Memphis District
Mississippi River Valley Division

Appendix G: Hydrologic and Hydraulic Appendix

Memphis Metropolitan Stormwater-North Desoto County, Mississippi

May 2021

CONTENTS

1.0 GENERAL DESCRIPTION OF WORK

The US Army Corps of Engineers (USACE), Memphis District (MVM), Hydraulics and Hydrology (H&H) Branch performed hydrologic and hydraulic modeling for the North Desoto County Feasibility Study. The major basins studied are Horn Lake Creek and Coldwater River. The purpose of this hydrologic and hydraulic modeling effort is to evaluate various design alternatives for Flood Risk Management (FRM). Hydrologic and Hydraulic models of the Horn Lake Creek Basin were developed by the Memphis District and modified to reflect development in the basin since the previous study in 2005. Modeling was performed for the 0.99, 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, and 0.002 Annual Exceedance Probability (AEP) rainfall events for existing conditions (year 2019), multiple design alternatives (year 2026), and Future without Project (FWOP, year 2070). Maximum water surface elevation results were extracted for each model run and provided to the Project Delivery Team (PDT) for use in economic, environmental, and engineering analyses.

2.0 SOFTWARE

2.1 HEC-HMS 4.3

The latest version of the USACE Hydraulic Engineering Center's (HEC) Hydrologic Modeling System (HMS), that was considered current, at the time of model development was version 4.3 and was used for the hydrologic modeling.

2.2 HEC-RAS 5.0.7

The latest version of the HEC's River Analysis System (RAS) that was considered current was version 5.0.7 and used for the updated hydraulic modeling.

3.0 MODEL DEVELOPMENT

The hydrologic and hydraulic models of the Horn Lake Creek Basin were originally developed for the Desoto County Flood Insurance Study (FIS) dated 1993, updated for the Memphis Metro Study dated 1997 and most recently for the Horn Lake Creek Study dated 2005. Although the study resulted in a positive economic analysis, a final report was never completed. To expedite this study process, the 2005 hydrologic and hydraulic information was utilized and updated to 2018 conditions, where possible.

The 2005 HEC-1 was imported into HMS. Runoff characteristics are based on 2002 land use. The HEC-2 model used for the 2005 study was imported into a HEC-RAS 1D Steady flow model. Channel conditions for the model are based on 2002 field surveys. Overbank geometry for the 2005 model was based on LiDAR flown in 2001. A field reconnaissance was conducted and coordinated with the sponsors to ensure any major construction in the streams and floodplain, not included in the previous studies, are captured in this analysis.

The Coldwater River Basin information was provided by the Vicksburg District and external Project Delivery team member (Waggoner Engineering). A majority of the RAS model results are shown in the Desoto County FIS. Information was readily available for the 10-year, 50-year, 100-year, and 500-year floods (0.1, 0.02 0.01 and 0.001 Annual Exceedance Probabilities (AEPs). Additional analysis and modeling was conducted in this study to develop information related to the 1.01-year, 2-year, 5-year, and 25-year (0.99, 0.50, 0.20, and 0.04 AEPs) floods.

4.0 HYDROLOGY

4.1 Basin Description

The Horn Lake Creek drainage basin is in the north central part of DeSoto County, Mississippi, and the southwest part of Shelby County, Tennessee. Horn Lake Creek, with a total drainage area of 54 square miles at the lower study limits, is a tributary of the Mississippi River. Horn Lake Creek and its tributaries serve as the primary drainage outlets for the cities of Horn Lake and Southaven, Mississippi. Tributaries in the basin include Rocky Creek, Cow Pen Creek, Lateral D, and Lateral E. The slope of Horn Lake Creek above Interstate Highway 55 is approximately 1.8 feet per Stream Mile. This slope steepens to approximately 5.9 feet per mile downstream between Interstate 55 and the Illinois Central Gulf Railroad.

Coldwater River Watershed encompasses 392,000 acres located in all or some portions of DeSoto, Marshall, and Tate counties. Tributaries in the watershed include Beartail Creek, Beartail Tributary, Buttermilk Creek, Byhalia Creek, Camp Creek, Chew Creek, Cuffawa Creek, Lick Creek, Little Beartail Creek, Nolehoe Creek, Nunnally Creek, Pigeon Roost Creek, and Red Banks Creek. The slopes within the watershed vary due in part to approximately 40 in-stream grade control structures installed by Vicksburg District as part of the Delta Headwaters Program."

The primary streams identified with flood risk were Upper Coldwater River, Licks Creek, Nolehoe Creek, and Camp Creek. Camp Creek, Nolehoe Creek and Lick Creek are major tributaries in the town of Olive Branch. Camp Creek is 63.6 square miles and has an approximate basin slope of 8.4 feet per mile. The drainage area of Nolehoe Creek is 9.9 square miles and the drainage area of Lick Creek is approximately 10.0 square miles. Basins slopes are 15.6 feet per mile and 18.1 feet per mile for Lick Creek and Nolehoe Creek, respectively.

Three tributaries within the Coldwater Basin provide drainage for the City of Hernando. Hurricane Creek drains the northwestern portion of the City. Short Fork Creek drains the eastern side of the community generally east of Interstate 55. Mussacunna Creek system drains the southwest portion of Hernando.

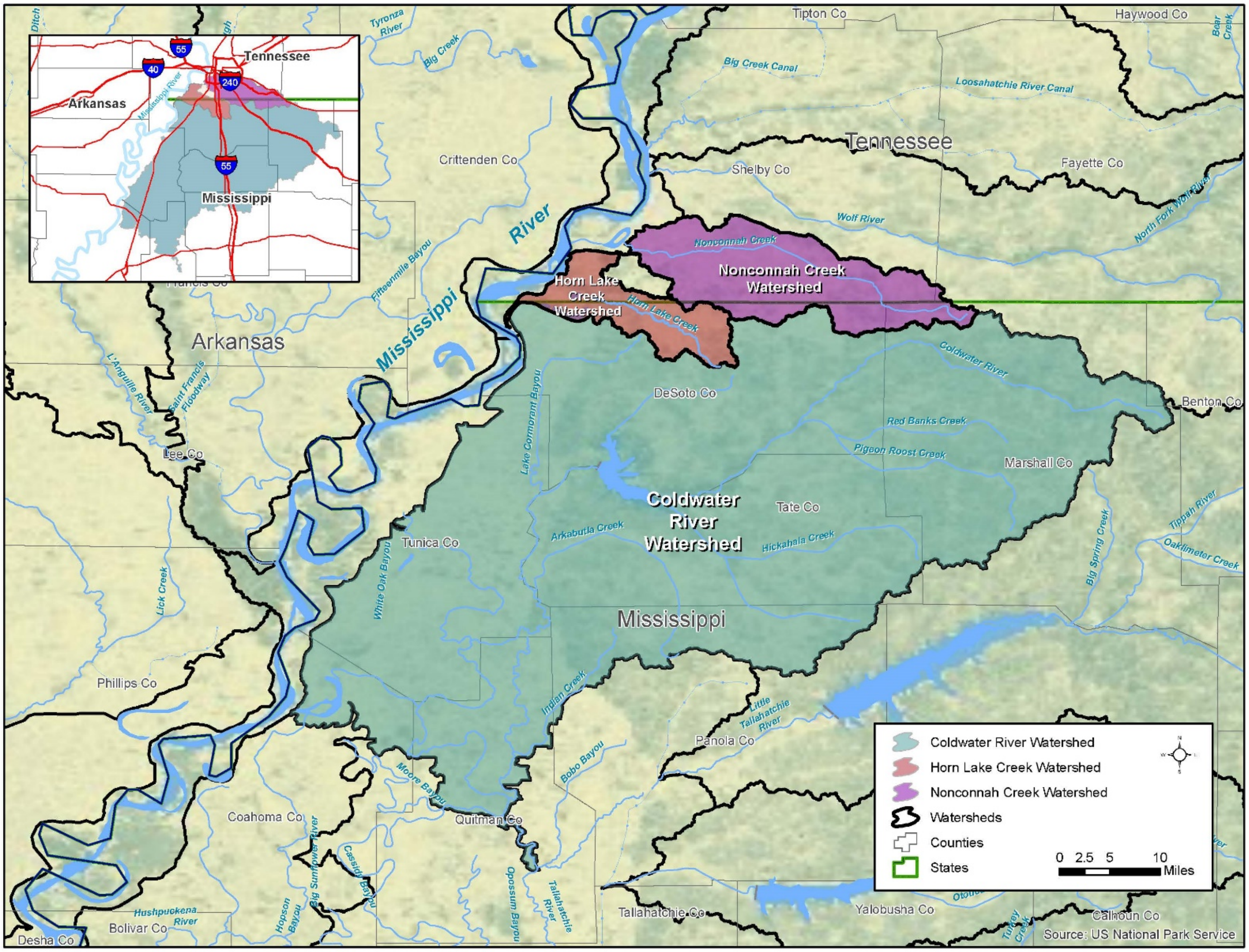

Figure 1 – Horn Lake Creek, Nonconnah Creek and Coldwater River Basins

4.2 Precipitation

Eight precipitation events were evaluated: the 1.01- year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 500-year average recurrence interval (0.99, 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, and 0.002 AEP), 24-hour duration events. Precipitation hyetographs were developed for each of those events based on rainfall intensities from the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 Point Precipitation Frequency Estimates. Figure 2 shows frequency estimates of precipitation intensity for the Horn Lake Creek basin from NOAA Atlas 14.

