PRELIMINARY FLOODPLAIN STUDY

for
Drainage District No. 1
and
Drainage District No. 2

The City of Garden City, Kansas

June 2009

Engineering Report

WILSON &COMPANY

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Executive Summary

The Federal Emergency Management Agency (FEMA) has updated the Flood Insurance Rate Maps (FIRM) for Finney County, including the City of Garden City. The updated FIRM's are scheduled to become effective September 2009.

The City of Garden City and Finney County, along with the Boards of Directors of Drainage District No.1 and the Second Drainage District, disagree with the inclusion of new floodplains for Drainage Ditch No. 1 (DD-1) and Drainage Ditch No. 2 (DD-2) on the new FIRM's. The new floodplains along DD-1 and DD-2 were developed as Zone A (approximate method). Floodplains along these manmade ditches have not been included on previous FIRM's. The City and County first adopted floodplain maps and regulations in 1978, the FIRM's were updated in 1987 and 1997. It is the desire of the City of Garden City and Finney County to have these new floodplains removed from the new DFIRM mapping, as it's believed they are not sufficiently accurate for this urbanized area.

If the floodplains for DD-1 and DD-2 are included on the new DFIRMS, it's recommended Garden City and Finney County request that FEMA perform a detailed study for this urbanized area, based on the significant number of properties impacted. It's recommended to verify FEMA used the correct census block group data to determine whether DD-1 and DD-2 should be mapped with Zone A or Zone AE.

This engineering report documents: the findings from the review of the FEMA Preliminary Digital Flood Insurance Rate Map (DFIRM) data, results of a field investigation conducted to verify FEMA's assumptions, identification of concept improvements to reduce the floodplains associated with DD-1 and DD-2, and a determination whether further study is warranted to provide significantly more accurate floodplain mapping for DD-1 and DD-2.

FEMA did not utilize the most accurate available ground surface elevation data to establish floodplain water surface elevations. Instead less accurate elevation data from 1976 was used.

From supporting Preliminary DFIRM data provided by Kansas DWR, it appears a drainage basin of approximately 780 square miles was utilized for DD-2, extending north and west into three neighboring counties. From historical data presented by the City, DD-2 does not have flow during major rainfall events in these other counties, indicating that such a large contributing drainage area may be inappropriate. There are many large depression areas in the DD-2 watershed, for example White Woman Bottoms and Corrigan Lake, which will significantly reduce the stormwater runoff. According to the FEMA Hydrology Report, USGS regression equations were used to complete the hydrology for this basin. These equations are generalized based on empirical data and do not accurately depict the unique characteristics of this watershed.

From the Preliminary DFIRM Hydrology Report provided by Kansas Division of Water Resources (DWR), an incorrect mean annual precipitation (MAP) of 22 inches for Ford County was used instead of the correct MAP of 19 inches for Finney County. Sufficient data was not provided to verify 22 inches was used to calculate discharges during the hydrologic analysis.

Based on these findings, to more accurately depict the floodplains, we recommend the following:

- FEMA perform a detailed study of DD-1 and DD-1 and utilize the most accurate ground surface elevation data available to determine floodplain water surface elevations for DD-1 and DD-2
- FEMA more accurately model the significant large depressions in DD-2 watershed north of Garden City
- FEMA update the hydrology for DD-1 and DD-2 using correct rainfall data, if the incorrect MAP was used

Section 1 FEMA Preliminary DFIRM Data Review

This section documents the findings from the review of the FEMA Preliminary DFIRM data and the resulting 100-year floodplains associated with DD-1 and DD-2. Three items are discussed below that may impact the 100-year floodplains along DD-1 and DD-2.

1.1 Regression Analysis

The Finney County, Kansas Hydrology Report, prepared for the State of Kansas, Division of Water Resources (KS DWR) and submitted on May 15, 2007, documents the use of regression analysis to calculate discharges along the streams of Finney County, including DD-1 and DD-2. The regression equations used during the hydrologic analysis are from the USGS document, "Estimation of Peak Streamflows for Unregulated Rural Streams in Kansas, Water-Resources Investigations Report 00-4079." The regression analysis is an acceptable method to calculate discharges along streams. The 2007 Hydrology Report documents an incorrect MAP value of 22 inches for Ford County used in the regression analysis. Upon reviewing "Figure 3, Distribution of mean annual precipitation for Kansas and surrounding areas, 1961-90," found in the USGS Report 00-4079, a value of 19 inches for Finney County should have been used in the regression analysis. However, sufficient data to verify the MAP value used to calculate discharges during the hydrologic analysis could not be provided. A more comprehensive method to compute discharges would be a new rainfall-runoff model. This method could allow for the use of more detailed soil parameters (i.e. infiltration rate) and to account for the large number of depressions that detain water.

