MASTER DRAINAGE PLAN
PHASE ONE

DEWITT COUNTY
DRAINAGE DISTRICT NO. 1

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I. EXECUTIVE SUMMARY

DeWitt County Drainage District No. 1 ("the District" or "DCDD1") is mandated by the State of Texas to manage drainage and protect lives and property within its jurisdiction. The primary cause of drainage issues within the District has been increased runoff due to new impervious cover associated with land development activities. Therefore, the District has undertaken a process in accordance with the requirements of the Texas Water Code, Title 4, Chapter 49 (TWC §49) for the District to develop, adopt, implement, and enforce regulations related to the review and approval of development projects.

TWC §49.211 requires the District to adopt a Master Drainage Plan (MDP) prior to adopting such rules. This MDP constitutes the Districts compliance with Texas statues and constitutes the required authority for the regulatory rules promulgated by the District. This MDP recommends that the District take the following actions:

- Identify priorities for future watersheds studies, including Phase Two of the MDP, which may include field survey data to improve model accuracy and resolution;
- Develop a Drainage Capital Improvement Plan (CIP) to evaluate and prioritize flood mitigation projects identified in this MDP (and/or in future phases) for high-priority flood problem areas;
- Develop regulations to implement the authority to review and approve drainage reports for proposed developments;
- Develop a Drainage Criteria Manual (DCM) for future design and analysis of drainage infrastructure within the District;
- Develop regulations to control runoff from new development during frequent storm events (i.e., 2-year), which contribute most to stream degradation;
- Develop a detailed maintenance plan for all new drainage infrastructure within the District and upgradient areas proposed by the District or others;
- Determine the condition of all potentially aging infrastructure within the District drainage system;
- Develop in-house capabilities for using Geographic Information System (GIS) technology;
- Coordinate with the County Floodplain Administrator in the revision of National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRMS) by the Federal Emergency Management Agency (FEMA); and,
- Continue to survey and collect high water mark data following local flood events to facilitate future modeling and mapping within the District.

This document serves as Phase One of the MDP, which will continue to be updated and improved as additional studies are performed and watershed conditions change over time within the District. Users should ensure they have the most recent edition of this document when using it for any purpose.

II. INTRODUCTION

The DeWitt County Drainage District No. 1 ("the District" or "DCDD1") was established by election in 1914 as a public utility to benefit public health. Although the District has "County" in its name, and District boundaries appear similar to the City of Cuero, the District is not part of the DeWitt County government or the City of Cuero government. The District is an independent, sole-purpose entity of the State of Texas.

The mission of the District is to provide, improve, and maintain the drainage systems within District jurisdiction, resulting in increased safety and enhanced quality of life within the local community. The District has a three-member board appointed by the DeWitt County Commissioners Court to serve two (2) year terms. Current board members are:

- Director – Doug Sethness
- Director – Emily Montgomery
- Director – Mary Alice Perales

1. Background

The Texas Water Code, Title 4 "General Law Districts" authorizes the creation and operation of regional districts for water, sanitary sewer, drainage, and municipal solid waste disposal. Texas Water Code, Title 4, Chapter 49 (TWC §49) addresses provisions applicable to all districts, and TWC §56 specifically addresses authorities granted to drainage districts. Additional powers and duties of districts are enumerated in TWC §49.211. Specifically, a district that is established to engage in drainage or flood control activities may adopt a Master Drainage Plan (MDP) and require district approval of a drainage report for subdivision plats as part of the approval process administered by municipalities and counties.

This document serves as Phase One of the DCDD1 MDP, which is a living, planning document designed to inform the community within the District of the future plans of the District. As the District is a service to the community and relies on taxes collected from within the District to fund the activities of the District, this document is a prime means of communication between the District and the community it serves. This MDP is intended to steer the efforts of the District in a manner that will best serve the majority of the community, consistent with the responsibilities of the District as defined by the State of Texas.

This Phase One study includes the development of GIS-based hydrologic and hydraulic engineering models based on best available data as of December 2018. These models should be considered preliminary, since no field survey data were used in the development of the models. Refer to the hydrologic and hydraulic analyses sections of this MDP for a detailed description of source data and methodology used for this Phase One study.

2. Jurisdictional Area

DCDD1 consists of a series of six (6) named channels, which generally lie within the boundary of the City of Cuero; however, the District boundary is independent of the City of Cuero boundary, and is recorded in Volume 1, page 72A of the Plat Records of DeWitt County, or as hereafter amended. An overall drainage system map is provided as **Exhibit A**. The study area included in this MDP includes the entire 5.6 square mile drainage area that contributes stormwater runoff to the District drainage system. The study area also includes areas downgradient of the District boundary, but upgradient of the Main Channel / Valley Channel Confluence, in order to establish downstream boundary conditions. The more densely-developed and impervious areas within the contributing watershed are generally located within the City of Cuero, which contributes a majority of the overall runoff to the drainage system. The District drainage system receives stormwater runoff from the City of Cuero aboveground and underground drainage systems, as well as all the Main Channel tributaries, which ultimately discharge into the Guadalupe River south of the District boundary. The District is also subject to flooding due to backwater from the Guadalupe River during extreme storm events that may occur miles from the District boundary, independent from local rainfall events.

The District is also a participant in an Interlocal Agreement with both the City of Cuero and DeWitt County to manage a separate drainage area called the North Cuero Watershed (NCWS). The mission of the NCWS is to intercept flood waters north of the City of Cuero and divert them to the Guadalupe River west of the City, thereby reducing potential flood damage within the City limits. The NCWS is not included in the limits of this MDP Phase One study; however, the District is responsible for one-third of the budget of the NCWS facilities, and therefore, future studies may include this area.

3. Previous Studies

The study area consists of a mix of FEMA Special Flood Hazard Zones A (limited detail study without Base Flood Elevations or "BFEs") and AE (detailed study with BFEs) as shown on the FEMA Flood Insurance Rate Map Panel 48123C0410C dated January 6, 2011 (**Exhibit B**). The associated FEMA effective Flood Insurance Study (FIS) for DeWitt County and Incorporated Areas also dated January 6, 2011, documents that the hydrologic and hydraulic analyses for areas within the City of Cuero were performed by URS/Forrest and Cotton, Inc., Consulting Engineers, Austin, Texas for FEMA in October 1979. Given the age of this study and changes to watershed conditions, precipitation estimates, and modeling methods in the last 40 years, limited comparisons are made to discharges and water surface elevations reported in the FIS.

4. Overview of Drainage System

The District drainage system consists of six (6) channels known by the district as the Alexander Channel, Daule Channel, Ice House Channel, West End Lateral, Main Channel (referred to as Gohlke Creek in the FEMA FIRM), and Valley Channel (referred to as Gohlke Creek Tributary in the FEMA FIRM). The entire drainage system discharges to the Main Channel, which serves as the system outfall to the Guadalupe River. Based on the current local topography, it may be assumed that many of the current channels were once creeks or low-lying areas that naturally drained the lands around Cuero; however, the drainageways have undergone manmade improvements (e.g., excavation, grading, concrete-lining) in attempts to more effectively control drainage patterns and reduce flooding. The channels generally flow to the south and are composed of various materials including grass slopes and bottoms, gabion slopes and rock bottoms, concrete-lined slopes and bottoms, and underground structural elements. The following paragraphs provide an overview of each of the six (6) primary drainage channels.

Alexander Channel

The Alexander Channel runs less than a mile along Alexander Street from Henry Street to Terrell Street (also Farm to Market Road 766) and then continues in the same direction along easements across private property until it reaches a drop structure within a 2-acre District-owned property. Downstream of the drop structure, the stream passes through a railroad crossing, where it essentially becomes the Main Channel. Alexander Channel is an open grass-lined channel from Henry Street to Esplanade Street where it drains into an undefined underground structure from Esplanade Street to Terrell Street. After passing under Terrell Street, it again drains into an open grass-lined channel to its confluence with the Main Channel.

Daule Channel

The Daule Channel is primarily a grass-lined channel which runs just under a mile from behind the old Daule school, crossing Heaton to join the Main Channel. A small portion of the Daule Channel is conveyed through culverts just upstream of Charles Street.

Ice House Channel

The Ice House Channel is primarily a grass-lined dich which runs just over a half mile from Gonzales Street, crossing Stockdale, and then joining the Valley Channel.

West End Lateral

West End Lateral is a concrete-lined channel which runs about two thirds (2/3) of a mile south from Evers street, southeast to meet with Main Channel. The last 400 feet of this channel consists of underground storm drain culverts.

Main Channel

The Main Channel (historically known as the Oil Mill Ditch) is a mix of grass- and concrete-lined channel that runs nearly four (4) miles from the railroad underpass downstream of Alexander Channel, south to Heaton SE crossing US 183, then east where it is joined by the Valley Channel. Downstream of the Valley Channel confluence, the Main Channel (also known as Gohlke Hollow) is an unimproved creek that runs south to the Guadalupe River.

Valley Channel

The Valley Channel consists of approximately two (2) miles of grass- and concrete-lined channel and underground storm drain culverts located along Valley Street from Bailey Street (also State Highway 1447) to south of Heaton Street, and discharges through ranch land to Main Channel confluence. The northernmost (upstream) stretch of channel is open with grass sides and bottom. Near Reuss Avenue, it enters an underground section which continues along Valley Street until it reopens at Main Street and becomes a concrete channel with both concrete sides and bottom. At Morgan Avenue, the Valley Channel changes structure to gabion sides and a rock bottom until it reaches a location about 275 feet south of McArthur Street, where it changes to riprap sides and rock bottom. Downstream of Heaton Street, the Valley Channel consists of grass sides and bottom for the remainder of its length to the Main Channel.

III. DISTRICT OBJECTIVES

The mission of DCDD1 is to provide, improve, and maintain the drainage systems within its jurisdiction, resulting in increased safety and enhanced quality of life within our community. To achieve this mission, the District has made the following its major goals:

Primary Goals

1. Engage the community to increase awareness of drainage challenges and flooding issues for the protection of lives and property;
2. To remove and prevent physical barriers and blockages which impede flow in channels;
3. Develop calibrated, computerized hydrologic and hydraulic models of the District drainage system;
4. Identify and perform high-priority drainage infrastructure repairs;
5. Develop and maintain a drainage system capable of conveying stormwater flows up to the 100-year storm event;
6. Develop a digital, GIS-based Asset Management Program (see secondary goals below); and,
7. Develop a Flood Early Warning System (FEWS) to effectively inform the community in advance of and during flood events.

Asset Management Program Goals

1. Determine legal history of district and district boundary [*complete*];
2. Determine ownership of ranch lands crossed by channels which are not actively maintained [*complete*];
3. Retain professional engineering firm to provide construction documents for District drainage improvement projects [*complete*];
4. Develop a schedule for compliance documents & actions, including eminent domain report & asset inventory [*complete*].
5. Develop a Geographic Information System (GIS) asset inventory database to house all drainage channel information [*initiated with this MDP Phase One*]; and,
6. Prioritize all infrastructure repairs and improvements to achieve desired level-of-service.

IV. HYDROLOGIC ANALYSES

The purpose of the hydrologic analyses conducted as part of this MDP, Phase One, is to develop new GIS-based hydrologic models using best available data, and compute peak runoff rates throughout the District drainage system for a variety of storm events, based on existing watershed conditions as of December 2018. Hydrologic modeling was performed using USACE HEC-HMS version 4.2.1.

Data were collected from numerous sources for this hydrologic analysis. Engineering parameters were estimated or assumed based on standard engineering practice using best available data. Collected data and parameter estimation are summarized as follows:

- Precipitation depths are based on NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas, published in September 2018;
- Precipitation data are distributed over the watershed assuming a Natural Resource Conservation Service (NRCS, formerly "Soil Conservation Service" or "SCS") Type III distribution;
- Land use categories are based on the City of Cuero Zoning Map adopted September 22, 2015, and digital support data provided by Kendig Keast Collaborative;
- For each land use category, cover type and impervious coverage are assigned for runoff estimation based on most recent, publicly available Google Earth (2018), ESRI (2018), and TNRIS (2016) aerial imagery;
- Hydrologic soil groups for runoff estimation are based on spatial data from the NRCS Soil Survey Geographic Database (SSURGO) for DeWitt County (TX123);
- Ground elevations within the watershed are based on a digital elevation model (DEM) developed using LiDAR topographic data collected by FEMA in 2016 for DeWitt County (LiDAR Acquisition and Processing Report: DeWitt County, Texas by Compass PTS JV dated June 30, 2016);

This section provides an overview of hydrologic modeling methods and assumptions used in this study, including drainage area boundary delineation, precipitation depths, parameter estimation, hydrograph methods, and modeling considerations, as well as a summary of computed peak flows throughout the drainage system.

1. Drainage Area

The entirety of the 5.6 square mile watershed draining to the District drainage system ("the watershed") was divided into sub-basins to adequately model variations in watershed runoff losses and timing. The watershed was manually delineated and subdivided using processed three-foot DEM data derived from FEMA 2016 LiDAR data utilizing ESRI ArcMap 10.5 software. Sub-basin boundaries were subsequently modified to reflect known drainage breaks as appropriate (e.g., along streets, berms, storm drain systems, etc.).

As shown in **Table 1**, the watershed was divided into 21 total sub-basins. The average sub-basin area is 0.26 square miles, the largest sub-basin area is 0.79 square miles, and the smallest sub-basin area is 0.04 square miles. Much of the watershed's boundaries and sub-basin boundaries were established by urban constraints (e.g., streets, storm drain infrastructure, etc.); however, assumptions were made regarding the areas served by local storm drain systems in the absence of associated as-built information or construction plans. A drainage area map is included as **Exhibit C**.

Table 1 – Sub-basin Drainage Areas

Stream	HEC-HMS Basin Name	Drainage Area (sq mi)	Drainage Area (acre)
Alexander Channel	AC01	0.142	91
Daule Channel	DC01	0.414	265
	DC02	0.075	48
	DC03	0.346	222
	DC04	0.395	253
Main Channel	MC01	0.114	73
	MC02	0.219	140
	MC03	0.235	150
	MC04	0.041	26
	MC05	0.407	261
	MC06	0.210	134
	MC07	0.275	176
	MC08	0.177	114
Ice House Channel	IH01	0.114	73
	IH02	0.233	149
	IH03	0.452	289
West End Lateral	WE01	0.365	234
	WE02	0.165	106
Valley Channel	VC01	0.271	173
	VC02	0.791	506
	VC03	0.218	140
	VC04	0.240	153
	VC05	0.121	78
	Totals	**6.02**	**3,854**

2. Precipitation

For this analysis, 24-hour storm precipitation depths are based on estimates published in the NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas. **Table 2** provides a tabulation of precipitation depths used for the 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance exceedance (i.e., 2-, 5-, 10-, 25-, 50-, 100-, and 500-year return period) storm events. Precipitation depths are temporally distributed using an NRCS Type III distribution in accordance with approximate geographic boundaries published in the U.S. Department of Agriculture NRCS

Urban Hydrology for Small Watersheds Technical Release 55 (TR-55). For comparison, previous precipitation depth estimates included in the 2004 USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas are included in Table X. As shown in **Table 2**, the newer Atlas 14 depth estimates are considerably larger (5% to 29%) than the 2004 USGS estimates.

Table 2 – 24-Hour Precipitation Depths

Annual Chance Exceedance	Return Period	24-Hour Precipitation Depth (inches)	
(%)	(years)	USGS (2004)	Atlas 14 (2018)
50	2	3.8	4.2
20	5	5.3	5.55
10	10	6.5	6.86
4	25	7.7	8.84
2	50	9	10.6
1	100	10.8	12.5
0.2	500	14	18.1

3. Runoff Losses

The U.S. Department of Agriculture NRCS has developed a rainfall runoff index called the runoff curve number (CN), which takes into account such factors as soil characteristics, land use/land condition, and antecedent soil moisture to derive a generalized rainfall/runoff relationship for a given area.

The NRCS classifies soils into four hydrologic soil groups: A, B, C, and D. These groups indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff potential (group D). Digital soil data is available from SSURGO database via the online Web Soil Service.

The NRCS provides runoff curve numbers for three Antecedent Moisture Conditions (AMC): I, II and III. AMC I represents dry soil conditions, and AMC III represents saturated soil conditions. AMC II is normally considered to be the average soil condition; however, studies have indicated that AMC II is not the average throughout Texas. Investigations have shown that the average condition ranges from AMC I in west Texas to between AMC II and III for east Texas. Runoff curve numbers vary from 0 to 100, with the smaller values representing soils with lower runoff potential and the larger values representing soils with higher runoff potential. This study assumes an AMC II to represent average conditions.