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.493 (0.417-0.585)	0.557 (0.471-0.661)	0.659 (0.556-0.785)	0.742 (0.623-0.887)	0.855 (0.696-1.04)	0.939 (0.751-1.16)	1.02 (0.795-1.28)	1.11 (0.830-1.42)	1.21 (0.881-1.59)	1.29 (0.920-1.71)
10-min	0.722 (0.611-0.857)	0.815 (0.690-0.969)	0.965 (0.814-1.15)	1.09 (0.913-1.30)	1.25 (1.02-1.52)	1.38 (1.10-1.69)	1.50 (1.16-1.88)	1.62 (1.22-2.07)	1.77 (1.29-2.32)	1.89 (1.35-2.51)
15-min	0.880 (0.746-1.05)	0.994 (0.841-1.18)	1.18 (0.993-1.40)	1.33 (1.11-1.58)	1.53 (1.24-1.86)	1.68 (1.34-2.07)	1.83 (1.42-2.29)	1.97 (1.48-2.53)	2.16 (1.57-2.83)	2.30 (1.64-3.06)
30-min	1.17 (0.989-1.39)	1.32 (1.12-1.57)	1.58 (1.33-1.88)	1.78 (1.50-2.13)	2.06 (1.68-2.50)	2.26 (1.81-2.79)	2.47 (1.92-3.10)	2.67 (2.01-3.42)	2.93 (2.13-3.84)	3.12 (2.23-4.15)
60-min	1.49 (1.26-1.77)	1.68 (1.42-1.99)	1.98 (1.67-2.36)	2.23 (1.87-2.66)	2.57 (2.10-3.14)	2.84 (2.28-3.50)	3.11 (2.42-3.90)	3.37 (2.54-4.33)	3.73 (2.72-4.89)	4.00 (2.85-5.31)
2-hr	1.82 (1.55-2.14)	2.03 (1.73-2.39)	2.38 (2.03-2.81)	2.68 (2.27-3.17)	3.09 (2.55-3.75)	3.42 (2.76-4.19)	3.74 (2.94-4.67)	4.08 (3.09-5.20)	4.53 (3.32-5.90)	4.87 (3.50-6.42)
3-hr	2.05 (1.75-2.40)	2.28 (1.95-2.67)	2.66 (2.27-3.13)	2.99 (2.54-3.53)	3.46 (2.87-4.18)	3.83 (3.11-4.68)	4.21 (3.32-5.24)	4.60 (3.51-5.85)	5.14 (3.79-6.68)	5.56 (4.00-7.30)
6-hr	2.47 (2.13-2.87)	2.77 (2.38-3.22)	3.26 (2.81-3.80)	3.69 (3.16-4.31)	4.30 (3.59-5.17)	4.79 (3.92-5.81)	5.29 (4.21-6.55)	5.82 (4.47-7.35)	6.54 (4.86-8.44)	7.11 (5.15-9.27)
12-hr	2.93 (2.55-3.38)	3.34 (2.91-3.85)	4.03 (3.49-4.65)	4.62 (3.98-5.35)	5.44 (4.58-6.48)	6.10 (5.03-7.34)	6.77 (5.42-8.31)	7.47 (5.77-9.36)	8.42 (6.29-10.8)	9.16 (6.69-11.9)
24-hr	3.46 (3.03-3.95)	3.97 (3.48-4.54)	4.83 (4.22-5.53)	5.56 (4.83-6.38)	6.59 (5.58-7.78)	7.40 (6.14-8.83)	8.24 (6.64-10.0)	9.10 (7.08-11.3)	10.3 (7.73-13.1)	11.2 (8.22-14.4)
2-day	4.06 (3.59-4.59)	4.61 (4.07-5.23)	5.55 (4.89-6.30)	6.36 (5.57-7.25)	7.52 (6.42-8.81)	8.44 (7.06-10.00)	9.39 (7.63-11.3)	10.4 (8.14-12.8)	11.8 (8.90-14.8)	12.8 (9.48-16.4)
3-day	4.46 (3.96-5.02)	5.05 (4.47-5.68)	6.04 (5.34-6.82)	6.90 (6.07-7.82)	8.13 (6.97-9.48)	9.11 (7.66-10.7)	10.1 (8.27-12.2)	11.2 (8.81-13.8)	12.7 (9.63-15.9)	13.8 (10.3-17.5)
4-day	4.81 (4.29-5.40)	5.42 (4.82-6.09)	6.45 (5.72-7.26)	7.34 (6.48-8.28)	8.61 (7.41-10.0)	9.63 (8.11-11.3)	10.7 (8.74-12.8)	11.8 (9.30-14.4)	13.3 (10.1-16.7)	14.5 (10.8-18.3)
7-day	5.78 (5.18-6.43)	6.42 (5.75-7.16)	7.51 (6.70-8.38)	8.43 (7.49-9.45)	9.75 (8.44-11.2)	10.8 (9.15-12.6)	11.9 (9.77-14.1)	13.0 (10.3-15.8)	14.5 (11.1-18.1)	15.7 (11.8-19.8)
10-day	6.61 (5.95-7.32)	7.30 (6.56-8.10)	8.46 (7.58-9.40)	9.45 (8.43-10.5)	10.8 (9.41-12.4)	11.9 (10.2-13.8)	13.1 (10.8-15.4)	14.2 (11.3-17.2)	15.8 (12.1-19.6)	17.0 (12.8-21.3)
20-day	8.82 (8.00-9.69)	9.75 (8.84-10.7)	11.3 (10.2-12.4)	12.5 (11.3-13.9)	14.3 (12.5-16.2)	15.6 (13.4-17.9)	17.0 (14.1-19.9)	18.4 (14.7-22.0)	20.2 (15.7-24.8)	21.6 (16.4-27.0)
30-day	10.7 (9.74-11.7)	11.8 (10.8-12.9)	13.7 (12.4-15.0)	15.2 (13.7-16.7)	17.3 (15.1-19.4)	18.8 (16.2-21.4)	20.4 (17.0-23.7)	21.9 (17.6-26.1)	23.9 (18.6-29.2)	25.4 (19.3-31.5)
45-day	13.1 (12.0-14.3)	14.5 (13.3-15.8)	16.8 (15.3-18.3)	18.6 (16.9-20.4)	21.0 (18.4-23.4)	22.8 (19.6-25.7)	24.4 (20.4-28.2)	26.1 (21.0-30.8)	28.1 (21.9-34.1)	29.6 (22.6-36.6)
60-day	15.3 (14.0-16.5)	16.9 (15.5-18.3)	19.5 (17.9-21.2)	21.6 (19.6-23.5)	24.2 (21.3-26.8)	26.0 (22.5-29.3)	27.8 (23.3-31.9)	29.4 (23.8-34.6)	31.4 (24.5-37.9)	32.8 (25.1-40.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 1
Point Precipitation Frequency Estimates from NOAA Atlas 14-Desoto County, MS

5.0 Climate Change Assessment for Desoto County, Mississippi

5.1 Introduction

In 2016, USACE issued Engineering and Construction Bulletin No. 2016-25 (USACE, 2016) (hereafter, ECB 2016-25), which mandated that climate change be considered for all federally funded projects in planning stages. This guidance was updated with ECB 2018-14 (USACE, 2018). A qualitative analysis of historical climate trends, as well as assessment of future projections was provisioned by ECB 2018-14. An extensive analysis was conducted for study, in accordance with the cited guidance, and presented in Climate Change Appendix. The following paragraphs briefly summarize the data used.

Detailed information presented in the appendix is related to the Horn Lake Creek basin since the primary Flood Risk Management project measures in this study lie within this watershed. It is assumed the Climate Change results and indicators would be representative of conditions in the Coldwater River Basin, if needed. Non-structural measures were investigated in both the Horn Lake Creek and Coldwater Basins and climate change assumptions and results were included in the Appendix.

5.2 Literature Review

As mandated in the guidance, A literature review was performed to summarize climate change literature relevant to the study area and highlight both observed and projected assessments of relevant climate change variables. As this is a flood risk management study, the primary relevant variable is streamflow. This variable is also affected by precipitation and air temperature. Therefore, this review focuses on observed and projected changes in air temperature, precipitation, and hydrology.

5.2.1 Temperature Precipitation

The IWR's Climate Change Literature Review notes that there is a statistically significant increasing trend in the number of one day extreme minimum temperatures in the Lower Mississippi Region. The consensus from the Climate Change Literature Review indicates only mild increases in annual temperature in the region over the past century with significant variability. However, there is consensus that the extreme minimum daily air temperatures are increasing.

Similar warming trends have been noted in the project area. The longest running gage in the area, located at the Memphis International Airport (MEM) has continuous records going back to the 1940s and is located seven miles south of the headwaters of the study area, as shown in Figure 2.

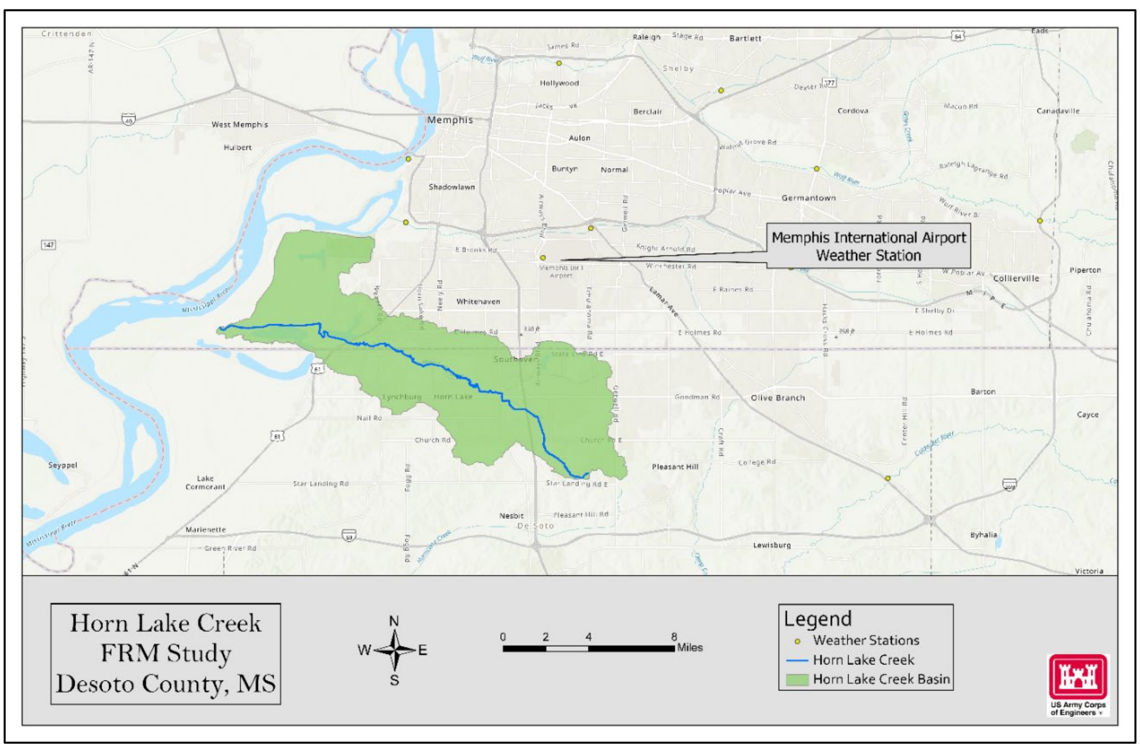

Figure 2. Study area and Memphis International Airport (MEM) Weather Station Statistical Temperature and precipitation Analysis for the Horn Lake Creek Basin

From 1930 to 1970, the average annual temperature at the gage followed no noticeable trend but transitioned to a consistent increase starting in the 1970s. The temperature period of record is shown in Figures 3 and 4.

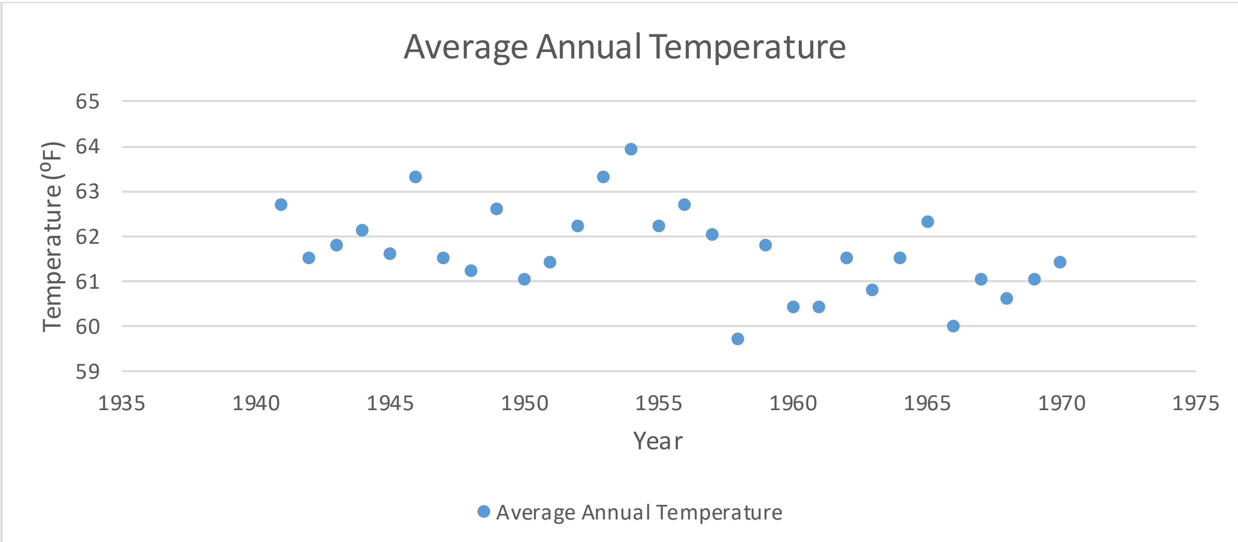

Figure 1: Annual average temperature from 1940 – 1970

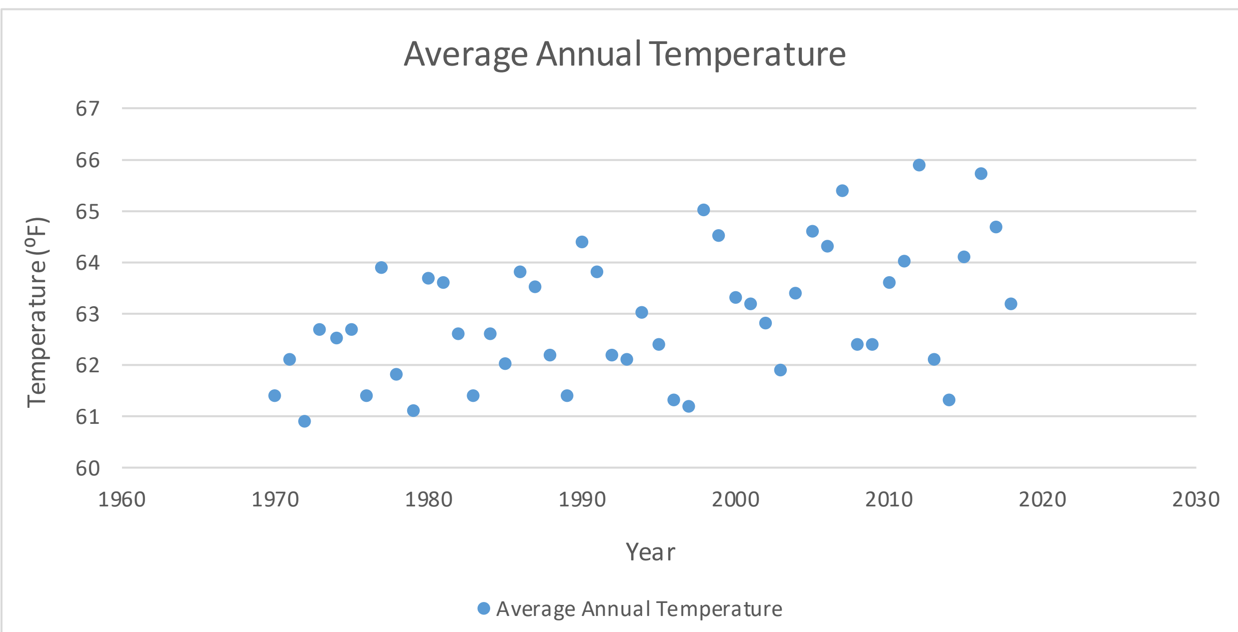

Figure 4: Annual average temperature from 1970 – 2018

5.2.2 Precipitation

The MEM Airport weather station shows variable annual average precipitation since 1940. The results in the Appendix show no statistically significant upward trend. Visually, it appears that extremes at either end are becoming more severe since the 1970s. An attempt to analyze the extremes was not undertaken since preliminary results showed no major concerns.