Figure 1 shows the drainage basins delineated by WCI using flow accumulation and direction grids provided by FEMA. Figure 2 shows the Preliminary DFIRM 1% chance event floodplains.

1.2 Elevation Data

The Finney County, Kansas Hydraulic Report and hydraulic models, prepared for the KS DWR and submitted on September 25, 2007, document using the USGS 10-meter Digital Elevation Model (DEM) to cut cross sections for the hydraulic model performed in HEC-RAS. The DEM was extrapolated from the 1976 USGS topographic quadrangle maps (with 5-foot contour elevation intervals) on a 10-meter grid. The location of FEMA's cross sections for DD-1 and DD-2 are shown on Figure 2. After completion of the hydraulic model and delineation of the resulting 100-year floodplains using the 10-meter DEM, FEMA was made aware of 2-foot contour data available from the City of Garden City (2005) and Finney County (2000). The extent of the 2-foot contour data is shown on Figure 3. FEMA adjusted the floodplain delineation by overlaying the same water surface elevations from the hydraulic model onto the City's 2-foot contour data instead of the 10-meter DEM as originally done. If the cross sections were to be cut on the City's 2-foot contour data instead of the 10-meter DEM, the resulting water surface elevations and corresponding floodplains would be more accurate.

It's understood the City and County are planning to obtain new aerial photography, sufficient for FEMA mapping compliant ground surface elevation data, in the spring of 2010 for the areas in and around Garden City and Holcomb. We recommend, as a minimum, the City and County obtain FEMA compliant ground surface elevation data (2' contours) for DD-1 and DD-2 to be utilized for more accurate floodplain mapping. If more accurate ground surface elevation data is desired (such as 1' contours) in the urbanized areas, it's recommended the additional lower level aerial photography necessary should be collected at that time.

1.3 Detention

There are many large depression areas in the DD-2 watershed, for example White Woman Bottoms and Corrigan Lake, which will significantly reduce the stormwater runoff. According to the FEMA Hydrology Report, USGS regression equations were used to complete the hydrology for this basin. These equations

are generalized based on empirical data and do not accurately depict the unique characteristics of this watershed.

A previous study conducted on DD-2 by TranSystems, dated October 1997, acknowledges the fact that several different computer programs used to calculate theoretical runoff volumes were significantly higher than had been experienced along the channel. A study completed by Wilson & Company (WCI) in September 2008 reports that discussions with the Finney County and Garden City Engineering Departments conclude the bottoms area west of Jennie Barker Road does not significantly contribute to the peak discharge flow rates. Figure 4 shows the location of the White Woman Bottoms area.

Section 2 Field Investigation

A field investigation was conducted by WCI employees on June 8 and 9, 2009. WCI representatives documented the site visit using a digital camera and hand-held global positioning system (GPS) unit. WCI investigated the major constrictions and channel characteristics along DD-1 and DD-2. Also, WCI investigated a couple tracts of land west of the city limits that might be suitable locations for detention / retention basins to decrease the peak discharges in DD-1.

Section 3 Concept Improvements

The preliminary concept improvements presented in this study are simplistic and focused on decreasing the size of the 1% chance floodplain through the City limits.

Table 1 and Table 2 summarize major drainage structures and channels encountered along DD-1 from Humphrey Road to Spruce Street.

Table 1 – DD-1 Drainage Structures

Cross Road	Structure (Finney County)[1]	End Treatments / Corrections (Site Visit)[2]	Estimated Capacity[3] (cfs)
Humphrey Rd.	84" CMP	Projected End	325
Railroad	84" RCP	CMP, Mitered, Concrete Headwall	350
Taylor Ave.	2 – 8' X 6' RCB	2 – 10' X 6.5' RCB Top Edge Beveled, 60° Wingwalls	1,300
11th St.	3 – 9' X 5' RCB	Chamfered, 45° Wingwalls	1,080
8th St.	3 – 8' X 6' RCB	Top Edge Rounded, 45° Wingwalls	1,080
Main St.	3 – 8' X 6' RCB	Chamfered, 75° Wingwalls	1,270
3rd St.	3 – 8' X 6' RCB	Chamfered, 75° Wingwalls	1,270
Center St.	3 – 8' X 6' RCB & 72" CMP	Chamfered, 45° Wingwalls	1,330
Fleming St.	3 – 8' X 7' RCB & 2 – 72" CMP	Top Edge Rounded, 45° Wingwalls	1,580
Harding Ave.	19' X 6' Bridge	45° Wingwalls	3,100[4]
College Dr.	3 – 7' X 6' RCB	3 – 10' X 6' RCB Top Edge Rounded, 15° Wingwalls	1,650
US-50	3 – 8' X 6' RCB	Top Edge Rounded, 15° Wingwalls, 60° Skew	1,320