CNs were evaluated independently of imperious cover for this analysis. HEC-HMS computes 100-percent runoff from impervious areas, while runoff from pervious areas is computed using the selected CN value. In order to facilitate development of CNs and impervious coverage values within the watershed, the City of Cuero Zoning Map and digital support data were used to delineate land use categories and associated boundaries. Land cover type and impervious coverage values were assigned to each land use category based on existing watershed conditions, as determined using best available aerial imagery (i.e., Google Earth, ESRI, TNRIS). Assumed land use categories and associated cover types, CNs, and impervious coverage values is provided in **Table 3**.

Table 3 – Assumed CN and Impervious Cover by Land Use Category

Zoning District / Land Use Classification		Assumed Land Cover Type*	Impervious Coverage	CN by Hydrologic Soil Group			
				A	B	C	D
R-1	Residential Estate	P	5%	49	69	79	84
R-2	Residential, General	P	10%	49	69	79	84
C-1	Commercial, General	P	80%	49	69	79	84
C-2	Central Business District	P	85%	49	69	79	84
I-1	Industrial, General*	P	60%	49	69	79	84
NC-R1	Neighborhood Conservation - Single-Family Detached	P	55%	49	69	79	84
NC-R2	Neighborhood Conservation - Single-Family Attached	P	45%	49	69	79	84
NC-R3	Neighborhood Conservation - Multi-Family	P	60%	49	69	79	84
NC-R4	Neighborhood Conservation - Single-Family Detached Larger Lot	P	50%	49	69	79	84
NC-MH	Neighborhood Conservation - Manufactured Home/Park	P	25%	49	69	79	84
NT-R5	Neighborhood Transition - 40' Lot	P	40%	49	69	79	84
NT-R6	Neighborhood Transition - 30' Lot	P	45%	49	69	79	84
PR	Public and Recreation	W	35%	43	65	76	82
AG	Agriculture	W	5%	43	65	76	82
INST	Institutional	P	40%	49	69	79	84

*P = Pasture, grassland, or range - fair condition; W = Wood-grass combination - fair condition

A composite CN is computed based on area weighting of each hydrologic soil group and land cover type within each sub-basin. **Table 4** provides a listing the weighted CN and weighted impervious coverage for each sub-basin is shown below. **Exhibit I** provides a detailed breakdown of land use categories and hydrologic soil groups by hydrologic sub-basin.

Table 4 – Area-Weighted CN and Impervious Cover by Sub-basin

Stream	HEC-HMS Basin Name	SCS Curve Number (CN)	Impervious Coverage
Alexander Channel	AC01	69	49.0%
Daule Channel	DC01	71	9.9%
	DC02	49	58.8%
	DC03	63	34.8%
	DC04	53	5.5%
Main Channel	MC01	77	25.9%
	MC02	80	21.2%
	MC03	80	44.9%
	MC04	72	71.1%
	MC05	56	19.5%
	MC06	66	7.1%
	MC07	60	7.0%
	MC08	60	2.0%
Ice House Channel	IH01	77	63.6%
	IH02	72	57.4%
	IH03	69	40.7%
West End Lateral	WE01	79	15.0%
	WE02	60	35.4%
Valley Channel	VC01	53	16.5%
	VC02	72	49.3%
	VC03	66	52.3%
	VC04	57	42.5%
	VC05	62	5.0%
Area-Weighted Average		**66.4**	**32.6%**

4. Unit Hydrograph Method

A rainfall/runoff transformation is required to convert rainfall excess (total rainfall minus infiltration losses) into a runoff hydrograph. The NRCS unit hydrograph option in HEC-HMS is used in this analysis to generate runoff hydrographs for each defined sub-basin within the studied watersheds. The unit hydrograph method represents a hydrograph for one unit [inch] of direct runoff and is a nationally accepted standard engineering practice approach.

In HEC-HMS, input data for this method consists of a single input parameter, T_{LAG}, which is equal to the time between the center of mass of rainfall excess and the peak of the unit hydrograph. In other words, there is a delay in time after a rain event begins before the runoff reaches it maximum peak. This delay is known as lag.

The NRCS method assumes that the lag time of a watershed is 60 percent of the watershed's time of concentration. The time of concentration is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. The time of concentration may be estimated by calculating and summing the travel time for each sub-reach defined by flow type: sheet flow, shallow concentrated flow, and channelized flow (including roadways, storm sewers, and natural/manmade channels). The methods prescribed in NRCS TR-

55 are used to determine the times of concentration for each flow segment in this analysis. **Exhibit I** contains the results of the calculations for this analysis utilizing each typical flow segment presented below.

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact, of drag over the plane surface and obstacles such as litter, crop ridges, and rocks, and of erosion and transportation of sediment. These n values are for very shallow flow depths of approximately 0.1 foot. Assuming sheet flow of less than or equal to 100 feet within urbanized areas and 200 feet within rural areas, travel time is computed as follows:

$$Tt = (0.007 \times (n \times L)^{0.8}) / (P_2^{0.5} \times s^{0.4}) \qquad \text{(Equation 1)}$$

Where:

- Tt = travel time (hr),
- n = Manning's roughness coefficient,
- L = flow length (ft),
- P_2 = 2-year, 24-hour rainfall (in), and
- s = slope of hydraulic grade line (land slope, ft/ft).

After a maximum of 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow is a function of watercourse slope and type of channel. The flow is still considered shallow in depth and flows in a swale or gutter instead of a channel, which has greater depth. After determining the average velocity, the following equation is used to compute travel time:

$$Tt = L / (3600 \times V) \qquad \text{(Equation 2)}$$

Where:

- Tt = travel time (hr),
- L = flow length (ft),
- V = average velocity (ft/sec) based on TR-55 Figure 3-1, and
- 3,600 = conversion factor from seconds to hours.

As the depth of concentrated flow increases, the shallow concentrated flow evolves into channelized flow. Open channels are assumed to begin where channels are visible on aerial imagery or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle maps. In the case of this analysis, channel flow either involves flow in man-made storm sewer infrastructure or flow in the natural channel. Manning's equation, as shown below, or water surface profile information can be used to estimate average flow velocity in open or closed conduits. Average flow velocity is usually determined for bank-full elevations.

$$V = 1.49 \times r^{2/3} \times s^{0.5} / n \qquad \text{(Equation 3)}$$

Where:

V = average velocity (ft/sec),
r = hydraulic radius (ft), equal to flow area divided by wetted perimeter,
s = slope of the hydraulic grade line (channel slope, ft/ft), and
n = Manning's roughness coefficient.

5. Hydrograph Routing

Stream routing is used to modify hydrographs to reflect the effects of translation and attenuation within a channel reach. For this analysis, the Muskingum-Cunge routing method is used. Muskingum-Cunge is a relatively simple routing method that does not account for riverine valley storage (overbank storage). The required input for Muskingum-Cunge routing includes: channel length, channel slope, Manning's roughness coefficients, and an estimate of the hydraulic grade line slope. If flow is primarily routed through a storm sewer, then pipe parameters are input. A trapezoidal channel shape is used to represent a typical channel section through each open channel routing reach. It is assumed that a composite Manning's n-value for a typical channel cross section in this study might range from 0.012 (concrete-lined) to 0.06 (densely-vegetated).

6. Summary of Results

Table 5 below provide a summary of computed peak flow rates at key locations within the District drainage system based on existing watershed conditions.

Table 5 – Summary of Computed Peak Flows – Existing Watershed Conditions

River	Location	HMS Element	Drainage Area	Computed Peak Flow Rates (cfs) by Return Period						
				2	5	10	25	50	100	500
Daule Channel	U/S Limit, W of Boundary Ave	J_DC01	0.414	90	150	200	300	380	470	740
	Daule Park; W of Milligan St	J_DC01	0.414	180	290	410	590	760	940	1,480
	E of Angie St	J_DC02	0.488	220	340	480	690	880	1,090	1,710
	N of Heaton St	J_DC03	0.835	310	490	670	960	1,220	1,520	2,390
Main Channel	U/S Limit, N McLeod St	AC01	0.142	60	90	110	160	190	230	360
	W of N Esplanade St / US183	AC01	0.142	120	170	230	310	390	470	710
	W of Railroad Crossing	J_MC01_AC01	0.256	160	230	300	420	520	630	960
	E of Williams St	J_MC02	0.475	190	280	370	510	640	780	1,180
	N or W Broadway St	J_MC03	0.710	370	530	700	960	1,190	1,440	2,180
	Confl. with Lateral No 1	J_MC03_LC02	1.241	490	720	950	1,320	1,650	2,000	3,060
	E of Bruce St	J_MC04	1.282	500	730	970	1,350	1,680	2,050	3,140
	Confl. with Daule Channel	J_MC04_DC03	2.117	830	1,270	1,720	2,450	3,120	3,850	6,040
	W of Alonzo St	J_MC05	2.524	890	1,370	1,890	2,710	3,480	4,320	6,860
	E of Stockdale Rd	J_MC06	2.734	910	1,420	1,970	2,840	3,650	4,550	7,260
	Confl. with Valley	J_GR	5.174	1,920	2,980	4,090	5,870	7,510	9,320	14,770
Ice House Channel	U/S Limit, S Gonzales St	J_IH02	0.348	280	400	530	710	880	1,070	1,610
	W of Hill St	J_IH03	0.800	400	570	740	1,000	1,240	1,500	2,270
West End Lateral	U/S Limit, Evers St	WE01	0.165	130	200	270	370	470	570	860
	W of Threlkeld St	J_WE02	0.531	180	270	370	520	650	800	1,240
Valley Channel	U/S Limit, E Bailey St	VC01	0.791	30	50	80	130	170	220	380
	N of 2nd St	VC01	0.791	60	100	160	250	340	450	770
	E Reuss Blvd	J_VC02	1.062	620	900	1,200	1,660	2,090	2,560	3,960
	E Courthouse St	J_VC03	1.280	760	1,100	1,460	2,020	2,530	3,100	4,770
	E Newman St	J_VC04	2.080	860	1,250	1,670	2,330	2,930	3,590	5,560
	Confl. with Ice House Channel	J_VC04_IH03	2.441	1,250	1,820	2,400	3,330	4,170	5,090	7,830
	600' N of Main Channel Confl.	J_VC05	0.365	1,270	1,860	2,470	3,440	4,320	5,280	8,150

V. HYDRAULIC ANALYSES

The purpose of the hydraulic analyses conducted as part of this MDP, Phase One, is to develop new GIS-based hydraulic models using best available data, and compute water surface elevations throughout the District drainage system for a variety of storm events, based on existing watershed conditions as of December 2018. The USACE HEC-RAS software version 5.0.6 is used for the hydraulic analyses. The modeling is one-dimensional and steady state.

Data are collected from numerous sources for this hydraulic analysis. Engineering parameters are estimated or assumed based on standard engineering practice using best available data. Collected data and parameter estimation may be summarized as follows:

- Manning's n roughness values are based on most recent, publicly available Google Earth (2018), ESRI (2018), and/or TNRIS (2016) aerial imagery;
- Channel and overbank ground elevations and floodplain mapping are based on a DEM developed on LiDAR topographic data collected by FEMA in 2016 for DeWitt County (LiDAR Acquisition and Processing Report: DeWitt County, Texas by Compass PTS JV dated June 30, 2016);

This section provides an overview of hydraulic modeling methods and assumptions used in this study, including stream centerline and cross section delineation, parameter estimation, modeling considerations, and floodplain mapping, as well as a summary of computed maximum water surface elevations throughout the drainage system.

1. Cross Sections

In order to facilitate model development, HEC-GeoRAS is used within ESRI ArcMap 10.5. Stream centerlines and cross sections are delineated based on the 2016 LiDAR DEM with consideration given to longitudinal changes in cross sectional geometry, streambed slope, roughness characteristics, bridge and culvert locations, stream confluences, ineffective flow areas, and other factors. HEC-GeoRAS is used within ESRI ArcMap to generate a georeferenced HEC-RAS-formatted input file. As shown in **Table 6**, the study area consists of 7.9 stream miles modeled using more than 200 hydraulic cross sections with an average spacing of 210 feet, and a total of 17 bridge crossings and 17 culvert crossings. A cross section location map is provided as **Exhibit G.**

Table 6 – Summary of Hydraulic Study Reaches

Study Stream	Stream Length (ft)	# of Cross Sections	Avg. Cross Section Spacing (ft)	# of Bridge Crossings	# of Culvert Crossings
Alexander Channel	3,761	16	180	-	2
Daule Channel	4,454	33	154	-	4
Ice House Channel	2,986	13	249	-	1
West End Lateral	3,453	21	192	-	3
Main Channel	16,548	82	238	13	3
Valley Channel	10,413	58	208	4	4
Totals	41,615	223	210	17	17

2. Parameter Estimation

Table 7 provides the various hydraulic parameters used to analyze the detailed hydraulic study. These tables are not reach specific, but rather, apply to the study area as a whole.

Table 7 – Summary of Hydraulic Parameters

Hydraulic Parameter	Value
Channel Manning's n Values (within banks)	
Concrete	0.012
Asphalt (street and parking lot)	0.02
Channel at bridges/culverts or uniform cross section with no vegetation	0.035
Channel, uniform cross section, straight, light vegetation	0.04
Channel, uniform cross section, straight, heavier vegetation	0.045
Channel, irregular cross section, meandering, brush	0.055
Channel, irregular cross section, meandering, heavier brush	0.06
Channel, irregular cross section, meandering, heavier brush with medium trees	0.07
Overbank Manning's n Values (outside banks)	
Asphalt (street and parking lot)	0.02
Asphalt (parking lot with obstacles)	0.03
Improved area, uniform cross section, straight, light vegetation	0.04
Improved area uniform cross section and straight	0.045
Natural area, uniform cross section, light/medium brush	0.05
Natural area, irregular cross section, medium brush	0.055
Natural area, irregular cross section, meandering, heavier brush	0.06
Natural area, irregular cross section, meandering, heavier brush, light trees	0.065
Natural channel, irregular cross section, meandering, heavier brush with medium trees	0.07
Light tree coverage, scattered tree clusters (10% - 25%)	0.08
Medium tree coverage (50%)	0.09
Heavy tree cover (>75%), commercial and residential areas (privacy fences not typical)	0.1
Residential areas with privacy fences typical	0.15
Miscellaneous Coefficients	
Bridge pier drag coefficient for momentum equation applications, Cd	2
Pressure and weir flow coefficient (submerged inlet and outlet), Cd	0.8
Expansion coefficients for bridges / culverts / in-line structures	0.5
Expansion coefficients for channels	0.3
Contraction coefficients for bridges / culverts / in-line structures	0.3
Contraction coefficients for channels	0.1
Weir coefficients (road deck)	2.6
Culvert entrance loss coefficient	0.7
Culvert exit loss coefficient	1
Reach Starting Slope (ft/ft)	**0.003**

3. Modeling Considerations

Various considerations are made when evaluating each hydraulic reach. These considerations include, but are not limited to, starting water surface elevations, structure crossings, islands and flow splits, ineffective flow areas, supercritical versus subcritical flow regimes, hydraulic calibration, and other considerations. The sections below describe the various considerations made for each reach.

A portion of Main Channel downstream of Evers St / Sarah St and upstream of its confluence with the West End Lateral overtops its bank and overflows along the right bank to the southwest towards the West End Lateral in storm events greater than the 10-year return period. Overflows re-enter the channel at or just upstream of the West End Lateral confluence. In events greater than the 50-

year return period, flood waters also overtop the left bank downstream (south) of the Main St. crossing, resulting in permanent loss of flow from the Main Channel. Overflows discharge to the southeast through the Southern Pacific Railroad culverts and residential area before discharging into the Ice House Channel. Both of these overflow conditions dictated that flows used for computing flood elevations in the main channel of Gohlke Creek be modified or reduced using the lateral weir split flow optimization tool with HEC-RAS.

Overflows also occur in frequent storm events along the right overbank (west) of Valley Channel upstream of E. Main St. This overflow occurs as a result of inadequate capacity in a series of underground culverts and open channels within this reach. Cross sections were extended to the west to capture overland flood conveyance within this reach; however, more detailed modeling methods should be considered in future studies to evaluate complex two-dimensional (2D) flow patterns and underground storm drain conveyance within the overflow area.

4. Floodplain Mapping

The hydraulic floodplain for each flood event analyzed, corresponding to each studied stream, is delineated on the 2016 LiDAR DEM using the RAS Mapper utility within HEC-RAS v5.0.6. A summary of floodplain limits is provided in **Exhibit H**, which shows the 2-, 25-, and 100-year inundation zones within each study reach. Effective FEMA flood zones are also shown for reference.

5. Summary of Results

Exhibit K provides a summary of computed maximum water surface elevations for each storm event analyzed at each cross section within the District drainage system based on existing watershed conditions.