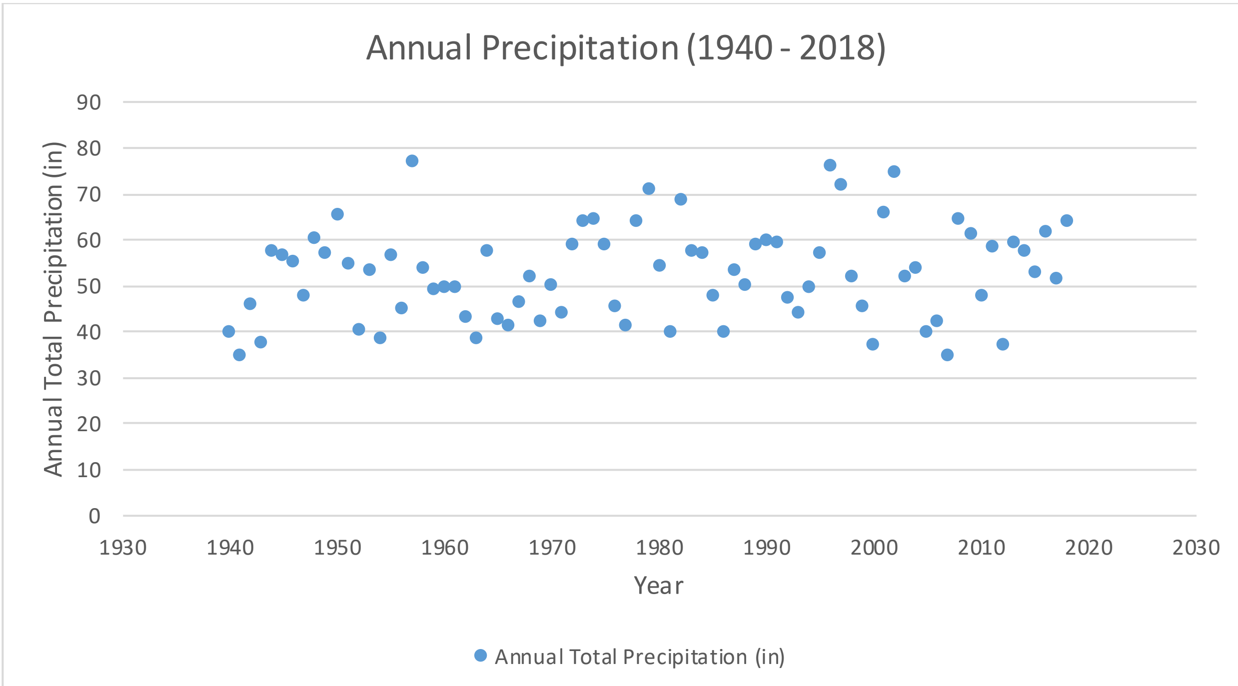

Figure 5. Annual total precipitation 1940 - 2018

5.2.3 Hydrology

5.2.3.1 Observed Streamflow

Generalized observations of streamflow trends in the Lower Mississippi River Region lack a clear consensus, with some models showing positive trends in some areas and others showing negative trends for areas in the southeast. Generally, most studies in the Lower Mississippi River Region indicated an increasing trend in streamflow.

Horn Lake Creek does not have a discharge gage, but a gage is located east in the adjacent Coldwater Basin. The USGS gage 07275900 on the Coldwater River near Olive Branch, MS, as shown in Figure 6,

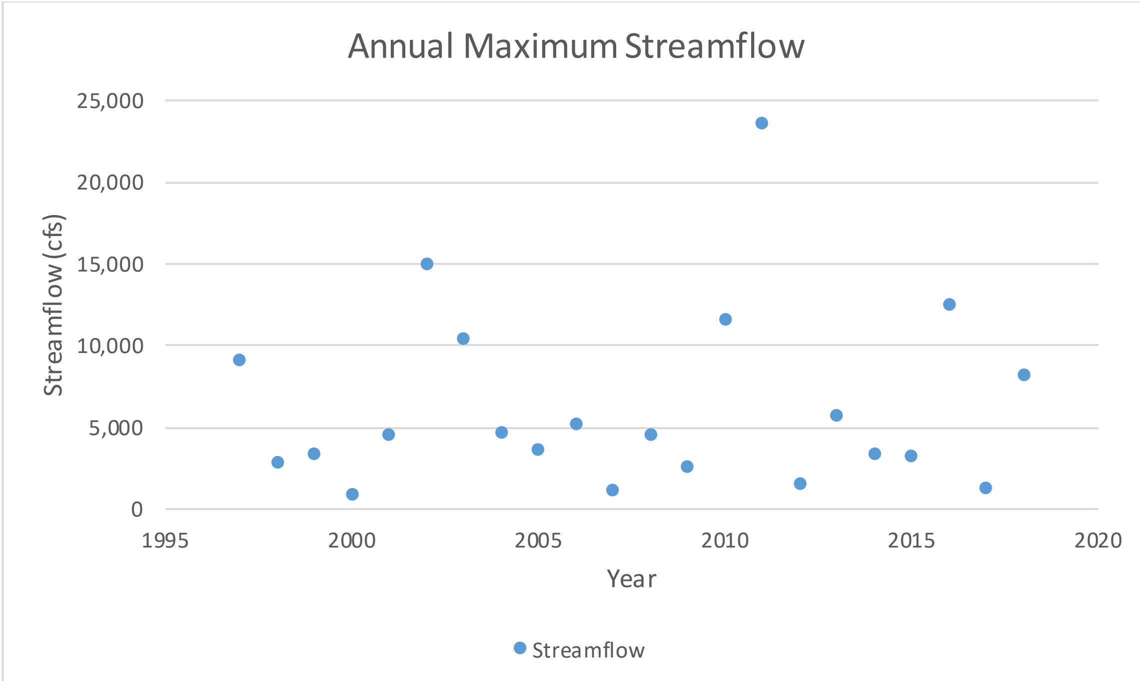

Figure 6: Annual Peak Streamflow at USGS 07275900 Gage Coldwater River near Olive Branch, MS

5.3 Non-Stationarity Assessment

In accordance with ECB 2018-14, a stationarity analysis was performed to determine if there are long-term changes in peak streamflow statistics within the Horn Lake Creek basin and its vicinity. Assessing trends in peak streamflow is considered appropriate as one of the primary purposes of this feasibility study is to assess and reduce flooding in the Horn Lake Creek Basin.

The Tentatively Selected Plan flood risk management measures include channel enlargement, inline storage, and off-channel storage and are significantly affected by changes in peak streamflow.

5.3.1 USACE Non-Stationarity Tool

The USACE Nonstationarity Tool was used to assess possible trends and change points in peak streamflow in the region. Since the Horn Lake basin does not possess a stream gage, USGS 7032200 was used for the analysis (Figure 7). The green area encompasses the study area within the larger Horn Lake Creek Basin. The gage in this analysis is located on Nonconnah Creek, approximately 8.6 miles northeast of the Horn Lake Creek Watershed boundary. The Nonconnah Creek gage was chosen as its topography and basin size are comparable to Horn Lake Creek.

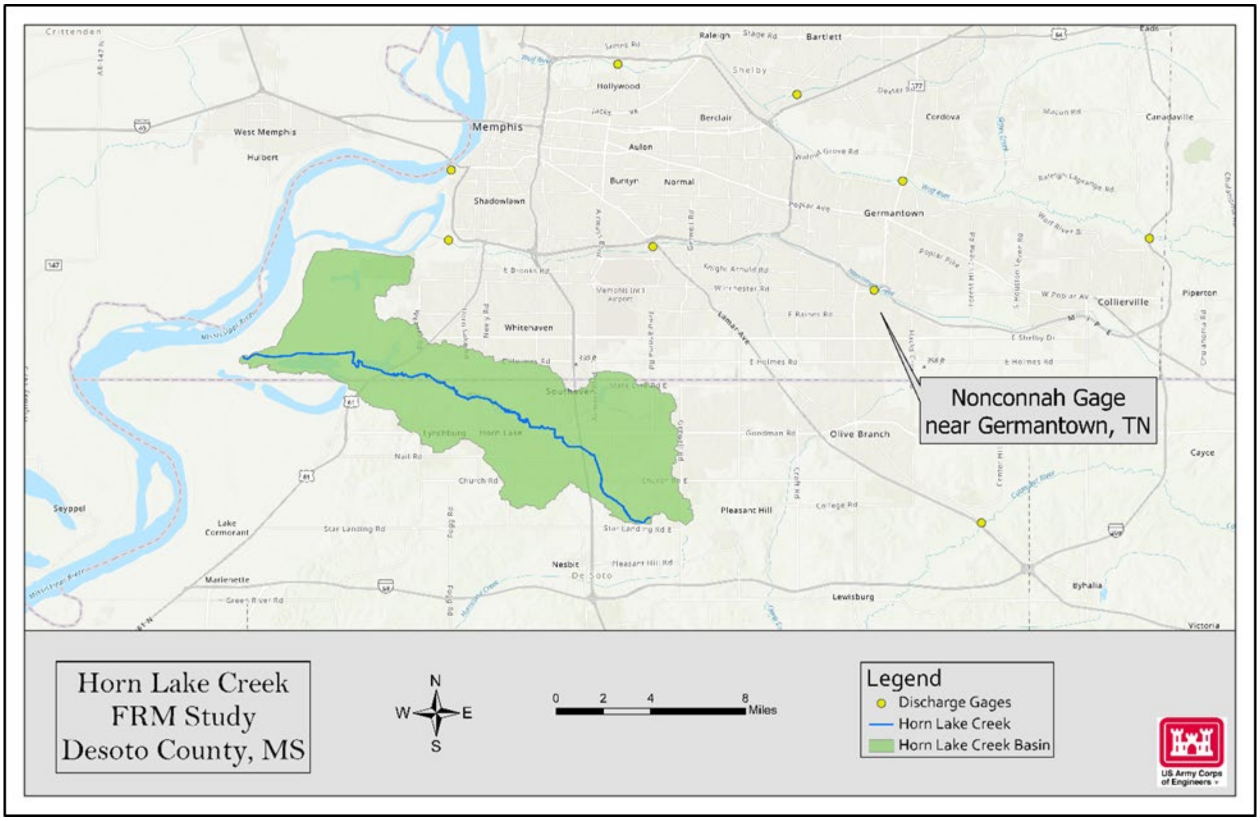

Figure 7: The Horn Lake Creek Basin in relation to the Nonconnah Gage near Germantown, TN

Additionally, this gage is the only site with similar basin characteristics in the area and at least 30 continuous years of record which is the minimum recommended years for this tool to detect non-stationarities. For this assessment, the continuous period of water years 1970 – 2014 was analyzed.

