N S W E

Title

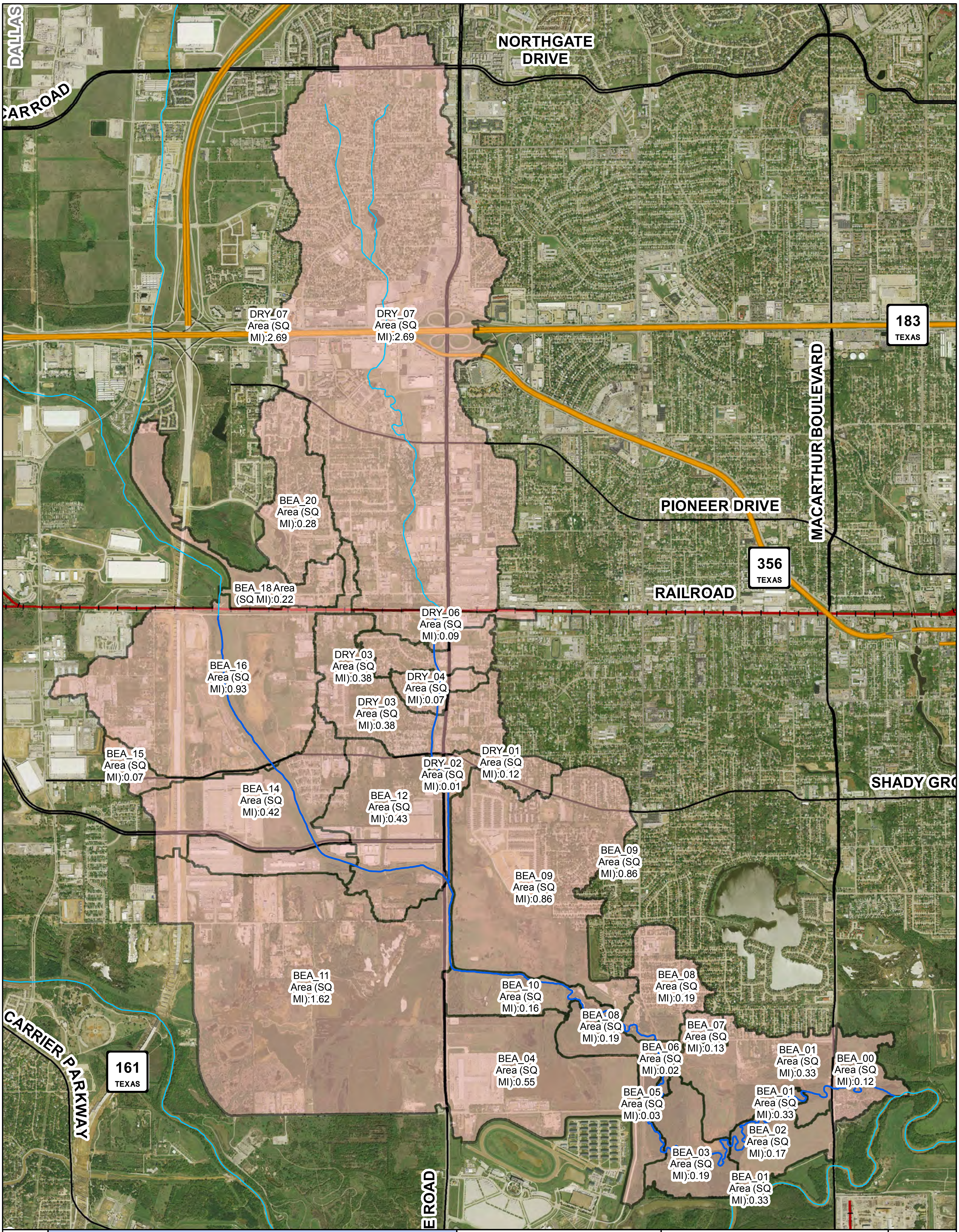
Overall Watershed Map

Watershed

Bear-Dry Creek

Figure

II-1A



Figure

II-1B

KEY TO FEATURES

- Project Stream
- Other Stream
- Drainage Areas
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Detailed Watershed Map

Panel 01

0 2,500 5,000

Scale in Feet

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C. LAND USE

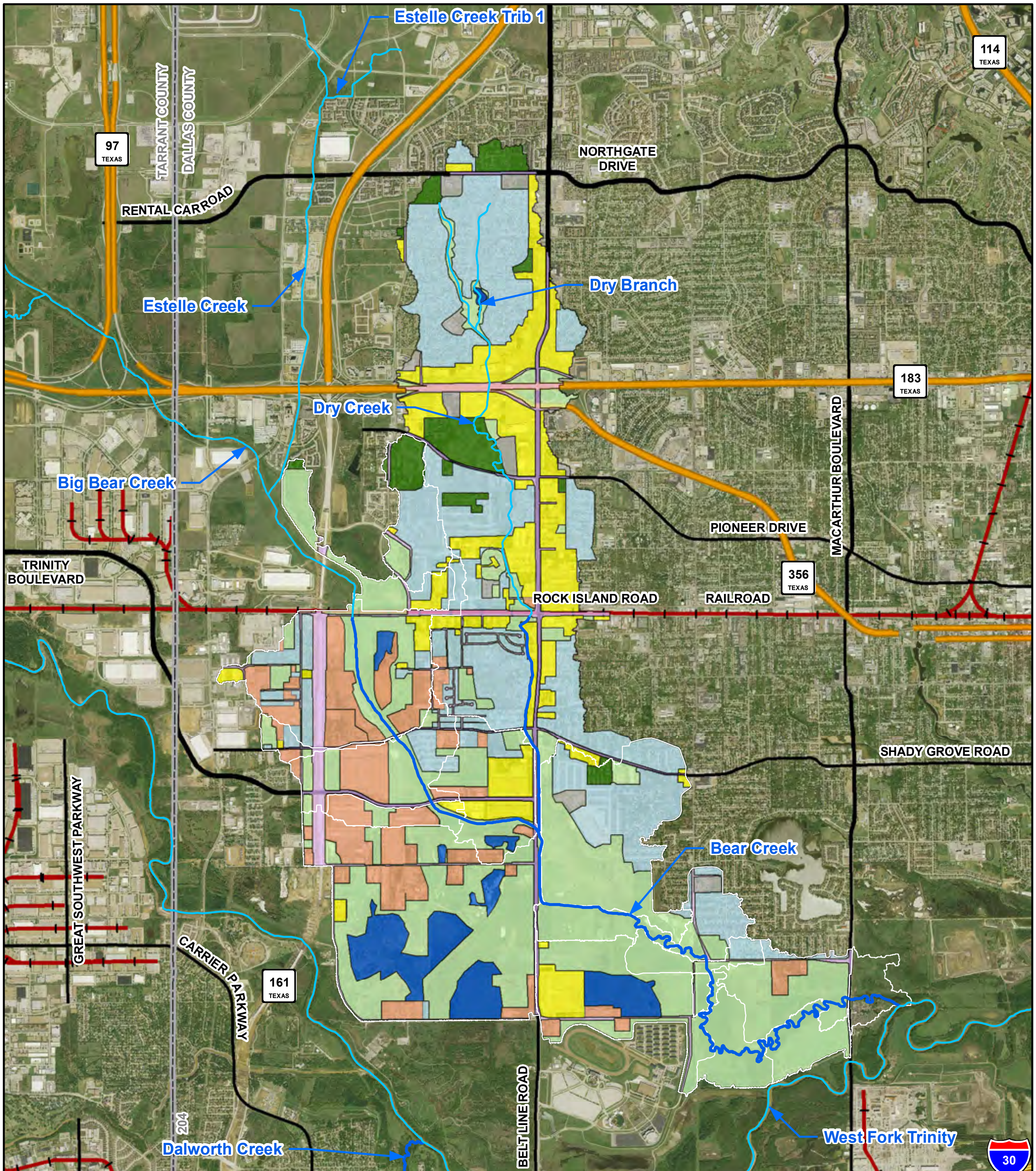
Land usage for the Bear Creek and Dry Creek watershed has been determined for both existing and ultimate conditions.

1. Existing Land Use

The Bear Creek and Dry Creek watershed land use was developed based on the 2013 City of Grand Prairie land use data and updated based on current aerial photography (2013). The Bear Creek and Dry Creek watershed is 60% developed with commercial, single family residential, multi-family residential, and industrial use. Figure II-2 shows the existing land use within the Bear Creek and Dry Creek watershed.

2. Ultimate Land Use

Ultimate land use conditions 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. Figure II-3 shows the ultimate land use within the Bear Creek and Dry Creek watershed.



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KEY TO FEATURES

Studied Stream	Government	Drainage Areas
Unstudied Stream	Commercial	County Boundary
Single Family	Open Space	Interstate Highway
Multi-Family	Water	State Highway
Industrial	Impervious	Major Road
		Railroad

0 2,500 5,000 10,000

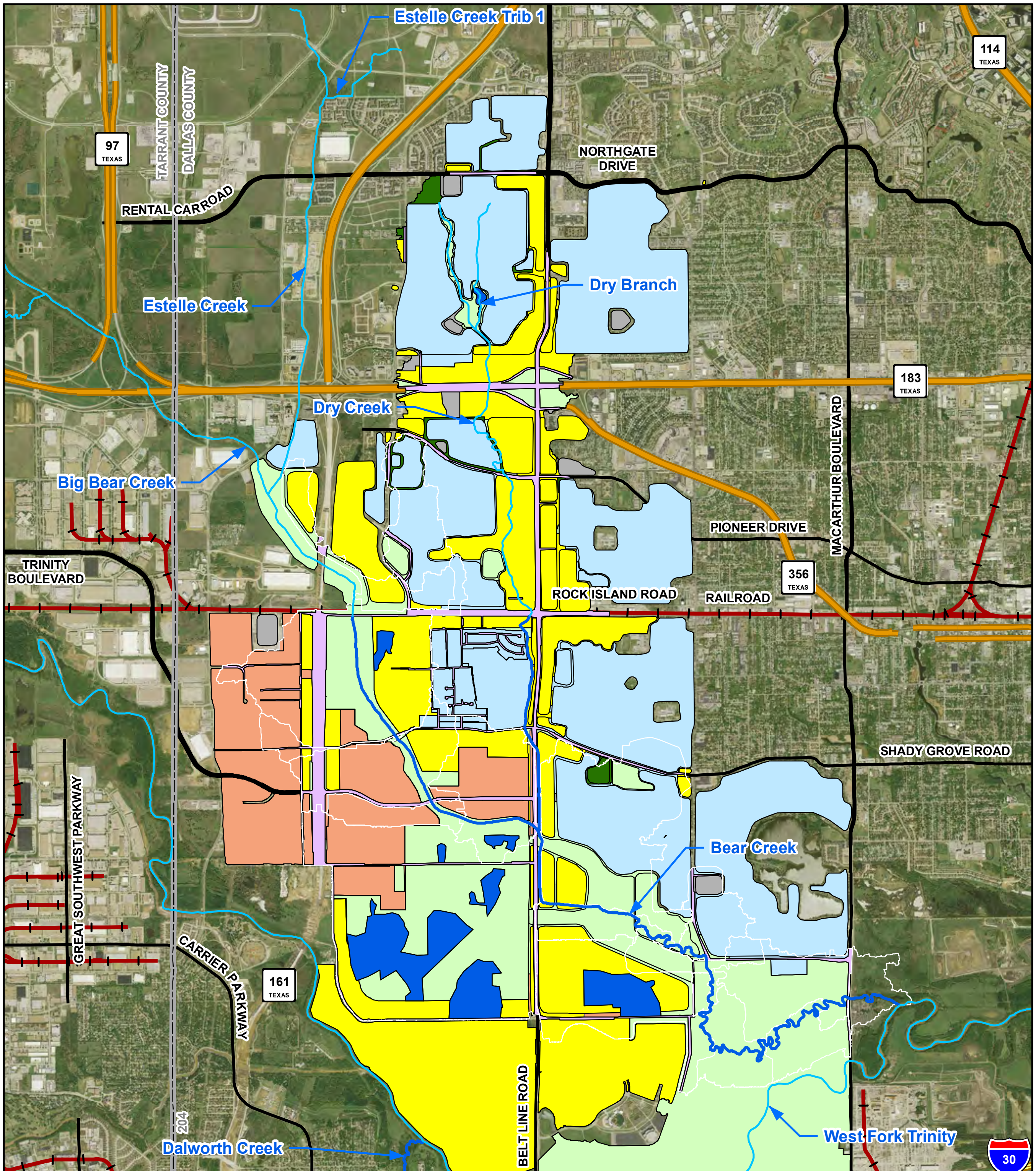
Scale in Feet

N S W E

Title
Existing Land Use

Watershed
Bear-Dry Creek

Figure
II-2



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KEY TO FEATURES

Studied Stream	Government	Drainage Areas
Unstudied Stream	Commercial	County Boundary
Single Family	Open Space	Interstate Highway
Multi-Family	Water	State Highway
Industrial	Impervious	Major Road
		Railroad

0 2,500 5,000 10,000

Scale in Feet

N W E S

Title

Ultimate Land Use

Watershed

Bear-Dry Creek

Figure

II-3

D. IMPERVIOUS COVERAGE

Percent impervious is a function of the various land uses within a watershed basin. The specific land uses and their corresponding percent impervious values are varied depending on the date each watershed was modeled. The percent impervious values for this study were obtained from the City's Drainage Design Manual (June 2015) Table 4.1a and Table 4.1c. A composite percentage of impervious area was computed for each sub-basin for both existing and ultimate conditions. The percent impervious values input into the HEC-HMS model represent the corresponding amount of existing or anticipated development. Table II-1 provides the specific land use classifications and the corresponding percent impervious values for the Bear Creek and Dry Creek watershed.

Table II-1 – Imperviousness for Land Use (2013 Study)

Land Use Description	Impervious (%) Condition	% Land Use in Watershed
Single Family Residential	50%	25.4%
Open Space/Dedicated Park	0%	35.5%
Commercial/Business/Retail	85%	12.6%
Impervious	98%	6.7%
Utilities	40%	0.0%
Industrial	72%	10.0%
Multi-Family Residential	65%	3.2%
Institutional	72%	1.5%
Water	100%	5.0%

E. SOIL TYPES

Soil information was obtained from the 2012 United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) 2.2 data model for Dallas County. The watershed consists of all four soil types, A, B, C, and D, but is predominately type D soils which are defined as clayey with slow infiltration rates and a high potential for runoff. The next largest portion of the watershed consists of Group A soils which are defined as soils with a high infiltration rates and a low runoff potential. The third largest portion of the watershed consists of Group B soils defined as soils having some content of gravelly sand with moderate infiltration rates and a low/moderate runoff potential. The smallest portion of the watershed consists of Group C defined as soils having moderately fine to fine texture and slow infiltration rates. The hydrologic soils for the Bear Creek and Dry Creek watershed are illustrated in the Hydrologic Soils Map, Figure II-4 found on the following page in Appendix A of this report.

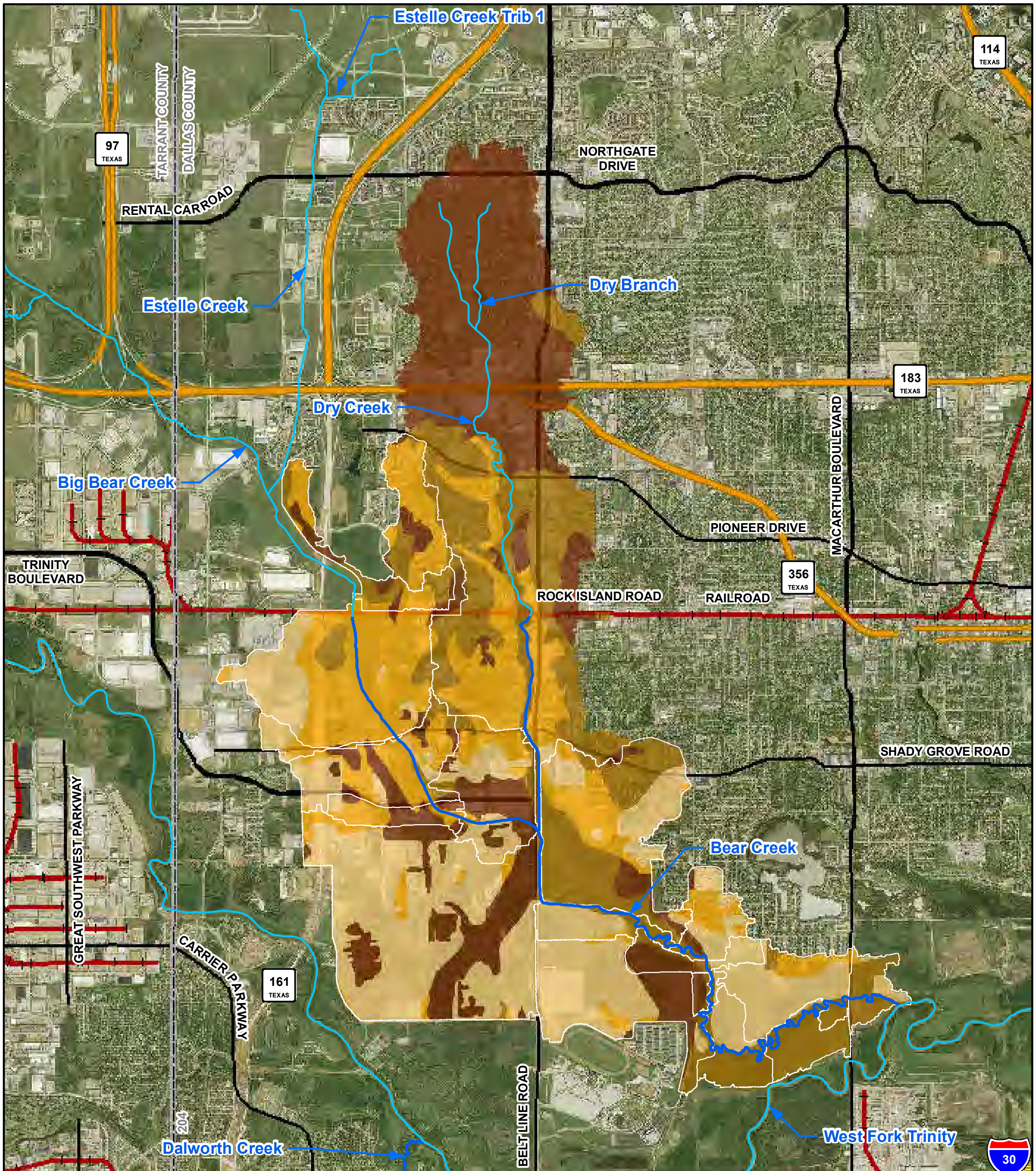
The antecedent moisture condition (AMC) defines the soil moisture condition prior to a storm. AMC-II, average soil moisture conditions, was used for the purposes of this study.

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 this study, the 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:



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KEY TO FEATURES

Soil Group A	Bear Creek Drainage Areas
Soil Group B	County Boundary
Soil Group C	Interstate Highway
Soil Group D	State Highway
Studied Stream	Major Road
Unstudied Stream	Railroad

0 2,500 5,000 10,000

Scale in Feet

N W E S

Title

Hydrologic Soils Map

Watershed

Bear-Dry Creek

Figure

II-4

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

A summary of the Bear Creek and Dry Creek watershed Curve Numbers, percent impervious values and initial abstractions is included in Appendix B.

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 each sub-basin 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.

Computed lag times for the NRCS Dimensionless Unit Hydrograph method used the following equation:

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

Time of concentration was computed separately for existing and ultimate conditions. Both were computed separately for existing and ultimate conditions. Both were based on TR-55 methodology for overland flow (sheet flow and shallow concentrated flow) and with Manning's equation to compute travel times through the underground storm sewer system. 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.

H. RAINFALL

The standard 24-hour duration storm event, for watersheds larger than 500 acres (0.78 square miles), was utilized to establish rainfall parameters. Point rainfall depths were obtained from the City's Drainage Design Manual (June 2015), Table 5.4, for five minute to twenty-four hour duration rainfall events. The rainfall data is summarized in Table II-2 below.

Table II-2 - Rainfall Depth / Duration for Grand Prairie

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 Drainage Design Manual (June 2015) Table 5.4

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

There were no detention ponds identified in the Bear Creek and Dry Creek watershed in the study area.

There were no diversions identified or modeled in the Bear Creek and Dry Creek watershed.

III. Hydraulic Studies

III. HYDRAULIC STUDIES

A. HYDRAULIC ANALYSES

Halff Associates developed detailed hydraulic models using existing and ultimate conditions hydrology for Bear Creek and Dry Creek using the City of Grand Prairie LiDAR data (2009), aerial digital photography (2013), Marshall Lancaster & Associates, Inc. field surveys (July 2011), and field observations.

The locations of hydraulic cross-sections for the Bear Creek and Dry Creek Study are displayed on the Floodplain Workmaps in the Figures section of this report. Channel roughness factors (Manning's "n" values) were assigned on the basis of field inspections of floodplain areas and aerial orthophotos. All elevations are measured from the North American Vertical Datum of 1988 (NAVD 88).

Computed peak discharges from each stream's HEC-HMS model 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 hydraulics models, respectively. The hydraulic results, including computed water surface elevations and profiles, are also discussed in Section IV.B – Hydraulic Study Results.

Bridge data was input to the hydraulic models for Shady Grove Road, Trinity Boulevard, Belt Line Road, Hunter-Ferrell Road, MacArthur Boulevard, Oakview Drive, Thousand Oaks Court, Sherwood Drive, and Shady Grove Road 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 hydraulic model.

A floodway model was developed as a part of this Bear Creek and Dry Creek study. The model was optimized with the maximum encroachment that would not cause a rise of 1-foot or greater at any point along the stream.

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

IV. Hydrologic and Hydraulic Study Results

IV. HYDROLOGIC AND HYDRAULIC STUDY RESULTS

A. HYDROLOGIC STUDY RESULTS

This section of the City-wide Drainage Master Plan for the Bear Creek and Dry Creek watershed compiles the results of the detailed hydrologic computer model. Hydrologic parameter data for all sub-basins modeled in the Bear Creek and Dry Creek watershed is included in Appendix B.

A detailed HEC-HMS hydrologic computer model has been prepared for the Bear Creek and Dry Creek watershed. The existing and ultimate land use conditions were analyzed with channel flood routing data based on existing channels and bridges. Table IV-1 contains available peak flood discharge information for existing and ultimate conditions at key locations along Bear Creek and Dry Creek for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood frequencies.

Table IV-1 – Summary of Discharges for Bear Creek and Dry Creek

Stream Name	Flooding Source and Approximate Location	Cross Section ID	Basin Area (sq. mi.)	2-Year Storm Event	5-Year Storm Event	10-Year Storm Event	25-Year Storm Event	50-Year Storm Event	100-Year Storm Event		500-Year Storm Event
				Existing	Existing	Existing	Existing	Existing	Existing	Ultimate	Existing
Bear Creek	At confluence with West Fork Trinity River	234	93.05	14,100	14,400	14,550	20,050	24,850	30,150	30,150	45,150
	At MacArthur Boulevard	2456	92.93	14,100	14,400	14,550	20,050	24,850	30,150	30,200	45,150
	At confluence with Dry Creek/Belt Line Road	27937	85.19	14,750	14,850	14,900	20,500	25,050	30,650	30,650	45,700
	At Trinity Boulevard	31825	85.06	15,500	15,600	15,650	21,050	25,550	31,100	31,100	45,950
	At Shady Grove Road	34391	84.64	15,500	15,600	15,650	21,050	25,500	31,200	31,200	45,950
	At Rock Island Road	38761	83.64	15,600	15,650	15,700	21,150	25,550	31,300	31,350	46,050
Dry Creek	At confluence with Bear Creek	400	3.49	2,350	3,700	4,600	5,550	6,350	7,100	7,100	8,650
	At Belt Line Road	3076	3.37	2,400	3,700	4,550	5,500	6,300	7,000	7,050	8,500
	At Shady Grove Road	3719	3.36	2,400	3,700	4,600	5,500	6,350	7,050	7,050	8,500
	At Rock Island Road	7735	2.69	2,100	3,200	3,950	4,750	5,450	6,100	6,100	7,800

*Note: Crossings are discussed in detail in Section VII

B. HYDRAULIC STUDY RESULTS

This section of the City-wide Drainage Master Plan for the Bear Creek and Dry Creek watershed compiles the results of the detailed hydraulic computer model.