Table 2 – DD-1 Drainage Structures (cont.)

Cross Road	Structure (Finney County)[1]	End Treatments / Corrections (Site Visit)[2]	Estimated Capacity[3] (cfs)
Kansas Ave.	3 – 7' X 7' RCB & 8' X 7' RCB	Top Edge Rounded, 15° Wingwalls	2,030
Spruce St.	5 – 8' X 6' RCB	Chamfered, 45° Wingwalls	2,000

1. Structure size and type reported from Finney County GIS shapefiles.
2. Additional field notes were collected by WCI during the site investigation performed on June 8 and 9, 2009.
3. Structure capacities were taken from nomographs found in "Hydraulic Design of Highway Culverts" by the Federal Highway Administration, dated September 2001 and revised in May 2005. Culverts assumed to be under inlet control and HW/D = 1.2.
4. Structure capacity for bridges was calculated using Manning's equation. Bridges assumed not to be under pressure flow.

Table 3 – DD-1 Channels

From Road	To Road	Channel (Finney County)[1]	Channel Notes/Corrections (Site Visit)[2]	Estimated Capacity[3] (cfs)
Railroad	Taylor Ave.	W = 25', D = 6'	BW = 10', SS = 2:1, n = 0.035	420
Taylor Ave.	11th St.	W = 25', D = 6'	BW = 10', SS = 2:1, n = 0.035	420
11th St.	8th St.	W = 25', D = 6'	BW = 10', SS = 2:1, n = 0.035	420
8th St.	Main St.	W = 30', D = 6'	BW = 12', SS = 2.5:1, n = 0.035	520
Main St.	3rd St.	W = 30', D = 6'	BW = 12', SS = 2.5:1, n = 0.035	520
3rd St.	Center St.	W = 30', D = 6'	BW = 12', SS = 2.5:1, n = 0.035	520
Center St.	Fleming St.	W = 36', D = 6'	BW = 20', SS = 2:1, n = 0.035	660
Fleming St.	Harding Ave.	W = 36', D = 6'	BW = 30', SS = 2:1, n = 0.035	910
Harding Ave.	College Dr.	W = 25', D = 6'	BW = 20', SS = 2:1, n = 0.013	1,780
College Dr.	Kansas Ave.	W = 25', D = 6'	BW = 20', SS = 2:1, n = 0.013	1,780
Kansas Ave.	US-50	W = 40', D = 6'	BW = 20', SS = 2.5:1, n = 0.035	710
US-50	Spruce St.	W = 58', D = 6'	BW = 20', SS = 3:1, n = 0.035	760

1. Channel size reported from Finney County GIS shapefiles.
2. Additional field notes were collected by WCI during the site investigation performed on June 8 and 9, 2009.
3. Channel capacity was calculated using Manning's equation. Channel slope was assumed to be 0.001 ft/ft.

To minimize DD-1 flow into Garden City from the west, approximately 2,700 acre-feet of storage would be required along DD-1. It's understood a major highway improvement project on US-50/400 is under construction and is scheduled to be completed by July 2011. It also understood several sites have been identified by the highway contractor for borrow areas, some of which are immediately adjacent or within a short distance of DD-1, and could be incorporated into the DD-1 system as detention basins. We recommend the City investigate this possibility.

It's understood there are existing borrow areas, such as one just north of DD-1 on the west side of US-50/83/400 that may be able to provide detention benefits to the DD-1 system. We recommend this possibility be studied as well.

Another alternative is to divert the DD-1 flow south to the Arkansas River upstream of the City limits. A combination of the 2 alternatives could be used as well. The sizing of recommended channel widening and structures along DD-1 within the City limits would need to be coordinated with selected future improvements.