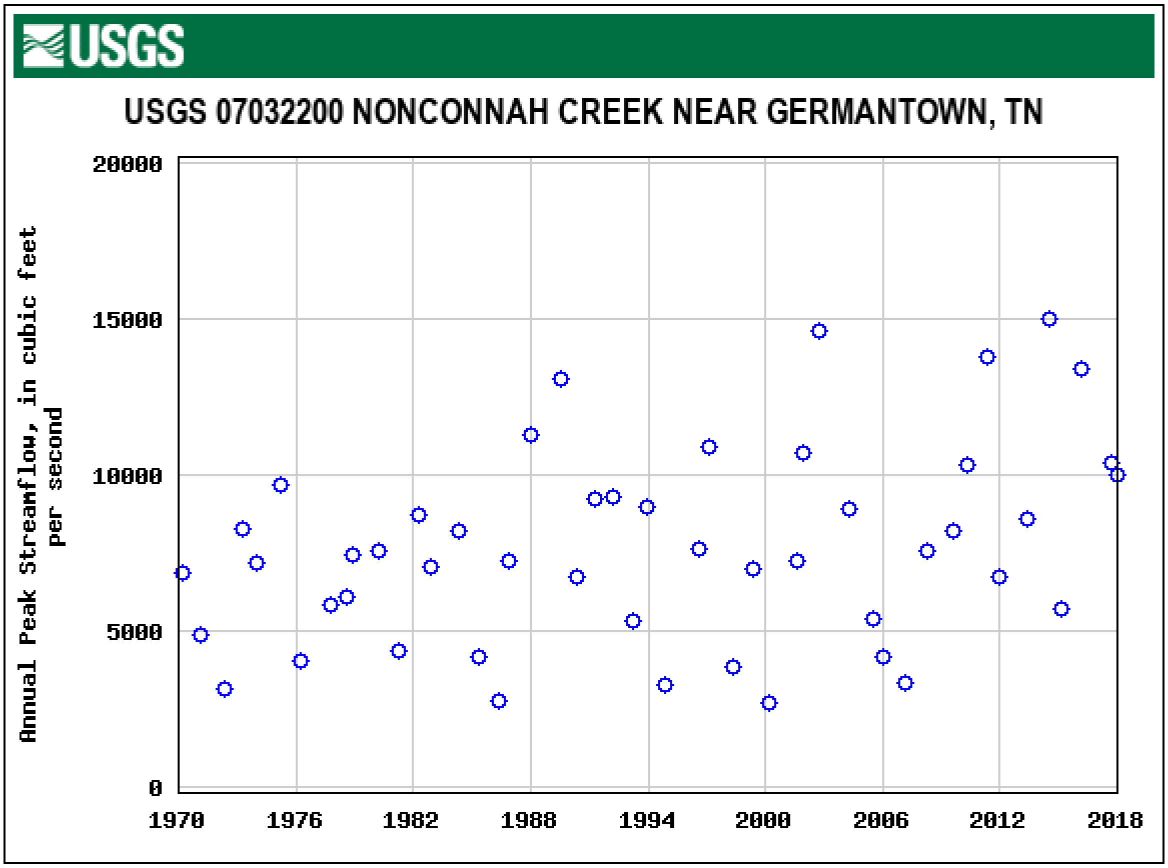

Figure 2: APF at USGS 07032200 Nonconnah Creek near Germantown, TN

5.3.3. Climate Hydrology Assessment

In addition to the stationarity assessment, the USACE Climate Hydrology Assessment Tool (CHAT) was used to assist in the determination of future streamflow conditions. For this assessment, the USGS 07032200 (Nonconnah Creek) was also used. The Nonconnah Creek basin continues to experience development and is projected to continue this growth for the near future. This development was a major consideration in quantifying the anticipated impacts from climate change.

5.4 Vulnerability Assessment

To understand potential climate change effects and to increase resilience/decrease vulnerability of flood risk management alternatives to climate change, the relative vulnerability of the basin to such factors was analyzed. In accordance with ECB 2018-14, the USACE Watershed Climate Vulnerability Assessment tool was used to identify vulnerabilities to climate change on a HUC-4 watershed scale relative to other HUC-4 basins across the nation. As this study is an assessment of flood risk management alternatives, vulnerability with respect to the Flood Risk Reduction business line is presented in the Climate Change Appendix H.

The Lower Mississippi-Hatchie HUC-4 Basin was used for this assessment. To address vulnerabilities due to climate change, the Vulnerability Assessment tool utilized two 30-year epochs centered on 2050 (2035-2064) and 2085 (2070-2099) as well as a base epoch. This provided two scenarios (wet and dry) for each of the two epochs, excluding the base epoch. Consideration of both wet and dry scenarios reveals some of the uncertainties associated with the results produced using the climate changed hydrology and meteorology used as inputs to the vulnerability tool.

6.0 Hydrologic Methodology and Modeling

6.1 Horn Lake Creek HEC-1 to HEC-HMS Conversion

As stated in Section 3.0, hydrologic modeling for this study was performed by importing the 2005 HEC-1 model into HEC-HMS version 4.3. The Horn Lake Creek drainage area was originally divided into subareas to simulate the runoff process. A synthetic unit hydrograph was developed for each subarea using Snyder's Unit Hydrograph method. Atlas 14 hypothetical rainfall was applied to the synthetic unit hydrograph to develop a flood hydrograph for each subarea. To develop composite hydrographs at all pertinent points within the basin, the flood hydrographs were combined and routed using the modified Puls and normal depth methods of stream flow routing. Modified Puls volume versus discharge relationships were derived using the original HEC-2 model and updated using the 2018 HEC-RAS model. The Modified Puls relationship was adjusted to reflect improved conveyance for channel improvement alternatives.

Figure 9 shows a delineation of the subareas for the Horn Lake Creek drainage basin developed in the original HEC-1 model. It should be noted the model extends into Highway 61 in Shelby County, Tennessee.

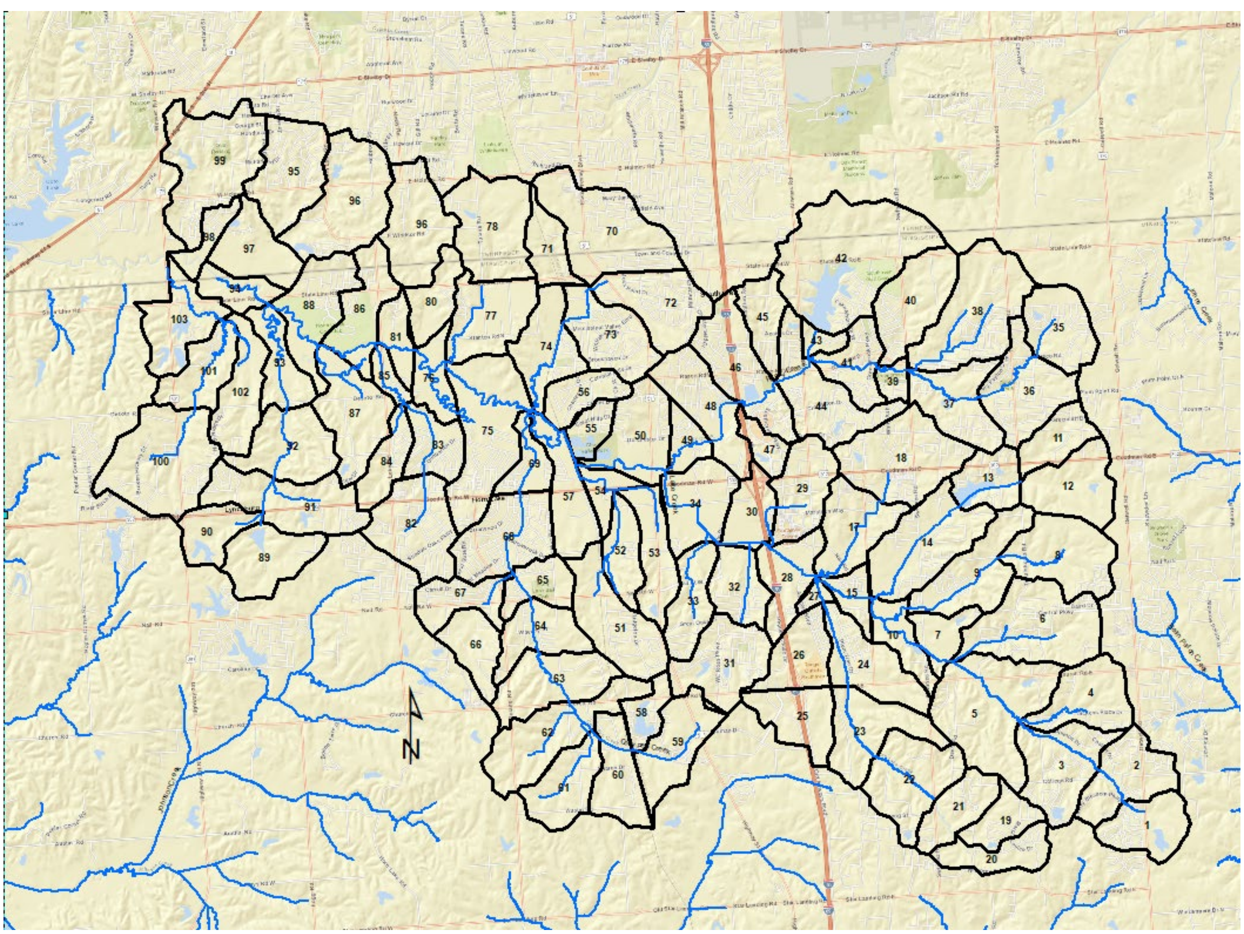

Figure 9.-Horn Lake Creek Subarea Delineation

The import process created a basin model, meteorological model and control specifications as needed for HEC-HMS. All features in the HEC-1 were successfully imported and only required very minor modifications to reproduce similar results.

6.2 Horn Lake Creek Basin Unit Hydrograph Parameters

Synthetic unit hydrographs were developed for each subarea using Snyder’s Unit Hydrograph method. Coefficients required in Snyder's relationship varied depending on individual drainage basin characteristics. All hydrologic coefficients, except for Snyder’s time to peak, Tp, were unchanged and parameters (i.e. watercourse lengths) were not altered for the present study. The criteria used to select C_t and C_p values were developed during a previous analysis of several gaged basins in the Memphis District. C_t and C_p values are regional coefficients dependent upon basin slopes, stream patterns, shapes, and other properties. Snyder's lag time, T_p, was calculated for each subarea from measured values of L and L_{ca} based on a weighted stream slope. The equation for Snyder’s T_p is shown below:

$$T_p=C_t\,(L*L_{ca})^{0.3}$$

Where:

L is the length in miles of the primary watercourse from the sub-basin outlet to the watershed divide.
L_{ca} is the length in miles of the primary watercourse from the sub-basin outlet to the center of gravity of the basin.

6.2 Coldwater River Basin (Desoto County FIS)

Hydrologic information for this basin is presented in the Desoto County Flood Insurance Study. Peak flows for the streams studied by detailed and limited details methods. The flows in several basins were developed using HEC-HMS. The SCS Curve Number method was used, and average antecedent moisture conditions were assumed. Time of Concentration (TC) values were calculated based on the SCS Lag method, using subbasin slope, CN and hydraulic length. Regression equations were used for the remaining basins. Rural reqression values were updated to reflect stream gage weighting. The Upper Camp Creek watershed is shown on Figure 10 highlighting the Nolehoe and Lick Creek basins.