The computed peak flood discharges from Bear Creek and Dry Creek were used in the HEC-RAS hydraulic model 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. There was negligible difference between the 100-year water surface elevations between existing and ultimate conditions for the Bear Creek and Dry Creek watershed.

The HEC-RAS hydraulic computer model for Bear Creek and Dry Creek and the City of Grand Prairie LiDAR data (2009) were used to delineate the existing conditions 100-year floodplain (Refer to the Floodplain Workmaps in Appendix A of this report). A DVD included in Appendix G contains the hydraulic model 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 2-, 5-, 10-, 25-, 50-, 100-, and 500-year frequency events and the ultimate 100-year frequency event are shown for all profiles.

C. QUALITY ASSURANCE / QUALITY CONTROL

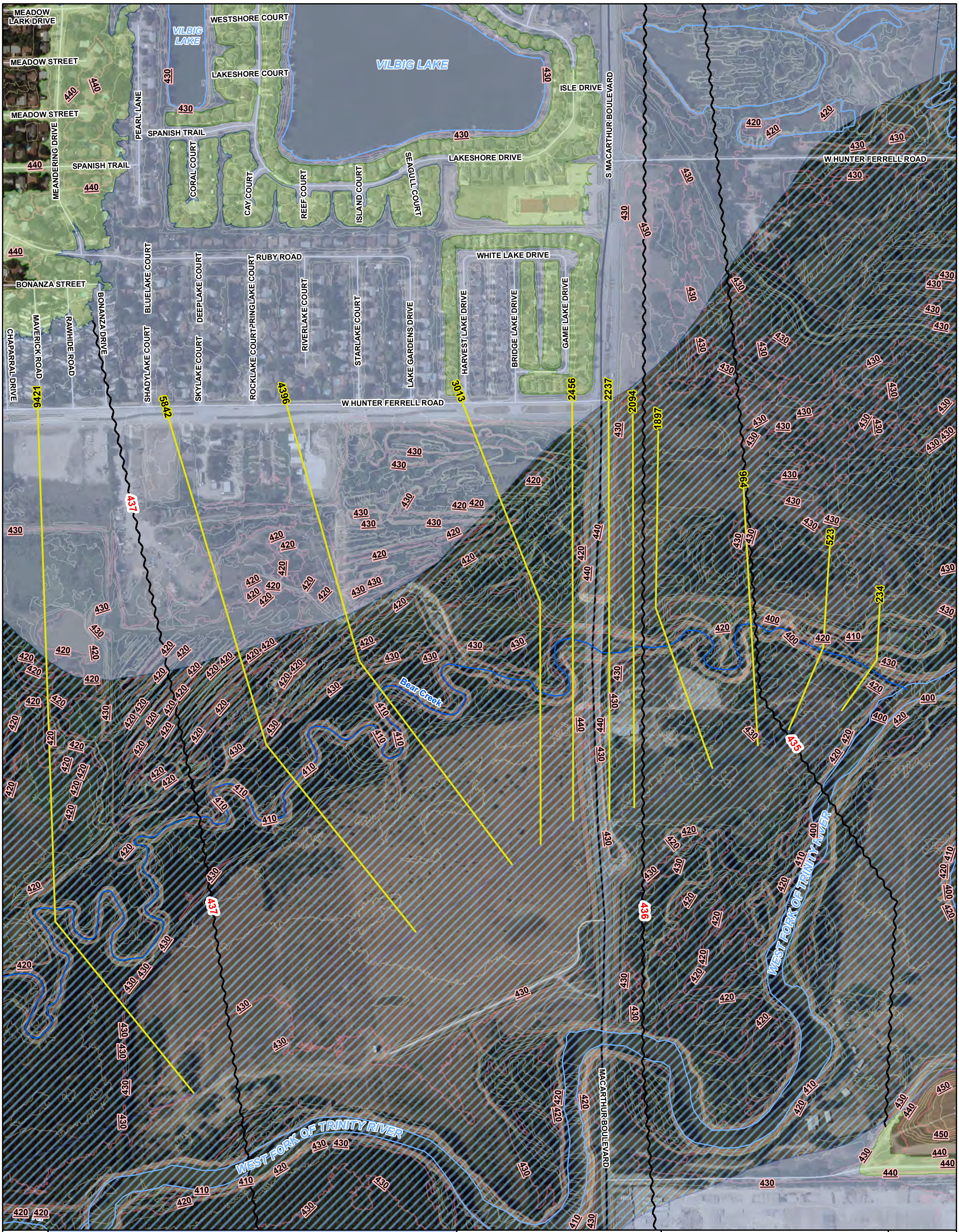
Quality assurance / quality control for the hydrologic and hydraulic studies was performed by Halff Associates, Inc. as part of the City of Grand Prairie – Y#0948 FEMA FY12 CTP Project. Storm events were added to the models during the preparation of this report and were also reviewed by Halff Associates, Inc.

V. Floodplain Mapping

V. FLOODPLAIN MAPPING

A. OVERVIEW

Halff Associates re-mapped the existing 100-year and 500-year floodplain for Bear Creek and Dry Creek as part of the FY 2012 City of Grand Prairie Cooperating Technical Partners Flood Study. 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. Base Flood Elevations (BFEs) along Bear Creek and Dry Creek were generated based on the HEC-RAS model output data. The BFEs were finalized per the FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C, dated November 2009. Floodways were delineated for Bear Creek and Dry Creek as part of the CTP study. The results of the CTP Risk Map project were submitted to FEMA in January 2014. Refer to the following pages and Appendix A for Floodplain Workmaps of Bear Creek and Dry Creek, a map of affected FEMA panels, and current effective FEMA panels. Floodplain shapefiles are included on the DVD in Appendix G.



KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Figure V-1

Watershed
Bear-Dry Creek

Hydraulic Work Maps

Panel 01 of 08

0 300 600
Scale in Feet

Grand Prairie TEXAS

FEMA

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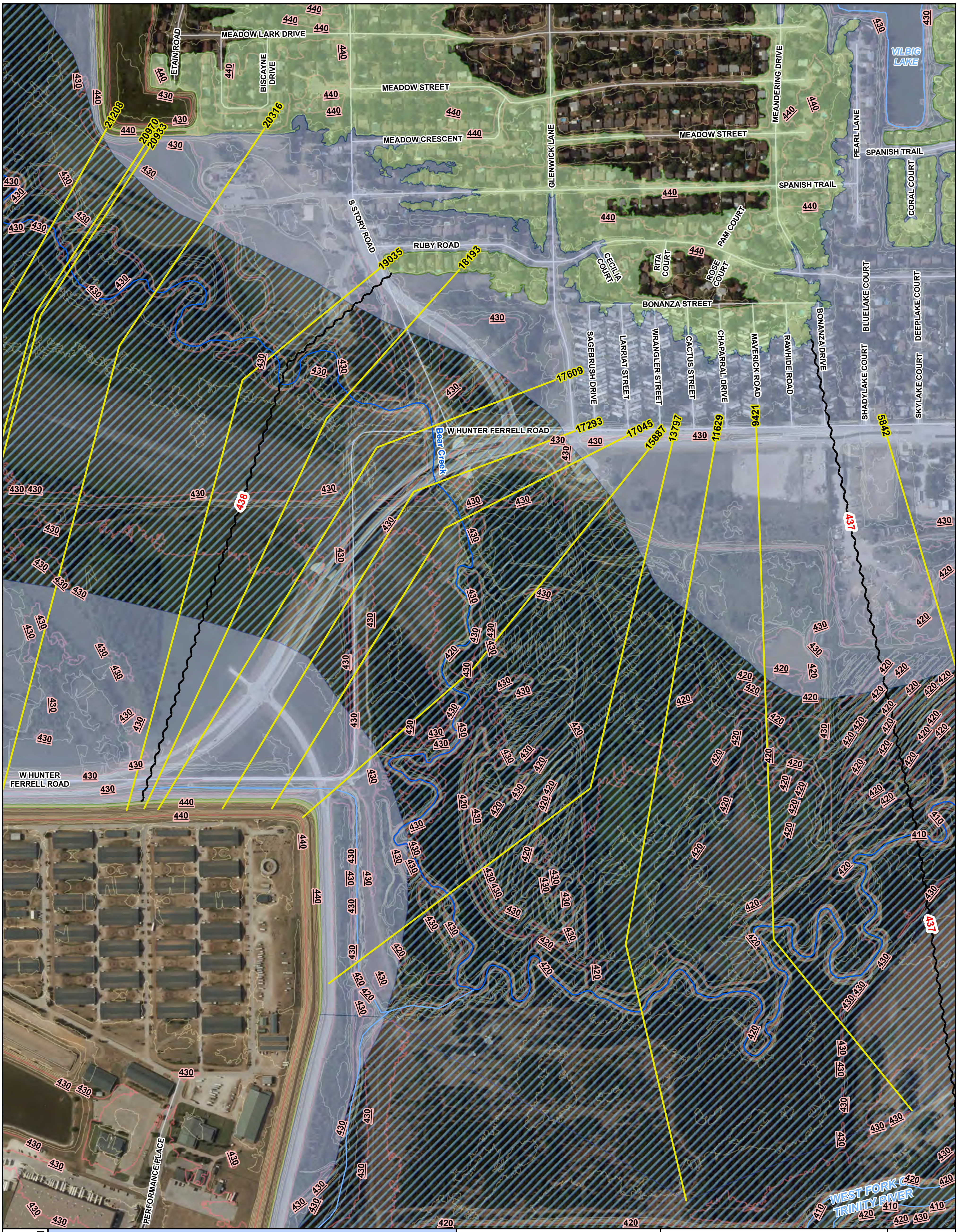

Figure

V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

Panel 02 of 08

0 300 600

Scale in Feet

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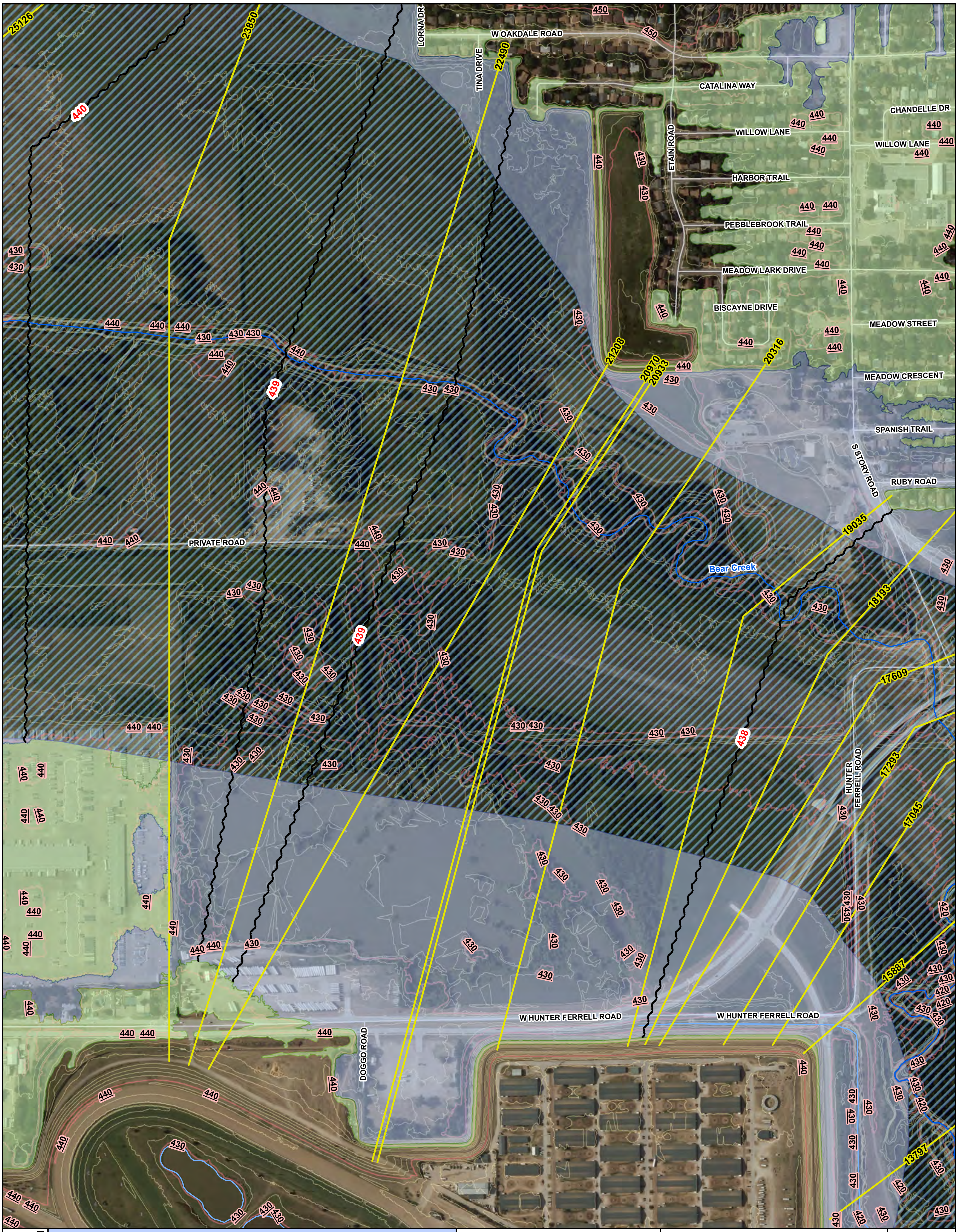

Figure V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

Panel 03 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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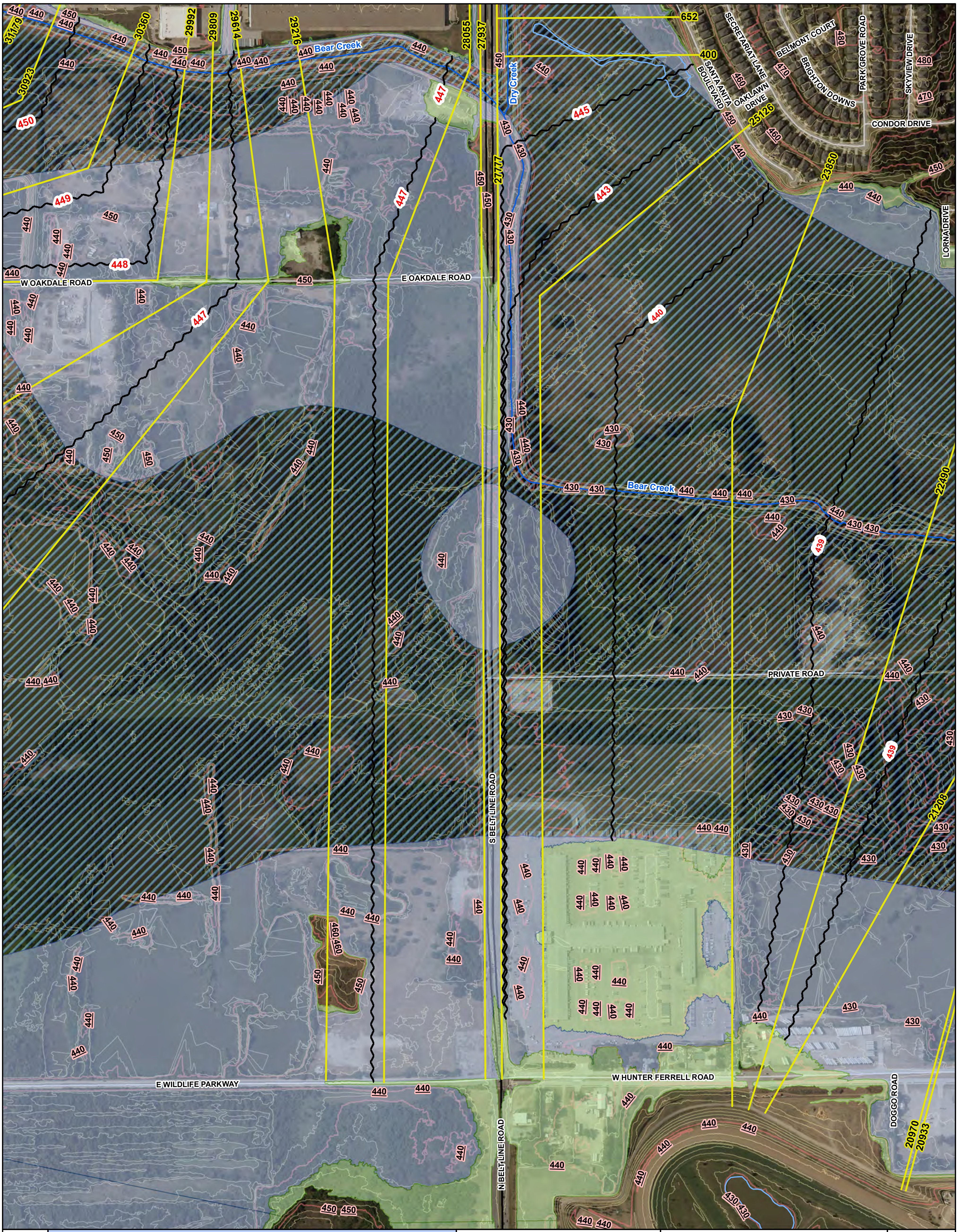

Figure V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

Panel 04 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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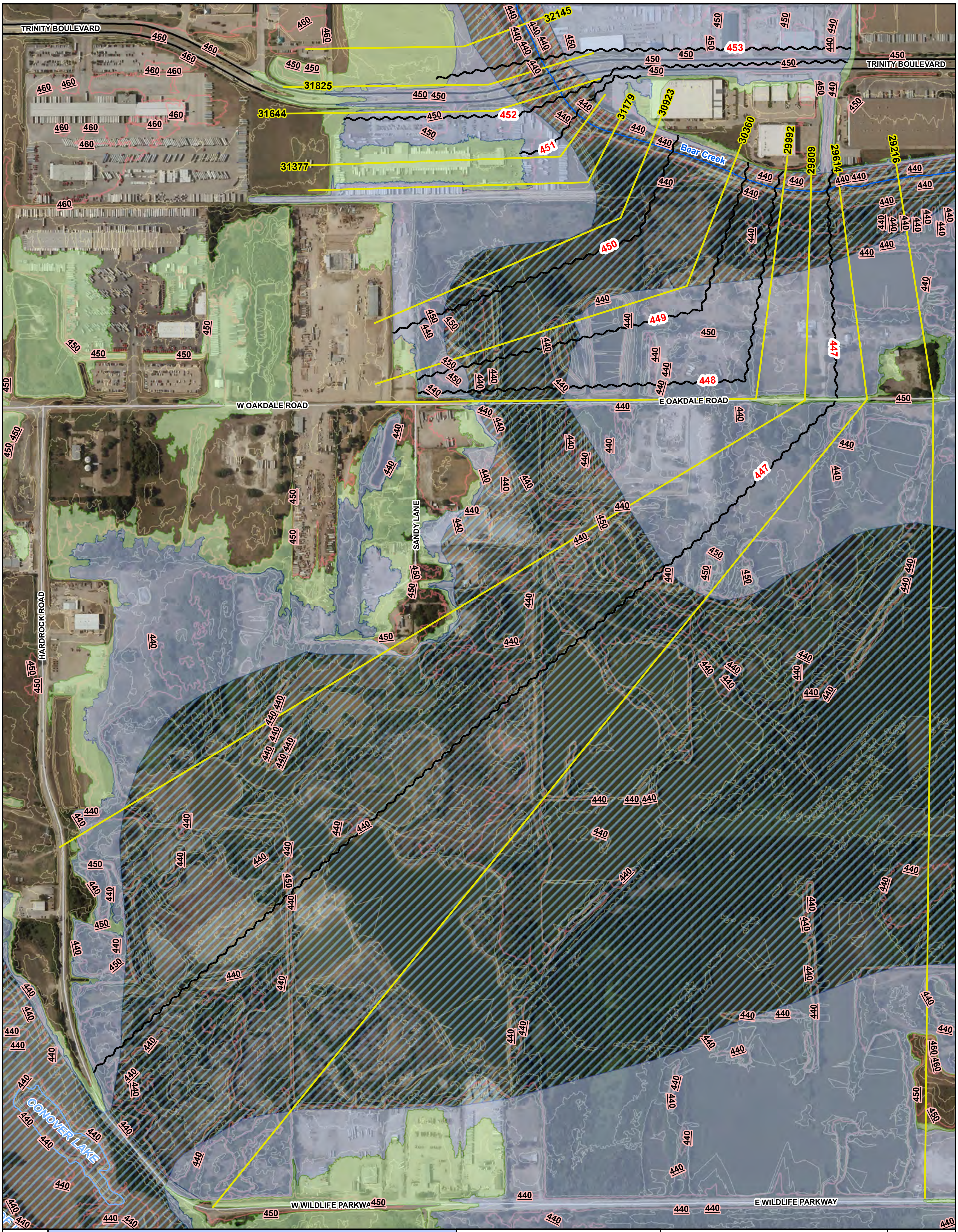


KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Figure V-1

Watershed

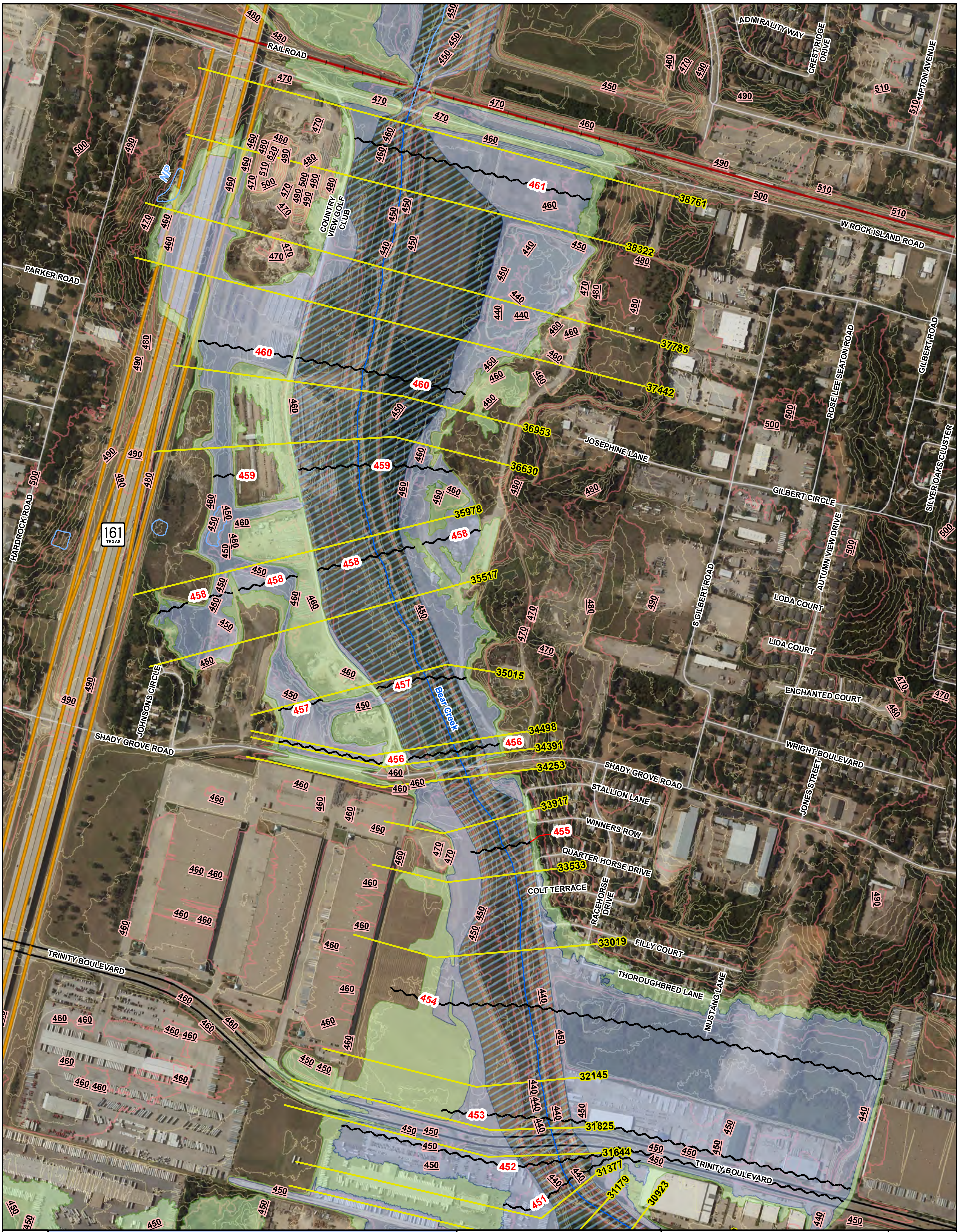
Bear-Dry Creek

Hydraulic Work Maps

Panel 05 of 08

0 300 600

Scale in Feet



Figure

V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

Panel 06 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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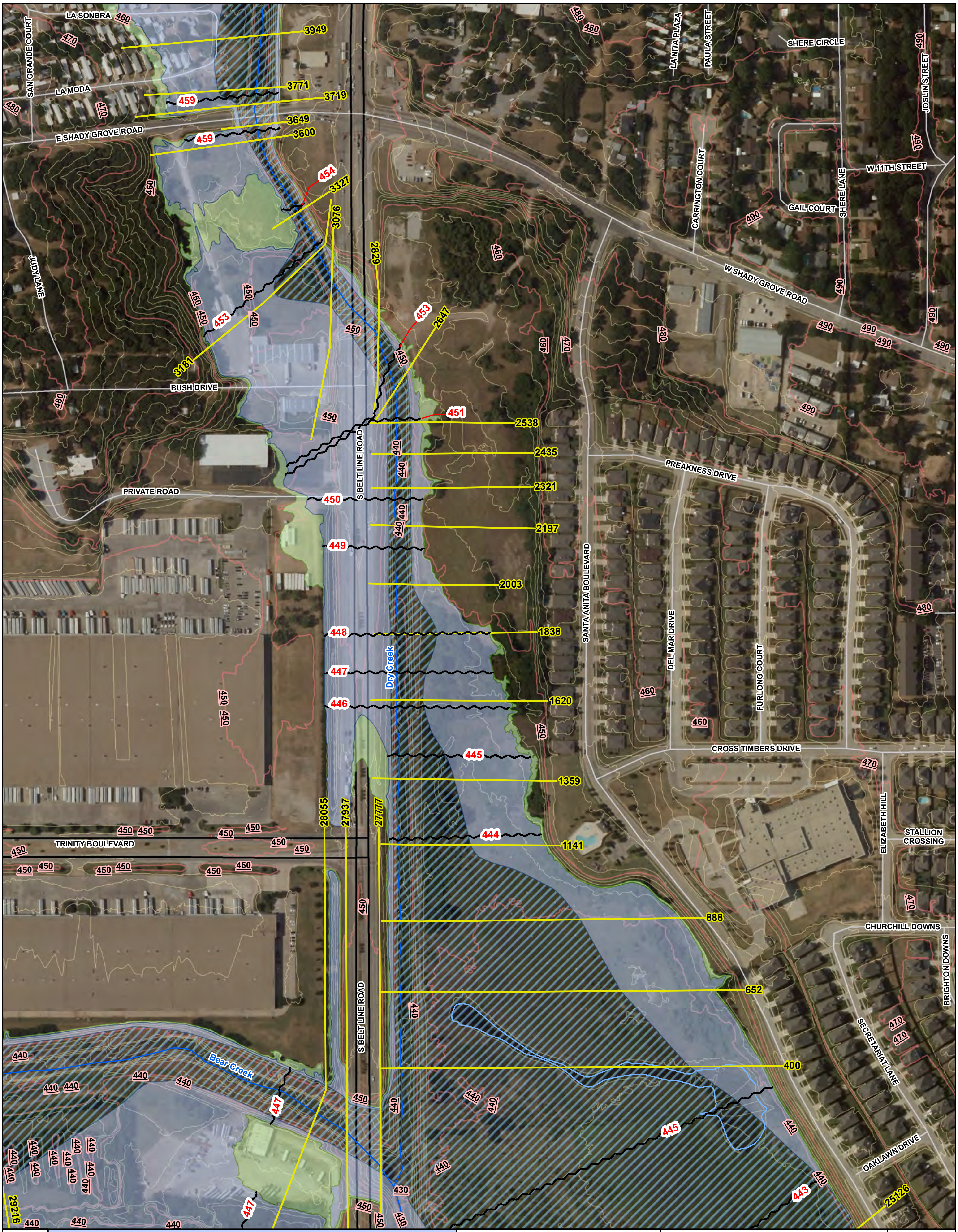

Figure

V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

0 300 600

Scale in Feet

Panel 07 of 08

Grand Prairie TEXAS

FEMA

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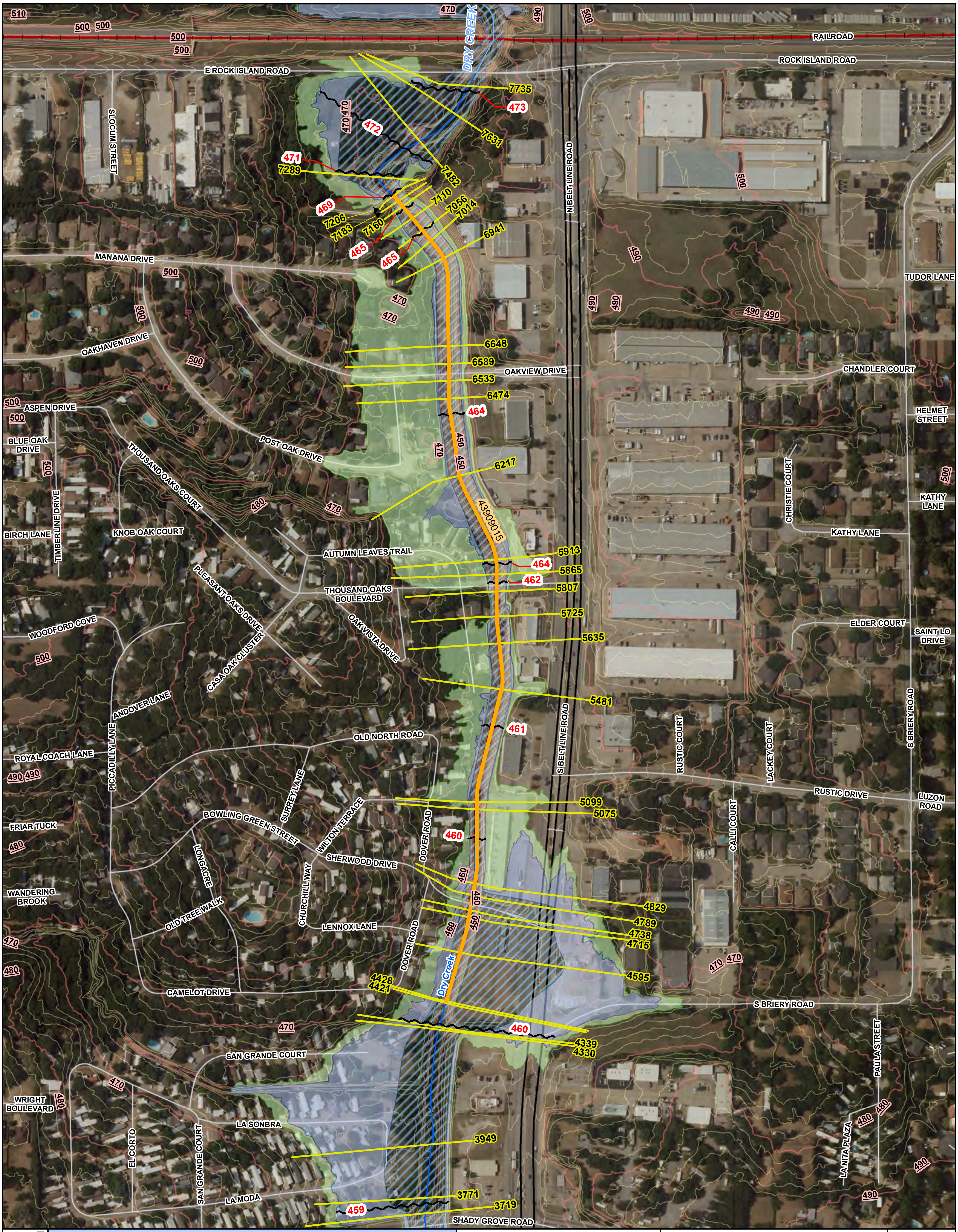

Figure

V-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Existing Crossing
- BFE
- Cross Section
- Floodway
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- 0.2-Percent-Annual-Chance Floodplain (Zone X)
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad
- Storm Drain Lines

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Hydraulic Work Maps

Panel 08 of 08

0 300 600

Scale in Feet

Grand Prairie
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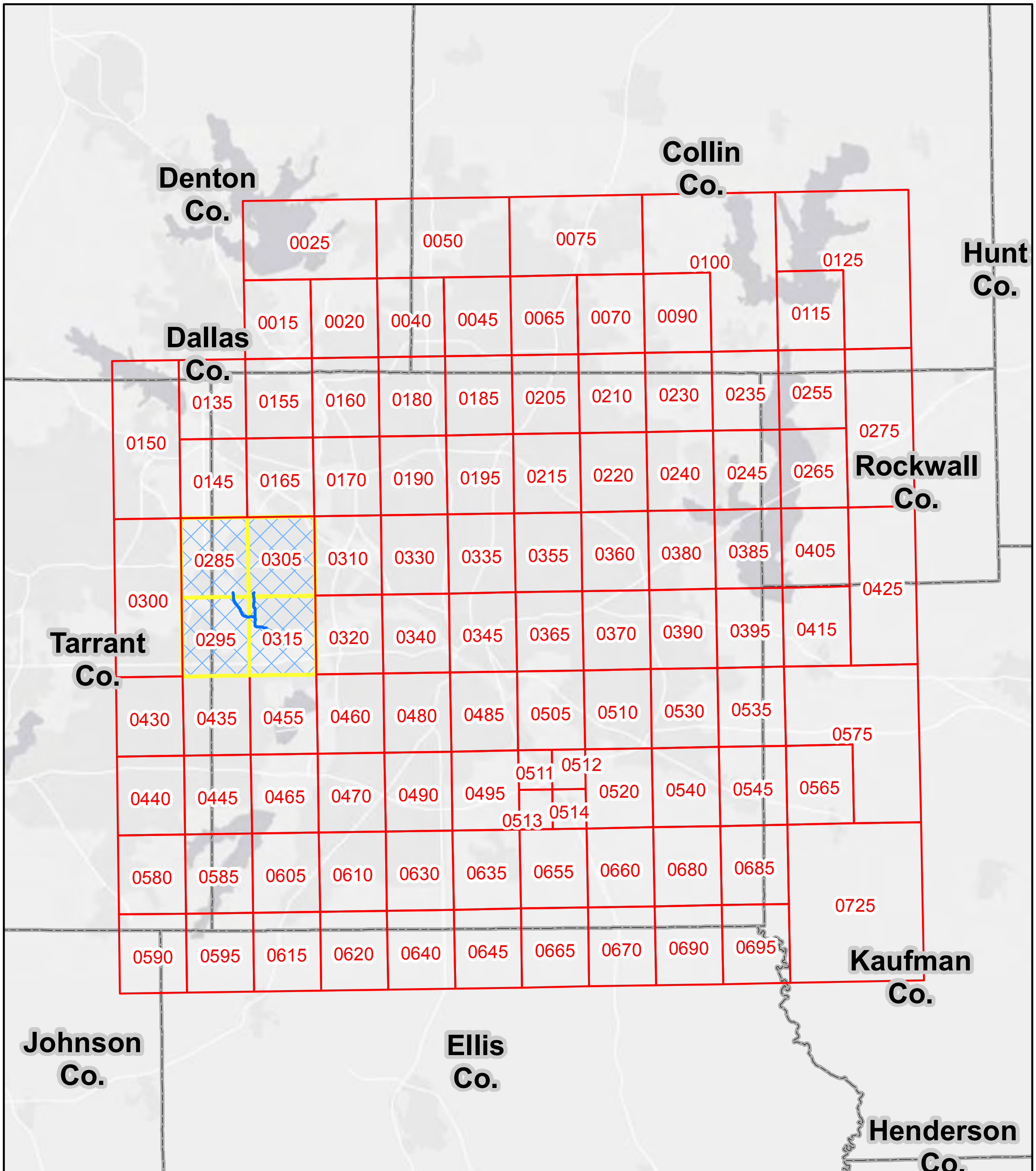

Title
City of Grand Prairie CWDMP
Bear-Dry Creek

Figure
V-2

FEMA Affected FIRM Panels

KEY TO FEATURES

- Dry Creek
- Bear Creek
- Panel Revised
- No Change
- Texas Counties

Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

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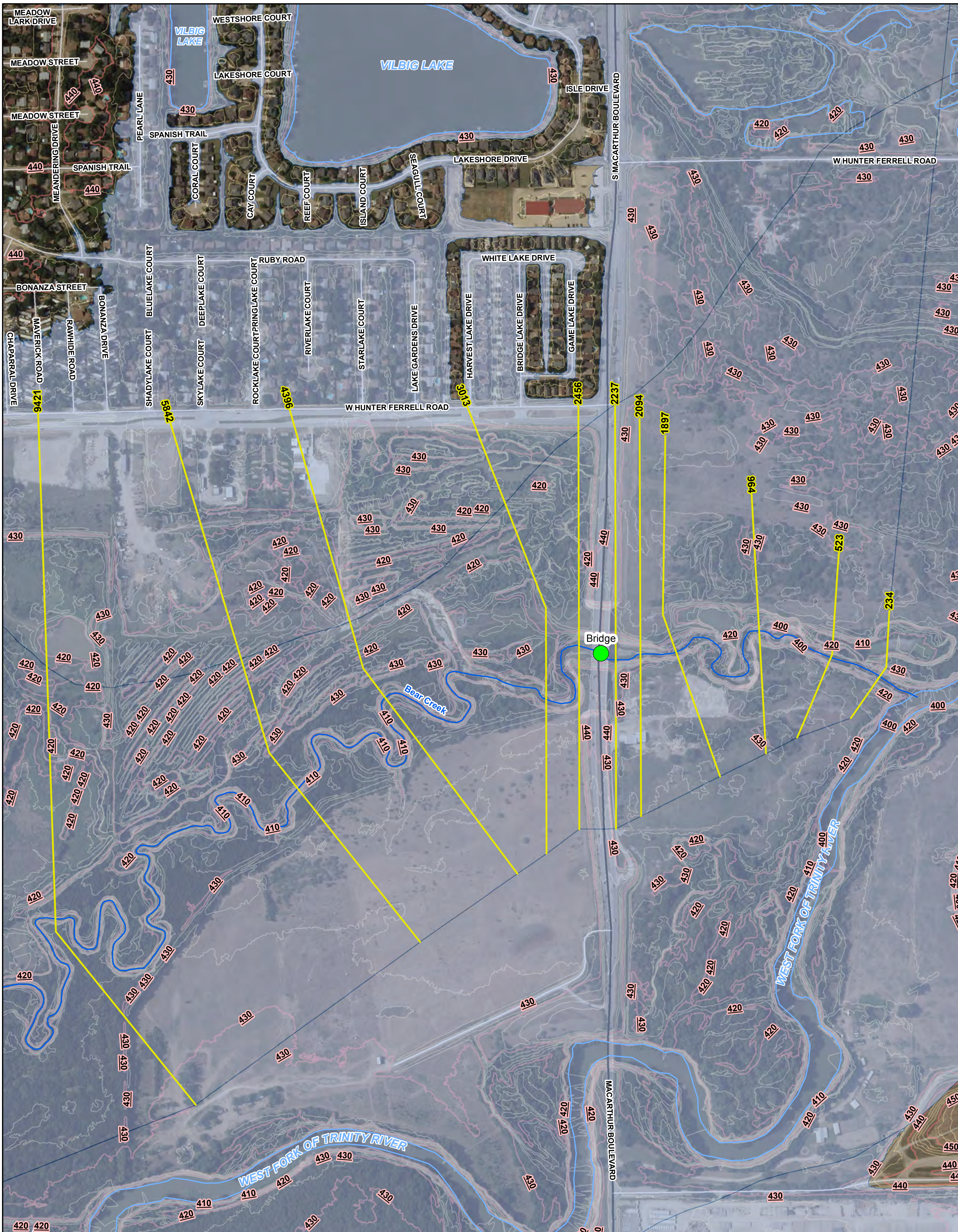

Figure

V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

Panel 01 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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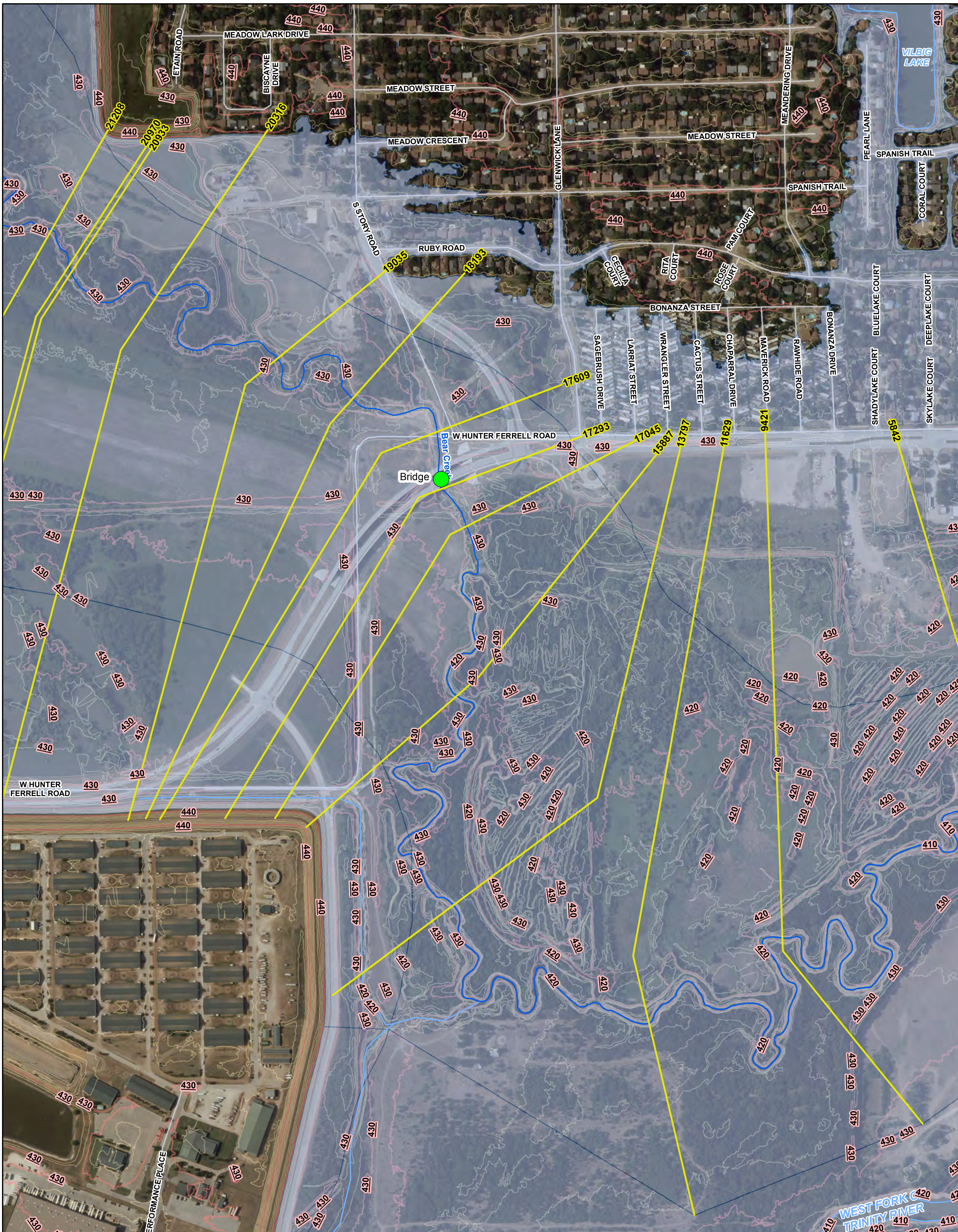

Figure

V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

Panel 02 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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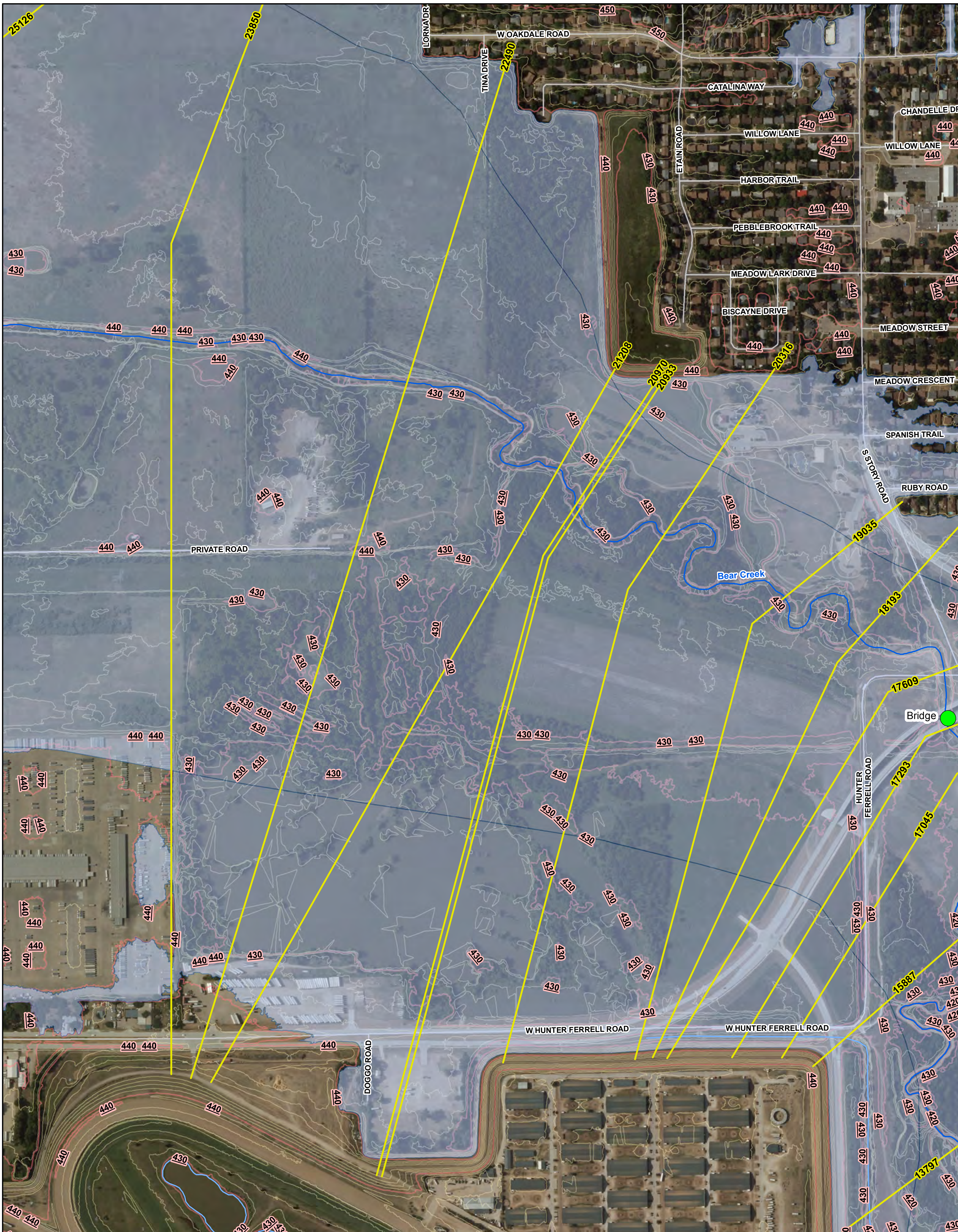