Upon reviewing the drainage structure and channel capacities in Table 1 and Table 2, the channel capacities do not have the same capacities as the drainage structures. It should also be noted that the 2 84" CMP conduits at the western City limits can only carry 325 cfs. These pipes are undersized and cause major constrictions in the channel system. These structures should be replaced with larger conduits if a new hydrologic study and selected improvements warrant.

The previously completed DD-2 drainage Studies (2008 WCI and 1997 TranSystems) summarizes the drainage structures encountered along DD-2 from Farmland Road upstream to Jenny Barker Road. Information available in theses reports include size / type, capacity, estimated flow quantities, etc. These reports generally assumed that the portion of the DD-2 watershed north and west of Jenny Barker Road does not contribute to the peak discharges for these structures along DD-2, based on historical performance information provided by the City and County.

It's understood DD-2 is considering a 2009-10 channel widening project for the DD-2 channel upstream of Schulman Avenue which would impact the DD-2 floodplain. To further aide in the reduction of flooding along DD-2, we recommend completing the other channel widening projects to match the capacity of the newer drainage structures, as recommended in the previously completed drainage studies. Additional channel and drainage structure improvements may be required to eliminate all floodplains. In addition, we recommend maintaining stream buffer zones along the channels where possible during future planning of city expansion.

Section 4 Recommendations

4.1 DD-1 Recommendations

1.A. Re-calculate hydrology using HEC-HMS to more accurately model the basin characteristics (initial abstraction, infiltration, retention, etc.). Consider flow rates calculated using USGS Regression equations with correct value of 19 inches of Mean Annual Precipitation while completing more detailed hydrology model. We recommend calculating flows for the 1% (100-yr) and 0.2% (500-yr) chance storm events necessary for a FEMA Letter on Map Revision (LOMR).

1.B. FEMA revise HEC-RAS model using most accurate ground surface elevation data (2005 Garden City 2-ft contour data or planned 2010 data) for a detailed study of DD-1.

If significant borrow areas are excavated along DD-1 for the US-50/400 highway construction project, these improvements should be considered in the hydrology and hydraulic analysis and corresponding floodplains.

If the existing borrow area just north of DD-1 on the west side of US-50/83/400 highway significantly impacts DD-1 hydrology, this borrow area should be considered in the hydrology and corresponding floodplains.

1.C. Assuming the updated floodplain resulting from Items 1.A. and 1.B. will still encompass an unacceptable amount of buildings and homes along DD-1, we recommend the following concept improvements be determined and modeled to reduce the DD-1 floodplain to an acceptable level through Garden City:

i. Add significant detention / retention, with over-flow diverted to the Arkansas River, on DD-1 immediately west of the city limits, to cut off DD-1 flows into Garden City from the west, to an acceptable level. This may be partially accomplished with borrow areas along DD-1, excavated for the US-50/ 400 highway construction project.

ii. Widen channels and undersized drainage structures to match the capacity of the larger drainage structures. We recommend analyzing DD-1 from the Arkansas River confluence upstream to Anderson Road (approximately 7.0 miles).

We recommend completing a FEMA Conditional Letter of Map Revision (CLOMR) to confirm that FEMA will modify the floodplain to reflect these improvements, prior to construction.

4.2 DD-2 Recommendations

2.A. Re-calculate hydrology using HEC-HMS to more accurately model the basin characteristics (initial abstraction, infiltration, retention, etc.). Consider flow rates calculated using USGS Regression equations with correct value of 19 inches of Mean Annual Precipitation while completing more detailed hydrology model. We recommend calculating flows for the 1% (100-yr) and 0.2% (500-yr) chance storm events necessary for a FEMA Letter on Map Revision (LOMR).