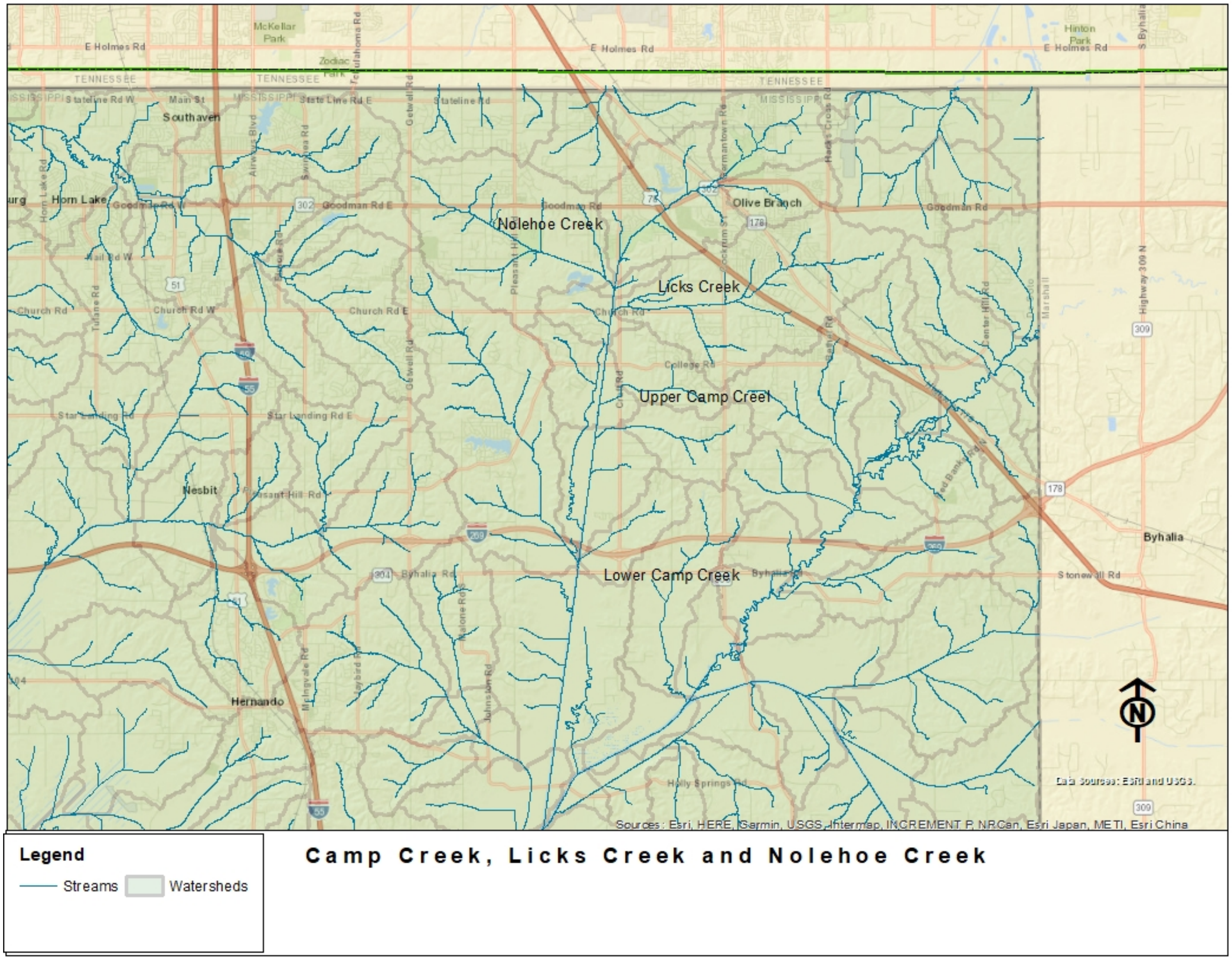

Figure 10.- Camp Creek Watershed

6.3 Horn Lake Creek Basin Urban Growth Estimates

Hydrologic parameters in HMS were adjusted to quantify the impacts to peak runoff rates in the Horn Lake Creek basin. Desoto County GIS department provided land use information showing subdivisions built prior to the 2002 study and the residential growth that transpired from 2002 to 2018. Figure 11 shows an estimate of the residential growth and development.

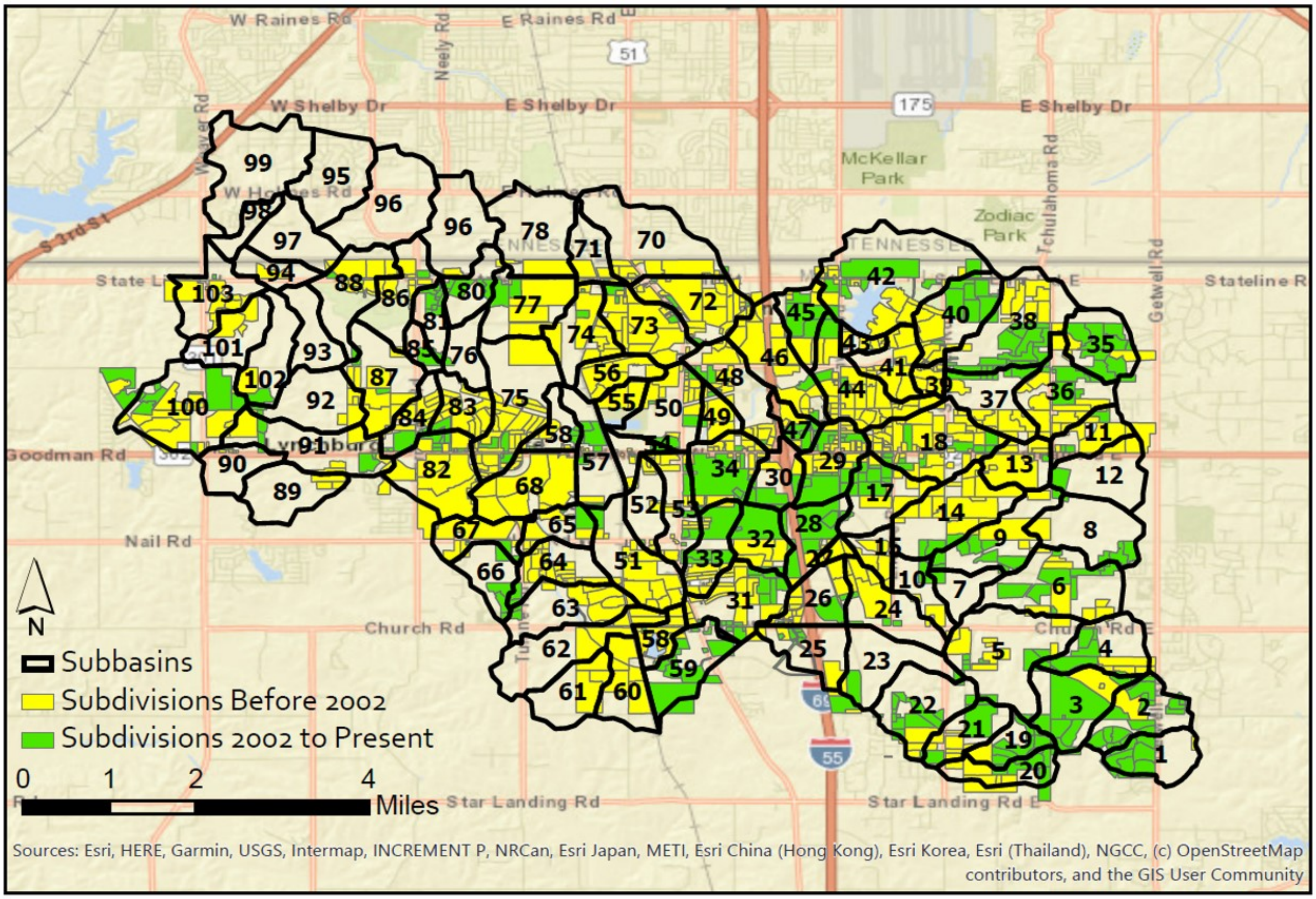

Figure 11. Horn Lake Creek HEC-HMS Hydrologic Subareas

Recent aerial photography was combined with the Desoto County subdivision land use map to approximate the total development that has occurred since the 2005 feasibility study. Subarea parameters were modified if pervious areas were converted to impervious surfaces by the construction of typical commercial, industrial, and office facilities. Residential development was considered to impact runoff if lot sizes were less than approximately three-fourths of an acre. MVM has traditionally assumed larger lot sizes possess pervious areas that tend to reduce rainfall runoff quantities and lessen urban development impact. The following bar-charts show the total growth, which includes both commercial and residential development, and their resulting changes to land use as applied to each individual subarea.