Figure

V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

Panel 03 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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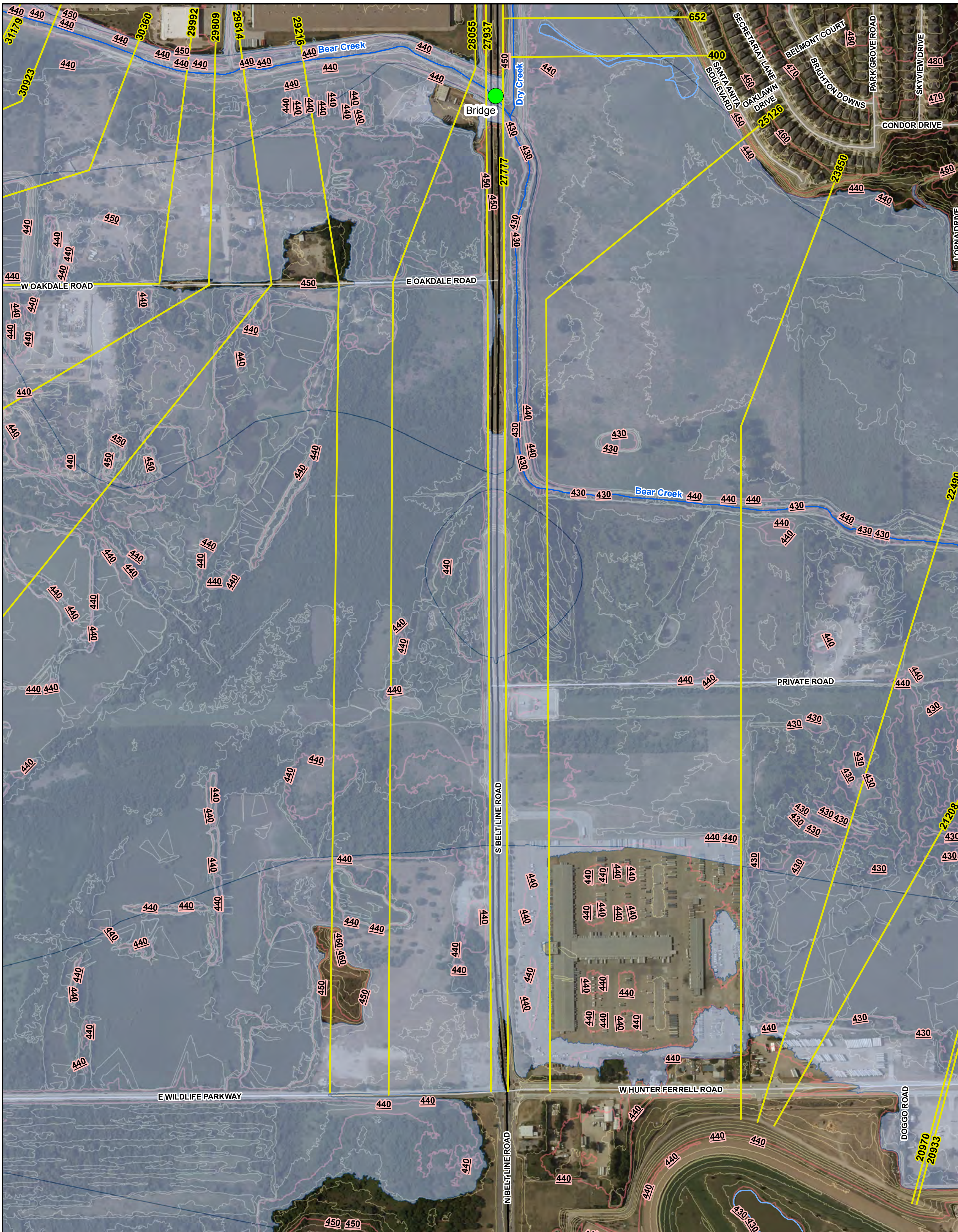

Figure

V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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Panel 04 of 08

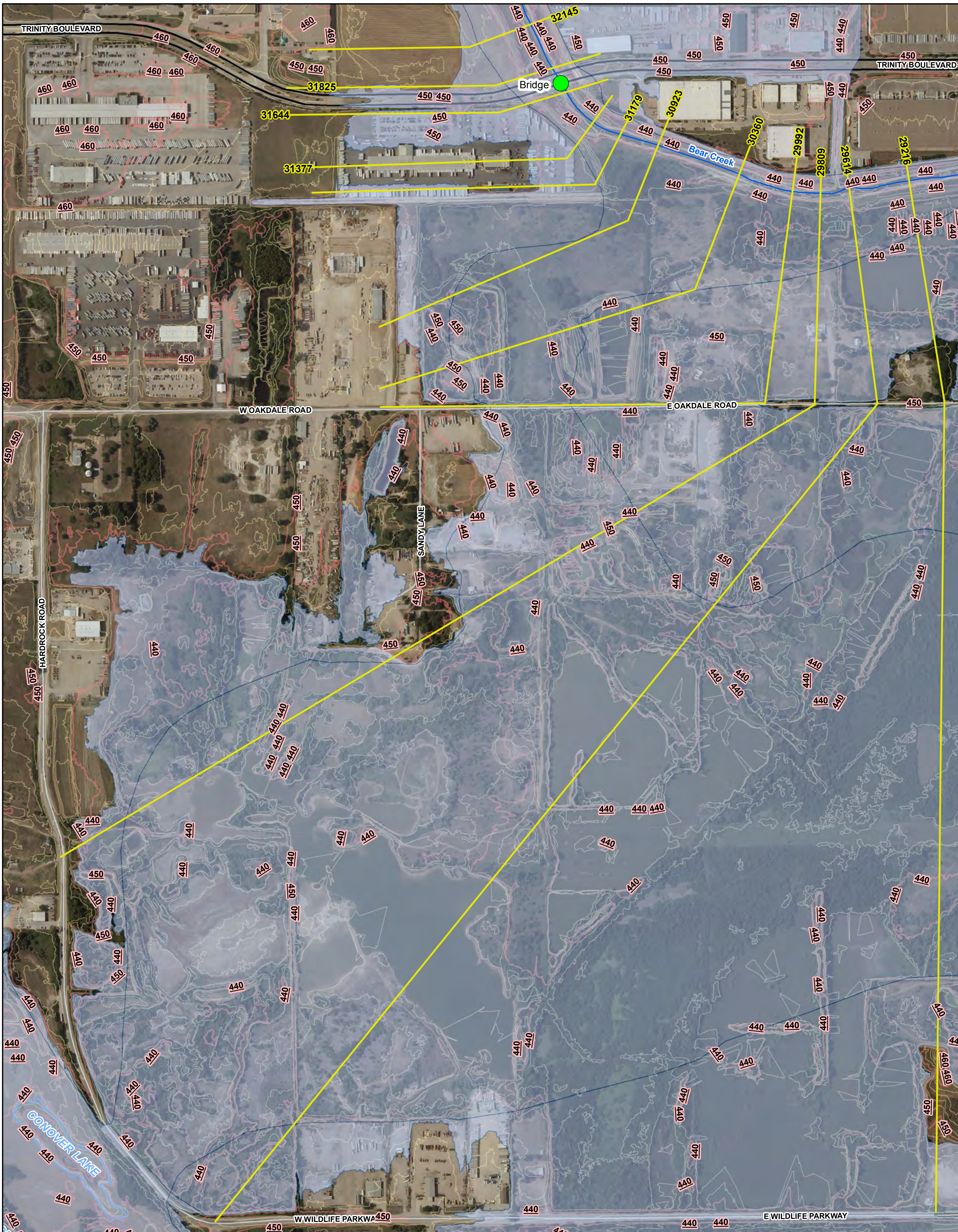

Figure
V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed
Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

0 300 600
Scale in Feet

Grand Prairie TEXAS

Panel 05 of 08

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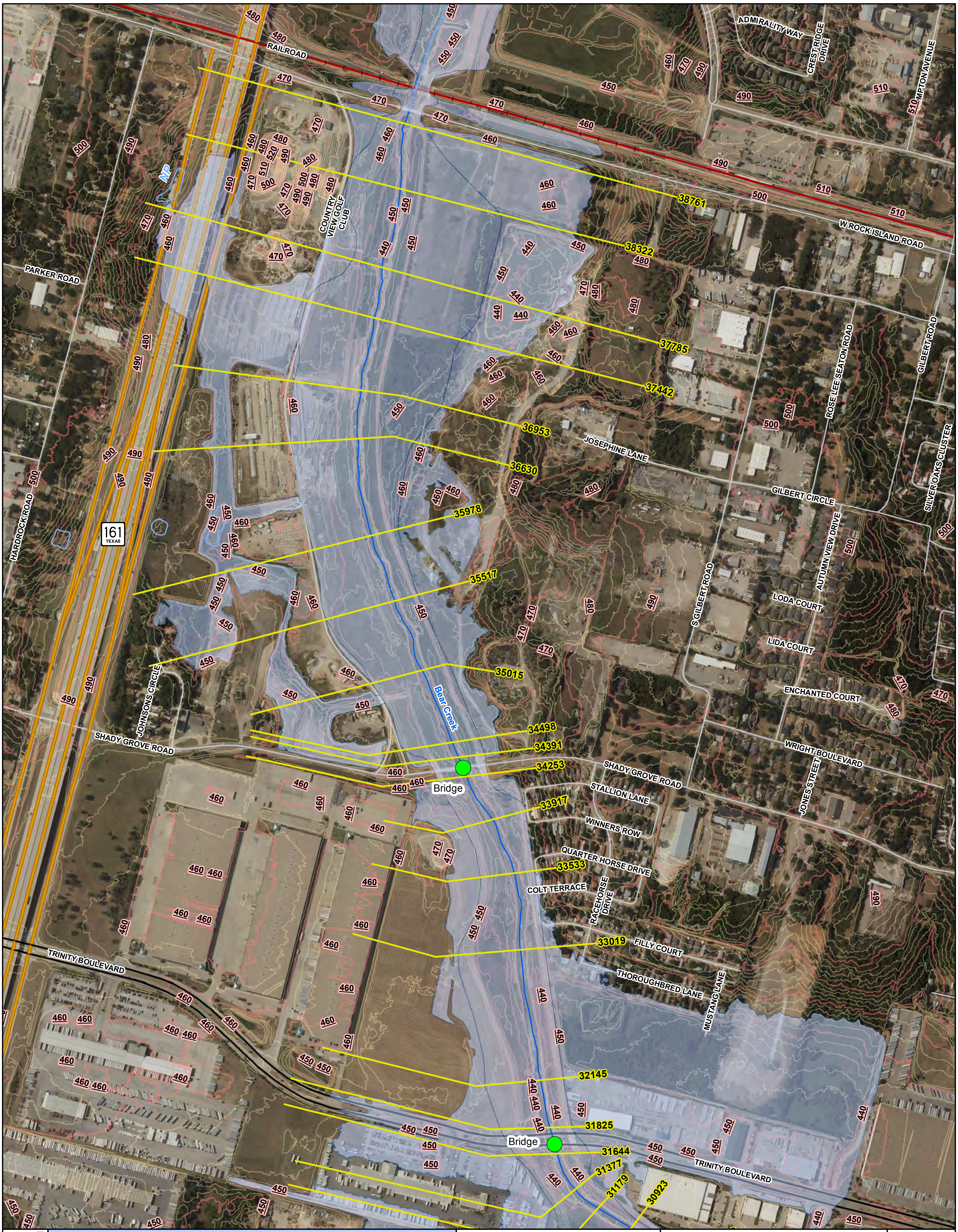


Figure V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

Panel 06 of 08

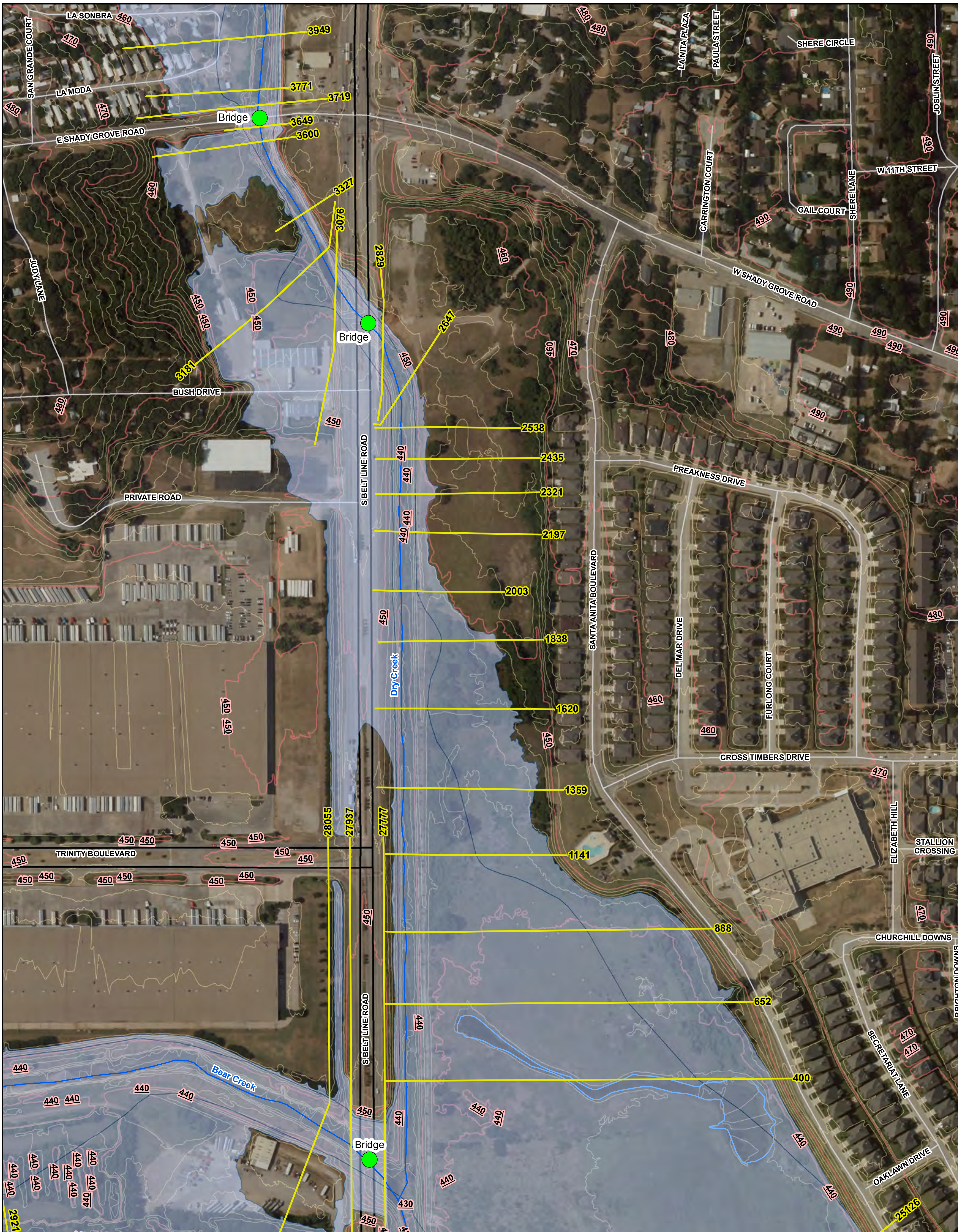
0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF



Figure

V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

Panel 07 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Figure V-3

KEY TO FEATURES

- Project Stream
- Other Stream
- BFE
- Cross Section
- Ultimate Conditions 1-Percent-Annual-Chance Floodplain
- Existing Crossing
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

*Contours generated from 2010 TNRIS LiDAR.

Watershed

Bear-Dry Creek

Ultimate Conditions Hydraulic Work Maps

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Panel 08 of 08

VI. Roadway Crossings

VI. ROADWAY CROSSINGS

A. EVALUATION OF EXISTING ROADWAY CROSSINGS

Existing roadway crossings along Bear Creek and Dry Creek were evaluated on their level of protection against the existing 10%, 2%, and 1% (10-year, 50-year, and 100-year) chance flood events. Table VI-1 below includes 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% chance flood event. Water Surface Elevations (WSEL) refer to the upstream face of the structure. Refer to Appendix A for a location map of existing bridge crossings along Henry Branch.

Table VI-1 - Existing Bridge Crossings

Stream: Bear Creek						
Model: Bear_Dry_Creek_Watershed.prj (HEC-RAS v4.1)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 10% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
1.	27850.5	*Beltline Road Bridge Deck*	448.50	No WSEL= 443.88	No WSEL= 445.63	No WSEL= 446.26
2.	31735	*Trinity Boulevard Bridge Deck*	453.00	No WSEL= 449.34	No WSEL= 451.67	No WSEL= 452.70
3.	34320.5	*Shady Grove Road Bridge Deck*	457.00	No WSEL= 451.51	No WSEL= 454.52	No WSEL= 455.86

Stream: Dry Creek						
Model: Bear_Dry_Creek_Watershed.prj (HEC-RAS v4.1)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 10% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
1.	2944	*Belt Line Road*	454.61	No WSEL= 451.73	No WSEL= 452.70	No WSEL= 453.05
2.	3685	*Shady Grove Road*	462.12	No WSEL= 456.51	No WSEL= 458.21	No WSEL= 458.62
3.	4767	*Sherwood Drive*	458.61	Yes WSEL= 459.04	Yes WSEL= 459.80	Yes WSEL= 460.39
4.	5839	*Thousand Oaks Court*	462.74	No WSEL= 460.33	No WSEL= 461.81	No WSEL= 462.09
5.	6561	*Oakview Drive*	466.68	No WSEL= 461.29	No WSEL= 46.45	No WSEL= 464.27

B. EVALUATION OF PROPOSED AND FUTURE ROADWAY CROSSINGS

According to the City of Grand Prairie's Master Thoroughfare Plan, there are no additional planned major thoroughfares within the Bear Creek and Dry Creek watershed. The current Master Thoroughfare Plan includes existing crossings at MacAurthur Boulevard, Hunter-Ferrell Road, Belt Line Road, Trinity Boulevard, Shady Grove Road, Rock Island Road, Sherwood Drive, Thousand Oaks Drive, and Oakview Drive along Bear Creek and Dry Creek. The existing roadway classifications match the planned roadway classifications for most of these crossings indicating there is no intention to resize these roadways in the future at this time. However, MacArthur Boulevard, Trinity Boulevard, Shady Grove Road, and Rock Island Road do not match the planned roadway classifications indicating that these roadways may be resized in the future. MacArthur Boulevard, Trinity Boulevard, and Shady Grove Road all pass the 100-year storm event. Rock Island Road is the upstream limit of the study.