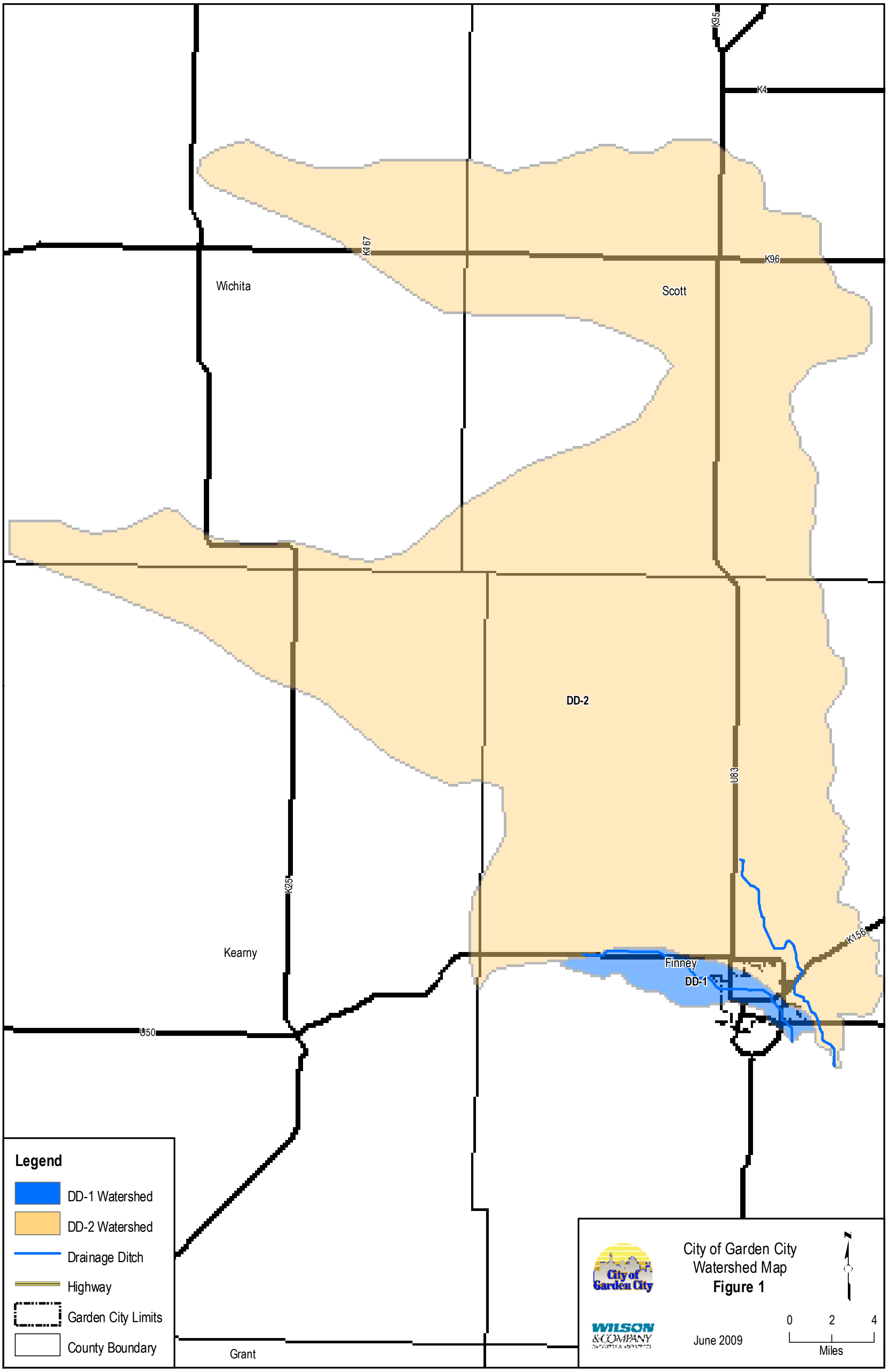
2.B. FEMA revise HEC-RAS model using most accurate ground surface elevation data (2005 Garden City 2-ft contour data or planned 2010 data) for a detailed study of DD-1.

If the 2009-10 DD-2 channel widening project is constructed north of Schulman Avenue, these improvements should be incorporated into the model and corresponding floodplains.

2.C. Assuming the updated floodplain resulting from Items 2.A. and 2.B. will still encompass an unacceptable amount of buildings and homes along DD-2, we recommend the following concept improvements be determined and modeled to reduce the DD-2 floodplain to an acceptable level:

i. Widen channels and undersized drainage structures to match the capacity of the larger drainage structures. We recommend analyzing DD-2 from the Arkansas River confluence upstream to Campus Drive (approximately 8.2 miles).

We recommend completing a FEMA Conditional Letter of Map Revision (CLOMR) to confirm that FEMA will modify the floodplain to reflect these improvements, prior to construction.