VI. FLOOD PROBLEM AREAS

Based on the results of the hydrologic and hydraulic analysis, the approximate level of service for the various study reaches was evaluated based on the ability of each channel or culvert segment to contain the storm events analyzed. As shown in Exhibit H, the 100-year floodplain inundates more the 700 acres across the district, including more than 1,100 properties. Given the extent of known flood risk, flood problem areas were identified based on reaches with the lowest level of service, largest inundation area, and greatest number of affected properties. The following paragraphs summarize the problem areas within each of the seven (7) primary District channels.

Alexander Channel

Based on the results of this Phase One analysis, the Alexander Channel currently provides an approximate 2-year level of service upstream (east) of N. Terrell St, with an approximate level of service up to the 25-year event downstream (west) of N. Terrell St. For storm events greater than the 2-year return period, modeling methods used in this analysis are not sufficient to evaluate the extent of flooding in this reach, since flood water may overtop the left bank of the channel and overflow to the south, primarily within the low-lying area between N. Terrell St and N. Esplanade St (US 183). Inundation limits within this overflow area are not delineated as part of this Phase One analysis and should be evaluated in future studies. For this reason, the number of affect properties is not quantified in this analysis.

Daule Channel

Based on the results of this Phase One analysis, the Daule Channel currently provides less than a 2-year level of service along most of its length. For storm events greater than the 2-year return period, modeling methods used in this analysis are not sufficient to evaluate the extent of flooding in this reach, since flood water may overtop both banks of the channel and overflow to adjacent areas. Inundation limits within this overflow area are not delineated as part of this Phase One analysis and should be evaluated in future studies. For this reason, the number of affect properties is not quantified in this analysis.

Ice House Channel

Based on the results of this Phase One analysis, the Ice House Channel currently provides less than a 2-year level of service upstream (west) of Stockdale Ave and a 5- to 10-year level of service downstream (east) of Stockdale Ave. Approximately 29 acres are inundated by 100-year flooding east of Gonzales St to the confluence with Valley Channel. The 100-year inundation area affects more than 69 properties, most of which are single-family and residential estate properties.

West End Lateral

Based on the results of this Phase One analysis, the West End Lateral currently provides a 5- to 10-year level of service along most of its length. For storm events greater than the 10-year return period, modeling methods used in this analysis are not sufficient to evaluate the extent of flooding in this reach, since flood water may overtop both banks of the channel and overflow to adjacent areas. This area is also subject to overflows from the right bank of the Main Channel between Bridge St and Evers St in events greater than the 5-year return period. Inundation limits along the West End Lateral and within the Main Channel right bank overflow area are not delineated as part of this Phase One analysis and should be evaluated in future studies. For this reason, the number of affect properties is not quantified in this analysis.

Main Channel

Based on the results of this Phase One analysis, the Main Channel currently provides a variable level of service along its length. Significant out-of-bank flow into adjacent channel systems occurs in multiple locations, as described in the following paragraphs.

Upstream of Evers St / Sarah St, the channel provides a 5-year level of service within its banks with events up to the 100-year generally contained within the overbanks in undeveloped land.

Downstream of Evers St / Sarah St and upstream of its confluence with the West End Lateral, the channel provides a 2- to 5-year level of service within its banks with events greater than the 10-year return period overflowing along the right bank to the southwest towards the West End Lateral. In events greater than the 50-year return period, flood waters also overtop the left bank downstream (south) of the Main St. crossing and flow to the southeast through the railroad culverts and residential area before discharging into the Ice House Channel.

Downstream of its confluence with the West End Lateral and upstream of its confluence with the Daule Channel, the improved channel provides a 50- to 100-year level of service within its banks.

Downstream of its confluence with the Daule Channel to the Valley Channel confluence, the channel provides less than a 2-year level of service within its banks with events up to the 100-year generally contained within the overbanks in undeveloped land.

Downstream of its confluence with the Valley Channel, the Main Channel currently provides a 5-year level of service within its banks, with events up to the 100-year contained within the overbanks in undeveloped ranch land. Due to the size and relatively steeper slope (0.004 ft/ft) of this reach in comparison to the other channels (roughly 0.002 ft/ft), the Main Channel does not incur a backwater condition that significantly affects the upstream drainage system.

Valley Channel

Based on the results of this Phase One analysis, the Valley Channel currently provides less than a 2-year level of service upstream (north) of E. Newman St. and a 50- to 100-year level of service downstream (south) of E. Newman St. For storm events greater than the 2-year return period, modeling methods used in this analysis are not sufficient to evaluate the extent of flooding in this reach, since flood water may overtop the right bank (west) of the channel and overflow to adjacent areas, which primarily consist of single-family residential land use, before rejoining the system via underground storm drain systems. Inundation limits within this overflow area are approximated as part of this Phase One analysis and should be evaluated in future studies. More than 220 acres are inundated by 100-year flooding along the Valley Channel upstream of E. Newman St. The 100-year inundation area affects more than 500 properties in this area, most of which are single-family residential properties.

Summary of Flood Problem Areas

The floodplain map included as **Exhibit H** illustrates the location of the highest priority flood problem areas identified within the District, which are also summarized in **Table 8** below.

Table 8 – Summary of Flood Problem Areas

Flood Problem Area No.	Study Stream	Location	Channel / Culvert Length (ft)	Approx. Inundation Area (acres)		Approx. # Affected Properties	
				2-yr	100-yr	2-yr	100-yr
AC01	Alexander Channel	U/S of Terrell St	2,500	*	*	*	*
DC01	Daule Channel	U/S of Charles St	1,600	*	*	*	*
IH01	Ice House Channel	Esplanade to Stockdale	1,100	4	6	29	35
MC01	Main Channel	Evers to Main	2,600	3	>42	5	>115
VC01	Valley Channel	U/S of Newman	7,000	112	213	366	538

**Inundation limits within this overflow area are approximated as part of this Phase One analysis and should be evaluated in future studies*

VII. RECOMMENDATIONS

This section provides an overview of conceptual recommendations associated with the flood problem areas identified in this study, as well as recommended development regulations and policies in accordance with TWC statutes.

1. Conceptual Flood Mitigation Alternatives

Table 9 provides a summary of conceptual flood mitigation alternatives associated with the problem areas identified in this study.

Table 9 – Summary of Conceptual Flood Mitigation Alternatives

Flood Problem Area No.	Study Stream	Location	Channel / Culvert Length (ft)	Conceptual Flood Mitigation Alternative(s)
AC01	Alexander Channel	U/S of Terrell St	2,500	Ditch Widening, Culvert Crossing Improvements
DC01	Daule Channel	U/S of Charles St	1,600	Ditch Widening & Concrete-Lining, Culvert Crossing Improvements
IH01	Ice House Channel	Esplanade to Stockdale	1,100	Ditch Widening & Concrete-Lining, Culvert Crossing Improvements
MC01	Main Channel	Evers to Main	2,600	Ditch Widening & Concrete-Lining, Bridge/Culvert Crossing Improvements
VC01	Valley Channel	U/S of Newman	7,000	Add Relief Box Culvert(s) and/or Open Channel, Channel Improvements, Bridge/Culvert Crossing Improvements

Below a brief summary is provided of potential drainage improvements and their application to the watershed.

Bridge and Culvert Improvements

This type of improvement consists of box culverts and pipes to be added to an existing roadway crossing to improve flow conveyance and reduce the floodwater depth over the road. In addition, an existing bridge could be expanded to increase the area of flow under the bridge with the effect of reducing floodwater depths over the road. A component of bridge and culvert improvements is the disturbance of traffic during construction and the coordination with regulatory agencies who may maintain the roadway.

Channel Modifications

A channel can be modified to increase the flow area and usually the flow depth within the channel to reduce the floodplain limits within a reach. The channel modification requires floodplain regrading within a dedicated drainage easement so homes and structures along the channel bank are less impacted by flooding. Disturbance within a natural waterway may involve impact to wetlands or other environmental features, therefore, a Corps of Engineers 404 Permit may be required. This may involve the mitigation of wetlands if they are found to be present within the project limits.

Regional Detention Ponds

Regional detention ponds are typically constructed on the channel to detain runoff from upstream contributing areas and release the stormwater runoff at a controlled rate to reduce downstream floodplain depths. The detention pond also delays the flood wave in time which allows downstream areas to runoff, further reducing downstream flow rates. The most effective location of a detention pond is in the upper one-half to one-third of the watershed. An added benefit of detention ponds is that recreational amenities can be constructed within the facility to serve the community needs. However, disturbance within the natural waterway may impact wetlands and necessitate a Corps of Engineers 404 permit.

Levees and Floodwalls

To prevent creek flooding under this scenario, a concrete or earthen floodwall would be required to protect a neighborhood or development from flooding. Special consideration is required at roadway crossings to ensure that the floodwaters cannot overtop the road and spill into the area protected by the levee. One impact of the levee is that the constricted but deep and swiftly moving floodplain could lead to significant stream channel erosion and require channel armoring in many locations. In addition to the creek flow conveyance, the levee system would need to collect stormwater in the neighborhood and pump the water over the levee to prevent flooding behind the levee. To accomplish this task, ponds and pump stations would need to be constructed adjacent to the levee to discharge water into the creek.

Acquisition

Acquisition and demolition of homes inundated by the 100-year floodplain is an option that can be investigated to determine the cost and benefit. Once a property is acquired, the structure is demolished and removed from the site to improve flood conveyance and prevent future flood damages. Also, the family who owned the home needs to be relocated at the District's expense in comparable housing. The cost of acquisition can vary greatly, but is typically two times the value of the property to cover all real estate and relocation expenses.

Flood-Proofing

Flood-proofing is the construction of barriers at each home to prevent the entrance of floodwaters into the structure. Many options exist for flood-proofing at each site and the feasibility of each option is dependent upon the structure type and local topography. Some of the options are:

- Raising the finished floor elevation above the flood level.
- Installing waterproofing devices that are implemented during the flood event before the floodwaters reach the finished floor elevation.
- Site grading and berming to divert flood waters around the structure.
- Closure of openings around the house to prevent floodwaters from entering the structure.

Some constraints that limit the feasibility and effectiveness of flood-proofing include:

- Concrete foundations that are difficult to elevate.
- Downstream flooding caused by berms that direct flow into adjacent homes.
- The need for the rapid closure of openings due to flash floods.

2. Future Watershed Studies

Based on the findings of this MDP, Phase One, it is recommended that the District develop a prioritized list of areas for which new engineering studies are needed in the next 5 to 10 years, including Phase Two of the MDP, to more effectively facilitate the District's consideration of flood mitigation alternatives, capital improvement projects, and the review of development proposals. Additional studies may focus specifically on the flood problem areas identified in this MDP, on adding detail to the overall system models, which do not currently include field survey data, or on more accurately defining overflow conditions within the watershed (i.e., south of Alexander Channel, Main Channel north of the West End Lateral confluence, Valley Channel north of Newman St).

3. Capital Improvement Plan

Relieving and reducing known flooding of residential areas is given the highest priority in the District's capital improvement project planning. Priorities are identified by examining several sources of information, including reports from citizens, questionnaires distributed by the District, location of NFIP flood insurance claims, and the personal experiences of the District staff and board. When a priority area is identified, the cause of flooding is analyzed and how the drainage in the area relates to a District outfall, lack of an outfall, or the inadequacies of an existing outfall. Flood problems may include street flooding, inadequate inlets from the streets, and inadequate outfall pipes. When new development is proposed, the impacts of the increased runoff on downstream flows is considered. If the increased runoff occurs in areas with known flooding and drainage problems, improvements at culverts and bridges, or channel improvements may provide sufficient capacity to handle the increases.

Examining the cost effectiveness of an improvement is part of the District's process to identify where improvements will be made. Existing watershed and floodplain studies are examined to determine if sufficient information is available to both identify the problem and evaluate alternatives. In general, channel improvements are more economical than detention and, unless there are specific environmental concerns, the channel improvements are undertaken. Some known problem areas require study to ascertain feasible solutions in order to determine costs and benefits.

4. Development Review

The District's concerns are largely focused on the impacts of receiving additional runoff into its existing drainage system from new developments, the hazards associated with physical blockage of flow in the channels, the availability of adequate easements for maintenance access, the areas affected when drainage system capacity is exceeded, and upstream or downstream adverse hydrologic and hydraulic impacts, especially in areas already known to flood frequently. With completion of this MDP, Phase One, the District will begin its legislated role in management of development within District as well as areas outside the District which contribute flow to the District drainage system.

Whether changes in runoff patterns due to new development create or worsen off-site flooding problems is a function of where the development takes place within the watershed, proposed on-site drainage improvements and/or detention, the capacity of existing receiving channels, and proposed or planned drainage improvements by the District. Combinations of these factors will vary from location to location. A drainage analysis and report should be prepared for a proposed development in order to evaluate potential off-site drainage impacts and develop mitigation measures. At a minimum, drainage reports should include:

- Hydrologic and hydraulic analysis of pre-development conditions within the site and receiving streams for the 2-, 10-, 25-, and 100-year return period storm events using models & methodology consistent with the MDP study;
- Hydrologic and hydraulic analysis of post-development conditions within the site and receiving streams for the 2-, 10-, 25-, and 100-year return period storm events using models & methodology consistent with the MDP study;
- Determination of any potential off-site adverse hydrologic or hydraulic impacts;
- Demonstration of proposed on-site or off-site alternatives to mitigate impacts not contained within the District drainage system or public easement.

As authorized in Section 49.211 of the Texas Water Code, a master drainage plan may include rules relating to the planning and design criteria for drainage channels, facilities, and flood control improvements. These regulations will form the basis of the District's review and approval of the drainage reports for proposed development that occurs within its jurisdiction in DeWitt County and the City of Cuero.

The District will develop regulations to implement the authority to review and approve drainage reports for proposed developments. The regulations will be subject to public review prior to adoption and are expected to address:

- The types of developments and construction activities that are subject to the requirements set forth in regulations, as well as those activities that are exempt.
- The District's review process and coordination with the County and City.
- A requirement for pre-design meetings and encouragement for negotiations with the District to address site-specific, channel-specific and watershed-specific needs.
- The contents of drainage reports and drainage plans.
- Availability of engineering studies and data; conditions under which new studies or contributions to studies may be required.
- The performance requirements for adequacy of post-development drainage and alternatives that may be considered to address runoff and flooding.
- Standards for drainage and flood hazard reduction to address runoff and flooding, including but not limited to: cooperative projects with the District; land or other contributions for new District channels or regional detention facilities; new or increased easements along drainage channels to be maintained by the District; design for replacement, upgraded, or new drainage pipes and culverts that carry drainage to District channels; design for upgraded or new erosion protection at outfalls; and on-site detention of increases in runoff.
- Procedures to enforce rules adopted by the District.

The District will develop application forms and a formal approval instrument. To implement the regulations in a manner that meets the stated goal, the District will work with DeWitt County and the City of Cuero to coordinate development processes and timelines, and to improve regulatory consistency. To facilitate compliance and understanding by the development community, the District will prepare a review checklist.

5. Stream Erosion Prevention

The impact of urbanization on stream flows is greatest for the frequent flow events (less than 2-year return period storms), which are described as the mid-bank full to bank-full flows in streams. The process of urbanization results in a fundamental shift in the flow regime due to the decrease in hydrologic storage (abstractions) and the decrease in basin response time. The result is a significant increase in runoff for the frequent, or minor, system flow events. The increase in flow magnitude and frequency is such that these events become the geomorphically dominant events that shape the stream channel.

As development occurs in a watershed, the associated increase in instream erosion potential can result in significant enlargement of the stream channel. This enlargement may occur through erosion of the bed (downcutting) and/or erosion of the channel banks (widening), depending upon the relative erodability of the soils.

Commensurate with this erosion is an increase in the capacity of the channel to contain larger flows. This increase starts a positive feedback process in motion in which the greater flow capacity is translated into even higher instream erosion potential causing the channel to further enlarge thereby increasing its flow capacity further and so on. The process of downcutting will continue until the channel encounters a material that is more resistant than the bank soils. The channel then widens until the erosive power of the prevailing flows is insufficient to erode the banks. This process is referred to as "valley formation" and is evident in many of the older developed watersheds.

The City of Austin, King County Washington, the State of Maryland, and the Center for Watershed Protection have conducted studies of urbanization's impact on streams. A common finding in these studies is that the use of volume control detention ponds (retention of the developed site's stormwater runoff for a design period) is the most effective approach in controlling stream erosion. Typically, communities require runoff retention for the 2-year and more frequent storms.

6. Operation & Maintenance

Maintenance of the existing drainage system is an ongoing project of high priority. Although some periods of the year are more known for storms, it is not possible to predict when the next major storm might occur. For this reason, the maintenance of the channels should be an everyday issue. The ability of storm drain infrastructure to be able to reach its design capacity is directly related to its ongoing maintenance. A detailed maintenance plan should be created for all new drainage infrastructure within the District and upgradient areas proposed by the District or others during design. The maintenance plan should include periodic mowing, removing debris from culverts and outlets, and periodic inspection of structures and embankments.