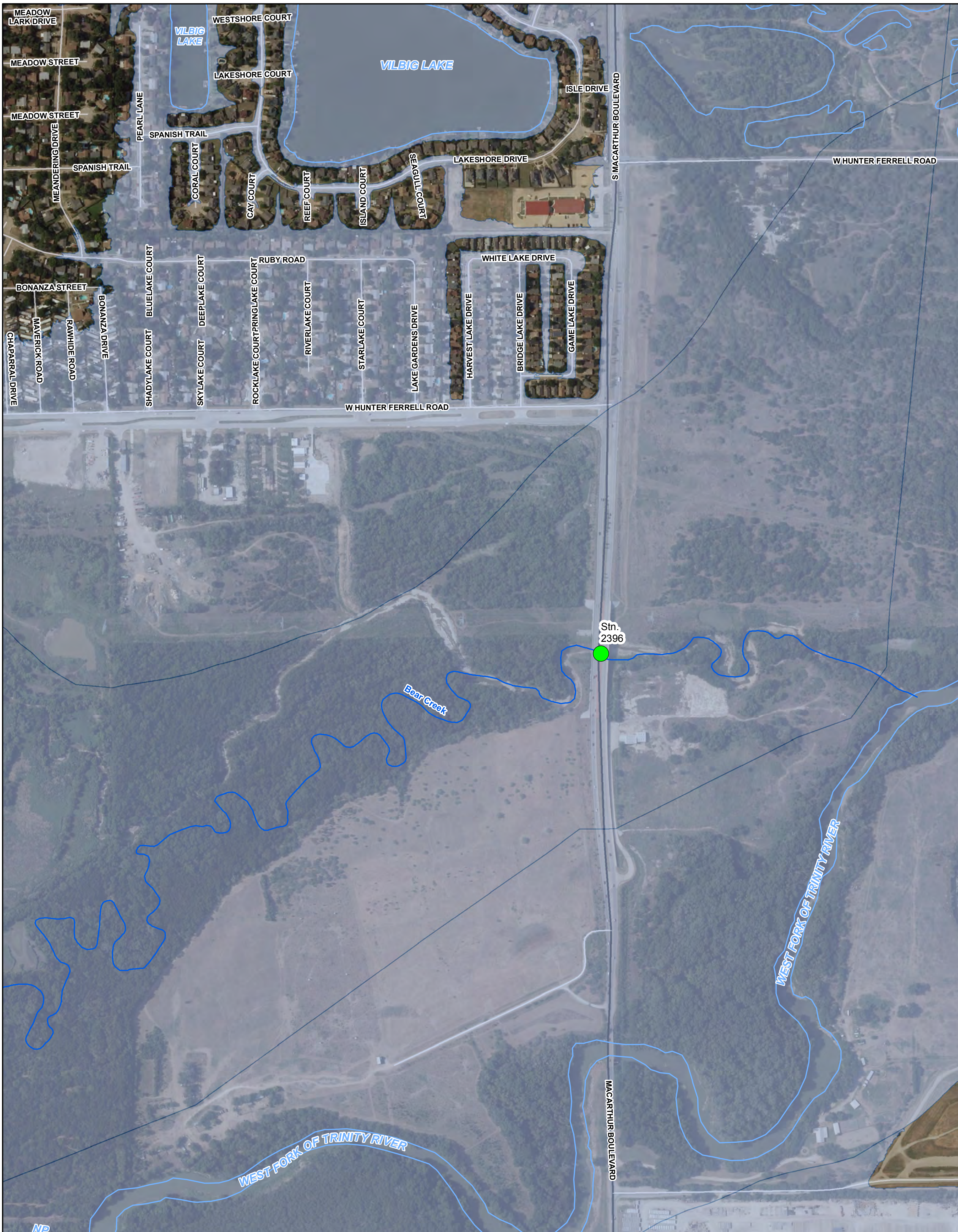


Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 01 of 08

0 500 1,000

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

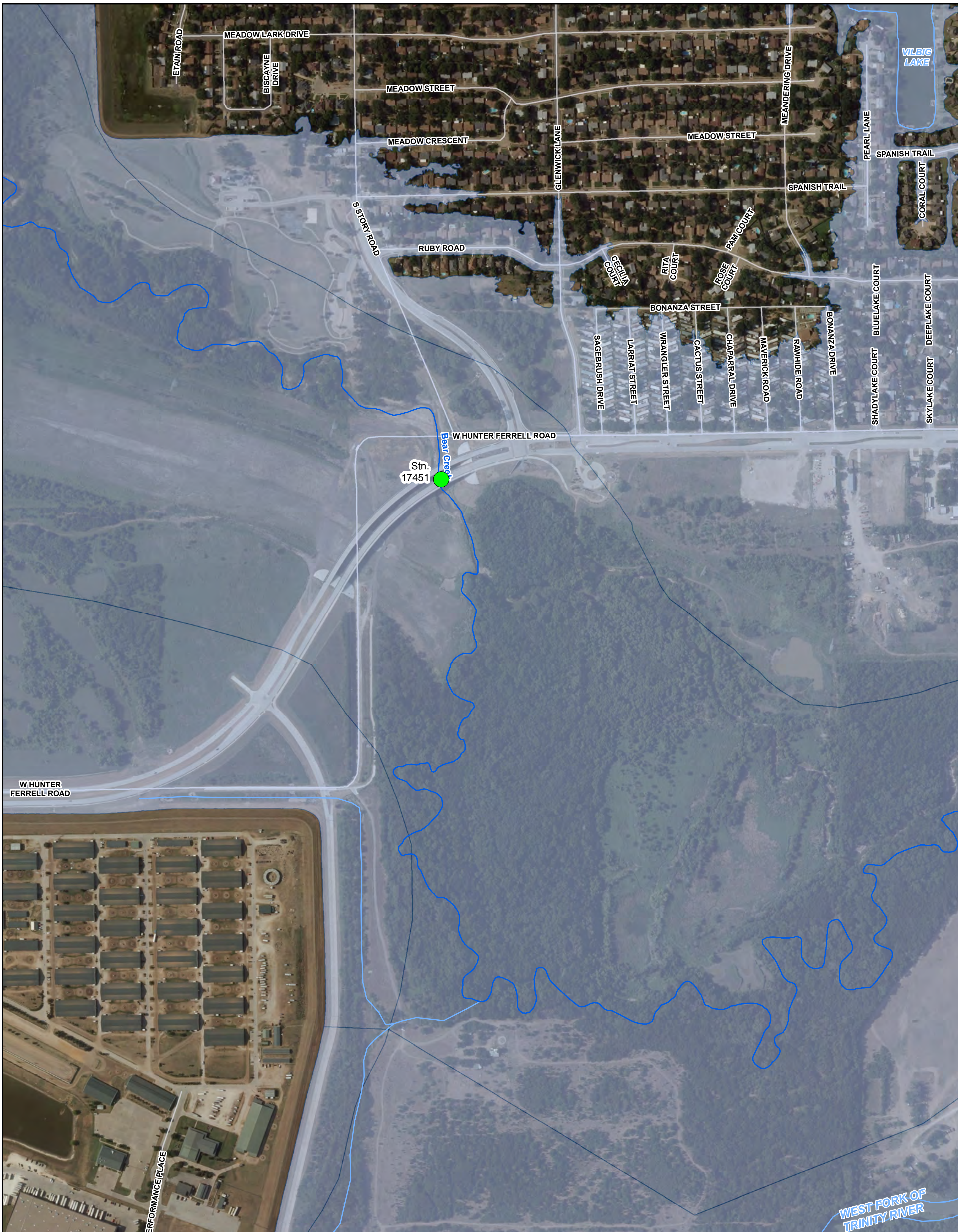


Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 02 of 08

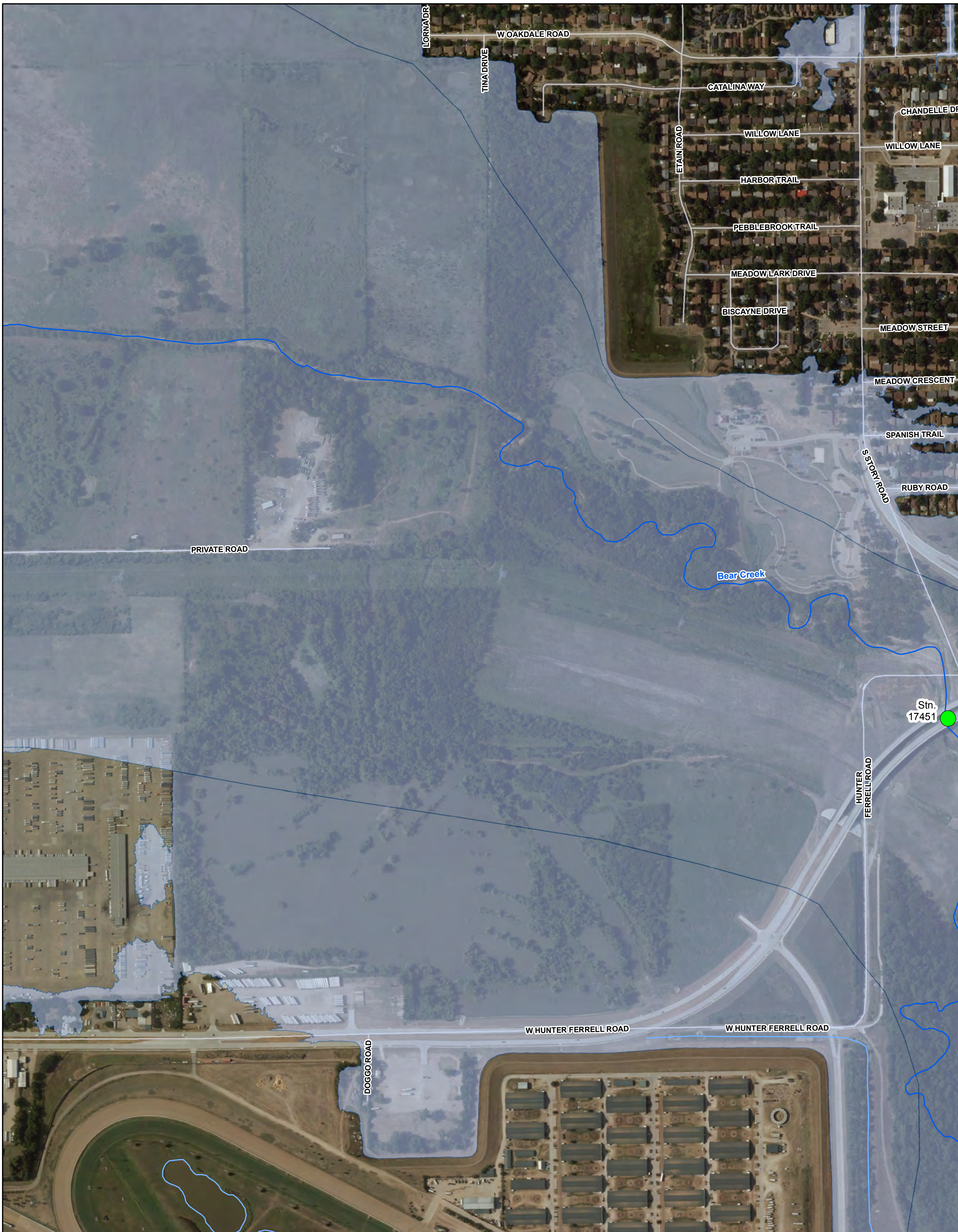
0 500 1,000

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF



Figure

VI-1

KEY TO FEATURES

Project Stream	Other Stream
100 yr Storm Event Passes Bridge Deck	1-Percent-Annual-Chance Floodplain (Zone AE)
Overtopped by 100 yr Storm Event	Interstate Highway
Overtopped by 25 yr Storm Event	Other Highway
Overtopped by 10 yr Storm Event	Major Road
Overtopped by 5 yr Storm Event	Minor Road
Overtopped by 2 yr Storm Event	Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 03 of 08

0 500 1,000

Scale in Feet

Grand Prairie
T E X A S

FEMA

HALFF

Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 04 of 08

0 580 1,160

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 05 of 08

0 580 1,160

Scale in Feet

Grand Prairie TEXAS

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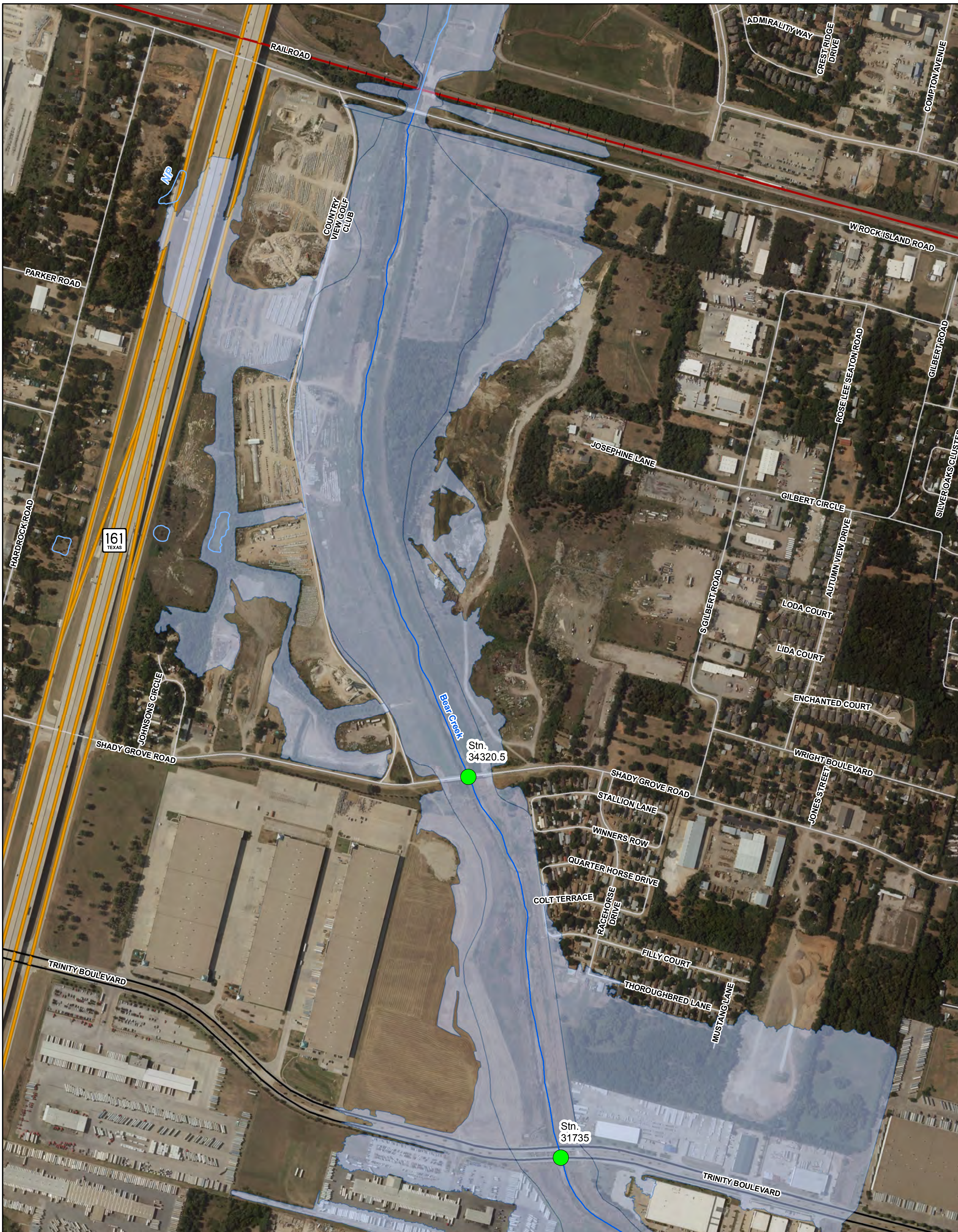

Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 06 of 08

0 580 1,160

Scale in Feet

Grand Prairie TEXAS

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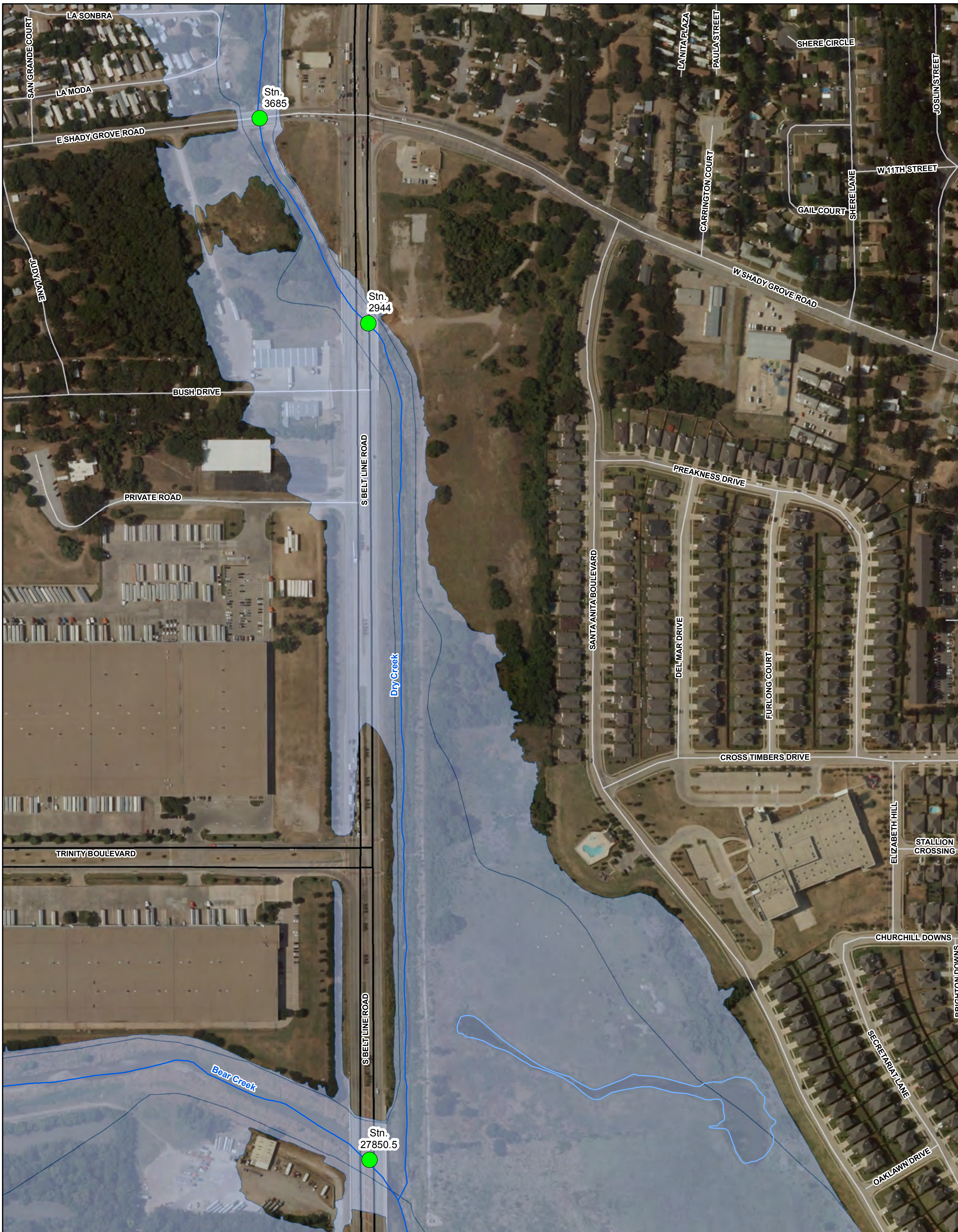

Figure VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 07 of 08

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Scale in Feet

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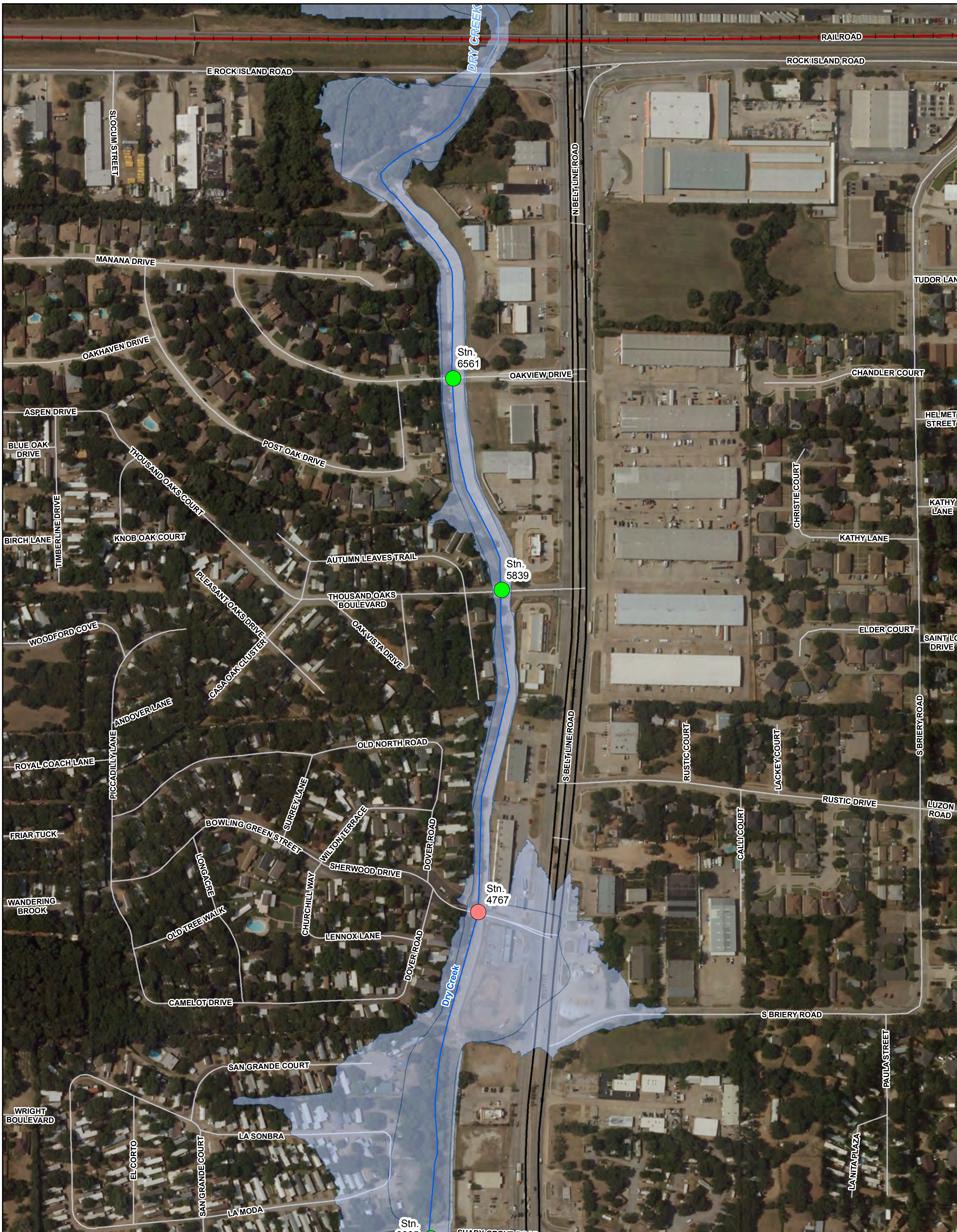

Figure

VI-1

KEY TO FEATURES

- Project Stream
- 100 yr Storm Event Passes Bridge Deck
- Overtopped by 100 yr Storm Event
- Overtopped by 25 yr Storm Event
- Overtopped by 10 yr Storm Event
- Overtopped by 5 yr Storm Event
- Overtopped by 2 yr Storm Event
- Other Stream
- 1-Percent-Annual-Chance Floodplain (Zone AE)
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Existing Roadway Crossings

Panel 08 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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VII. Alternatives for Streams and Open Channels

VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS

A. OVERVIEW

Non-structural and structural measures were considered for proposed alternatives to mitigate flood damages in the City of Grand Prairie. Halff Associates analyzed proposed alternatives for structures inundated by the ultimate 100-year flood event and existing roadway crossings overtopped by the existing 100-year flood event within the Bear Creek and Dry Creek watershed.

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 Bear Creek and Dry Creek to identify potentially flooded structures. A total of one hundred and seven (107) structures were identified within the existing 100-year floodplain. All of these structures were considered a significant, enclosed structure that would qualify as an insurable structure. Flood protection alternatives were not considered economically feasible for the structures in the Bear and Dry Creek 100 – year floodplain. Buyouts are are a viable alternative for some of these structures.

Bear Creek and Dry Creek are 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 E for more information regarding Section 404 Permits.

Proposed bridge alternatives were considered for all existing roadway crossings modeled within the Bear Creek and Dry Creek watershed that were overtopped by the existing 100-year flood event. There are zero road crossings overtopped by the 100-year flood event along Bear Creek in the study area, however there is one road crossing, Sherwood Drive, overtopped by the 100-year flood event along Dry Creek in the study area.

Several factors in the area made a redesign of the crossing difficult. Much of the the flow overtopping the structure is carried in the left overbank, along Belt Line Road. The elevation of Belt Line Road and the need to tie Sherwood Drive into Belt Line Road made a redesign of the Sherwood Drive crossing impractical. An online detention pond downstream of Shady Grove Road was considered as an alternative, however the reduction in water surface elevation along Dry Creek was not significant enough to justify the inclusion of the project. Halff Associates recommends the implementation of flood warning signage at this crossing.

Any future improvements (including bridge piers) encroaching into a FEMA mapped floodway which result in a rise in water surface elevation will require submittal of a FEMA Conditional Letter of Map Revision (CLOMR) including the following information:

- An evaluation of alternatives, which would not result in a BFE increase above that permitted demonstrating why these alternatives are not feasible;
- Documentation of individual legal notice to all affected property owners within and outside of the community, explaining the impact of the proposed action on their property;
- Concurrence of the Chief Executive Officer (CEO) and any other communities affected by the proposed actions; and
- Certification that no structures are located in areas that would be impacted by the increased base flood elevation.

VIII.Storm Water Infrastructure Analysis

VIII. STORM WATER INFRASTRUCTURE ANALYSIS

A. OVERVIEW

Storm water drainage network models have been analyzed as part of the City Wide Internal Storm Drain Master Plan Study (CWISDMP), which was completed in 2015. These were prepared utilizing the City-wide Storm Water Infrastructure GIS database and existing record plans. StormCad V8i was utilized to convert plan data into a digital model for the storm sewer trunk lines in the Bear Creek and Dry Creek watershed. The age of each system was calculated based on the dates from the GIS database and plan data.

The StormCad models are only conversions of existing storm drain plans for trunk lines in the watershed. Models should be checked for inaccuracies in the existing plans and data conversion process prior to utilizing these models for design.

Shapefiles were exported from the StormCAD models with all of the input and output data from the storm water infrastructure analysis. Information within these shapefiles can be queried to analyze multiple hydraulic parameters. For example, the shapefiles could be used to identify locations where the EGL calculations were within one foot of the inlet elevation or locations where velocities were greater than 6 ft/s. These locations can quickly be identified and visualized within GIS.

Maps presenting study results and proposed improvements can be found in Appendix A of the CWISDMP report. The Bear and Dry Creek watershed encompasses the StormCAD modeling regions named BC01S, BC02S, AND DB01S.

IX. Channel Stability Assessment & Erosion Hazard Analysis

IX. CHANNEL STABILITY ASSESSMENT & EROSION HAZARD ANALYSIS

A. OVERVIEW OF EROSION ASSESSMENT

This section of the City-Wide Drainage Master Plan for Bear Creek and Dry Creek provides the results of the erosion assessment based on visual analysis and field visits conducted for Bear Creek and Dry Creek. Halff Associates utilized local drainage and erosion criteria from the City of Grand Prairie and available stream bank stability measures to come up with solutions to existing and potential erosion problems for the Bear Creek and Dry Creek watershed.

B. CITY OF GRAND PRAIRIE EROSION AND CHANNEL INITIATIVES FOR THE BEAR AND DRY CREEK STUDY

1. City Resolution No. 3919

This resolution (included in Appendix G) states, "Erosion and/or flooding problems on private property will be investigated on a case-by-case basis. The City will focus on improvements to 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."

Halff Associates, Inc. recommends that the City of Grand Prairie view any pre-development stream bank stability improvements as public benefits. If future development encroaches onto existing or potential erosion areas, then improvements required to benefit these developments should be considered private.

2. 100-Year Floodplain (1% Annual Chance Floodplain)

Floodplain Workmaps illustrating the locations of the 100-year (1% Chance) existing conditions floodplains for Bear and Dry Creek watershed can be found in the Figures section of this report.

City design standards state that all land having an elevation at or below the fully developed 100-year flood elevation shall be contained within an easement dedicated to the public for the purpose of providing drainage (Drainage Design Manual, June 2015, Section 9.0.A). Halff Associates recommends that all future development follow this criteria to not encroach into future 100-year (1% chance) floodplain locations along Bear Creek and Dry Creek (i.e. locate development away from and above future 100-year floodplain elevations). Due to additional downcutting and widening that has the potential to occur, the City may desire to make these standards more stringent for the Bear Creek and Dry Creek study tributaries at particular locations where floodplains are generally more narrow and closer to existing main channel banks (along outside of meanders). Prior to proposed development occurring in proximity to these channel locations, an individual detailed analysis should be performed based on the information and results studying in this report. The Figures section of this report includes illustrations of the existing and future land use conditions within these watersheds and confirms the fact that these floodplains need to be managed properly as new development occurs.

3. Open Channel Design Guidelines

The City of Grand Prairie Drainage Design Manual provides many valuable tools for consideration of channel velocities and stream bank erosion (Chapter 9.3). If any work is to be done within the limits of Bear Creek and Dry Creek, the requirements established in Chapter 9.3 should be followed. This section states that the certifying engineer shall submit a letter report stating that the proposed drainage easement is of sufficient size to take into account any additional width to accommodate future bank erosion as determined by engineering slope stability calculation. The project engineer should be able to utilize the information provided in the CWDMP for the Bear Creek and Dry Creek as a guideline for his or her analysis and design, but separate individual studies should be performed for specific future development and channel projects to occur within these streams and tributaries. An end product of future development complying with Chapter 9.3 would be drainage easements that encompass the areas of the future 100-year floodplain and in some locations could be even wider to take into account channel erosion, side slopes erosion, and channel meanders.

Halff Associates, as well as the City Drainage Design Manual guidelines, also recommends that any constructed natural earthen banks within the limits of Bear Creek and Dry Creek have engineered slopes of 4:1 or greater (less steep). Also, any design of erosion control measures at meanders and bends should be considered carefully, since there is much evidence of migration of meanders in the study tributaries.