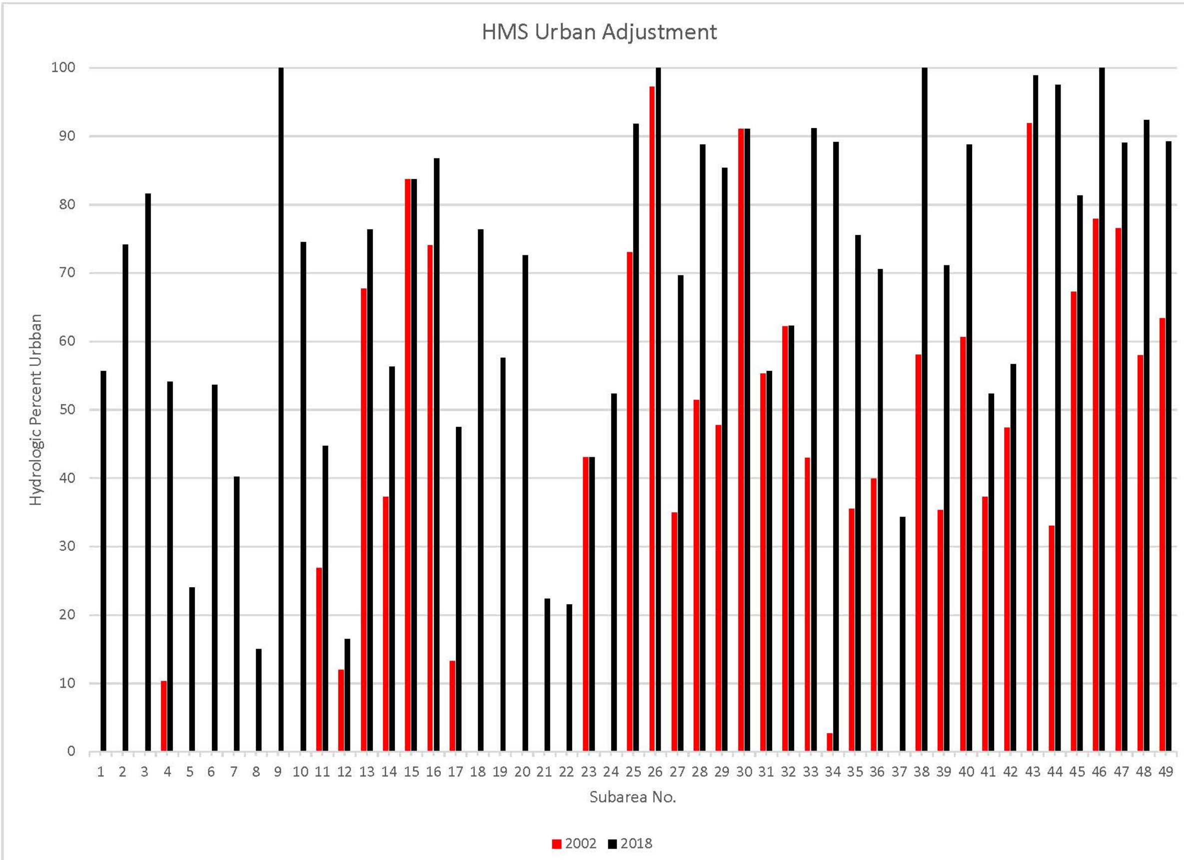

Figure 12. Subarea HEC-HMS Percent Urban 2002 vs. 2018

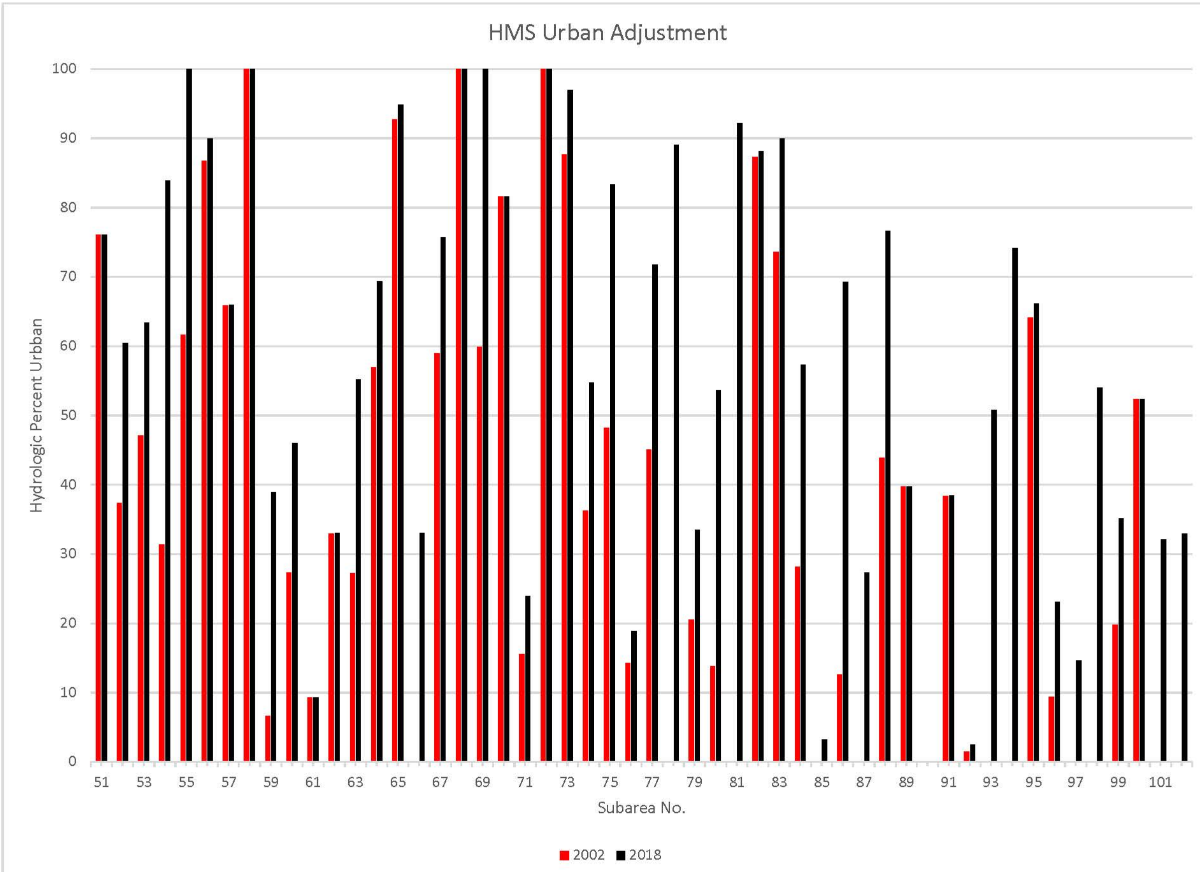

Figure 13. Subarea HEC-HMS Percent Urban 2002 vs. 2018 cont.

Subareas, which contained urbanized or impervious areas, were adjusted to reflect the accelerated runoff associated with urbanization and development. The adjustments are reflected in the Snyders Tp and initial and uniform loss rate parameters. The percent of urban/developed area was applied to the unit hydrograph parameter Snyder's T_p by using the following relation:

$$T_{pu} = 1 + \frac{\%urban}{100}$$

where:

T_{pu} is the adjusted time to peak based on percent impervious area.

This relationship is based on the assumption that maximum urbanization will result in a 50% reduction in the time to peak of a subarea hydrograph.

The initial and uniform loss rates were also adjusted to reflect progressive urbanization. Unadjusted initial losses were assumed to 1.0 inches and uniform loss rates were assumed to be 0.1 inch/hour. The equations to adjust initial and uniform loss rates are shown below:

L_i = initial loss rate*urban percentage/100
L_u = uniform loss rate*urban percentage/100

Table 1 shows the resulting adjustments and parameters used in the HMS model.

Subarea	Drainage Area (Sq. Mi)	2002 % Urban	2018 % Urban		2002 Initial Loss (Inches)	2018 Initial Loss (Inches)		2002 Snyders' Tp (Hours)	2018 Snyders' Tp (Hours)
1	0.41	0	56		1.00	0.72		0.36	0.32
2	0.51	0	74		1.00	0.63		0.68	0.28
3	0.67	0	82		1.00	0.59		0.97	0.53
4	0.47	10	54		1.00	0.73		0.86	0.56
5	0.97	0	24		1.00	0.88		0.94	0.76
6	0.82	0	54		1.00	0.73		0.96	0.62
7	0.23	0	40		1.00	0.8		0.82	0.59
8	0.61	0	15		1.00	0.93		0.79	0.69
9	0.58	0	100		1.00	0.5		1.07	0.54
10	0.28	0	74		1.00	0.63		0.91	0.52
11	0.29	27	45		0.94	0.92		0.58	0.56
12	0.51	12	17		0.87	0.78		0.57	0.5
13	0.33	68	76		0.67	0.62		0.34	0.32
14	0.72	37	56		0.84	0.72		0.77	0.65
15	0.18	84	84		0.59	0.58		0.44	0.44
16	0.76	74	87		0.77	0.57		0.48	0.37
17	0.5	13	47		0.94	0.76		0.94	0.71
19	0.27	0	76		1.00	0.71		0.6	0.38
20	0.3	0	58		1.00	0.62		0.63	0.36
21	0.35	0	73		1.00	0.64		0.72	0.42
22	0.62	0	22		1.00	0.89		0.74	0.6
23	0.53	0	21		1.00	0.89		0.62	0.51
24	0.5	43	43		0.78	0.78		0.92	0.94
25	0.4	0	52		1.00	0.74		0.59	0.39
26	0.39	73	92		1.00	0.54		0.75	0.39
27	0.07	97	100		0.50	0.5		0.14	0.14
28	0.4	35	70		0.80	0.65		0.52	0.43
29	0.45	51	89		0.82	0.56		0.55	0.4
30	0.3	48	85		0.77	0.57		0.71	0.56
31	0.57	91	91		0.55	0.54		0.34	0.34
32	0.34	55	56		0.72	0.72		0.94	0.94
33	0.37	62	62		0.70	0.69		0.51	0.51
34	0.48	43	91		0.80	0.54		1.08	0.79
35	0.45	3	89		1.00	0.55		0.6	0.32
36	0.6	36	76		0.79	0.62		0.52	0.43
37	0.49	40	71		0.80	0.65		0.61	0.5
38	0.87	0	34		1.00	0.83		0.97	0.72
39	0.11	58	100		0.73	0.5		0.39	0.3
40	0.54	35	71		0.83	0.64		0.63	0.5
41	0.33	61	89		0.71	0.56		0.56	0.47
42	1.34	37	52		0.77	0.74		1.05	1.01
43	0.1	47	57		0.80	0.72		0.33	0.29
44	0.63	92	99		0.53	0.51		0.45	0.44
45	0.3	33	97		0.50	0.51		0.35	0.35
46	0.61	67	81		0.50	0.59		0.32	0.35
47	0.17	78	100		0.56	0.5		0.29	0.28
48	0.53	76	89		0.60	0.55		0.31	0.3
49	0.19	58	92		0.87	0.54		0.47	0.33
50	0.52	63	89		0.67	0.55		0.83	0.73
51	0.61	76	76		0.65	0.62		0.53	0.51
52	0.3	37	60		0.94	0.7		0.84	0.59
53	0.42	47	63		0.83	0.68		0.92	0.75
54	0.16	31	84		0.86	0.58		0.69	0.48
55	0.18	62	100		0.72	0.5		0.26	0.2

Table 1. Subarea Hydrologic Parameters

56	0.28	87	90		0.59	0.55		0.39	0.37
57	0.44	66	66		0.67	0.67		1.16	1.16
58	0.19	100	100		0.92	0.81		0.78	0.66
59	0.49	7	39		0.50	0.5		0.31	0.31
60	0.41	27	46		0.81	0.77		0.6	0.57
61	0.41	9	9		1.00	0.95		0.8	0.73
62	0.66	33	33		0.94	0.84		0.55	0.47
63	0.55	27	55		0.85	0.72		0.44	0.37
64	0.38	57	69		0.84	0.65		0.45	0.35
65	0.27	93	95		0.59	0.53		0.24	0.23
66	0.31	0	33		0.58	0.62		0.3	0.41
67	0.33	59	76		0.55	0.83		0.4	0.44
68	0.62	100	100		0.50	0.5		0.41	0.41
69	0.23	60	100		0.70	0.5		1.7	1.37
70	0.88	82	82		0.62	0.59		0.85	0.82
71	0.28	16	24		0.58	0.5		0.56	0.52
72	0.54	100	100		1.00	0.88		1.03	0.83
73	0.51	88	97		0.61	0.52		0.35	0.32
74	0.46	36	55		0.85	0.73		1.25	1.05
75	0.87	48	83		0.74	0.58		1.09	0.9
76	0.7	14	19		0.93	0.91		0.78	0.75
77	0.54	45	72		0.75	0.64		0.87	0.76
78	0.26	0	89		1.00	0.55		1.7	0.9
79	0.61	21	33		0.91	0.83		0.71	0.63
80	0.3	14	54		0.94	0.73		0.81	0.6
81	0.2	0	92		1.00	0.54		0.33	0.17
82	0.62	87	88		0.60	0.56		0.49	0.47
83	0.32	74	90		0.57	0.55		0.61	0.6
84	0.29	28	57		0.82	0.71		0.61	0.53
85	0.12	0	3		1.00	0.98		0.94	0.91
86	0.48	13	69		0.93	0.65		1.07	0.73
87	0.57	0	27		1.00	0.86		1.01	0.79
88	0.53	44	77		0.87	0.62		0.5	0.36
89	0.46	40	40		0.92	0.8		0.53	0.44
90	0.3	0	0		1.00	1		0.72	0.72
91	0.68	38	38		0.85	0.81		0.44	0.41
92	0.53	1	2		1.00	0.99		1.1	1.07
93	0.35	0	51		1.00	0.75		1.99	1.32
94	0.23	0	74		1.00	0.63		1.76	1.01
95	0.6	64	66		1.00	0.67		1.39	1.13
96	0.82	9	23		0.68	0.88		0.57	0.57
97	0.44	0	15		1.00	0.93		1.2	1.05
98	0.21	0	54		1.00	0.73		0.84	0.55
99	0.87	20	35		0.91	0.82		0.89	0.55
100	0.87	52	52		0.68	0.74		0.61	0.78
101	0.38	0	32		1.00	0.84		1.22	0.66
102	0.42	0	33		1	0.84		0.94	0.94
			53						

Table 1cont. Subarea Hydrologic Parameters

6.4 Flow Verification

The Horn Lake Creek Basin does not have any stream gages. Due to the absence of stream gage information, the original 2005 information was verified by use of the U.S.G.S. regression relationships and calibrated HEC-1 models developed in the Coldwater River basin. A 1990 study entitled “Hydrologic Analysis of the Coldwater River Watershed” was conducted by Lenzotti and Fullerton Consulting Engineers, Inc. for the Vicksburg District Corps of Engineers. The Coldwater River watershed is an adjacent basin with similar runoff characteristics as Horn Lake Creek. The flow versus frequency relationships in the Coldwater Basin are thought to be applicable to the Horn Lake Creek basin.

Since the previous calibration was conducted in 2005, it was uncertain if the comparison(s) were still reliable and valid. The FIS contains a table with updated HMS flows for a range of probabilities. Also, the RAS models contain flows (not included in the FIS report) that were used to develop water surface elevations. These flows were also used to assist in the verification of 2018 flows. Comparison plots of the Coldwater tributaries and the Horn Lake Creek flows for 2005 and 2019 are shown in Figures 14 to 17.