The District's area of jurisdiction is toured and examined routinely by the General Manager, as well as the Directors, and all personnel document concerns as they travel the area. Property owners in the area also are a source of information about problem areas; their phone calls and visits are logged and are given significant weight when determining maintenance priorities. When a citizen reports a concern, a District representative, generally the General Manager, is dispatched to assess the area and to evaluate the priority for work. Problems that are deemed more important, such as a major blockage of a culvert or major build-up of debris under a bridge, are addressed as soon as possible, usually within a couple of days. Minor problems are addressed sequentially.

7. Aging Infrastructure

The District has been in operation since 1914 and, although improvements have been made throughout its history, much of the infrastructure is in need of repair or rehabilitation, and design assumptions, calculations, construction documents, or as-built records are no longer available. For this reason, a primary interest of the current District commissioners is to document the entire drainage system and determine its
condition and capacity.

8. Geographic Information System Development

Geographic Information Systems (GIS) is a computerized tool for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a GIS database is used for handling maps and other data that can be displayed spatially. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image on a map and a record in an attribute table. GIS can relate otherwise disparate data on the basis of common geography, revealing hidden patterns, relationships, and trends that are not readily apparent in spreadsheets or statistical packages, often creating new information from existing data resources.

With GIS, spatial elements of data can be displayed, such as flood-prone areas, drainage channel locations, drainage structure locations, easements, etc. The District currently performs a number of manual tasks that could be performed more efficiently and accurately with GIS-based maps and features of the District's drainage system. These tasks include:

- Inventory and evaluation of drainage and water quality infrastructure materials, dimensions, condition, associated easements, historical and planned maintenance activities, and other attributes;

- Development of grant applications for mitigation funds, including plotting historical claims information and flood hazard information for repetitively-flooded homes; and

- Prepare and use maps of areas for which studies have been undertaken and will be undertaken.

Therefore, it is recommended that the District develop in-house GIS capabilities. This action will include the purchase of GIS software, the incorporation of GIS-based hydrologic and hydraulic models and features developed as part of this MDP (i.e., drainage boundaries, stream centerlines, topographic data, floodplain limits, etc), the development of additional spatial data, and staff training. Data relevant to the following are expected to be developed or converted: channel inventory (dimensions, easements, etc.); drainage structure inventory (type, size, capacity, etc.); statistics on homes in flood-damage areas (addresses, building characteristics, property values, etc.); historical flood losses (flood insurance claims and uninsured losses); prior flood depths, and others.

9. Regional Floodplain Coordination

It is recommended that the District coordinate with and contribute to the County and City's efforts related to FEMA's Map Modernization effort to revise and update the Flood Insurance Rate Maps (FIRM) for those areas that are within the District's jurisdiction.

10. Post-Flood Event Data Collection

In order to calibrate and validate hydrologic and hydraulic models as part of future watershed studies, it is recommended that the District continue to survey and collect high water data immediately following local flood events, especially in areas that are not shown as mapped floodplain on the FIRMs. Data collection tools should be standardized and data should be collected, georeferenced in GIS software, and stored so that information can be retrieved readily to support recommendations for development in areas susceptible to flooding and drainage problems.

11. Flood Early Warning System

Ultimately, hydrologic and hydraulic models calibrated with post-flood data should be used to develop a Flood Early Warning System (FEWS) to effectively inform the community of current and/or anticipated flood risks in advance and during storm events. Development of a FEWS would also require installation of stream gages at strategic locations, as well as telemetric gage monitoring technology.

12. Drainage Design Criteria Manual

With the adoption of regulations for drainage reports and District's review of development proposals, it will be helpful for the development community to have a manual that outlines the appropriate design criteria. The manual will address drainage and flooding conditions experienced in the area, including channel and creek flooding, localized ponding and street flooding, storm drainage, and development in flood-prone areas.

Therefore, it is recommended that the District will develop a Drainage Design Criteria Manual. The manual will be generally consistent with other local and regional criteria but will be tailored to the conditions of the area and the District. The manual is expected to include design methods and criteria that are specific to the District and that have been successfully applied in the region. The manual will be subject to public review and comment.

APPENDIX A

EXHIBITS

EXHIBIT A

DISTRICT OVERVIEW MAP

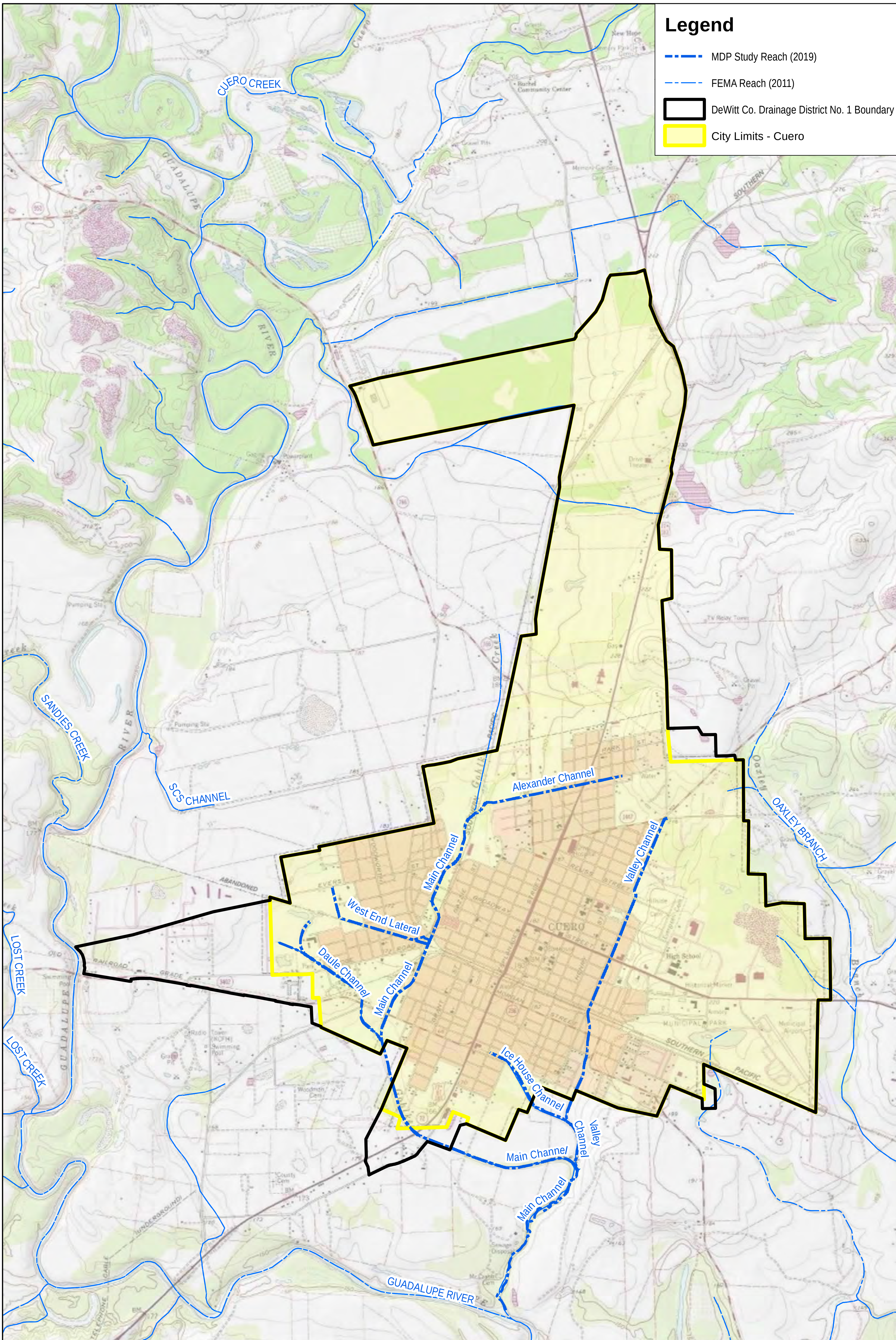


EXHIBIT A - DISTRICT OVERVIEW MAP
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

EXHIBIT B

FEMA Flood Insurance Rate Map

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Texas State Plane south central zone (FIPSZONE 4204). The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by the Texas Natural Resource Information System (TNRIS). This information was photogrammetrically compiled at a scale of at least 1:24,000 from aerial photography dated 2004.

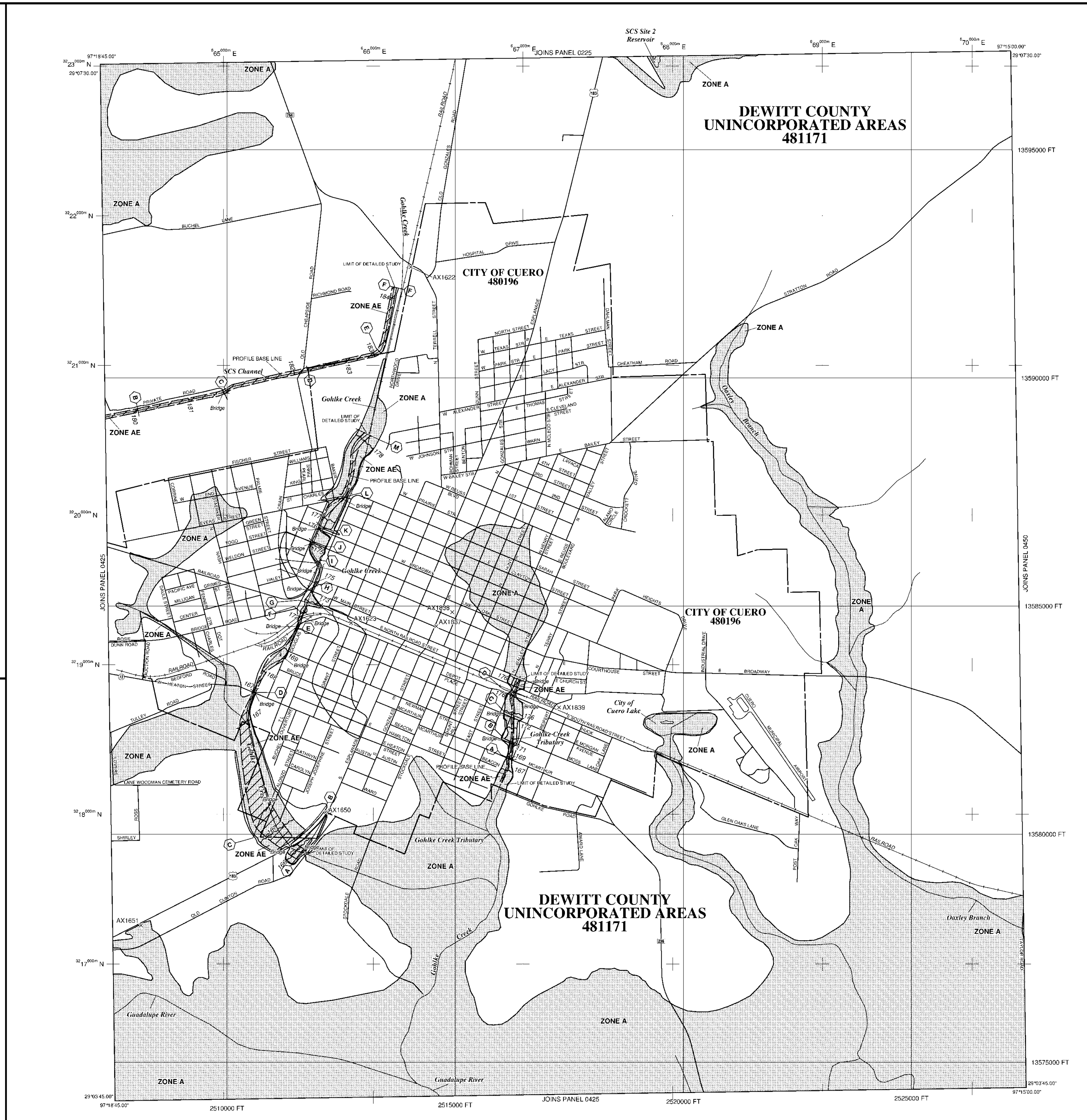
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data)* may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid, zone 14
6000000 FT	5000-foot grid : Texas State Plane coordinate system, south central zone (FIPSZONE 4204), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
January 6, 2011
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0410C

FIRM
FLOOD INSURANCE RATE MAP
DEWITT COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 410 OF 750
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DEWITT COUNTY	481171	0410	C
CUERO, CITY OF	480196	0410	C

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community

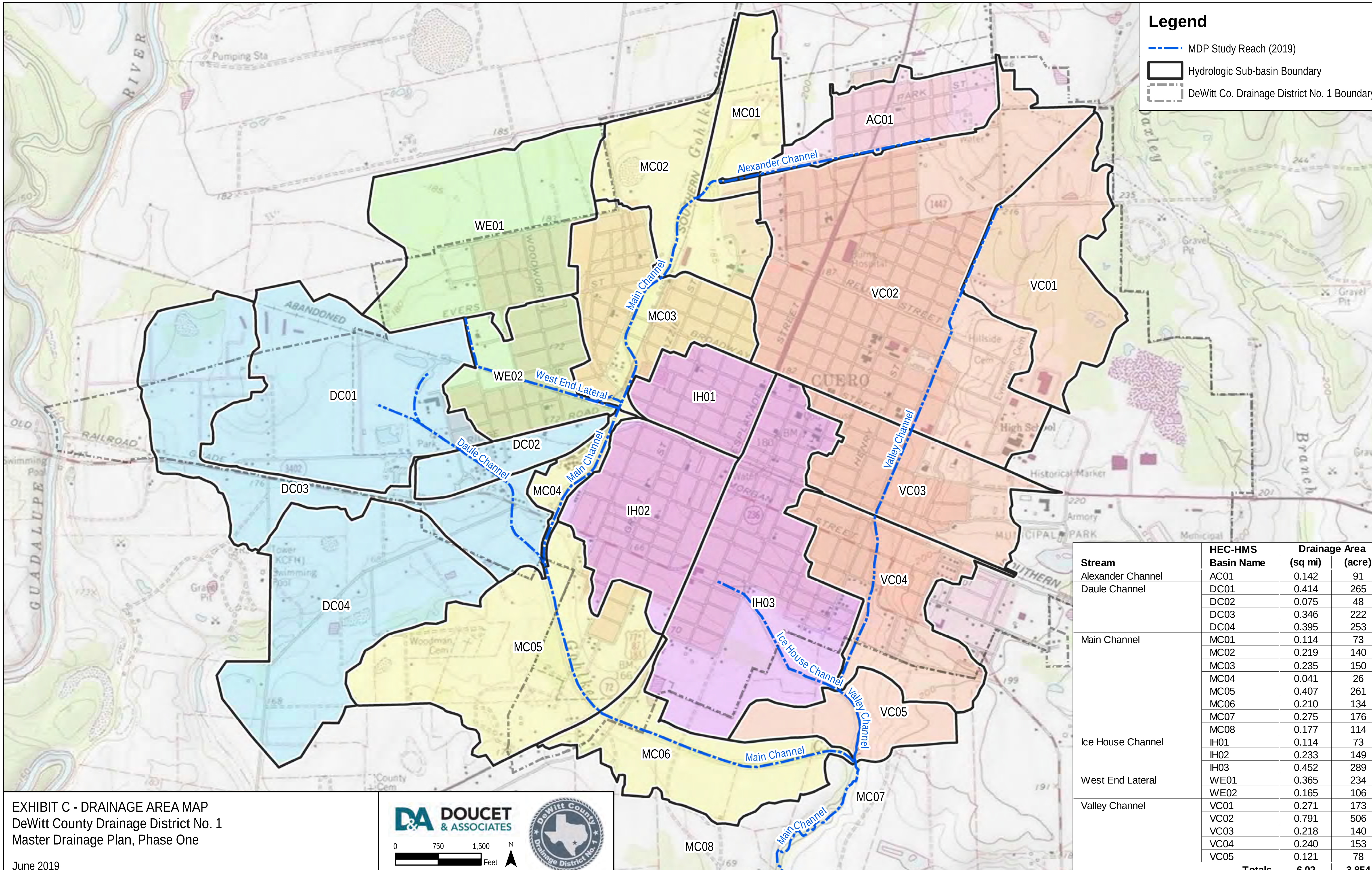
MAP NUMBER
48123C0410C

EFFECTIVE DATE
JANUARY 6, 2011

Federal Emergency Management Agency

EXHIBIT C

Drainage Area Map



Stream	HEC-HMS Basin Name	Drainage Area (sq mi)	Drainage Area (acre)
Alexander Channel	AC01	0.142	91
Daule Channel	DC01	0.414	265
	DC02	0.075	48
	DC03	0.346	222
	DC04	0.395	253
Main Channel	MC01	0.114	73
	MC02	0.219	140
	MC03	0.235	150
	MC04	0.041	26
	MC05	0.407	261
	MC06	0.210	134
	MC07	0.275	176
	MC08	0.177	114
Ice House Channel	IH01	0.114	73
	IH02	0.233	149
	IH03	0.452	289
West End Lateral	WE01	0.365	234
	WE02	0.165	106
Valley Channel	VC01	0.271	173
	VC02	0.791	506
	VC03	0.218	140
	VC04	0.240	153
	VC05	0.121	78
	Totals	6.02	3,854