C. EROSION HAZARD SETBACKS (NON-STRUCTURAL)

Erosion setbacks have been determined for the Bear Creek and Dry Creek study for the intention of preserving existing natural channel corridors. Setbacks could be determined as described in this section or as described in Section 2.6.F. of the Drainage Design Manual. These setbacks would apply to areas being developed beyond the 100-year ultimate floodplain but where existing channel meanders and potential erosion areas are in proximity to the floodplain limits. Figure IX-1, showing the erosion hazard setbacks is located immediately after this page and in Appendix A.

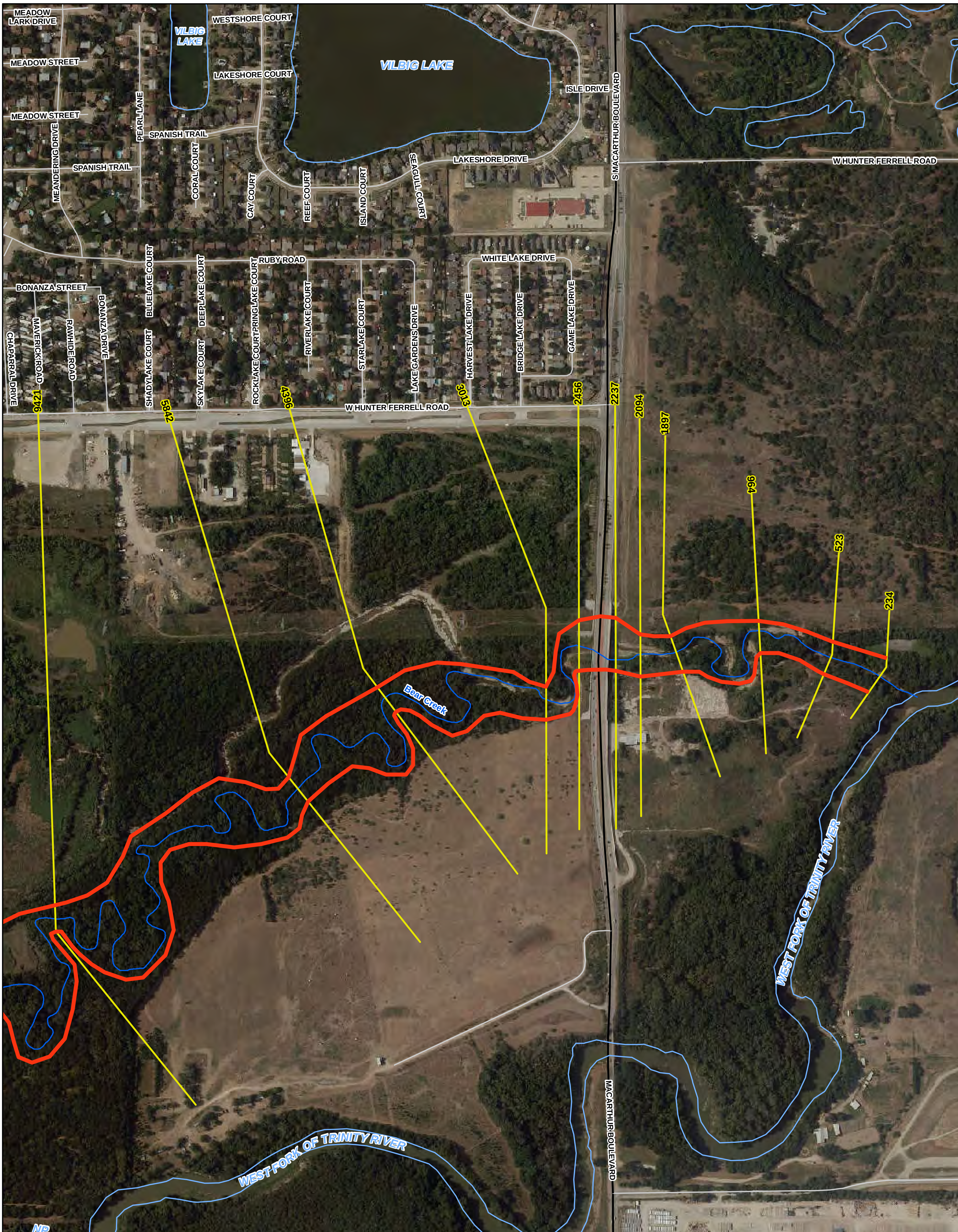
The following is a suggested setback program designed for use in the preservation of natural streams in North Central Texas. It is based on the philosophy of maintainable slopes and allows the natural erosion processes to continue without threatening structures. The stream bank erosion setback zone has been established as follows:

- Locate the toe of the natural stream bank
- From this toe, construct a 4 (horizontal) to 1 (vertical) line away from the stream and intersect the natural ground
- Continue past the intersection an additional 10 feet to the outer edge of the setback (per City standard criteria)

As previously stated, setbacks established for the purposes of stream bank erosion hazard protection may extend beyond the limits of the future 100-year floodplain limits. If the exercise above yields an erosion setback limit within the future 100-year floodplain limits, then Halff recommends utilizing the limits of the 100-year floodplain (as shown in the Figures section) 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 future 100-year floodplain limits. Once again, setback lines should take into account future widening and downcutting of existing channels.

Also, no building, fence, wall, deck, swimming pool or other structure should be located, constructed, or maintained within the area encompassing the setback.



Figure

IX-1

KEY TO FEATURES

Project Stream	Interstate Highway
Other Stream	Other Highway
Erosion Hazard Setbacks	Major Road
Cross Section	Minor Road
Index Contour*	Railroad
Intermediate Contour*	

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 01 of 08

0 500 1,000

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Figure

IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 02 of 08

0 500 1,000

Scale in Feet

Grand Prairie TEXAS

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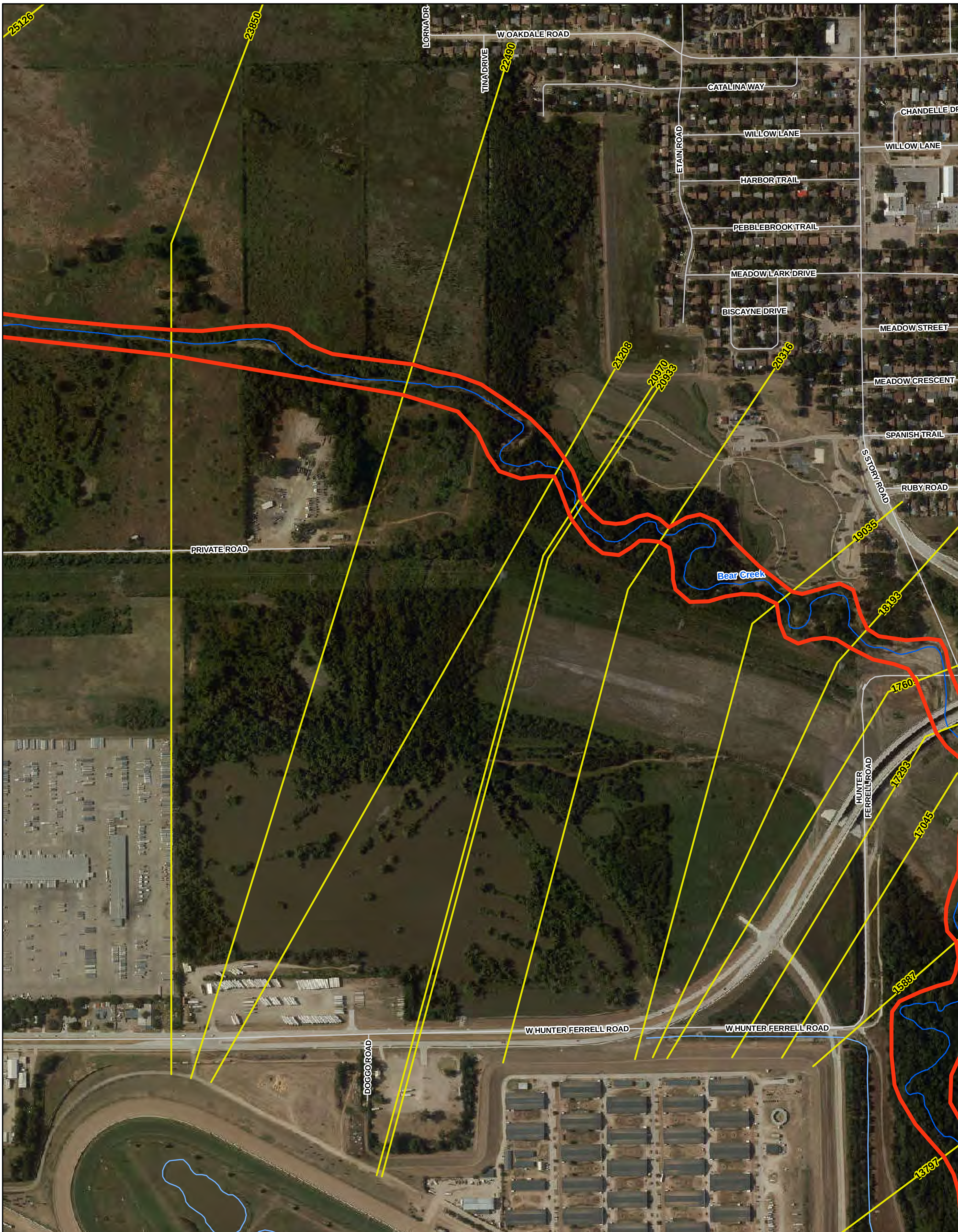

Figure IX-1

KEY TO FEATURES

Project Stream	Interstate Highway
Other Stream	Other Highway
Erosion Hazard Setbacks	Major Road
Cross Section	Minor Road
Index Contour*	Railroad
Intermediate Contour*	

Watershed

Bear-Dry Creek

0 500 1,000

Scale in Feet

Erosion Hazard Setbacks

Grand Prairie TEXAS

Panel 03 of 08

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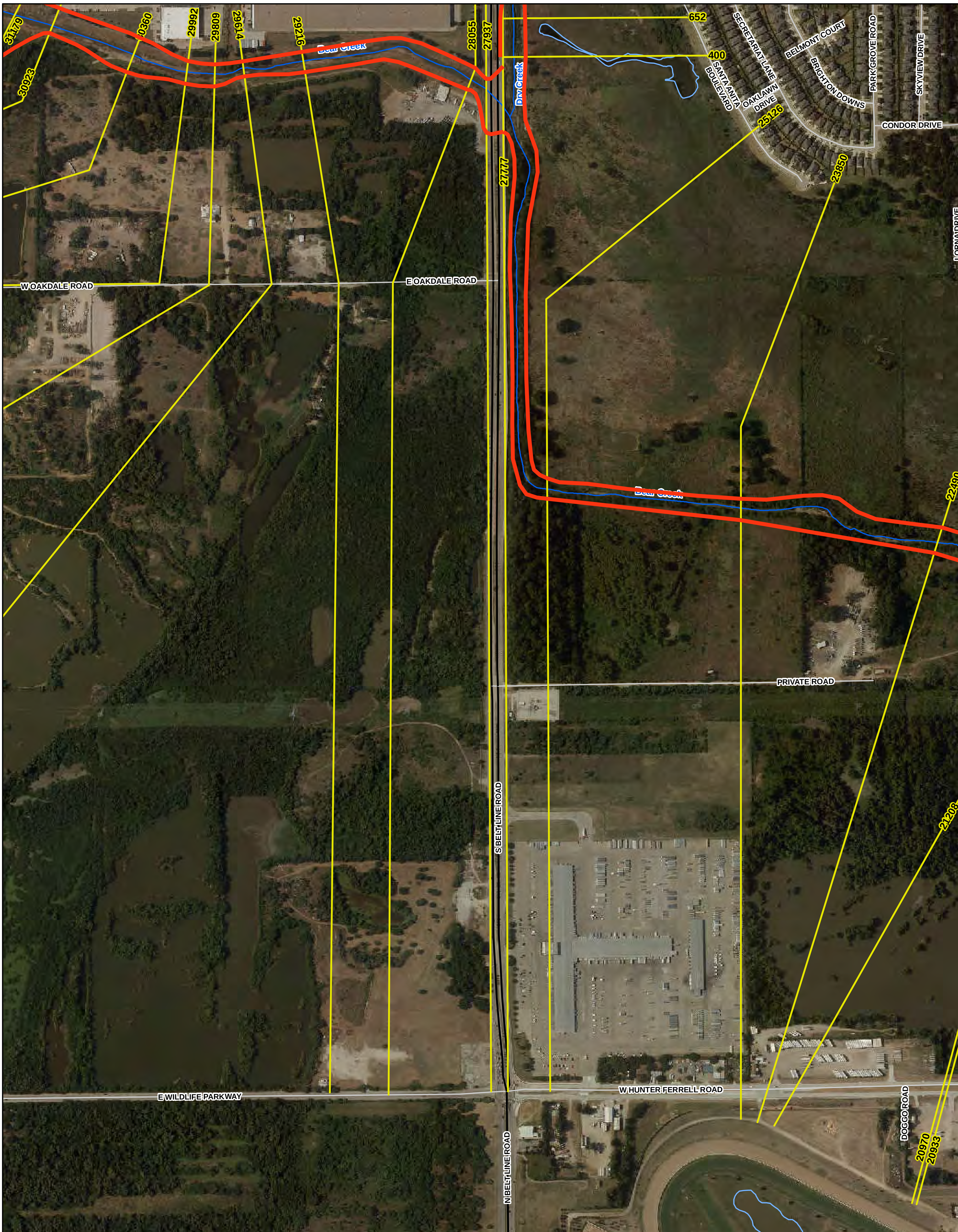

Figure

IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 04 of 08

0 580 1,160

Scale in Feet

Grand Prairie TEXAS

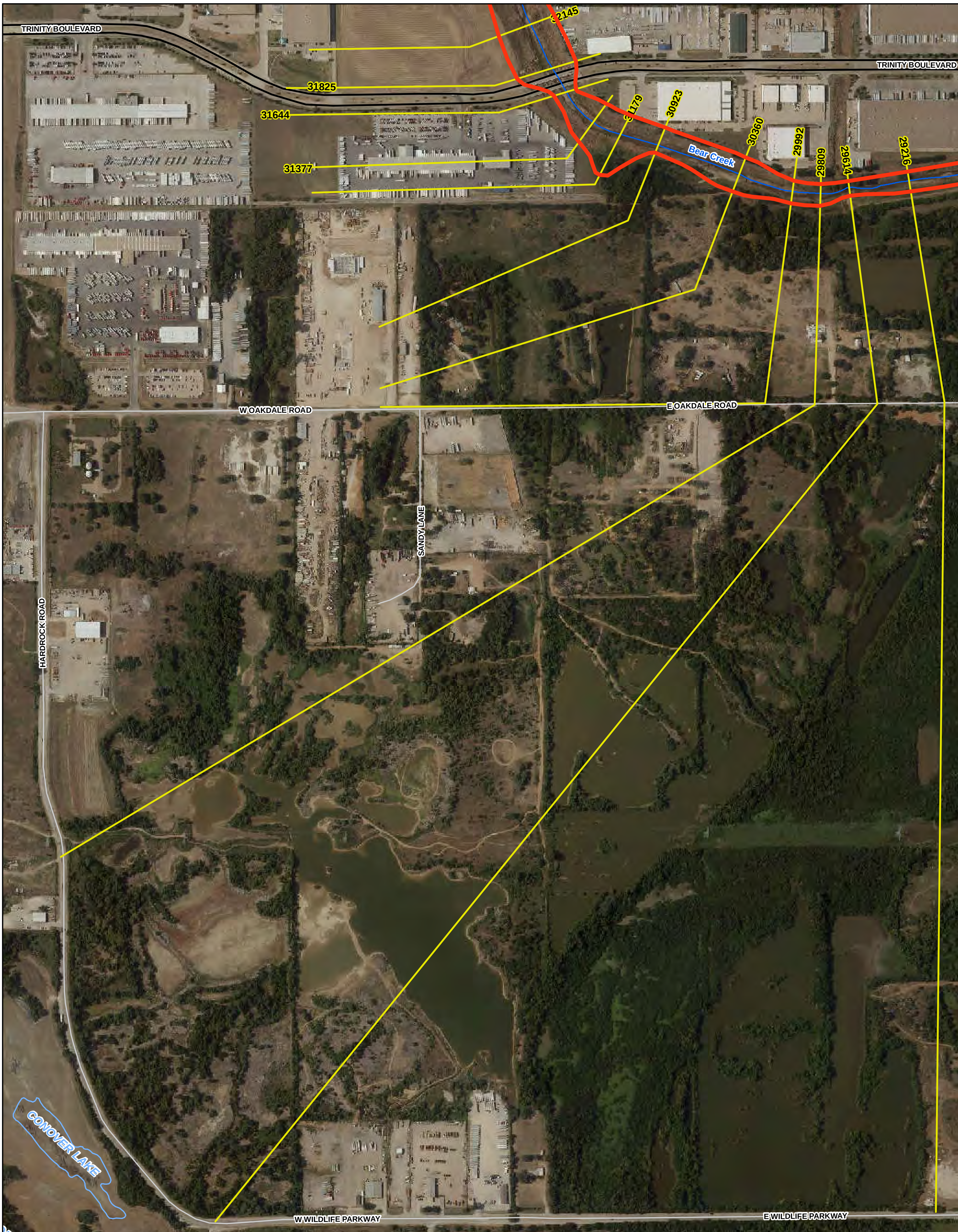

Figure IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 05 of 08

0 580 1,160

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Figure

IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 06 of 08

0 580 1,160

Scale in Feet

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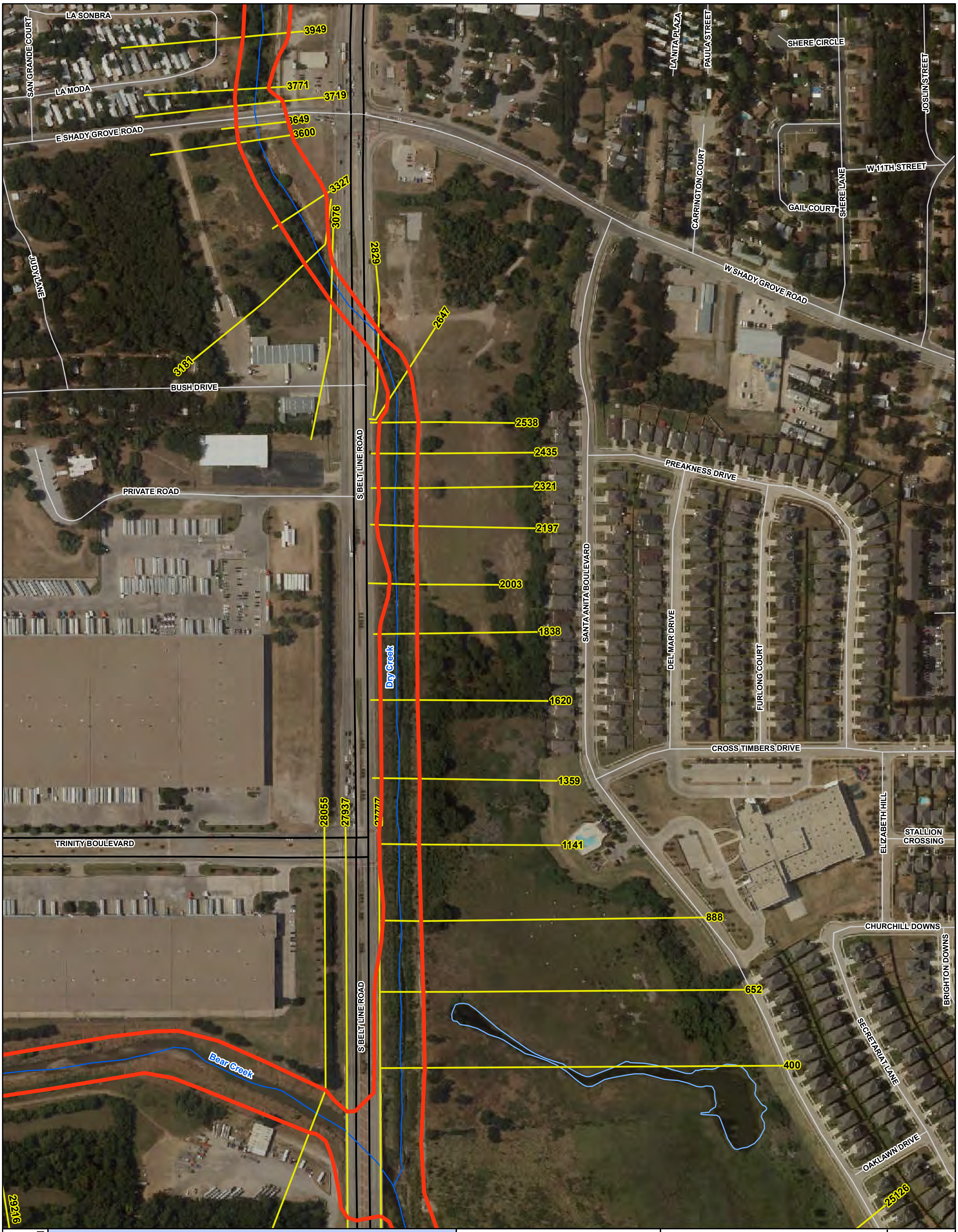

Figure

IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 07 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

HALFF

Figure IX-1

KEY TO FEATURES

- Project Stream
- Other Stream
- Erosion Hazard Setbacks
- Cross Section
- Index Contour*
- Intermediate Contour*
- Interstate Highway
- Other Highway
- Major Road
- Minor Road
- Railroad

Watershed

Bear-Dry Creek

Erosion Hazard Setbacks

Panel 08 of 08

0 300 600

Scale in Feet

Grand Prairie TEXAS

FEMA

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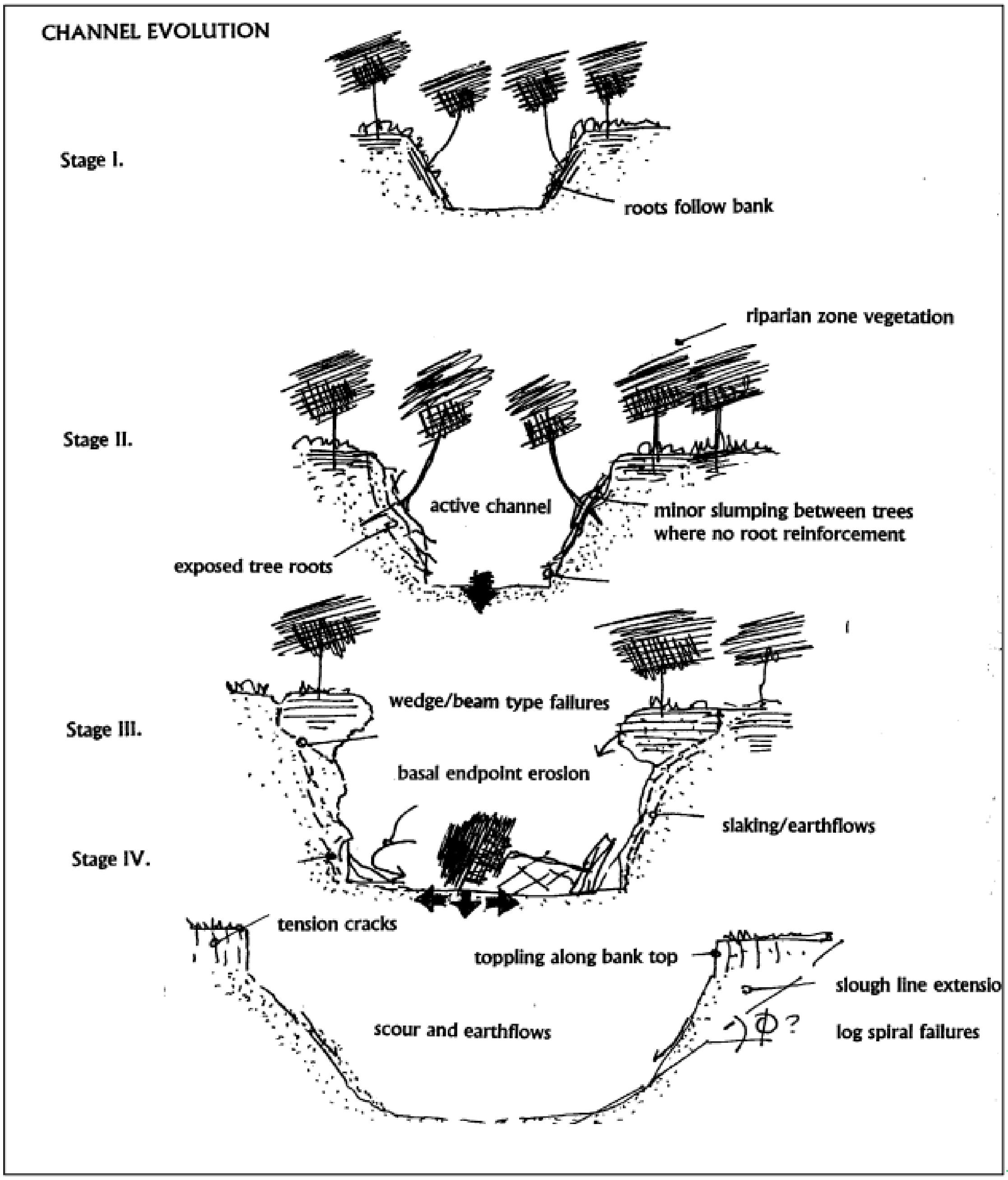
As an alternative to the setback, the developer or landowner may submit to the City Engineer a plan to stabilize and protect stream banks threatened by erosion. Stabilization shall be of a permanent nature, consistent with the guidelines established in this study and by the City of Grand Prairie, and 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 the Bear Creek and Dry Creek watershed. The following page shows a model of channel evolution and erosion.