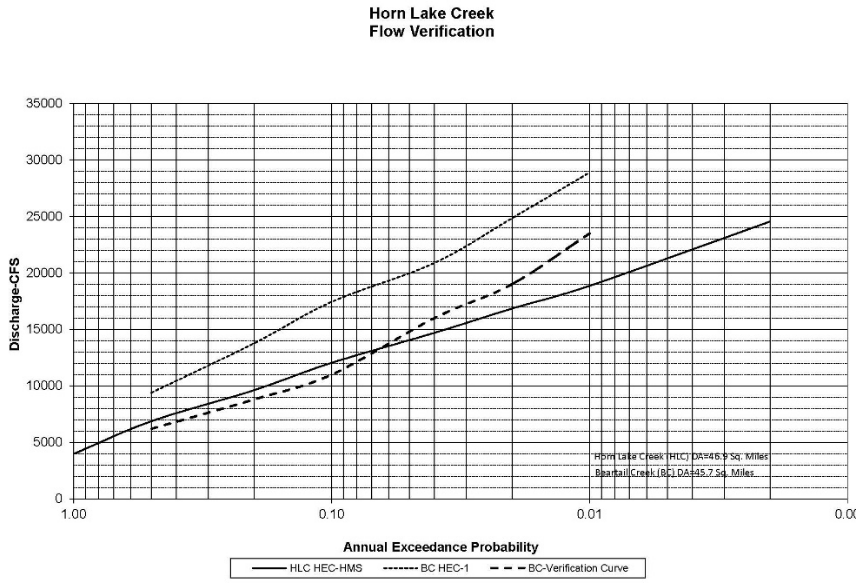

Figure 14. Horn Lake Creek Flow Verification
Approximate DA=47 square miles

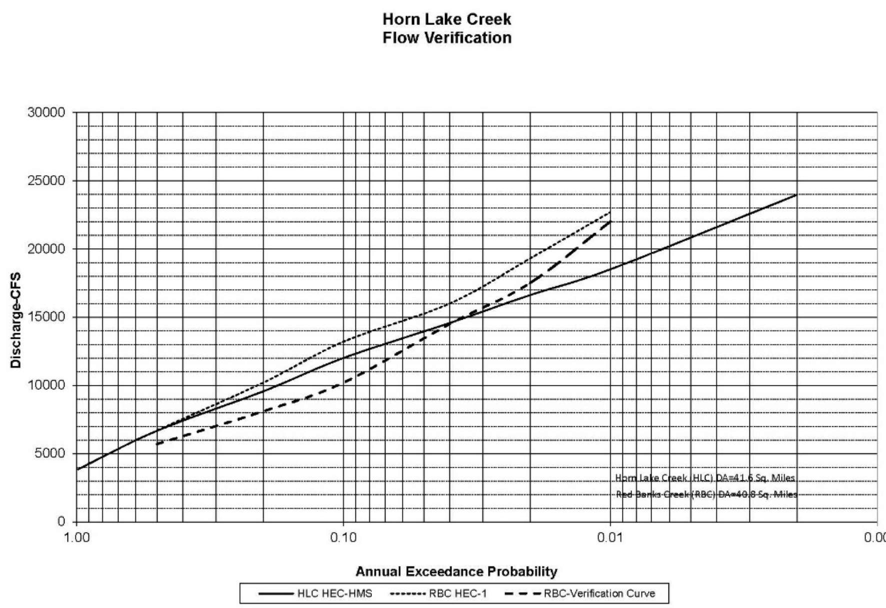

Figure 15. Horn Lake Creek Flow Verification
Approximate DA=42 square miles

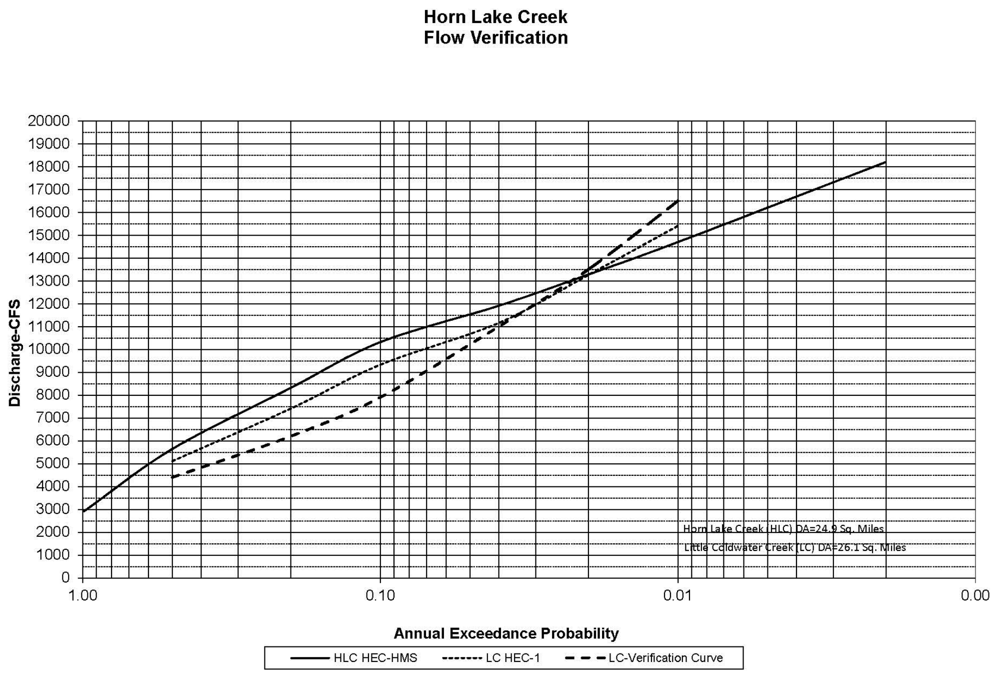

Figure 16. Horn Lake Creek Flow Verification
Approximate DA=26 square miles

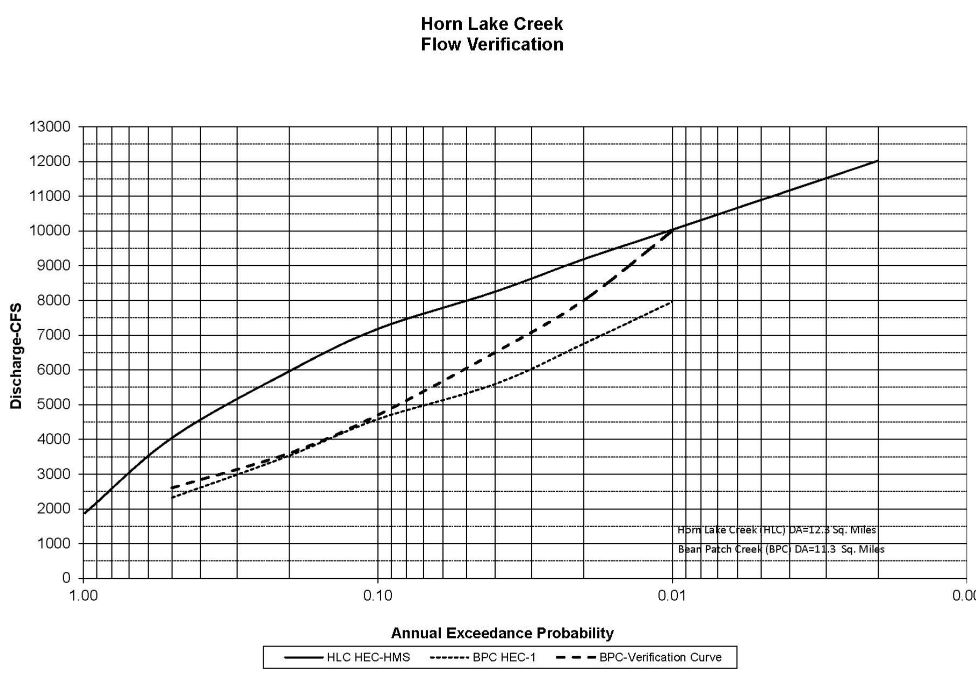

Figure 17. Horn Lake Creek Flow Verification
Approximate DA=12 square miles

7.0 Hydraulic Modeling and Methodology

7.1 Horn Lake Creek Basin Modeling Overview

Hydraulic modeling was performed using HEC-RAS River Analysis System (RAS) version 5.0.7 computer software. The HEC-2 model, previously developed for the original 1993 Desoto County Flood Insurance Study (FIS) and updated in the 2005 study, was imported into HEC-RAS for this study.

The imported model was basically unchanged for this study except for the inclusion of the HEC-HMS 2019 updated flows. It should be noted additional surveys were not obtained for this study and still reflect channel 2002 conditions. Study limitations dictated the use of outdated 2002 sections and any concerns in water surface accuracy is captured in the Risk and Uncertainty assessments in conjunction with the economic analysis.

Overbank topography originally developed for the Desoto County FIS was updated using Light Detection and Radar (LIDAR) flown in 2003. The downstream boundary conditions for Horn Lake Creek was established using the slope-area method. Downstream boundary conditions for Cow Pen Creek, Rocky Creek, and Lateral D were based on Horn Lake Creek frequency water surface elevations.

A field reconnaissance was conducted 2018 to determine and verify Manning's roughness coefficients used in the 2005 study. Manning's channel roughness coefficients (n values) were estimated to range from 0.040 to 0.07. Overbank n values ranged from about 0.080 for cropland, 0.105 for wooded areas, and 0.055 for overbank urban areas. Manning's roughness coefficients were not altered for future conditions. Any uncertainty related to channel and overbank roughness changes will be documented in the "Risk Register".

Bridge modeling in the original HEC-2 model was conducted using the "Special Bridge Method", which has limitations for piling and pier modeling. A thorough review of the imported variables and results was conducted to ensure the conversion did not introduce errors or inaccurate water surface profiles. Crossings at the Canadian National Railroad and Highway 51/Goodman Road intersection are major project flooding concerns.

Future hydraulic analysis is expected use current state of the art modeling (i.e., RAS 1D/2D Unsteady Flow). This updated modeling will incorporate representative channel surveys or bathometry, detailed bridge modeling options, and other study items related to uncertainty and accuracy.

7.2 Coldwater River Basin Modeling Overview (Desoto County FIS)

The Coldwater River Basin was analyzed using models developed for the Desoto County FIS. Cross section geometries were obtained from a combination of terrain data and field surveys. Bridges and culverts located with the detailed study and limited detailed study limits were field surveyed to obtain elevation and data and structural geometry. Manning's roughness coefficients for Camp Creek are 0.04 for the channel and 0.05-0.10 for the overbanks.

Downstream boundary conditions for the hydraulic models were set to normal depth using the starting slope calculated from values taken from topographic data, or where applicable, derived from the water surface elevations. Water-surface profiles were computed using HEC-RAS version 4.1.

Information presented in this report was supplemented with data from the Vicksburg District Corps of Engineers. The COE data is the most recent information and utilized where deemed appropriate. Figure 18 shows the main streams of investigated for flood risk management and reduction measures.

Figure 17. Flood Risk Management Streams of Interest

7.3 Risk Based Analysis

The HEC-FDA Flood Damage Reduction Analysis was used to compute flood damages. To expedite the analysis, uncertainty parameters are based on a simplistic procedure which uses an estimated period of record. Guidance for using this procedure are presented in the HEC-FDA Technical Reference entitled “Uncertainty Estimates for Graphical Frequency Curves. For stage uncertainty, a period of record of 25-years was adopted. It is assumed shorter periods of record produce a larger uncertainty in the stage information. This uncertainty in stage is applied to the flow versus stage relationship (i.e., rating curves) and produces the uncertainty bounds for the flow parameter. The use of FDA program was conducted during the Economic analysis and is presented in more detail in that respective Section. Future analysis will incorporate more detailed guidance as presented in EM 1110-2-1619 and ER 1105-2-105; both entitled, “Risk-Based Analysis for Flood Damage Reduction Studies” dated August 1996 and January 2009.

7.4 Base Conditions and Alternatives

7.3.1 Water Surface Profiles

Water surface profiles and stage frequency (elevation vs. probability) curves were produced for the Annual Exceedance Probability (AEP) events developed by Atlas 14 (0.99 to 0.002 probabilities) for baseline without project (2026) and FWOP (2076). Project conditions were developed for the same probabilistic events. The following figures show resulting HEC-RAS water surface profile plots.