EXHIBIT C - DRAINAGE AREA MAP
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

DeWitt County Drainage District No. 1

EXHIBIT D

Hydrologic Soil Group Map

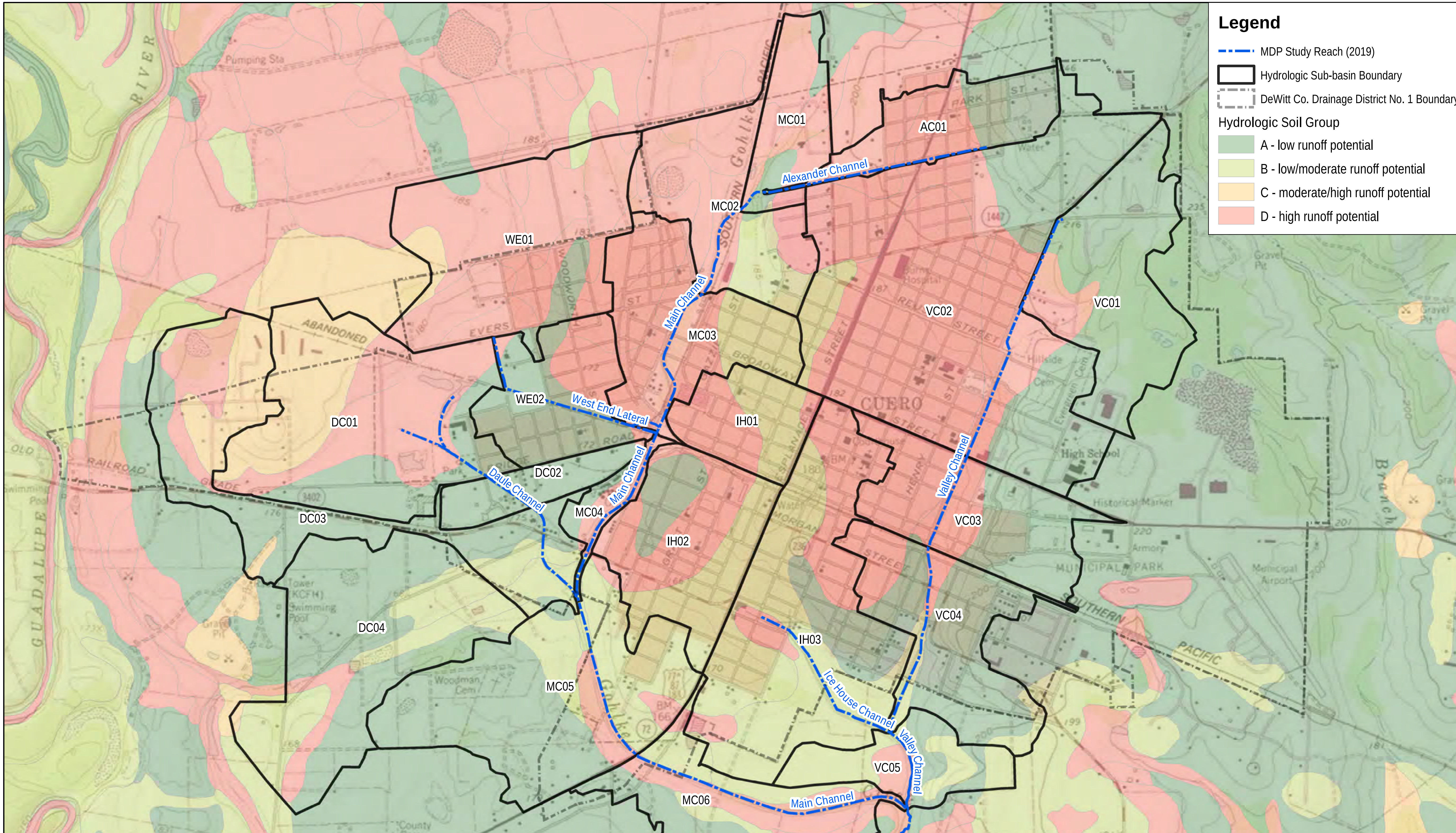


EXHIBIT D - HYDROLOGIC SOIL GROUP MAP
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

0 750 1,500 Feet

N

DeWitt County Drainage District No. 1

EXHIBIT E

Existing Land Use Conditions Map

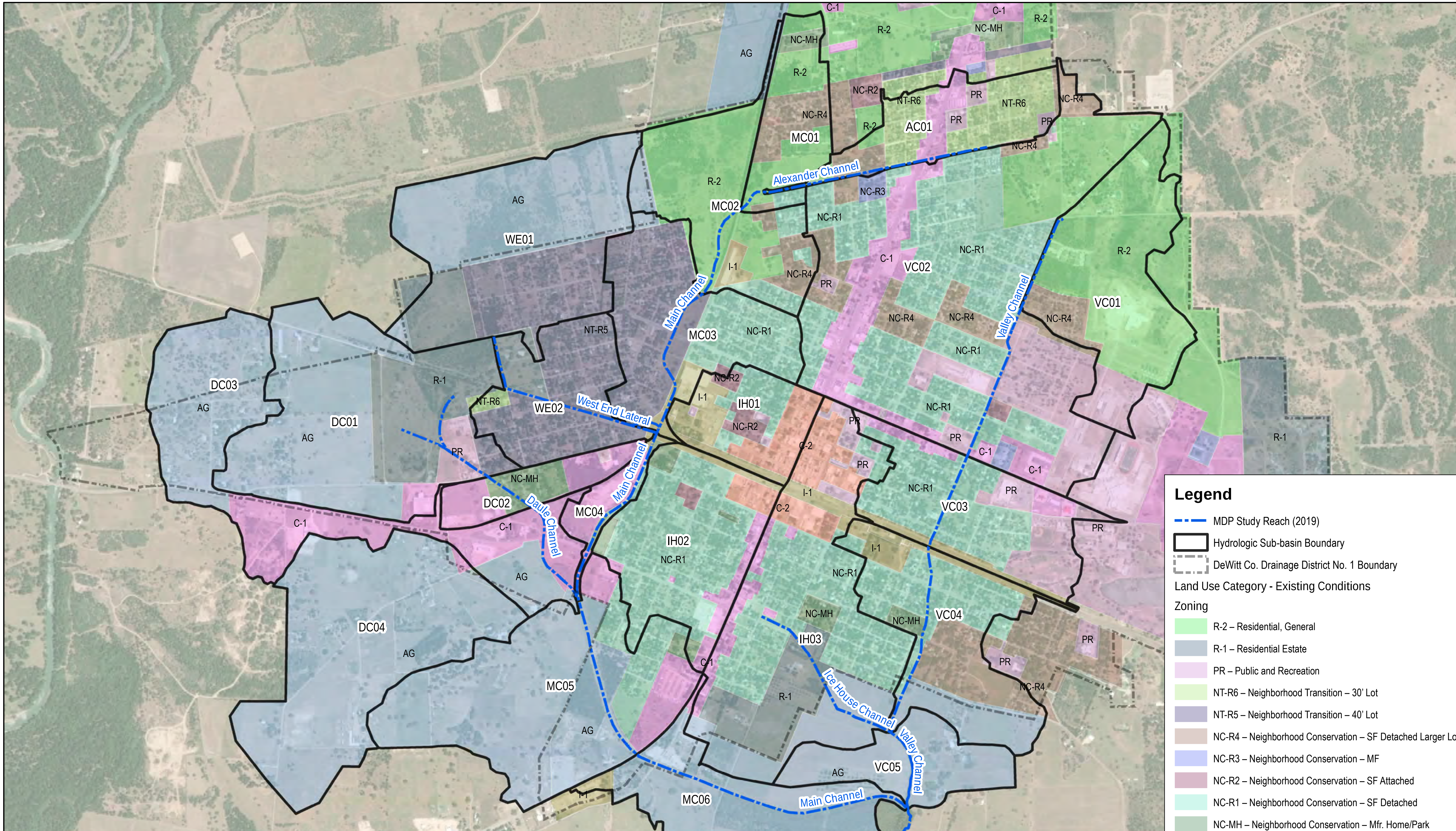


EXHIBIT E - EXISTING LAND USE CONDITIONS MAP
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

0 750 1,500 Feet N

EXHIBIT F

(RESERVED)
Future Land Use Conditions Map

EXHIBIT G

Cross Section Location Map

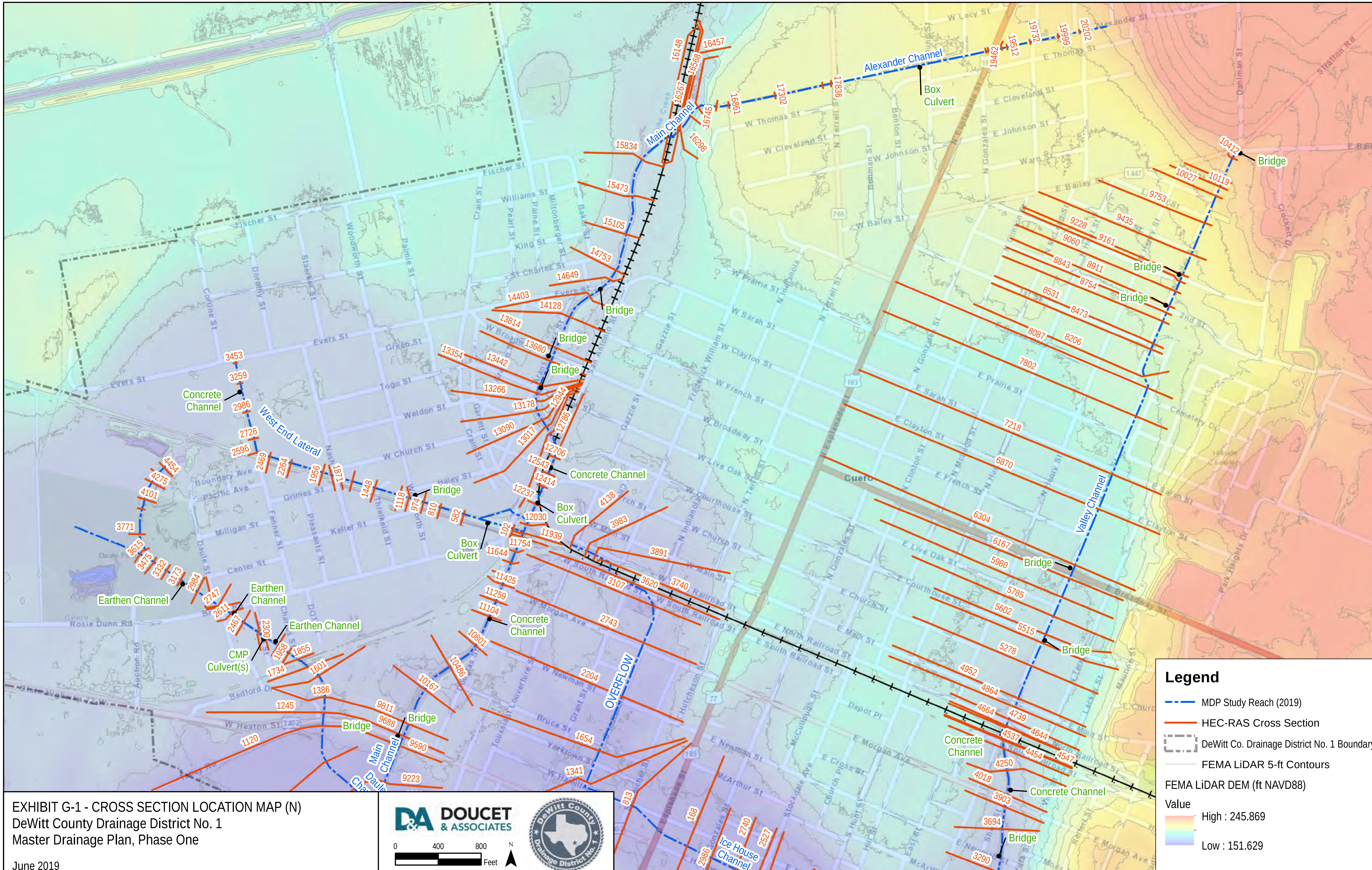


EXHIBIT G-1 - CROSS SECTION LOCATION MAP (N)
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

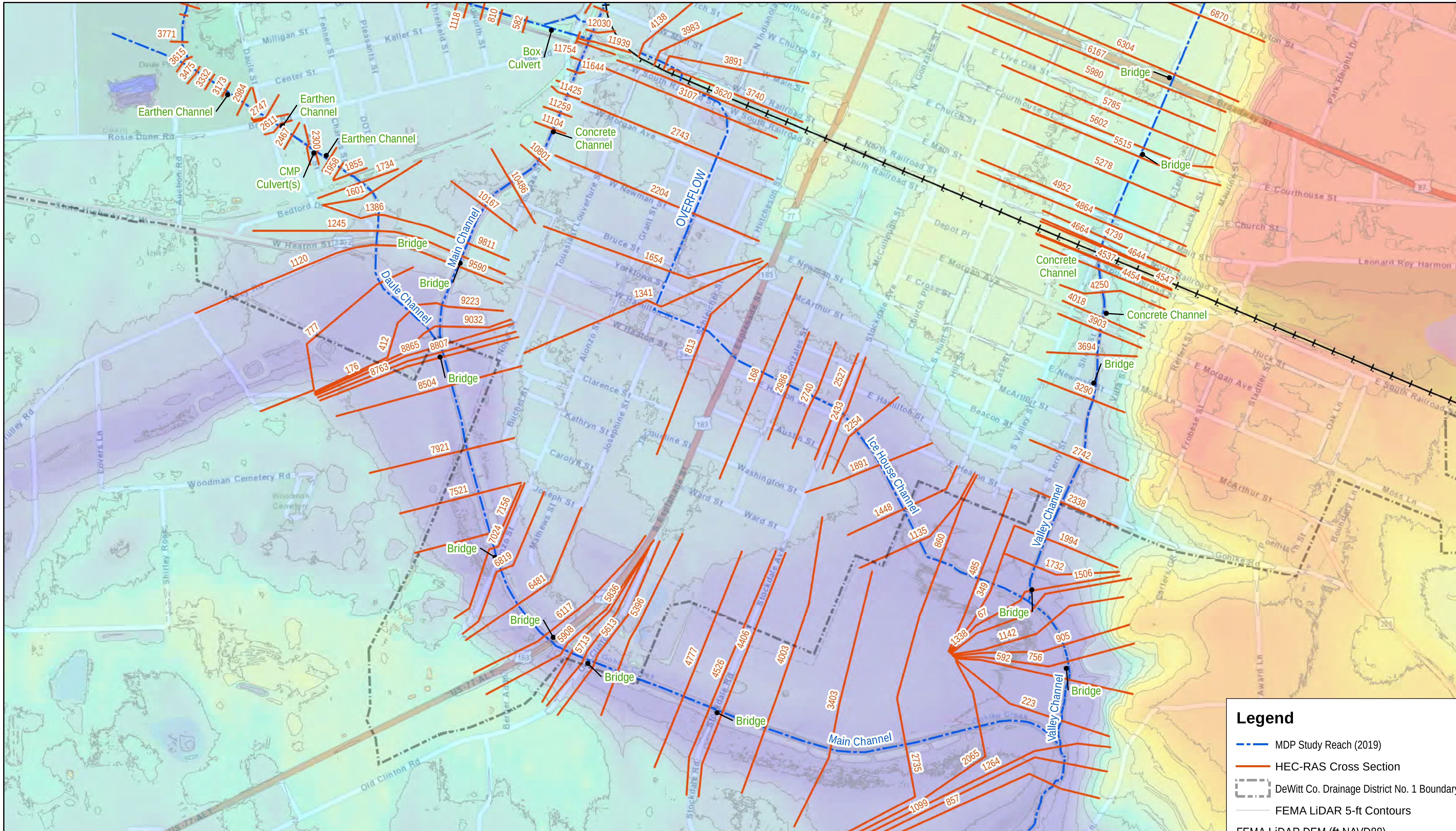


EXHIBIT G-2 - CROSS SECTION LOCATION MAP (S)
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