Channel Evolution Model



D. <u>EROSION CONTROL MEASURES (STRUCTURAL)</u>

Halff Associates identified several structural erosion control methods that could be used to help control the effects of erosion on Bear Creek and Dry Creek. 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.

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. 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 made on 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 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 adding additional grade control structures in the downstream reach.

vii. *Typical Grade Control Structures for Bear and Dry Creek*

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 Halff 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 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. A list of approved soil retention blanket products from TxDOT is included in Appendix D. 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. Also, hard armor slope protection is not recommended under most current conditions since the majority of stream corridors are currently undeveloped. 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.

E. FUTURE BRIDGE/CULVERT IMPROVEMENTS – MASTER THOROUGHFARE PLAN

Future stream bank stability improvements would also need to consider existing and future bridge/culvert improvements. Before implementing any structural stability measures, future City Master Thoroughfare planning would need to be considered and existing crossings should be re-sized based on the recommendations in this report.

Future Master Thoroughfare Crossings

According the City of Grand Prairie’s Master Thoroughfare Plan, there are multiple planned upgrades for existing thoroughfares in the Bear Creek and Dry Creek watershed. Refer to Section VI of this report for information regarding existing and future roadway crossings.

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

For any future channel or slope improvements to the Bear and Dry Creek studied tributaries, 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.

G. OVERVIEW OF ALTERNATIVES TO HELP STABILIZE STREAM BEDS AND BANKS ALONG BEAR CREEK AND DRY CREEK WATERSHED

Based on visual analysis and field visits conducted for Bear Creek and Dry Creek watershed, Halff Associates has prepared the following alternatives to help stabiliaze stream beds and banks along Bear Creek and Dry Creek. See Appendix A for a location map of erosion sites.

Table IX-1 Stream Stability and Erosion Hazard Alternatives for Bear and Dry Creek

	Location	Proposed Alternative
1	Stations 74+80 and 72+90 along Dry Creek	Install Rock Riprap for Stream Stabilization to Protect Against Channel Erosion

1. Riprap near Rock Island Road along Dry Branch

Rock riprap is needed just upstream of the channelized portion of Dry Creek. The area between station 74+80 and 72+90 should be stabilized with 24” rock riprap. While it appears that some riprap has been placed downstream of this area previously, additional riprap will assist with stabilization.

STATEMENT OF PROBABLE COST - 2015	
Subtotal	$60,800
30% Contingency	$18,240
12% for Engineering and Survey	$9,500
TOTAL	**$88,500**

H. GENERAL GUIDELINES FOR FUTURE DEVELOPMENT IN THE BEAR AND DRY CREEK WATERSHED

Bear and Dry Creek is a dynamic stream system that is constantly changing with time. Currently, the majority of the watershed contributing to this stream is developed. While it may not be drastic, the stream evolution will change, whether it is by more constant low flows, increased flood discharges, new stream crossings, or encroachments into floodplain and channel areas. Following are some general guidelines to consider as new development arises in this watershed.

1. During Pre-Development Conditions (City of Grand Prairie)

Based on City Resolution 3919 perform pre-development improvements (public) to reduce erosive conditions along a given stream, including:

i. *Grade Control Structures*
ii. *Armored Slope Protection* near existing structures
iii. Recommended *Bridge/Culvert Improvements*

2. As Development is Occurring (Developer/City)

i. *100-Year Floodplain* – The developer shall review Section I through Section V of this report to determine future 100-year floodplain elevations and delineations. Where practical, development shall be located beyond the limits of the 100-year ultimate floodplain and developer shall dedicate a public drainage easement for all land, within property limits, having an elevation at or below the future 100-year flood elevation.

ii. *Open Channel Guidelines* – New development shall be required to ensure that the public drainage easement is of sufficient size to take into account any additional width beyond future 100-year flood elevation to accommodate future bank erosion

iii. *Armored Slope/Channel Protection* – If development is allowed to encroach into floodplain areas where it is in proximity to existing streams, the developer shall be responsible for implementing channel protection, whether it be a soft armor (TRM) or hard armor (rock riprap or gabion) solution, as necessary.

iv. *Bridges/culverts* – Review locations of existing bridge/culverts to determine if new development is in proximity. Review Master Thoroughfare plan to determine proximity of development to the new roadways and future stream crossings. <u>Both City and developer shall consider all existing and proposed roadways to determine potential impacts to proposed developments</u>. If new development requires additional bridges or culverts that are not listed in this report, developer shall provide an engineering study detailing the impacts of the bridge/culvert on future floodplain conditions for the given stream and shall design proposed bridge/culvert systems to contain future 100-year flood events without creating negative floodplain impacts upstream.

v. *Outfall Design Guidelines* – Storm drain outfalls into existing streams shall be required to adhere to the requirements in Section 8.9 of the Grand Prairie Drainage Design Manual.

vi. *Potential Sedimentation* – The developer shall review the Floodplain Workmap Exhibits in the Figures Section of this report to determine if the new development will need to consider sedimentation for the stream located in the public drainage easement adjacent to or within the development.

vii. *Section 404 permits* – If developer or City is providing either public or private benefits that affect the actual stream corridor, then a determination needs to be made on whether a Section 404 permit is required or not (Nationwide or Individual). Bear and Dry Creek should be considered as jurisdictional waters of the United States and any improvements to these streams shall obtain the required permits for construction. Refer to Appendix E.

3. Post-Development Conditions (City of Grand Prairie)

City shall inspect public drainage easements periodically for the following scenarios:

i. *Observed erosion – Does erosion within easement have potential to encroach beyond the easement (or setback, if determined)?*

ii. *Observed sediment deposition – Review and annotate locations of observed sediment deposition*

iii. *Functionality – Ensure constructed grade control, channel, and/or slope improvements are functioning properly*

iv. *Physical features within easement – Ensure that no building, fence, wall, deck, swimming pool or other structure is located within the area encompassing the public drainage easement (or erosion hazard setback, if determined)*

v. *Bridge/Culvert crossings – Check bridge/culvert crossings for functionality and erosion*

X. Detention

X. DETENTION

A. DETENTION PONDS

Zero (0) detention ponds were identified in the City of Grand Prairie for the Bear Creek and Dry Creek watershed.

XI. Storm Drain Outfall Assessment

XI. STORM DRAIN OUTFALL ASSESSMENT

This section of the CWDMP for the Bear Creek and Dry Creek report covers the assessment and prioritization rankings of storm drain outfalls in need of repair in the Bear Creek and Dry Creek watershed. Halff Associates utilized resources from the City of Grand Prairie, including recent photos and field reports, to determine the condition of each outfall and to rank each outfall based on need of repair using criteria established for this assessment. The high priority outfalls were field checked by Halff Associates to finalize their ranking. The results showing the condition, criteria category, and ranking of each outfall can be seen in Table XI-1 at the end of this section.

A. ASSESSMENT RESOURCES

Halff Associates determined the initial ranking of each outfall based on three resources; the City of Grand Prairie Drainage Design Manual criteria, the City of Grand Prairie database of field-checked storm drain outfalls, and photos of the Bear Creek and Dry Creek outfalls obtained from the City of Grand Prairie. From the Drainage Design Manual Halff Associates noted city requirements for storm drain outfalls and identified outfalls not meeting this criterion. The database of field-checked storm drain outfalls provided information on the condition of each outfall and gave a description of the issues needing repair/maintenance. The storm drain outfall photos helped reveal the severity of the condition of each outfall. These three resources provided the information needed to assess conditions and establish criteria to prioritize the outfalls based on necessity to repair.

B. CONDITION AND CRITERIA

Each storm drain outfall was assigned a condition and a criteria category. The four possible conditions included: **1) Good** (requires no remedial maintenance-continued normal inspections), **2) Fair** (may require some remedial maintenance – not immediate), **3) Poor** (requires immediate remedial maintenance), **4) Failure** (requires immediate assistance beyond remedial maintenance).

Next, the outfalls were assigned a criteria category: Structural, No Headwall, RipRap/Scour, Siltation, or Aesthetics. Criteria were assigned by answering the following criteria questions: “Is there a threat to the structural integrity of the outfall?”; “Does the outfall have a headwall?”; “Is erosion control needed at the outfall?”; “Is there siltation at the outfall limiting its conveyance?”; “Is the outlet structure of concern aesthetically?”; After each storm drain outfall was assessed based on condition and criteria, a number ranking was given based on need of repair (number 1 being of highest priority). The following paragraphs give a brief description of each criteria category. The photos show examples of outfalls from each criteria category that are in poor condition.

1. Structural Criteria Category

Outfalls were placed under the structural criteria category if there was a threat to the structural integrity of the outfall or if there was already a structural failure of the outfall. This threat was typically due to erosion around the outfall structure, wingwalls, or toewalls.

Picture XI-1 – Example of Structural Criteria (Photo ID 1613)

2. RipRap/Scour Criteria Category

Outfalls where there was a threat to the structure due to erosion or where erosion/scour was occurring downstream were placed under the RipRap/Scour criteria category. Most of the erosion/scour at these outfalls could be reduced or eliminated with the placement of rock riprap or other outfall protection.

Picture XI-2 – Example of RipRap/Scour Criteria (Photo ID 1613)

3. Siltation Criteria Category

Outfalls where the conveyance of the drainage pipe/culvert could be hindered due to silt deposition were placed under the siltation criteria category. Decreased capacity at the outfall structure due to silt deposition could cause flooding concerns upstream if the silt is not removed.

Picture XI-3 – Example of Siltation Criteria (Photo ID 1613)

4. No Headwall Criteria Category

Outfalls where there was no headwall to protect the structural integrity of the pipe/culvert were placed under the no headwall criteria category. The City of Grand Prairie Drainage Design Manual requires City standard or TxDOT standard headwalls for all inlets and outfalls on closed conduits.

Picture XI-4 – Example of No Headwall Criteria (Photo ID 1613)

5. Aesthetics Criteria Category

Outfalls where the aesthetic appearance of the structure requires maintenance were placed under the aesthetics criteria category. Some examples of poor aesthetic appearance would be a downed tree near the outfall structure, loose rock around the outfall structure, or signs of vandalism.

Picture XI-5 – Example of Aesthetics Criteria (Photo ID 1613)

C. FIELD CHECK

Halff Associates field checked many of the high priority outfalls to verify their necessity to repair. This exercise was necessary for two reasons. The first reason was to re-prioritize the outfall rankings based on their most current condition. The second was to confirm the final rankings of each high priority outfall. Some questions concerning the risk of an outfall were not able to be answered from the resources mentioned above, such as does the outfall drain an entire subdivision or does the outfall convey flow at a minor road crossing? After the field visit, the rankings were adjusted and finalized based on the need of repair for each outfall.

D. USACE SECTION 404 PERMITS

For any future channel or slope improvements to Henry 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. OUTFALL CONCLUSIONS/RECOMMENDATIONS

It is the recommendation of this study that the City of Grand Prairie proceed immediately with maintenance for the 5 outfall structures identified as failed and the 7 identified as being in poor condition in Table XI-1 (included at the end of this section). The maintenance schedule may need to be adjusted based on budget availability but it is advised that the City proceed with maintenance for these outfalls as soon as possible. These structures appear to be at risk of either structural damage that would render the structures irreparable or of siltation that would compromise the ability of the outfall to adequately convey the design discharge. 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. Recommended maintenance activities are as follows.

1. Recommended Maintenance Activities

i. *Structural*

Evaluate necessary structural repairs and determine whether replacement of outfall structure is necessary. Restore outfall to adequate operating condition and install erosion protection to prevent future structural undermining. Design of any outfalls or structural repairs shall be according to the City of Grand Prairie standards.

Estimated Cost: $5,000 - $25,000 per outfall

ii. *Siltation/Scour/Riprap*

Refer to the City of Grand Prairie Drainage Design Manual Section 8.9 Outfall Design Guidelines for acceptable design applications for outfall protection. Additional information is available in the North Central Texas Council of Governments iSWM Technical Manual Section 4.0 and Section XI.D of this report. Scour protection should be designed to adequately protect structural integrity of the outfall and to prevent erosion and siltation downstream. Siltation blocking the outfall should be removed.

Estimated Cost: $1,000 - $5,000 per outfall

iii. *No Headwall*

All outfall and inlets shall have reinforced concrete headwall. Headwalls shall be City of Grand Prairie or TxDOT standard. Refer to current City of Grand Prairie Drainage Design Manual.

Estimated Cost: $5,000 - $25,000 per outfall

iv. *Aesthetics*

Remove accumulated debris including trees, vegetation, and garbage from the outfall structure. Repair superficial defects to the outfall structure. These defects could include displaced riprap, vandalization in the form of graffiti or disturbance to erosion protection, and overgrown vegetation.

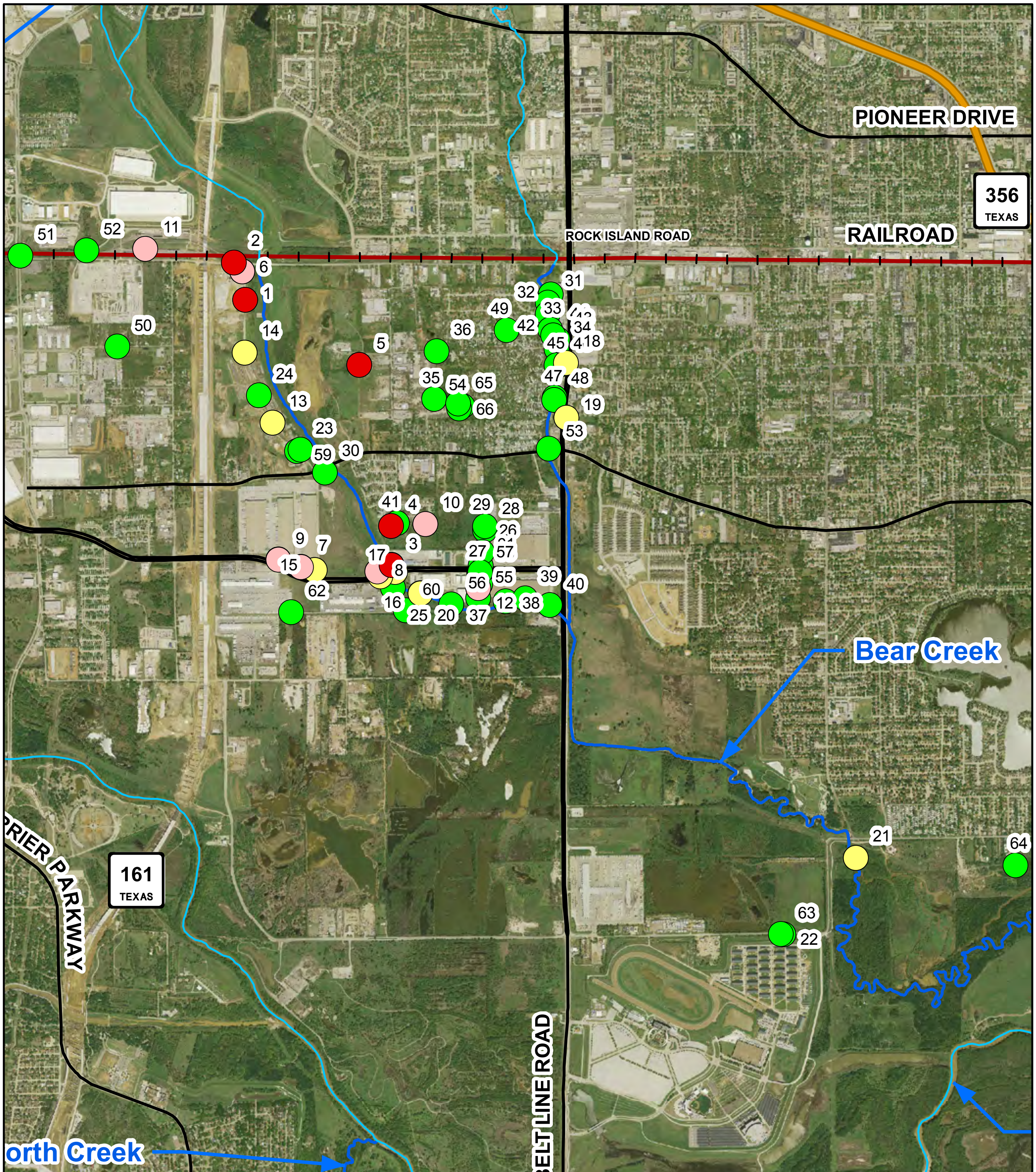
Estimated Cost: $1,000 - $5,000 per outfall

v. *Continued Monitoring*

All repaired outfalls and those categorized as “good” in this report should continue to be monitored in a regularly scheduled cycle (determined by the City) to ensure that repairs are adequate and to determine where additional maintenance is needed.

Table XI-1 Storm Drain Outfall Assessment

Location	ID Number	Condition	Description	Criteria Category
1	254	Failure	The intake is obstructed by silt.	Siltation
2	256	Failure	The intake is completely obstructed by silt.	Siltation
3	334	Failure	The outfall is seperated and disjointed from the pipe. Repair needed.	Structural
4	922	Failure	It appears that 50 percent of the flow area is obstructed by silt and debris.	Siltation
5	1810	Failure	There is a build-up of debris that is obstructing the outfall structure.	Siltation
6	255	Poor	The intake is obstructed by silt.	Siltation
7	332	Poor	The intake is partially obstructed by silt and grass.	Siltation
8	545	Poor	The edges are being eroded by water flow. Recommend placing rock rip-rap on either side to solidify the slopes.	Erosion
9	563	Poor	The outfall is obstructed by siltation. Also the grade is such that there is water sitting in the pipe. Recommend that the ground surface is regraded so that the water drains away from the outfall.	
10	921	Poor	A third of the flow area of the outfall is obstructed by silt and debris.	Siltation
11	1234	Poor	The pipe seems to be in good condition but should be stabilized by a headwall	Headwall
12	1451	Poor	Rock rip-rap should be applied around the outfall structure. On the slope, above and below the outfall, portions of the ground have eroded which will lead to undermining.	
13	251	Fair	The outfall appears to be partially obstructed by siltation.	Siltation
14	253	Fair	The outfall is overgrown with brush.	Aesthetic
15	333	Fair	The ground around the outfall has been eroded. Over a lengthy period of time this could cause the structure to be undermined. Recommend the ground surface to be graded such that water can disperse more easily.	Erosion
16	694	Fair	There are some large rocks and silt that are obstructing the outfall. These obstructions should be removed.	Siltation
17	695	Fair	The structure is in good condition, however the outflow from the pipe has eroded a plunge pool at the bottom of the abutment.	Erosion
18	1192	Fair	The structure itself is in good condition, however the outflow from the pipe has eroded some areas around the structure.	Erosion
19	1242	Fair	Recommend gradind the ground surface to evenly distribute the outflow from the outfall.	Aesthetic
20	1450	Fair	There appears to be erosion around the outfall that needs repair.	Erosion
21	1841	Fair	There is some silt build up.	Siltation
22	1840	Good	The is ponding of water in the area, but it is not due to the outfall	
23	247	Good		
24	252	Good		
25	289	Good		
26	335	Good		
27	336	Good		
28	578	Good		
29	579	Good	There is a buildup of vegitation that could be cleared from the area.	Aesthetic
30	648	Good		
31	720	Good		
32	721	Good		
33	722	Good		
34	734	Good		
35	840	Good		
36	841	Good		
37	846	Good		
38	847	Good		
39	848	Good		
40	849	Good		
41	920	Good		
42	1073	Good		
43	1074	Good		
44	1075	Good		
45	1076	Good		
46	1077	Good		
47	1078	Good		
48	1079	Good		
49	1080	Good		
50	1081	Good		
51	1177	Good		
52	1191	Good		
53	1193	Good		
54	1241	Good		
55	1452	Good		
56	1453	Good		
57	1454	Good		
58	1499	Good		
59	1575	Good		
60	1584	Good		
61	1590	Good		
62	1741	Good		
63	1839	Good		
64	1842	Good		
65	1873	Good		
66	1874	Good		



HALFF	Grand Prairie TEXAS

KEY TO FEATURES

- Studied Stream
- Unstudied Stream
- Good Condition
- FairOutfallConditions
- PoorOutfallConditions
- FailureOutfallConditions
- County Boundary
- Interstate Highway
- State Highway
- Major Road
- Railroad

*Exhibit only shows location numbers for outfalls with problems and labeled numbers correspond to Table XI-1

0 1,500 3,000 6,000

Scale in Feet

N W E S

Title

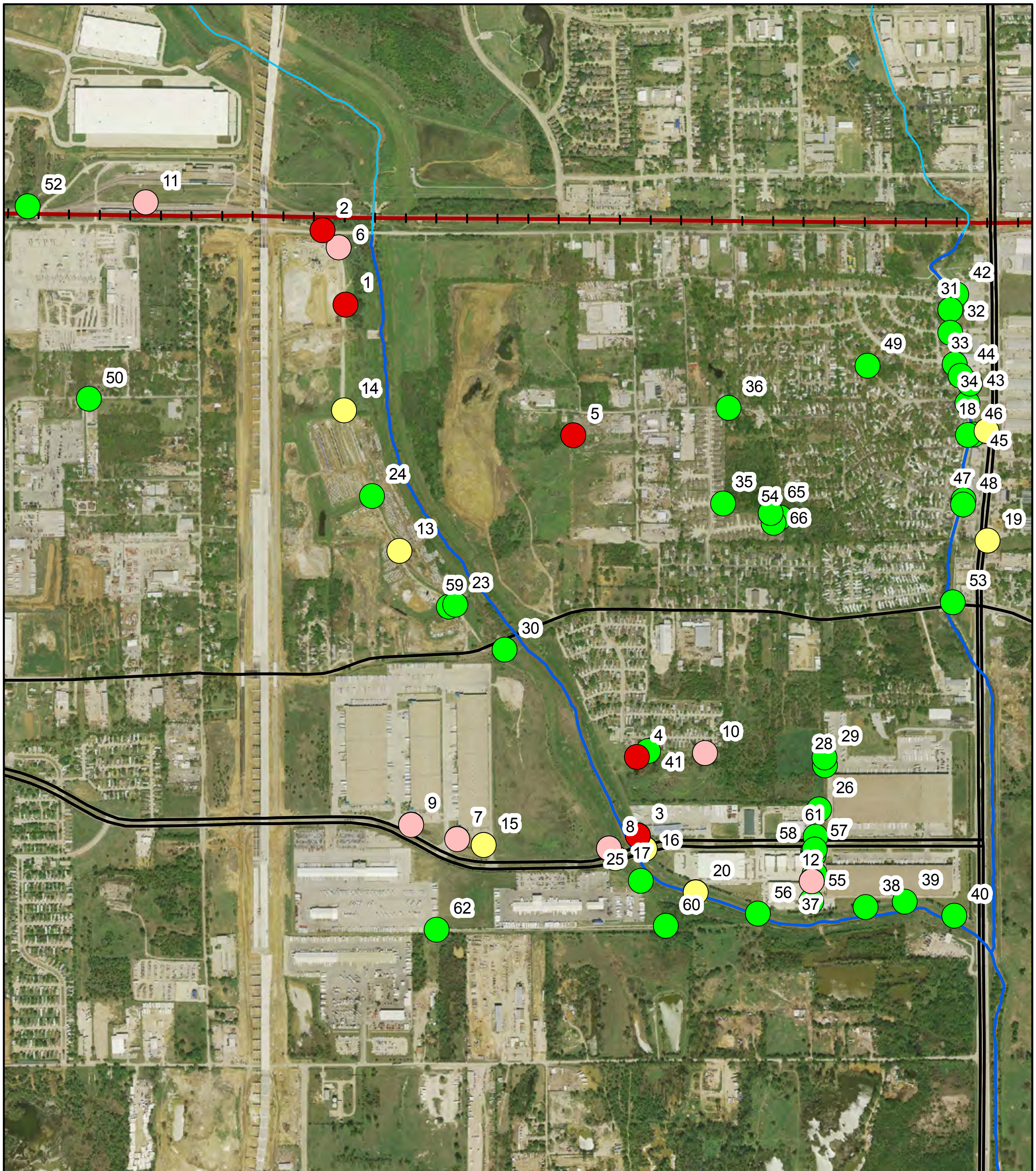
Storm Drain Outfall Location

Watershed

Bear-Dry Creek

Figure

XI-1



HALFF

Grand Prairie TEXAS

FEMA

KEY TO FEATURES

- Studied Stream
- Unstudied Stream
- Good Condition
- FairOutfallConditions
- PoorOutfallConditions
- FailureOutfallConditions
- County Boundary
- Interstate Highway
- State Highway
- Major Road
- Railroad