K95
K4
K167
K96
Wichita
Scott
DD-2
U83
K25
Kearny
K156
Finney
DD-1
U50
Grant
Legend
DD-1 Watershed
DD-2 Watershed
Drainage Ditch
Highway
Garden City Limits
County Boundary
City of Garden City
Watershed Map
Figure 1
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June 2009
0 2 4
Miles

Drainage District #2

Drainage District #1

Arkansas River

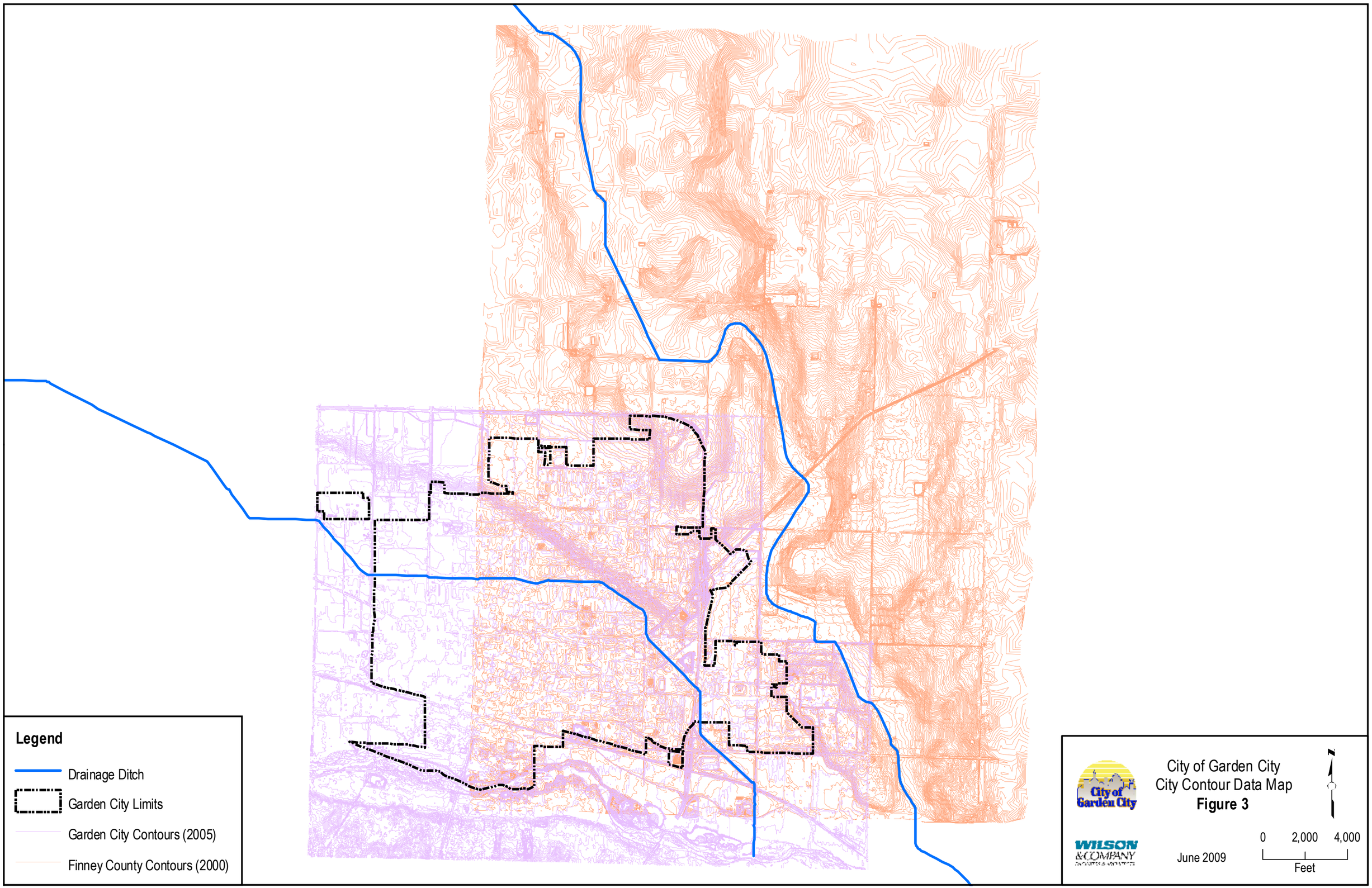
Legend

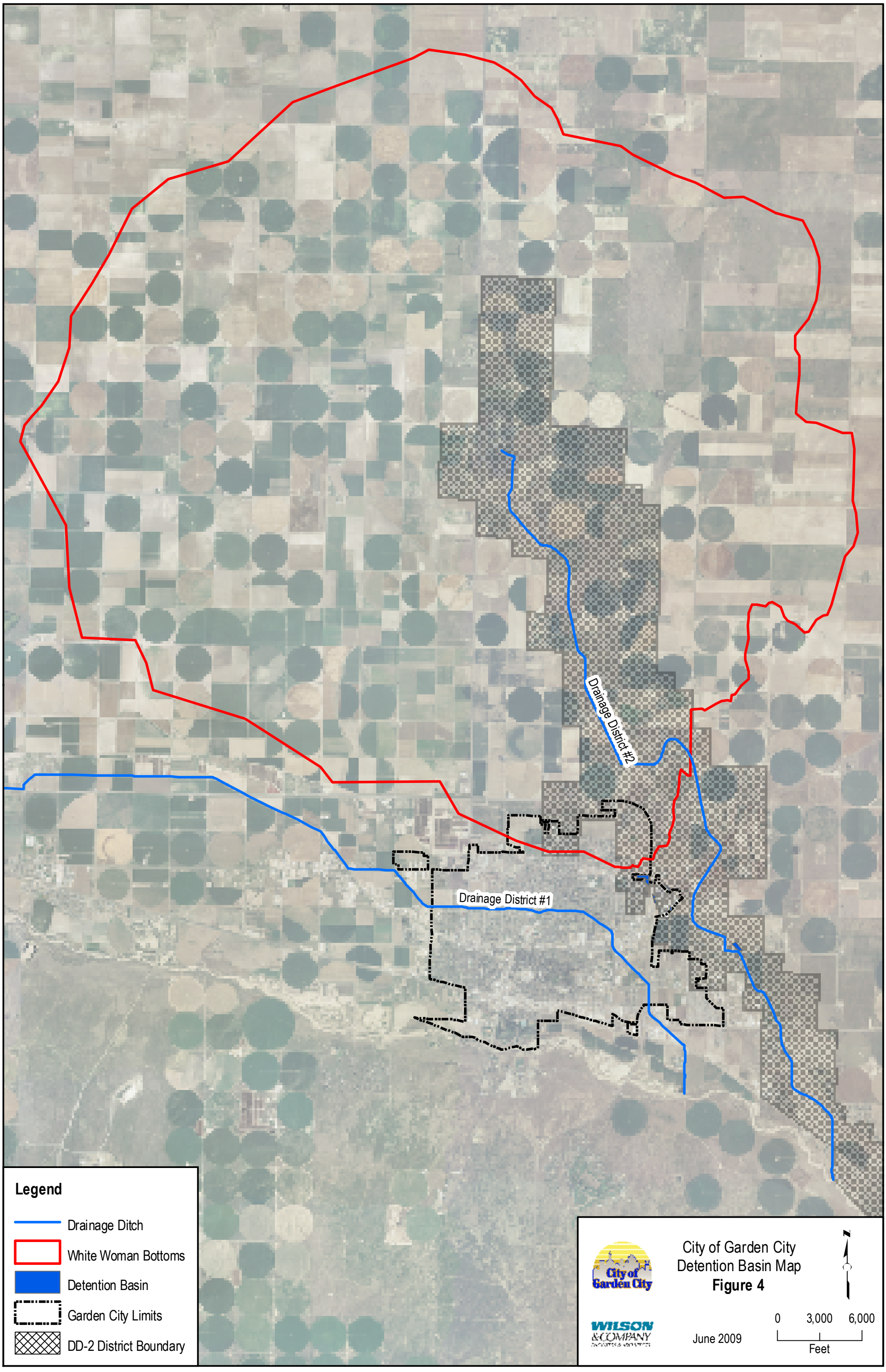
- FEMA Cross Section
- Drainage Ditch
- FEMA Floodplain
- Garden City Limits
- DD-2 District Boundary

City of Garden City
FEMA Floodplain Map
Figure 2

June 2009

0 3,000 6,000
Feet


Legend
Drainage Ditch
Garden City Limits
Garden City Contours (2005)
Finney County Contours (2000)
City of Garden City
City Contour Data Map
Figure 3
N
WILSON & COMPANY
June 2009
0
2,000
4,000
Feet


Drainage District #2
Drainage District #1
Legend
Drainage Ditch
White Woman Bottoms
Detention Basin
Garden City Limits
DD-2 District Boundary
City of Garden City
Detention Basin Map
Figure 4
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June 2009
0
3,000
6,000
Feet