0 400 800 Feet

DeWitt County Drainage District No. 1

EXHIBIT H

Floodplain Map

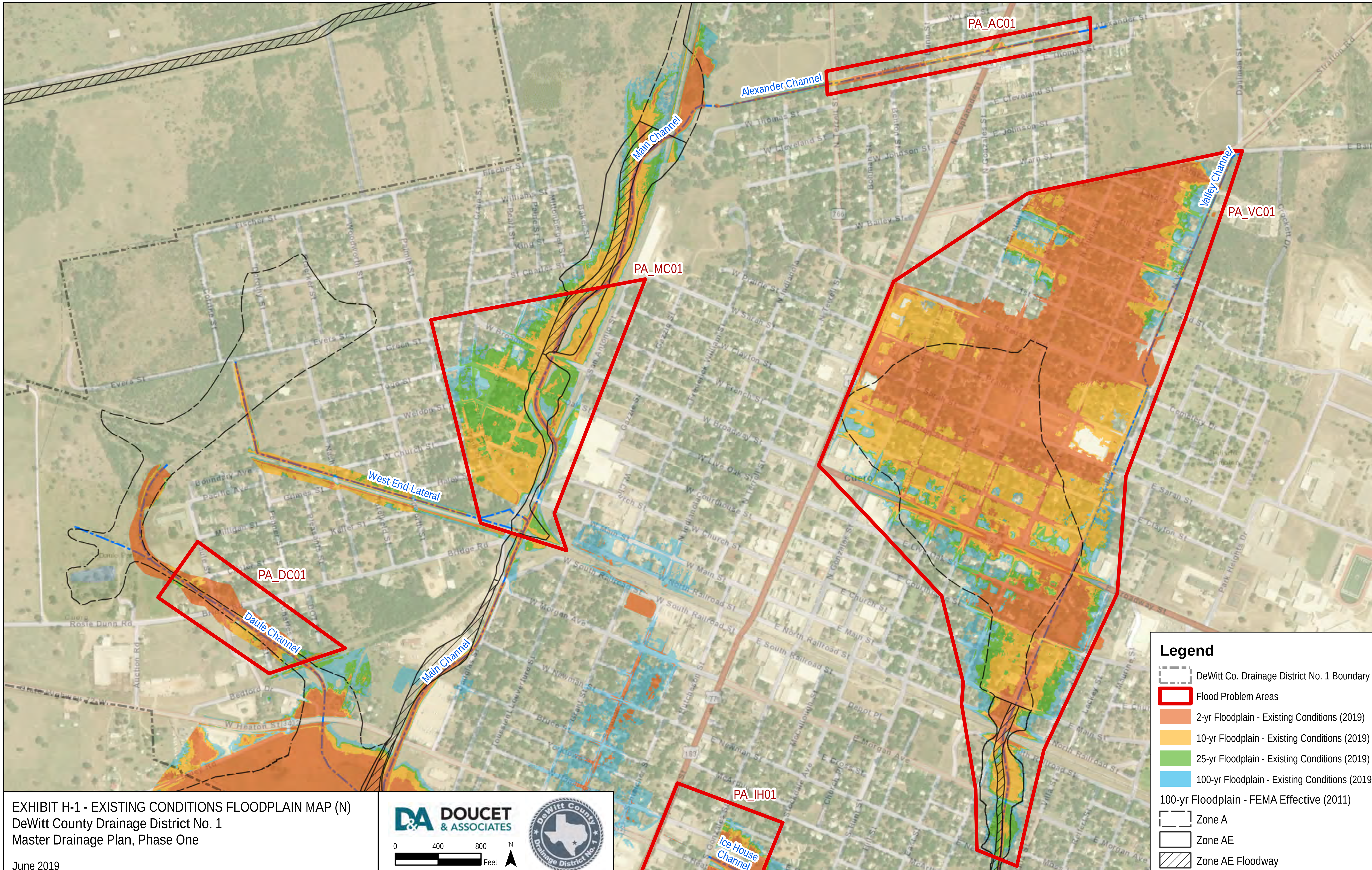


EXHIBIT H-1 - EXISTING CONDITIONS FLOODPLAIN MAP (N)
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

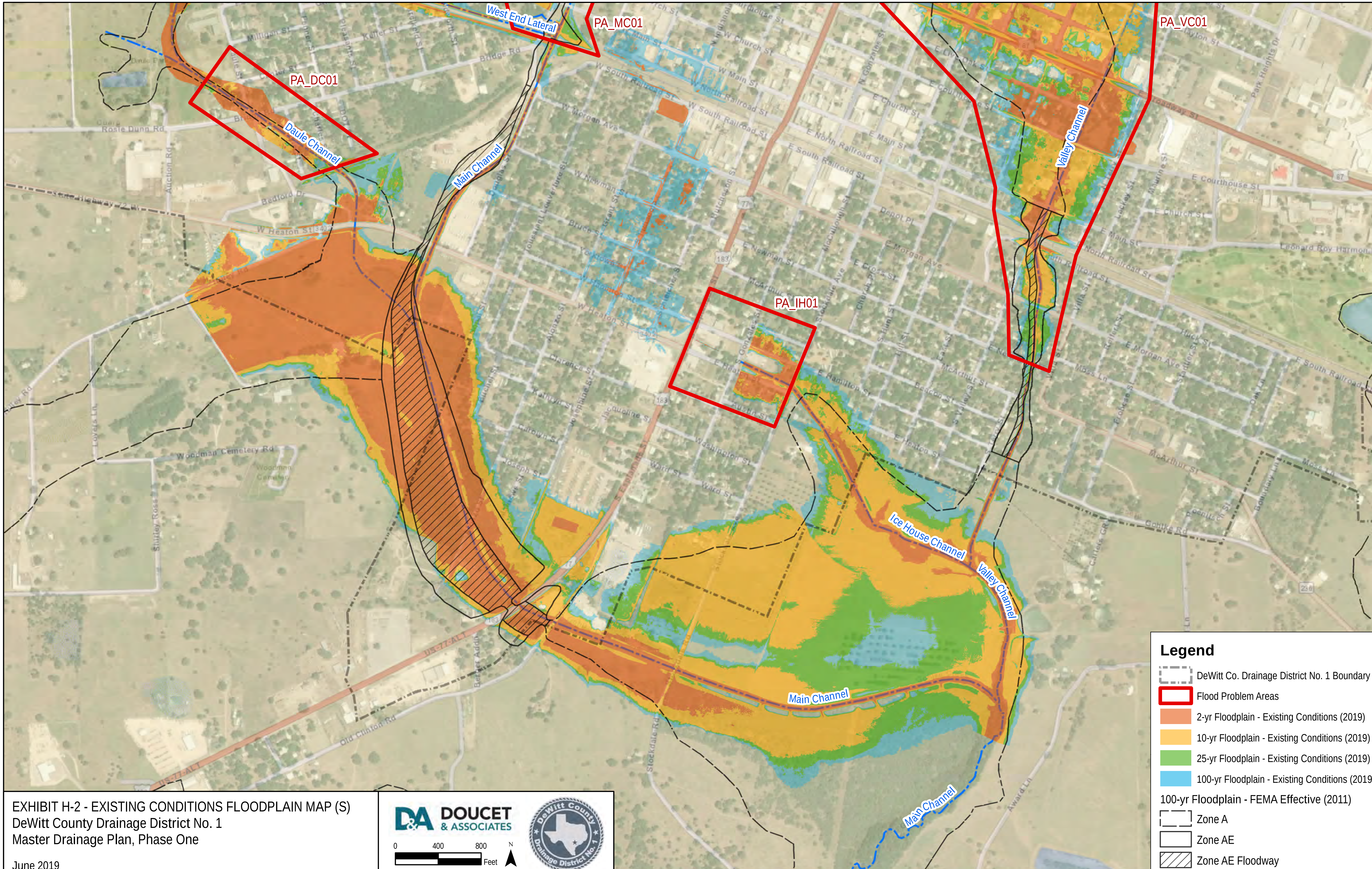


EXHIBIT H-2 - EXISTING CONDITIONS FLOODPLAIN MAP (S)
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

June 2019

DOUCET & ASSOCIATES

DeWitt County Drainage District No. 1

EXHIBIT I

Summary of Hydrologic Parameters

Land Use Category	**R-1**				**R-2**				**C-1**				**C-2**			
Hydrologic Soil Group	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SCS Curve Number (AMC II)	49	69	79	84	49	69	79	84	49	69	79	84	49	69	79	84
Impervious Cover	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.8	0.8	0.8	0.8	0.85	0.85	0.85	0.85

Breakdown by Hydro Sub-Basin

AC01	-	-	-	-	0.0003	-	-	0.0063	0.0013	-	-	0.0210	-	-	-	-
DC01	0.0144	-	-	0.1054	-	-	-	-	0.0115	-	-	0.0007	-	-	-	-
DC02	-	-	-	-	-	-	-	-	0.0443	-	-	0.0012	-	-	-	-
DC03	-	-	-	-	-	-	-	-	0.1184	0.0134	0.0046	0.0011	-	-	-	-
DC04	-	-	-	-	-	-	-	-	0.0014	0.0011	-	-	-	-	-	-
MC01	-	-	-	-	0.0171	0.0000	-	0.0459	-	-	-	-	-	-	-	-
MC02	-	-	-	-	0.0007	0.0172	-	0.1266	-	-	-	-	-	-	-	-
MC03	-	-	-	-	-	-	-	0.0029	-	-	-	-	-	0.0000	-	-
MC04	-	-	-	-	-	-	-	-	0.0131	0.0021	-	0.0162	-	-	-	-
MC05	-	-	-	-	-	-	-	-	-	0.0331	-	0.0122	-	-	-	-
MC06	-	-	-	-	-	-	-	-	-	0.0020	-	0.0003	-	-	-	-
IH01	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0225	-	0.0110
IH02	-	-	-	-	-	-	-	-	-	0.0221	-	0.0021	-	0.0076	-	0.0051
IH03	0.0015	0.0720	-	0.0074	-	-	-	-	-	0.0239	-	0.0010	-	0.0243	-	0.0274
LC01	0.0027	-	0.0041	0.0374	-	-	-	-	-	-	-	-	-	-	-	-
LC02	0.0203	-	-	0.0029	-	-	-	-	0.0004	-	-	0.0001	-	-	-	-
VC01	-	-	-	-	0.2033	-	-	0.0130	-	-	-	-	-	-	-	-
VC02	-	-	-	-	0.0944	-	-	0.0000	0.0151	0.0016	-	0.0943	-	0.0001	-	0.0002
VC03	-	-	-	-	-	-	-	-	0.0100	-	-	0.0099	-	-	-	0.0007
VC04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VC05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	0.0390	0.0720	0.0041	0.1531	0.3158	0.0173	-	0.1946	0.2154	0.0995	0.0046	0.1600	-	0.0546	-	0.0444

EXHIBIT I - SUMMARY OF HYDROLOGIC PARAMETERS
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

Land Use Category	I-1				NC-R3				NC-R4				NC-MH			
Hydrologic Soil Group	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SCS Curve Number (AMC II)	49	69	79	84	49	69	79	84	49	69	79	84	49	69	79	84
Impervious Cover	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.25	0.25	0.25	0.25

Breakdown by Hydro Sub-Basin

AC01	-	-	-	-	0.0000	-	-	0.0012	0.0035	-	-	0.0132	-	-	-	-
DC01	-	-	-	-	-	-	-	-	-	-	-	-	0.0005	-	-	-
DC02	-	-	-	0.0000	-	-	-	-	-	-	-	-	0.0276	-	-	-
DC03	0.0000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DC04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC01	-	-	-	-	-	-	-	-	0.0023	0.0005	-	0.0336	0.0018	-	-	0.0058
MC02	-	0.0042	-	0.0054	-	-	-	-	0.0005	0.0122	-	0.0106	-	-	-	-
MC03	-	-	-	0.0141	-	-	-	-	-	-	-	-	-	-	-	-
MC04	-	-	-	0.0018	-	-	-	-	-	-	-	-	-	-	-	0.0038
MC05	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0036	-	-
MC06	0.0050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IH01	-	0.0027	-	0.0320	-	-	-	-	-	-	-	-	-	-	-	-
IH02	0.0000	0.0019	-	0.0060	-	-	-	-	-	-	-	-	0.0028	0.0026	-	0.0087
IH03	-	0.0068	-	0.0066	-	-	-	-	-	-	-	-	0.0087	0.0012	-	0.0000
LC01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LC02	-	-	-	0.0008	-	-	-	-	-	-	-	-	0.0004	-	-	-
VC01	-	-	-	-	-	-	-	-	0.0030	-	-	0.0227	-	-	-	-
VC02	-	-	-	-	0.0050	-	-	0.0080	0.0217	0.0110	-	0.0587	-	-	-	-
VC03	0.0084	-	-	0.0091	-	-	-	-	-	-	-	-	-	-	-	-
VC04	0.0093	-	-	0.0199	-	-	-	-	0.0561	0.0046	-	-	0.0053	0.0020	-	-
VC05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	0.0227	0.0156	-	0.0957	0.0050	-	-	0.0092	0.0871	0.0283	-	0.1387	0.0471	0.0094	-	0.0183

EXHIBIT I - SUMMARY OF HYDROLOGIC PARAMETERS
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

Land Use Category	**NT-R5**				**NT-R6**				**PR**				**AG**			
Hydrologic Soil Group	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SCS Curve Number (AMC II)	49	69	79	84	49	69	79	84	43	65	76	82	43	65	76	82
Impervious Cover	0.4	0.4	0.4	0.4	0.45	0.45	0.45	0.45	0.35	0.35	0.35	0.35	0.05	0.05	0.05	0.05
Breakdown by Hydro Sub-Basin																
AC01	-	-	-	-	0.0455	-	-	0.0346	0.0072	-	-	0.0042	-	-	-	-
DC01	0.0116	-	-	-	0.0012	-	-	-	0.0147	-	-	0.0071	0.0485	-	0.1401	0.0580
DC02	-	-	-	-	-	-	-	-	0.0014	-	-	-	-	-	-	-
DC03	-	-	-	-	-	-	-	-	-	-	-	-	0.0401	0.0400	0.0682	0.0604
DC04	-	-	-	-	-	-	-	-	-	-	-	-	0.2387	0.1230	0.0025	0.0279
MC01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0015
MC02	-	-	-	0.0007	-	-	-	-	-	0.0000	-	-	-	-	-	0.0163
MC03	0.0006	-	-	0.1399	-	-	-	-	-	-	-	-	-	-	-	0.0039
MC04	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0004	-	-
MC05	-	-	-	-	-	-	-	-	-	-	-	-	0.2192	0.0625	-	0.0277
MC06	-	-	-	-	-	-	-	-	-	-	-	-	0.0581	0.0566	-	0.0879
IH01	-	-	-	-	-	-	-	-	-	0.0020	-	0.0009	-	-	-	-
IH02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IH03	-	-	-	-	-	-	-	-	-	0.0008	-	0.0176	0.0001	0.0744	-	0.0050
LC01	0.0223	-	-	0.0821	-	-	-	-	-	-	-	-	0.0066	0.0041	0.0126	0.1933
LC02	0.0875	-	-	0.0473	0.0056	-	-	-	0.0001	-	-	-	-	-	-	-
VC01	-	-	-	-	-	-	-	-	0.0282	-	-	-	-	-	-	-
VC02	-	-	-	-	-	-	-	-	0.0711	0.0030	-	0.0556	-	-	-	-
VC03	-	-	-	-	-	-	-	-	0.0567	-	-	0.0034	-	-	-	-
VC04	-	-	-	-	-	-	-	-	0.0002	-	-	-	0.0369	0.0152	-	-
VC05	-	-	-	-	-	-	-	-	-	-	-	-	0.0337	0.0689	-	0.0187
Totals	0.1220	-	-	0.2700	0.0523	-	-	0.0346	0.1797	0.0059	-	0.0888	0.6819	0.4452	0.2235	0.5007