*Exhibit only shows location numbers for outfalls with problems and labeled numbers correspond to Table XI-1

0 750 1,500 3,000

Scale in Feet

N W E S

Title

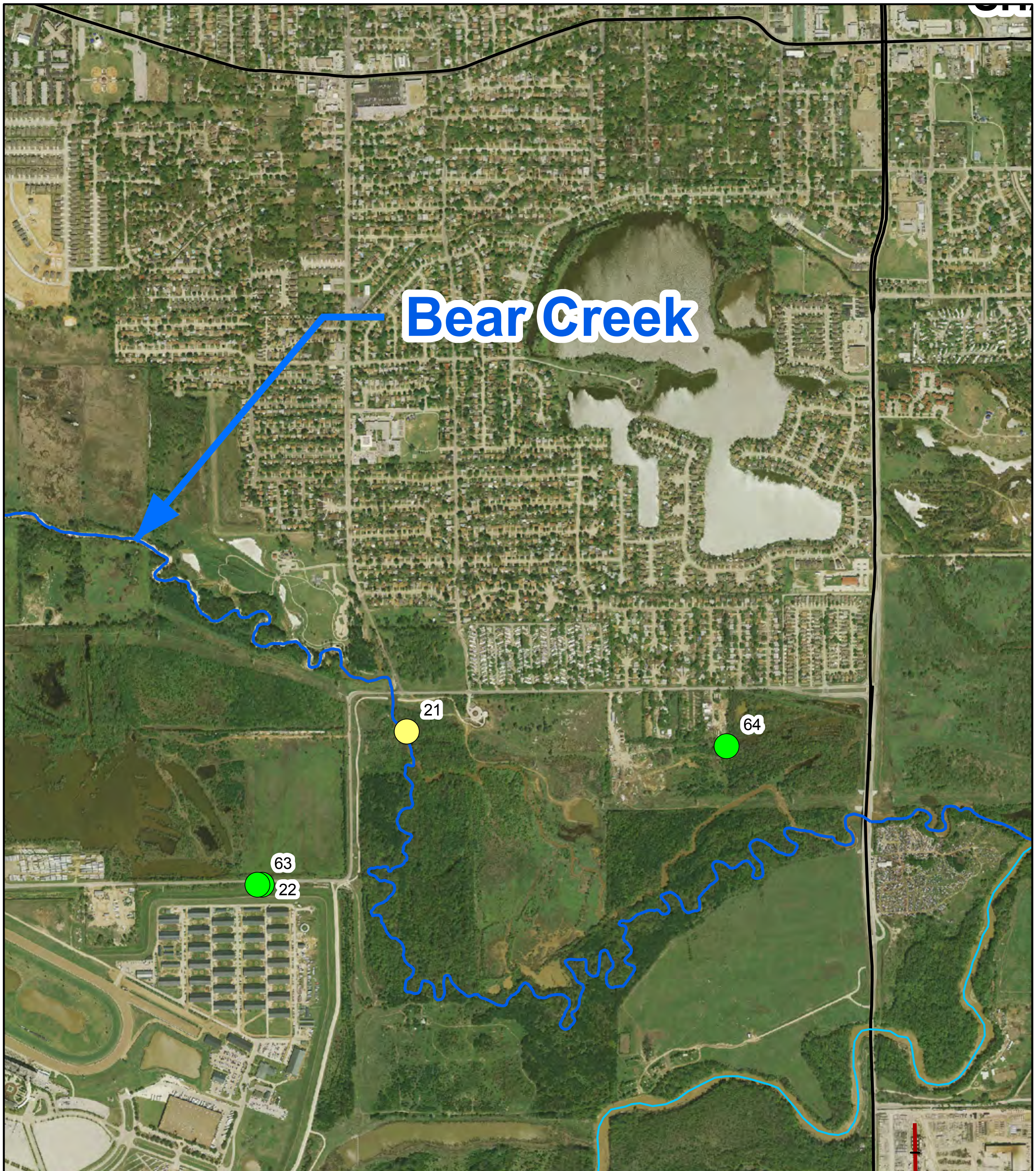
Storm Drain Outfall Location

Watershed

Bear-Dry Creek

Figure

XI-1A



HALFF

Grand Prairie
TEXAS

FEMA

KEY TO FEATURES

Studied Stream	FailureOutfallConditions
Unstudied Stream	County Boundary
Good Condition	Interstate Highway
FairOutfallConditions	State Highway
PoorOutfallConditions	Major Road
	Railroad

*Exhibit only shows location numbers for outfalls with problems and labeled numbers correspond to Table XI-1

0 750 1,500 3,000

Scale in Feet

N S W E

Title
Storm Drain Outfall Location

Watershed
Bear-Dry Creek

Figure
XI-1B

XII. Preliminary Quantities/Estimates of Probable Cost

XII. PRELIMINARY QUANTITIES/ESTIMATES OF PROBABLE COST

Preliminary quantities and estimates of probable cost were calculated for the stream stabilization alternative from Section IX of this report.

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

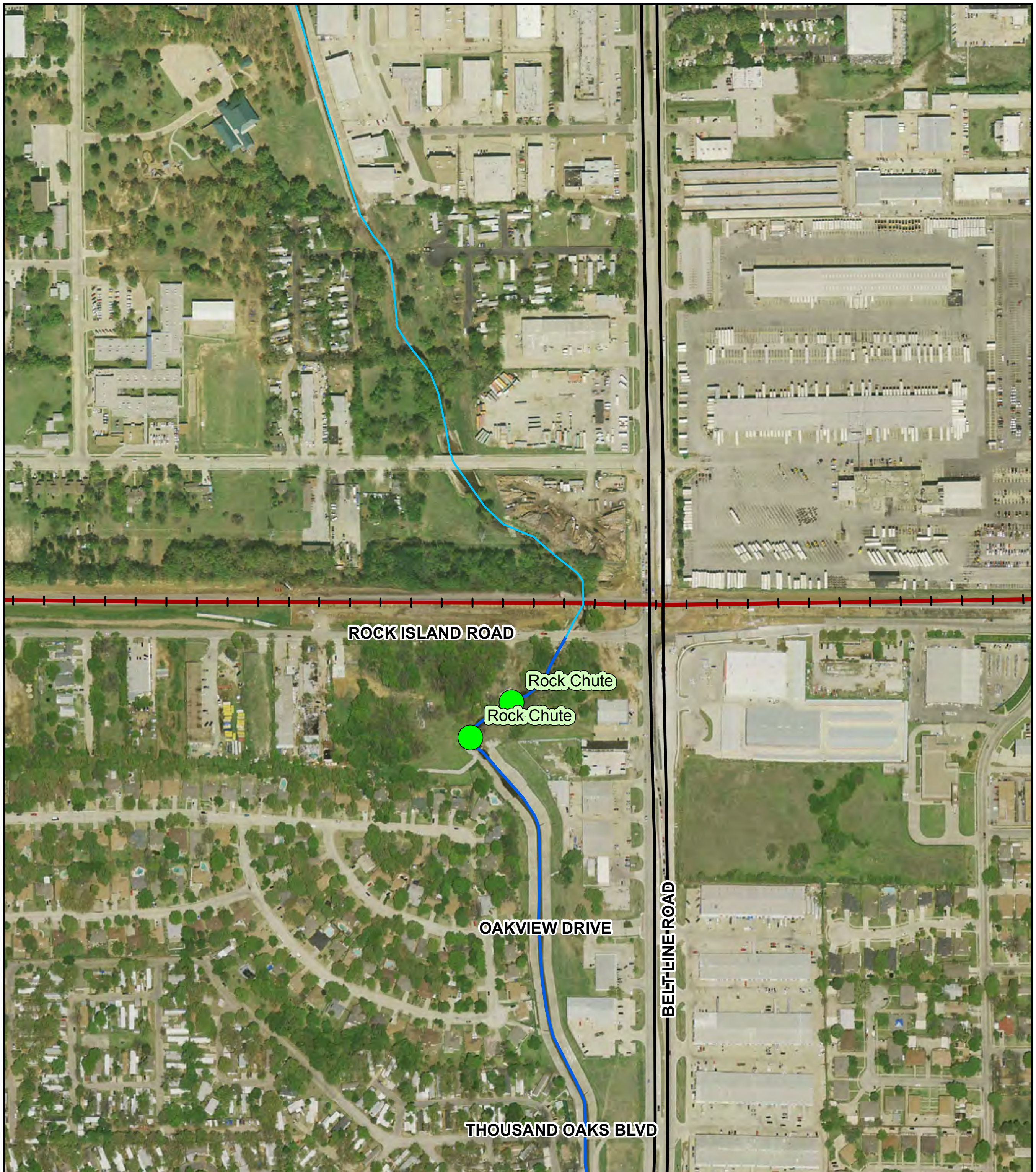
ENGINEER'S STATEMENT OF PROBABLE COST

Rock Chutes and Bank Stabliization along Dry Creek at Two Locations (Stations: 74+80, and 72+90)

Project: Bear Creek and Dry Creek CWDMP **Prepared by:** TH
Client: City of Grand Prairie

ITEM NO.	DESCRIPTION	UNIT	QTY	Engineer's Estimate	
				UNIT PRICE	EXTENDED PRICE
	Rock Chute Construction				
1	Mobilization	LS	1	$20,000	$20,000
2	24" Rock Riprap (Dry)	CY	220	$175	$38,500
3	Filter Fabric for 24" Rock Riprap	SY	100	$3	$300
4	Channel Excavation	CY	100	$20	$2,000
				Subtotal Improvements	***$60,800.00***
				CONTINGENCY (30%)	***$18,240.00***
				ENGINEERING & SURVEYING SERVICES (12%)	***$9,500.00***
				TOTAL IMPROVEMENTS	***$88,500.00***

NOTE: This statement was prepared utilizing standard cost and/or estimating practices. It is understood and agreed that this is a statement of probable construction cost only, and the Engineer shall not be liable to the Owner or any Third Party.



HALFF

Grand Prairie TEXAS

FEMA

KEY TO FEATURES

- Studied Stream
- Unstudied Stream
- CIP Location
- County Boundary
- Interstate Highway
- State Highway
- Major Road
- Railroad

* The upper portions of the Bear Creek watershed was not modeled in this study and are included only for hydrologic purposes.

0 250 500 1,000

Scale in Feet

N W E S

Title

CIP Location Map

Watershed

Bear-Dry Creek

Figure

XII-1

XIII.Evaluation & Prioritization/Phasing & Implementation

XIII. EVALUATION & PRIORITIZATION/PHASING & IMPLEMENTATION

A. EVALUATION & PRIORITIZATION

Halff Associates analyzed multiple open channel alternatives that are described in Section VII of this report. However, the projects were either found to be impractical or the benefits did not justify the costs. In the future there are projects that need to be ranked the following is a brief summary of the criteria and methodology utilized to rank short-term and long-term priority projects to be incorporated into the overall City-wide implementation plan.

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 alternative. Due to the lack of development at the majority of proposed CIP alternative 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 alternative 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 alternative 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 alternative roadway crossing. Halff 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 alternative if no improvements were made.

vi. *Ultimate 100-Year Discharge* – The ultimate 100-year discharge was determined for each proposed CIP alternative 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%
[1]Based 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

[1]Based 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 CIP alternatives 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 , or Environmental Protection Agency
- 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:

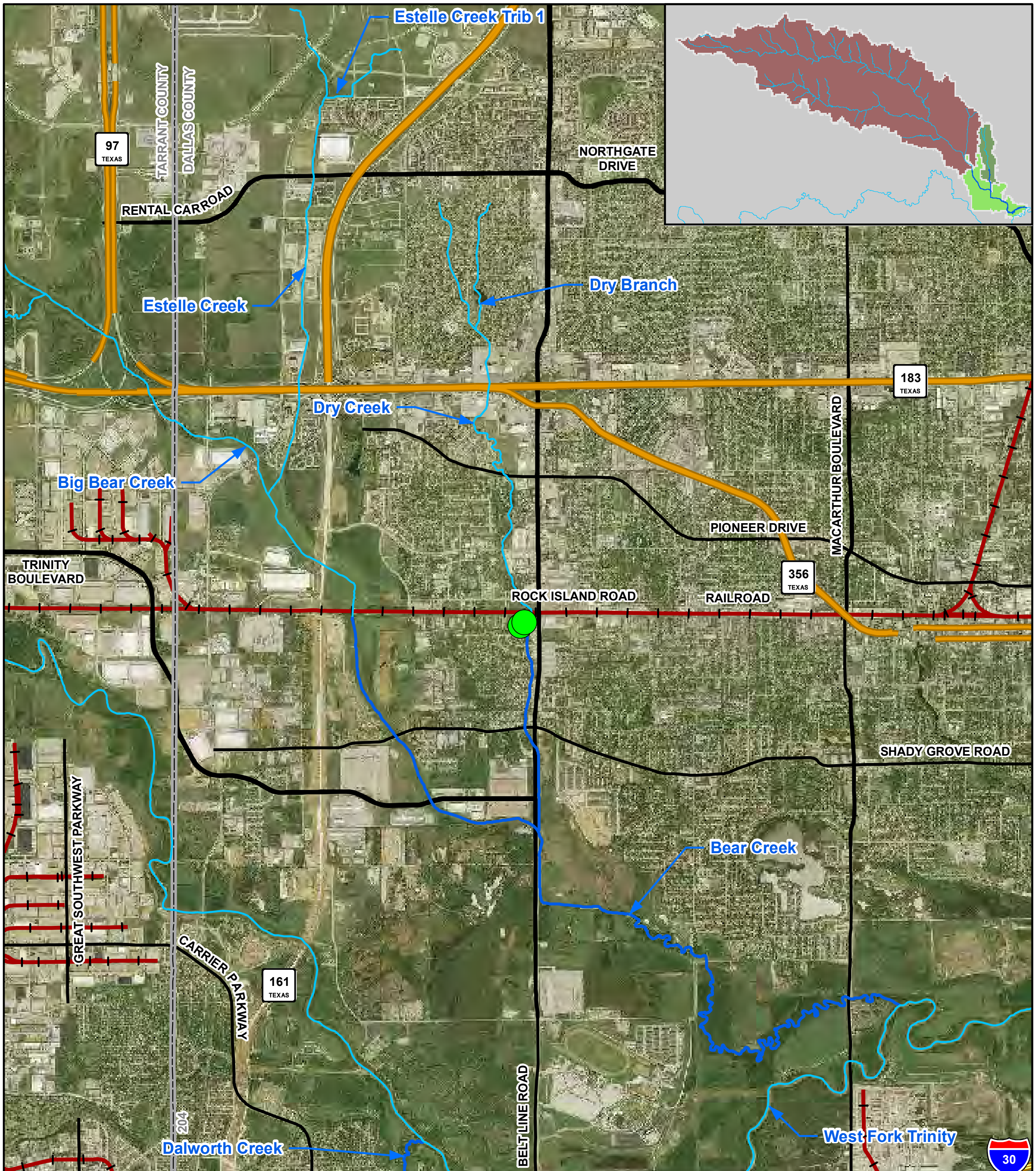
- All the Short-term issues listed above
- Longer range funding plans for larger projects, including phasing (look into State and Federal grants and construction loans)
- More global view, watershed-wide or regional type projects (look into cooperative efforts with U.S. Army Corps of Engineers, NCTCOG, 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

Table XIII-1 Stream Stability Capital Improvement Projects

Rank	Stream	Capital Improvement Project	Short-Term/Long-Term	Public/Private	Probable Cost
1	Dry Creek	Rock Chutes	Short-Term	Public	$88,500



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KEY TO FEATURES

- Studied Stream
- Unstudied Stream
- CIP Location
- County Boundary
- Interstate Highway
- State Highway
- Major Road
- Railroad

* The upper portions of the Bear Creek watershed was not modeled in this study and are included only for hydrologic purposes.

0 2,500 5,000 10,000

Scale in Feet

N W E S

Title

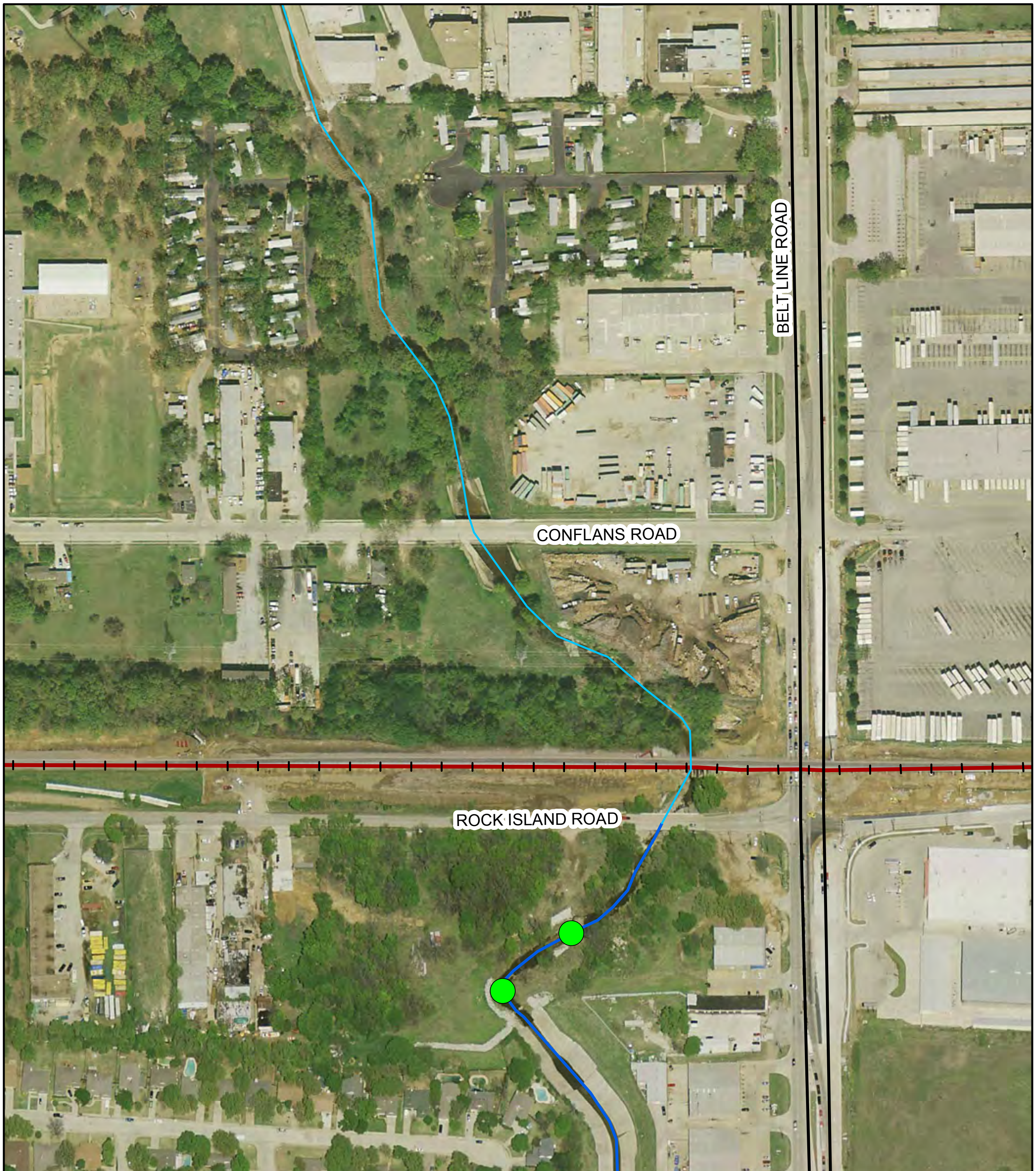
CIP Location Map

Watershed

Bear-Dry Creek

Figure

XIII-1



HALFF

Grand Prairie TEXAS

FEMA

KEY TO FEATURES

- Studied Stream
- Unstudied Stream
- CIP Location
- County Boundary
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- State Highway
- Major Road
- Railroad

* The upper portions of the Bear Creek watershed was not modeled in this study and are included only for hydrologic purposes.

0 150 300 600

Scale in Feet

N W E S

Title

CIP Location Map - Zoom In

Watershed

Bear-Dry Creek

Figure

XIII-2

XIV. Short Term Priorities & Long Term Plan

XIV. SHORT TERM PRIORITIES & LONG TERM PLAN

A. SHORT-TERM PRIORITIES IMPLEMENTATION

There is one (1) short-term capital improvement project located in the watershed. This short-term CIP is a stream stability alternative 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 and is included on the DVD in Appendix G of this report. It is recommended that the setback shapefile be utilized to help manage future development in the watershed.

B. LONG-TERM PLAN IMPLEMENTATION

There are zero (0) long-term CIPs located in the Bear Creek and Dry Creek watershed.

XV. Master Plan Study Wrap-Up & Recommendations

XV. MASTER PLAN STUDY WRAP-UP & RECOMMENDATIONS

This City-wide Drainage Master Plan for the Bear Creek and Dry Creek provides comprehensive, updated technical data for the management of the Bear Creek and Dry Creek watershed and its tributaries. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood 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 the Bear Creek and Dry Creek watershed.

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

A. STREAMS AND OPEN CHANNELS

A relatively small number of structures are currently inundated by the 100-year floodplain in the Bear Creek and Dry Creek watershed. The watershed is mostly undeveloped at this time and the developed area in the peninsula near Mira Lagos has been constructed relatively recently utilizing the City's current drainage criteria. Therefore, Halff recommends the following Non-Structural action items for the Bear Creek and Dry Creek streams and tributaries:

- **Continue floodplain regulation and encourage responsible development of the watershed.**
- Place flood warning signage at Sherwood Drive.
- Budget for future thoroughfares and infrastructure improvements based on the conceptual roadway sizings provided with this report.
- Provide CWDMP report and updated technical data to Ellis and Johnson Counties to improve floodplain management in the ETJ.

B. STREAM BANK STABILITY

One (1) stream stability alternative was developed by Halff Associates along Dry Creek intended to protect public infrastructure and help control future erosion to stream beds and stream banks. Halff recommends that the City implement this alternative. Halff also recommends that the City utilize the Erosion Hazard Setbacks delineated as part of this study to manage new development in the Bear Creek and Dry Creek watershed.

C. MAINTENANCE

Maintenance should be considered an ongoing task in the Henry Branch watershed 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

Storm drain outfall maintenance issues identified in this report include four main categories: 1) **Good** (requires no remedial maintenance- continued normal inspections), 2) **Fair** (may require some remedial maintenance – not immediate), 3) **Poor** (requires immediate remedial maintenance), 4) **Failure** (requires immediate assistance beyond remedial maintenance).

For the storm drain outfalls, refer to Table XI-1 for a list of the condition of each outfall. 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

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 G.

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