EXHIBIT I - SUMMARY OF HYDROLOGIC PARAMETERS
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

Land Use Category	INST				NC-R1				NC-R2					Area-Weighted Hydrologic Parameters	
Hydrologic Soil Group	A	B	C	D	A	B	C	D	A	B	C	D			
SCS Curve Number (AMC II)	49	69	79	84	49	69	79	84	49	69	79	84	Total Area (sq mi)	CN	IC (%)
Impervious Cover	0.4	0.4	0.4	0.4	0.55	0.55	0.55	0.55	0.45	0.45	0.45	0.45			
Breakdown by Hydro Sub-Basin															
AC01	-	-	-	-	0.0005	-	-	0.0030	-	-	-	0.0002	0.14216	69.2	49.0
DC01	-	-	-	-	-	-	-	-	-	-	-	-	0.41374	71.4	9.9
DC02	-	-	-	-	-	-	-	-	-	-	-	-	0.07458	49.5	58.8
DC03	-	-	-	-	-	-	-	-	-	-	-	-	0.34631	62.5	34.8
DC04	-	-	-	-	-	-	-	-	-	-	-	-	0.39463	52.9	5.5
MC01	-	-	-	-	0.0003	-	-	0.0053	-	-	-	-	0.11413	77.3	25.9
MC02	-	-	-	-	-	0.0129	-	0.0115	-	-	-	-	0.21880	80.5	21.2
MC03	-	-	-	-	-	0.0553	-	0.0170	-	0.0006	-	0.0008	0.23512	80.3	44.9
MC04	-	-	-	-	0.0002	-	-	0.0034	-	-	-	-	0.04096	71.6	71.1
MC05	-	-	-	-	-	0.0478	-	0.0012	-	-	-	-	0.40729	55.8	19.5
MC06	-	-	-	-	-	-	-	-	-	-	-	-	0.20990	65.7	7.1
IH01	-	-	-	-	-	0.0225	-	0.0067	-	0.0045	-	0.0094	0.11431	76.8	63.6
IH02	-	-	-	-	0.0351	0.0573	-	0.0778	0.0033	-	-	0.0010	0.23347	71.9	57.4
IH03	-	-	-	-	0.0488	0.0733	-	0.0506	-	-	-	-	0.45174	69.4	40.7
LC01	-	-	-	-	-	-	-	-	-	-	-	-	0.36534	79.3	15.0
LC02	-	-	-	-	-	-	-	-	-	-	-	-	0.16535	59.8	35.4
VC01	-	-	-	-	0.0003	-	-	0.0004	-	-	-	-	0.27081	53.0	16.5
VC02	-	-	-	-	0.0364	0.0166	-	0.2947	0.0010	-	-	0.0029	0.79127	71.9	49.3
VC03	-	-	-	-	0.0299	-	-	0.0900	-	-	-	-	0.21804	65.5	52.3
VC04	-	-	-	-	0.0584	0.0061	-	0.0255	-	-	-	-	0.23951	56.8	42.5
VC05	-	-	-	-	-	-	-	-	-	-	-	-	0.12136	61.5	5.0
Totals	-	-	-	-	0.2099	0.2917	-	0.5872	0.0043	0.0051	-	0.0143	5.56881		

EXHIBIT I - SUMMARY OF HYDROLOGIC PARAMETERS
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

	TIME OF CONCENTRATION CALCULATIONS																			
	ENTIRE FLOW PATH					SHEET FLOW					SHALLOW CONCENTRATED					CHANNEL				
	Tc (min)	Lag (min)	Length (ft)	Average Slope (%)	Average Vel (fps)	Length (ft)	Tt (min)	V (fps)	Slope (%)	N-value	Length (ft)	Tt (min)	V (fps)	Slope (%)	Surface	Length (ft)	Tt (min)	Average V (fps)	Average Slope (%)	Average N-value
Breakdown by Hydro Sub-Basin																				
AC01	49.3	29.6	5,720	1.04	1.8	100	29.8	0.06	0.66	0.41	444	4.5	1.6	1.02	UNPAVED	4,673	15.0	5.2	1.17	0.023
DC01	83.2	49.9	4,629	0.45	0.9	200	40.7	0.08	1.21	0.41	616	6.7	1.5	0.90	UNPAVED	3,813	35.7	1.8	0.33	0.042
DC02	81.4	48.8	2,235	0.27	0.5	100	43.5	0.04	0.26	0.41	120	1.8	1.1	0.48	UNPAVED	2,015	36.2	0.9	0.26	0.060
DC03	150.9	90.5	10,741	0.29	1.2	200	40.3	0.08	1.24	0.41	1,947	30.3	1.1	0.44	UNPAVED	8,594	80.2	1.8	0.22	0.042
DC04	167.0	100.2	5,971	0.29	0.6	200	54.5	0.06	0.58	0.41	2,782	48.7	1.0	0.35	UNPAVED	2,989	63.9	0.8	0.02	0.050
MC01	106.1	63.7	3,825	0.36	0.6	200	55.6	0.06	0.55	0.41	516	5.0	1.7	1.12	UNPAVED	3,109	45.4	1.1	0.22	0.079
MC02	191.4	114.8	4,776	0.26	0.4	200	123.0	0.03	0.08	0.41	1,200	23.8	0.8	0.27	UNPAVED	3,376	44.6	1.3	0.24	0.060
MC03	66.1	39.7	4,408	0.49	1.3	100	33.7	0.05	0.49	0.41	240	5.1	0.8	0.24	UNPAVED	4,832	27.4	2.9	0.43	0.028
MC04	64.8	38.9	2,365	0.64	0.6	200	47.0	0.07	0.84	0.41	622	9.6	1.1	0.44	UNPAVED	1,543	8.1	3.2	0.70	0.040
MC05	121.4	72.8	6,282	0.39	0.9	200	44.3	0.08	0.98	0.41	1,101	18.3	1.0	0.38	UNPAVED	4,981	58.8	1.4	0.36	0.044
MC06	79.2	47.5	5,635	0.62	1.2	100	52.2	0.03	0.16	0.41	241	6.2	0.6	0.16	UNPAVED	5,294	20.8	4.2	0.63	0.042
IH01	73.3	44.0	2,527	0.70	0.6	100	60.8	0.03	0.11	0.41	50	0.3	3.0	2.12	PAVED	2,377	12.3	3.2	0.68	0.020
IH02	41.7	25.0	3,751	0.26	1.5	100	19.7	0.08	1.86	0.41	346	5.6	1.0	0.40	UNPAVED	3,305	16.4	3.4	0.19	0.013
IH03	145.3	87.2	6,955	0.47	0.8	100	108.5	0.02	0.03	0.41	209	2.2	1.6	0.93	UNPAVED	6,644	34.6	3.2	0.45	0.024
LC01	172.4	103.5	3,236	0.42	0.3	200	89.8	0.04	0.17	0.41	1,753	69.1	0.4	0.07	UNPAVED	1,283	13.5	1.6	0.92	0.050
LC02	111.8	67.1	2,993	0.31	0.4	200	54.9	0.06	0.57	0.41	502	45.7	0.2	0.01	UNPAVED	2,291	11.1	3.4	0.35	0.017
VC01	88.1	52.8	5,488	0.92	1.0	200	39.9	0.08	1.27	0.41	1,499	18.3	1.4	0.71	UNPAVED	3,789	29.9	2.1	0.90	0.048
VC02	73.2	43.9	8,268	0.80	1.9	200	65.0	0.05	0.38	0.41	312	5.3	1.0	0.37	UNPAVED	7,756	25.6	5.1	0.80	0.023
VC03	45.2	27.1	3,846	0.43	1.4	100	27.9	0.06	0.78	0.41	73	2.6	0.5	0.09	UNPAVED	3,673	14.7	4.2	0.43	0.014
VC04	40.8	24.5	4,472	0.80	1.8	100	22.4	0.07	1.34	0.41	109	1.1	1.6	1.03	UNPAVED	4,263	17.2	4.1	0.78	0.026
VC05	93.6	56.2	3,000	0.72	0.5	200	45.9	0.07	0.90	0.41	2,161	45.8	0.8	0.24	UNPAVED	639	1.9	5.5	2.29	0.045

EXHIBIT J

Summary of Computed Peak Flow Rates

EXHIBIT J - SUMMARY OF COMPUTED PEAK FLOW RATES

DeWitt County Drainage District No. 1

Master Drainage Plan, Phase One

River	Location	HMS Element	Area (sq mi)	Computed Peak Flow Rates (cfs) by Return Period						
				2	5	10	25	50	100	500
Daule Channel	U/S Limit, W of Boundary Ave	J_DC01	0.414	90	150	200	300	380	470	740
	Daule Park; W of Milligan St	J_DC01	0.414	180	290	410	590	760	940	1,480
	E of Angie St	J_DC02	0.488	220	340	480	690	880	1,090	1,710
	N of Heaton St	J_DC03	0.835	310	490	670	960	1,220	1,520	2,390
Main Channel	U/S Limit, N McLeod St	AC01	0.142	60	90	110	160	190	230	360
	W of N Esplanade St / US183	AC01	0.142	120	170	230	310	390	470	710
	W of Railroad Crossing	J_MC01_AC01	0.256	160	230	300	420	520	630	960
	E of Williams St	J_MC02	0.475	190	280	370	510	640	780	1,180
	N or W Broadway St	J_MC03	0.710	370	530	700	960	1,190	1,440	2,180
	Confl. with Lateral No 1	J_MC03_LC02	1.241	490	720	950	1,320	1,650	2,000	3,060
	E of Bruce St	J_MC04	1.282	500	730	970	1,350	1,680	2,050	3,140
	Confl. with Daule Channel	J_MC04_DC03	2.117	830	1,270	1,720	2,450	3,120	3,850	6,040
	W of Alonzo St	J_MC05	2.524	890	1,370	1,890	2,710	3,480	4,320	6,860
	E of Stockdale Rd	J_MC06	2.734	910	1,420	1,970	2,840	3,650	4,550	7,260
	Confl. with Valley	J_GR	5.174	1,920	2,980	4,090	5,870	7,510	9,320	14,770
Ice House Channel	U/S Limit, S Gonzales St	J_IH02	0.348	280	400	530	710	880	1,070	1,610
	W of Hill St	J_IH03	0.800	400	570	740	1,000	1,240	1,500	2,270
West End Lateral	U/S Limit, Evers St	WE01	0.165	130	200	270	370	470	570	860
	W of Threlkeld St	J_WE02	0.531	180	270	370	520	650	800	1,240
Valley Channel	U/S Limit, E Bailey St	VC01	0.791	30	50	80	130	170	220	380
	N of 2nd St	VC01	0.791	60	100	160	250	340	450	770
	E Reuss Blvd	J_VC02	1.062	620	900	1,200	1,660	2,090	2,560	3,960
	E Courthouse St	J_VC03	1.280	760	1,100	1,460	2,020	2,530	3,100	4,770
	E Newman St	J_VC04	2.080	860	1,250	1,670	2,330	2,930	3,590	5,560
	Confl. with Ice House Channel	J_VC04_IH03	2.441	1,250	1,820	2,400	3,330	4,170	5,090	7,830
	600' N of Main Channel Confl.	J_VC05	0.365	1,270	1,860	2,470	3,440	4,320	5,280	8,150

EXHIBIT K

Summary of Computed Maximum Water Surface Elevations

River	Reach	River Sta	Computed Water Surface Elevation (ft NAVD88)						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Valley Channel	VD02	10412	210.98	210.98	211.71	212.23	212.58	212.95	214.02
Valley Channel	VD02	10192	207.30	207.30	207.90	207.75	208.01	208.30	208.77
Valley Channel	VD02	10119	207.30	207.30	207.90	207.77	207.70	207.36	208.02
Valley Channel	VD02	10069	Private Driveway						
Valley Channel	VD02	10027	203.95	203.95	204.72	205.23	205.51	205.75	206.64
Valley Channel	VD02	9753	201.08	201.08	201.83	202.29	202.54	202.79	203.04
Valley Channel	VD02	9435	197.11	197.11	197.69	198.10	198.39	198.70	199.45
Valley Channel	VD02	9228	195.85	195.85	196.81	197.11	196.67	197.10	197.07
Valley Channel	VD02	9194	3rd St						
Valley Channel	VD02	9161	193.25	193.25	193.92	194.64	195.03	195.43	196.45
Valley Channel	VD02	9060	193.06	193.06	193.34	193.19	193.55	193.94	194.9
Valley Channel	VD02	8911	192.89	192.89	193.50	193.46	193.45	193.46	193.46
Valley Channel	VD02	8879	2nd St						
Valley Channel	VD02	8843	191.28	191.28	192.36	192.70	192.40	192.61	192.61
Valley Channel	VD02	8754	190.25	190.25	191.11	191.70	192.17	192.26	192.26
Valley Channel	VD02	8531	190.03	190.03	189.03	189.39	189.85	189.38	191.31
Valley Channel	VD02	8473	190.02	190.02	188.93	189.16	189.47	188.45	188.24
Valley Channel	VD02	8206	190.02	190.02	188.76	188.76	188.77	188.83	188.94
Valley Channel	VD02	8087	188.23	188.23	188.74	188.74	188.75	188.75	188.75
Valley Channel	VD02	7802	184.57	184.57	186.89	186.89	186.90	186.90	186.9
Valley Channel	VD02	7218	183.46	183.46	183.46	183.46	183.46	183.47	183.74
Valley Channel	VD02	6870	180.34	180.34	182.64	182.64	182.80	182.97	183.43
Valley Channel	VD02	6304	180.87	180.87	181.19	181.43	181.73	182.00	182.52
Valley Channel	VD02	6167	180.24	180.24	180.91	181.22	181.60	181.87	182.39
Valley Channel	VD02	5980	179.86	179.86	180.01	180.56	180.79	180.94	181.4
Valley Channel	VD02	5785	179.93	179.93	179.66	180.02	180.31	180.55	181.3
Valley Channel	VD02	5602	179.91	179.91	179.46	179.83	180.09	180.33	181.12
Valley Channel	VD02	5515	177.11	177.11	178.93	179.28	179.41	179.71	180.88
Valley Channel	VD02	5278	176.37	176.37	177.38	178.37	178.96	179.37	180.77
Valley Channel	VD02	4952	175.72	175.72	177.31	178.26	178.84	179.22	180.65
Valley Channel	VD02	4864	175.50	175.50	176.18	176.86	177.24	178.10	180.28
Valley Channel	VD02	4739	175.48	175.48	176.18	176.43	177.09	177.95	179.99
Valley Channel	VD02	4702	North Railroad St.						
Valley Channel	VD02	4664	175.24	175.24	175.98	176.72	177.43	178.23	180.17
Valley Channel	VD02	4644	175.26	175.26	176.00	176.72	177.44	178.23	180.14
Valley Channel	VD02	4599	Railroad Crossing						
Valley Channel	VD02	4547	175.19	175.19	175.65	176.03	176.40	176.74	178.1
Valley Channel	VD02	4537	175.18	175.18	175.63	175.99	176.34	176.67	178.09
Valley Channel	VD02	4494	South Railroad St.						
Valley Channel	VD02	4454	171.28	171.28	174.66	175.01	175.33	175.61	176.47
Valley Channel	VD02	4250	171.08	171.08	174.63	174.97	175.28	175.56	176.49
Valley Channel	VD02	4018	170.98	170.98	174.55	174.84	175.09	175.28	175.01
Valley Channel	VD02	3959	E Morgan Ave						
Valley Channel	VD02	3903	165.78	165.78	170.16	172.87	173.58	173.80	174.89
Valley Channel	VD02	3694	167.31	167.31	170.11	172.97	173.73	174.04	174.94
Valley Channel	VD02	3411	E Newman St.						
Valley Channel	VD02	3290	163.56	163.56	166.48	168.21	169.36	168.61	171.03
Valley Channel	VD02	2742	159.84	159.84	160.82	161.68	162.24	163.67	165.02
Valley Channel	VD02	2338	159.80	159.80	161.79	162.86	163.45	164.22	164.42

River	Reach	River Sta	Computed Water Surface Elevation (ft NAVD88)						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Valley Channel	VD02	1994	159.40	159.40	161.25	162.15	162.30	162.13	164.4
Valley Channel	VD02	1732	158.93	158.93	160.40	160.65	161.83	162.44	163.99
Valley Channel	VD02	1506	158.77	158.77	160.59	161.14	161.68	162.34	163.84
Valley Channel	VD01	1338	158.64	158.64	160.59	161.18	161.74	162.40	163.92
Valley Channel	VD01	1142	157.63	157.63	159.49	160.75	161.57	162.31	163.87
Valley Channel	VD01	905	156.84	156.84	159.41	160.61	161.47	162.24	163.83
Valley Channel	VD01	756	156.73	156.73	159.28	160.48	161.39	162.19	163.79
Valley Channel	VD01	592	156.50	156.50	159.20	160.44	161.36	162.17	163.78
Valley Channel	VD01	223	156.36	156.36	159.05	160.34	161.28	162.12	163.74
OVERFLOW	OF01	4138	169.07	169.07	169.07	169.07	169.80	170.65	175.08
OVERFLOW	OF01	3983	168.84	168.84	168.84	168.84	169.61	170.60	175.08
OVERFLOW	OF01	3891	168.59	168.59	168.59	168.59	169.43	170.56	175.08
OVERFLOW	OF01	3740	168.08	168.08	168.08	168.08	169.39	170.52	175.03
OVERFLOW	OF01	3700	Railroad Crossing						
OVERFLOW	OF01	3620	167.09	167.09	167.09	167.09	167.61	168.06	168.46
OVERFLOW	OF01	3107	167.09	167.09	167.09	167.09	167.61	168.08	168.7
OVERFLOW	OF01	2743	167.03	167.03	167.03	167.03	167.45	167.96	168.55
OVERFLOW	OF01	2204	165.60	165.60	165.60	165.60	166.13	166.35	166.91
OVERFLOW	OF01	1654	164.55	164.55	164.55	164.55	164.98	165.26	166.03
OVERFLOW	OF01	1341	163.98	163.98	163.98	163.98	164.47	164.79	165.47
OVERFLOW	OF01	813	163.24	163.24	163.24	163.24	163.79	164.04	164.98
OVERFLOW	OF01	168	160.36	160.36	160.36	160.36	161.40	162.23	163.98
Main Channel	OM03	20202	207.29	207.29	207.73	207.92	208.01	208.14	208.52
Main Channel	OM03	19999	205.63	205.63	206.13	206.43	206.61	206.85	207.39
Main Channel	OM03	19794	205.50	205.50	205.95	206.20	206.36	206.60	207.1
Main Channel	OM03	19763	N Clinton St						
Main Channel	OM03	19732	203.70	203.70	203.97	204.39	204.58	204.81	205.13
Main Channel	OM03	19512	201.80	201.80	202.86	203.06	203.21	203.38	204.34
Main Channel	OM03	19462	201.93	201.93	202.96	203.21	203.39	203.60	204.47
Main Channel	OM03	19390	N Esplanade St (US183)						
Main Channel	OM03	19335	201.44	201.44	202.40	202.79	203.14	203.52	204.4
Main Channel	OM03	19310	201.26	201.26	202.22	202.58	202.88	203.23	203.99
Main Channel	OM03	17878	Box Culvert						
Main Channel	OM03	17836	194.95	194.95	196.10	196.76	197.33	197.79	198.89
Main Channel	OM03	17756	194.71	194.71	195.91	196.53	197.06	197.54	198.66
Main Channel	OM03	17302	193.63	193.63	194.90	195.54	196.08	196.57	197.74
Main Channel	OM03	16861	190.95	190.95	191.62	192.17	192.64	193.08	194.19
Main Channel	OM03	16745	188.77	188.77	189.13	189.23	189.32	189.39	189.64
Main Channel	OM03	16568	178.02	178.02	178.55	179.13	179.53	180.57	181.41
Main Channel	OM03	16457	178.02	178.02	178.55	179.13	179.53	180.57	181.41
Main Channel	OM03	16298	178.02	178.02	178.55	179.13	179.53	180.57	181.41
Main Channel	OM03	16267	177.93	177.93	178.55	179.13	179.53	180.57	181.41
Main Channel	OM03	16190	Railroad Crossing						
Main Channel	OM03	16148	176.48	176.48	177.36	177.86	178.11	178.29	178.99
Main Channel	OM03	15834	175.42	175.42	176.97	177.40	177.67	177.92	178.51
Main Channel	OM03	15473	174.91	174.91	176.70	177.12	177.36	177.62	178.23
Main Channel	OM03	15105	174.48	174.48	176.49	176.88	177.08	177.32	177.9
Main Channel	OM03	14753	174.06	174.06	176.31	176.67	176.82	177.04	177.58
Main Channel	OM03	14649	173.92	173.92	176.28	176.64	176.79	177.00	177.54

River	Reach	River Sta	Computed Water Surface Elevation (ft NAVD88)						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Main Channel	OM03	14557	Evers St.						
Main Channel	OM03	14403	173.62	173.62	175.85	176.27	176.47	176.67	177.31
Main Channel	OM03	14128	173.41	173.41	175.75	176.16	176.35	176.54	177.18
Main Channel	OM03	13814	172.82	172.82	175.54	175.94	176.08	176.23	177
Main Channel	OM03	13744	W Broadway St						
Main Channel	OM03	13680	172.40	172.40	174.53	175.25	175.53	175.56	176.83
Main Channel	OM03	13442	171.60	171.60	174.21	175.18	175.48	175.49	176.8
Main Channel	OM03	13396	W Live Oak St						
Main Channel	OM03	13354	171.35	171.35	173.50	174.56	174.52	175.40	176.77
Main Channel	OM03	13353	Lateral Weir						
Main Channel	OM03	13266	171.14	171.14	173.38	174.46	174.33	175.37	176.76
Main Channel	OM03	13178	170.97	170.97	173.29	174.33	174.16	175.35	176.75
Main Channel	OM03	13090	170.87	170.87	173.23	174.27	174.09	175.34	176.75
Main Channel	OM03	13017	170.81	170.81	173.19	174.24	174.07	175.34	176.75
Main Channel	OM03	12944	170.65	170.65	173.12	174.27	174.10	175.34	176.75
Main Channel	OM03	12854	Railroad Crossing						
Main Channel	OM03	12786	170.44	170.44	173.02	174.17	174.05	175.28	176.66
Main Channel	OM03	12706	170.43	170.43	173.01	174.16	174.04	175.27	176.63
Main Channel	OM03	12705	Lateral Weir						
Main Channel	OM03	12543	170.40	170.40	172.99	174.15	174.04	175.26	176.63
Main Channel	OM03	12414	170.39	170.39	172.98	174.14	174.04	175.26	176.64
Main Channel	OM03	12273	Main St						
Main Channel	OM03	12237	168.74	168.74	170.84	172.11	173.15	174.34	176.57
Main Channel	OM03	12129	168.72	168.72	170.85	172.12	173.15	174.35	176.57
Main Channel	OM03	12030	168.70	168.70	170.77	171.97	173.01	174.26	176.52
Main Channel	OM02	11939	168.62	168.62	170.59	171.70	172.65	173.88	176.54
Main Channel	OM02	11923	Pedestrian Crossing						
Main Channel	OM02	11902	168.36	168.36	170.30	171.40	172.38	173.52	176.17
Main Channel	OM02	11754	168.00	168.00	169.95	171.10	172.17	173.38	175.76
Main Channel	OM02	11694	Pedestrian Crossing						
Main Channel	OM02	11644	167.75	167.75	169.69	170.84	171.96	173.20	175.07
Main Channel	OM02	11515	167.25	167.25	169.13	170.19	171.34	172.99	175.06
Main Channel	OM02	11475	W Morgan St						
Main Channel	OM02	11425	167.29	167.29	169.17	170.24	170.97	171.61	173.05
Main Channel	OM02	11259	166.48	166.48	168.33	169.34	170.06	170.74	172.02
Main Channel	OM02	11104	166.18	166.18	168.02	168.97	169.64	170.27	171.47
Main Channel	OM02	10801	165.57	165.57	167.44	168.40	169.07	169.72	170.93
Main Channel	OM02	10486	165.02	165.02	166.99	167.92	168.60	169.25	170.5
Main Channel	OM02	10167	164.68	164.68	166.74	167.66	168.34	169.00	170.52
Main Channel	OM02	9811	164.21	164.21	166.26	167.06	167.68	168.30	169.77
Main Channel	OM02	9688	163.99	163.99	165.98	166.66	167.22	167.77	169.19
Main Channel	OM02	9639	W Heaton St						
Main Channel	OM02	9590	163.82	163.82	165.79	166.38	166.88	167.40	168.83
Main Channel	OM02	9223	163.61	163.61	165.84	166.49	167.04	167.61	169.1
Main Channel	OM02	9032	163.49	163.49	165.84	166.49	167.04	167.60	169.1
Main Channel	OM01	8865	163.53	163.53	165.84	166.49	167.04	167.60	169.1
Main Channel	OM01	8807	163.49	163.49	165.84	166.49	167.04	167.60	169.1
Main Channel	OM01	8786	Pedestrian Crossing						
Main Channel	OM01	8763	163.49	163.49	165.83	166.48	167.03	167.59	169.09

EXHIBIT K - COMPUTED MAXIMUM WATER SURFACE ELEVATIONS
DeWitt County Drainage District No. 1
Master Drainage Plan, Phase One

River	Reach	River Sta	Computed Water Surface Elevation (ft NAVD88)						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Main Channel	OM01	8504	163.47	163.47	165.83	166.47	167.02	167.59	169.08
Main Channel	OM01	7921	163.43	163.43	165.82	166.46	167.00	167.57	169.06
Main Channel	OM01	7521	163.39	163.39	165.80	166.43	166.98	167.54	169.03
Main Channel	OM01	7156	163.34	163.34	165.77	166.40	166.93	167.49	168.97
Main Channel	OM01	7024	163.33	163.33	165.77	166.39	166.92	167.48	168.96
Main Channel	OM01	6910	Alonzo St						
Main Channel	OM01	6819	163.27	163.27	165.75	166.36	166.90	167.45	168.93
Main Channel	OM01	6481	163.20	163.20	165.72	166.32	166.85	167.40	168.88
Main Channel	OM01	6117	163.15	163.15	165.69	166.30	166.82	167.37	168.86
Main Channel	OM01	6023	S Esplanade St (US 183)						
Main Channel	OM01	5908	163.04	163.04	165.46	165.88	166.20	166.49	166.93
Main Channel	OM01	5836	163.01	163.01	165.44	165.84	166.13	166.40	166.74
Main Channel	OM01	5713	162.92	162.92	165.39	165.77	166.14	166.42	166.82
Main Channel	OM01	5673	Old Clinton Road						
Main Channel	OM01	5613	162.14	162.14	163.88	164.50	164.93	165.43	166.3
Main Channel	OM01	5396	161.90	161.90	163.82	164.43	164.84	165.33	166.17
Main Channel	OM01	4777	161.43	161.43	163.72	164.29	164.76	165.26	166.1
Main Channel	OM01	4526	161.26	161.26	163.68	164.23	164.74	165.24	166.08
Main Channel	OM01	4464	Stockdale Ave						
Main Channel	OM01	4406	160.29	160.29	163.56	164.11	164.62	165.12	166.06
Main Channel	OM01	4003	159.75	159.75	163.08	163.30	163.55	163.76	164.28
Main Channel	OM01	3403	158.86	158.86	162.20	162.92	163.21	163.49	164.45
Main Channel	OM01	2735	157.49	157.49	160.55	161.94	162.27	162.61	163.95
Main Channel	OM01	2065	156.29	156.29	158.83	159.97	161.06	162.05	163.73
Main Channel	MD01	1264	156.33	156.33	158.99	160.23	161.12	161.97	163.63
Main Channel	MD01	1099	155.55	155.55	158.42	159.71	160.63	161.52	163.31
Main Channel	MD01	857	154.50	154.50	157.57	158.90	159.83	160.72	162.52
West End Lateral	WE01	3453	172.42	172.42	174.13	174.59	174.92	175.31	176.82
West End Lateral	WE01	3259	171.89	171.89	174.14	174.61	174.96	175.37	176.92
West End Lateral	WE01	2986	171.87	171.87	174.12	174.59	174.93	175.34	176.91
West End Lateral	WE01	2726	171.80	171.80	174.08	174.53	174.86	175.25	176.85
West End Lateral	WE01	2596	171.77	171.77	174.07	174.53	174.85	175.25	176.87
West End Lateral	WE01	2469	171.75	171.75	174.07	174.54	174.88	175.28	176.91
West End Lateral	WE01	2264	171.73	171.73	174.07	174.53	174.86	175.26	176.9
West End Lateral	WE01	1956	171.64	171.64	174.03	174.49	174.82	175.22	176.88
West End Lateral	WE01	1871	171.66	171.66	174.04	174.50	174.83	175.23	176.89
West End Lateral	WE01	1829	Nash St						
West End Lateral	WE01	1784	170.64	170.64	173.85	174.45	174.81	175.18	176.83
West End Lateral	WE01	1668	170.61	170.61	173.83	174.43	174.78	175.15	176.81
West End Lateral	WE01	1448	170.49	170.49	173.80	174.39	174.74	175.11	176.78
West End Lateral	WE01	1208	170.39	170.39	173.77	174.34	174.69	175.05	176.75
West End Lateral	WE01	1118	170.36	170.36	173.77	174.35	174.69	175.05	176.75
West End Lateral	WE01	1067	Woodworth St						
West End Lateral	WE01	974	169.37	169.37	171.43	172.65	173.63	174.74	176.7
West End Lateral	WE01	810	169.19	169.19	171.34	172.58	173.55	174.66	176.64
West End Lateral	WE01	582	169.09	169.09	171.29	172.54	173.53	174.64	176.63
West End Lateral	WE01	139	Bridge St						
West End Lateral	WE01	102	168.90	168.90	170.98	172.19	173.17	174.36	176.52
Ice House Channel	IH01	2986	163.11	163.11	163.72	164.04	164.28	164.51	165.18

River	Reach	River Sta	Computed Water Surface Elevation (ft NAVD88)						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Ice House Channel	IH01	2740	162.87	162.87	163.29	163.55	163.73	163.96	164.73
Ice House Channel	IH01	2527	162.73	162.73	163.01	163.16	163.19	163.32	164.39
Ice House Channel	IH01	2487	Stockdale Ave						
Ice House Channel	IH01	2433	160.94	160.94	162.07	162.54	162.88	163.30	164.35
Ice House Channel	IH01	2254	160.69	160.69	161.79	162.28	162.64	163.10	164.27
Ice House Channel	IH01	1891	160.25	160.25	161.44	161.90	162.28	162.77	164.1
Ice House Channel	IH01	1448	159.69	159.69	161.06	161.54	161.98	162.56	164.01
Ice House Channel	IH01	1135	159.35	159.35	160.90	161.42	161.91	162.52	163.99
Ice House Channel	IH01	860	159.15	159.15	160.83	161.36	161.87	162.50	163.98
Ice House Channel	IH01	485	159.01	159.01	160.76	161.31	161.83	162.47	163.97
Ice House Channel	IH01	349	158.97	158.97	160.74	161.29	161.82	162.46	163.96
Ice House Channel	IH01	67	158.88	158.88	160.69	161.25	161.79	162.44	163.95
Daule Channel	DD01	4454	173.99	173.99	174.92	175.56	175.80	176.17	177.1
Daule Channel	DD01	4372	173.99	173.99	174.91	175.55	175.79	176.16	177.08
Daule Channel	DD01	4275	173.99	173.99	174.91	175.55	175.79	176.15	177.08
Daule Channel	DD01	4101	173.99	173.99	174.91	175.54	175.78	176.14	177.07
Daule Channel	DD01	4008	173.89	173.89	174.78	175.41	175.61	175.95	176.81
Daule Channel	DD01	3771	173.93	173.93	174.83	175.45	175.66	176.01	176.89
Daule Channel	DD01	3615	173.93	173.93	174.82	175.45	175.66	176.01	176.89
Daule Channel	DD01	3475	173.92	173.92	174.81	175.43	175.63	175.97	176.83
Daule Channel	DD01	3332	173.88	173.88	174.75	175.37	175.54	175.87	176.7
Daule Channel	DD01	3173	173.61	173.61	174.43	175.10	175.12	175.42	176.2
Daule Channel	DD01	2984	173.43	173.43	174.31	175.05	175.02	175.33	176.13
Daule Channel	DD01	2850	173.41	173.41	174.28	175.02	174.99	175.29	176.08
Daule Channel	DD01	2781	Daule St						
Daule Channel	DD01	2747	173.41	173.41	174.29	175.02	174.99	175.30	176.09
Daule Channel	DD01	2720	173.41	173.41	174.28	175.01	174.98	175.28	176.07
Daule Channel	DD01	2672	Bridge St						
Daule Channel	DD01	2611	173.23	173.23	174.25	175.01	174.96	175.27	176.06
Daule Channel	DD01	2467	173.05	173.05	174.19	174.97	174.89	175.20	175.99
Daule Channel	DD01	2300	173.00	173.00	174.17	174.95	174.87	175.17	175.95
Daule Channel	DD01	2255	Aggie St						
Daule Channel	DD01	2203	172.96	172.96	174.15	174.94	174.83	175.14	175.91
Daule Channel	DD01	2078	172.66	172.66	174.05	174.86	174.69	174.98	175.7
Daule Channel	DD01	1958	171.77	171.77	173.04	173.64	174.23	174.58	175.24
Daule Channel	DD01	1855	170.67	170.67	171.82	172.71	173.40	173.58	174.6
Daule Channel	DD01	1734	170.40	170.40	171.51	172.43	173.11	173.65	172.22
Daule Channel	DD01	1601	169.98	169.98	170.02	170.41	170.93	171.41	172.58
Daule Channel	DD01	1386	170.00	170.00	170.36	170.59	170.74	170.89	171.29
Daule Channel	DD01	1245	170.00	170.00	170.34	170.56	170.70	170.84	171.2
Daule Channel	DD01	1182	W Heaton St						
Daule Channel	DD01	1120	166.18	166.18	166.71	166.71	167.05	167.62	169.11
Daule Channel	DD01	777	163.56	163.56	165.85	166.50	167.05	167.61	169.11
Daule Channel	DD01	412	163.56	163.56	165.85	166.49	167.04	167.61	169.11
Daule Channel	DD01	176	163.55	163.55	165.84	166.49	167.04	167.61	169.1