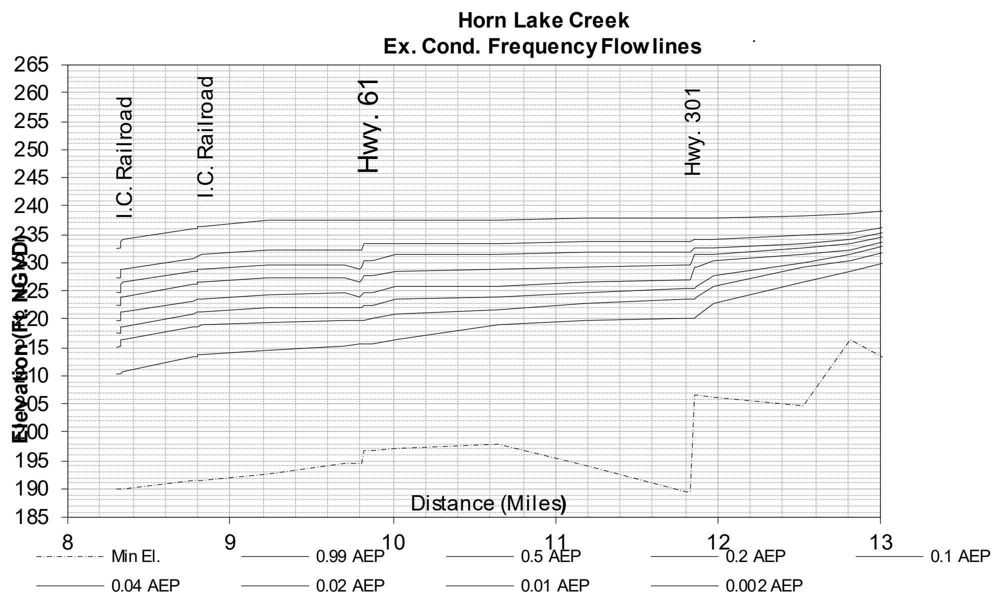

Figure 18. Horn Lake Creek Frequency Flowlines

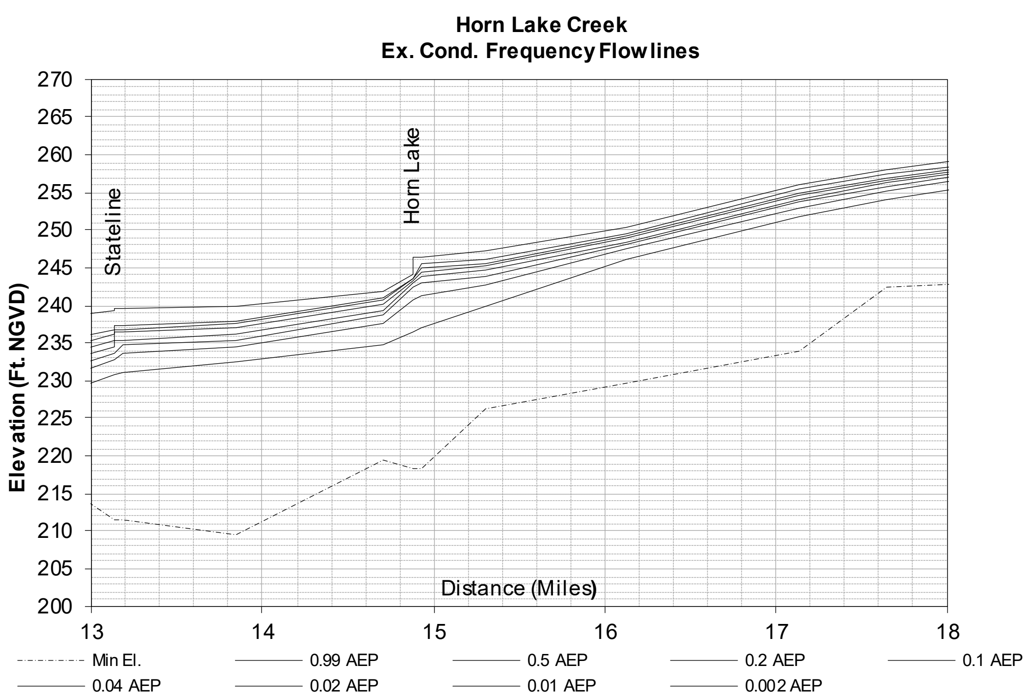

Figure 19. Horn Lake Creek Frequency Flowlines

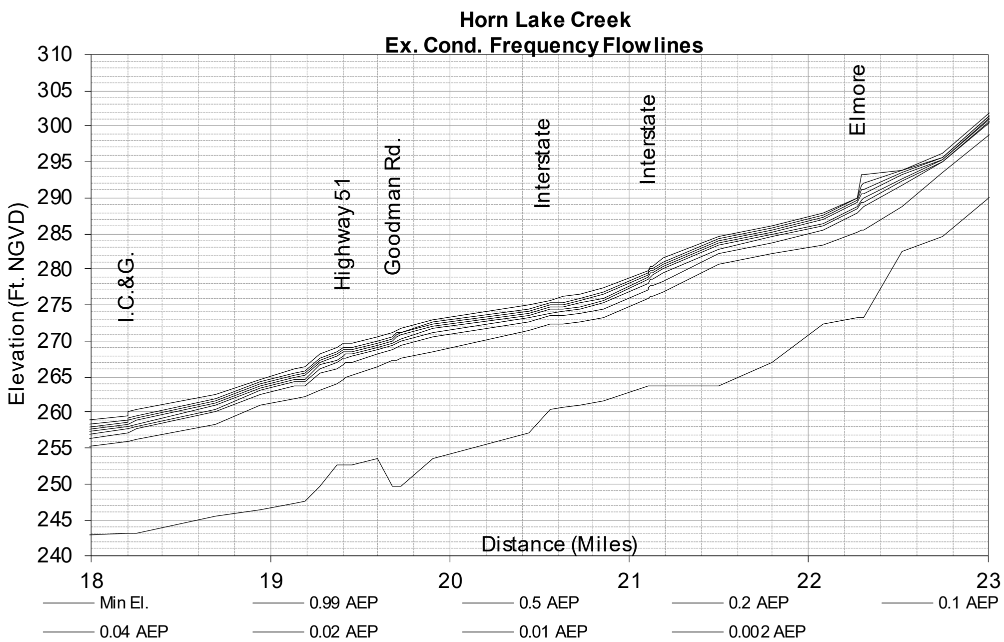

Figure 20. Horn Lake Creek Frequency Flowlines

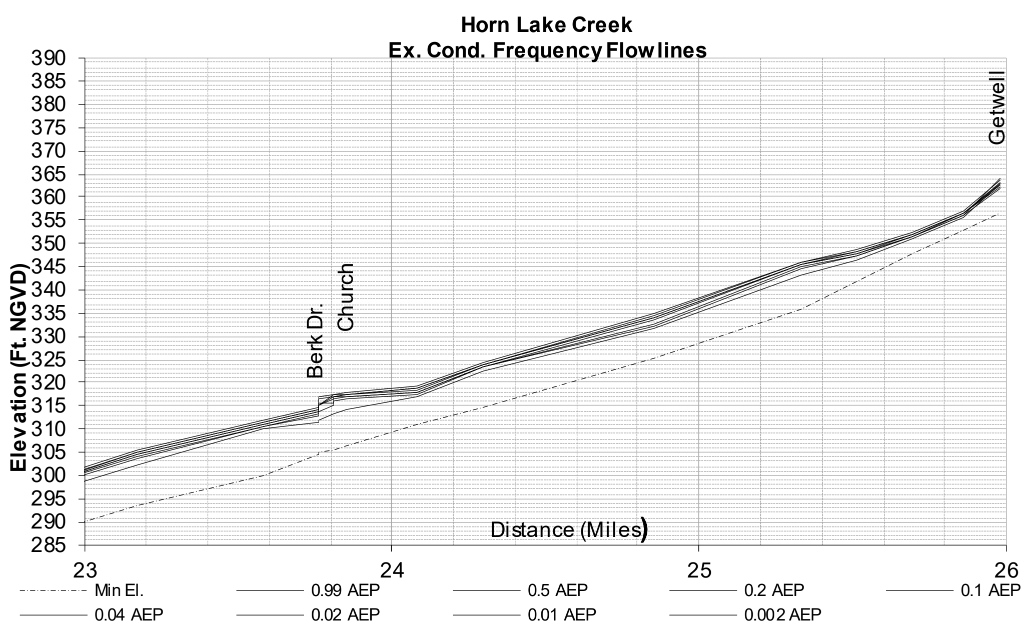

Figure 21. Horn Lake Creek Frequency Flowlines

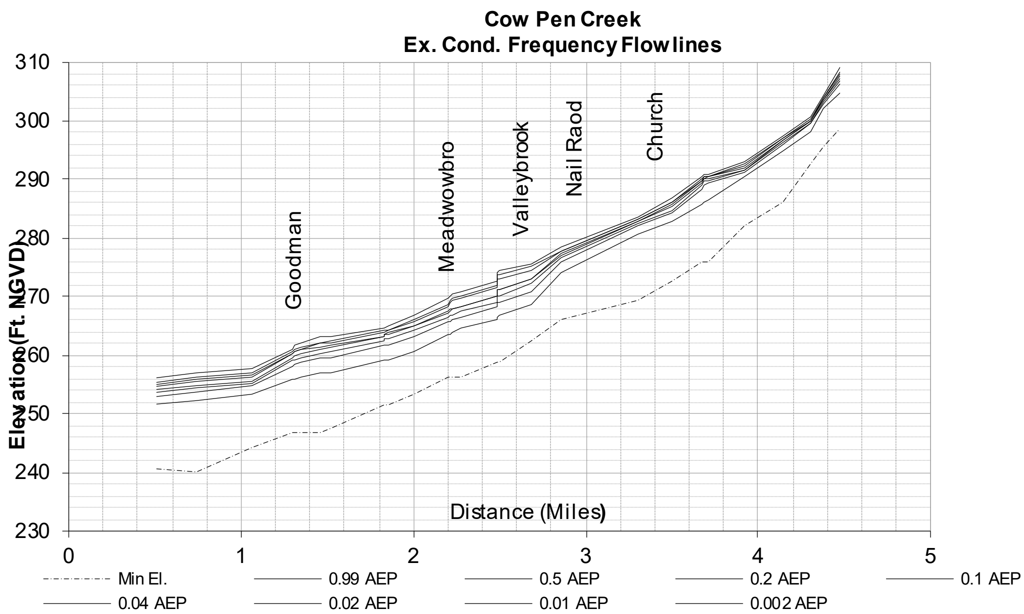

Figure 22. Cow Pen Creek Frequency Flowlines

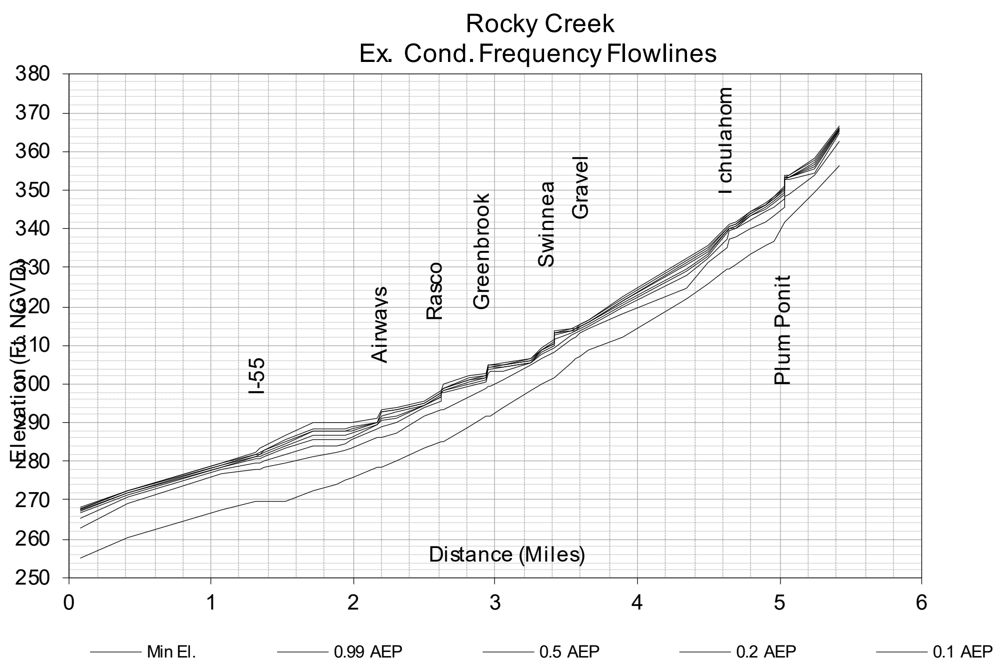

Figure 23. Rocky Creek Frequency Flowlines

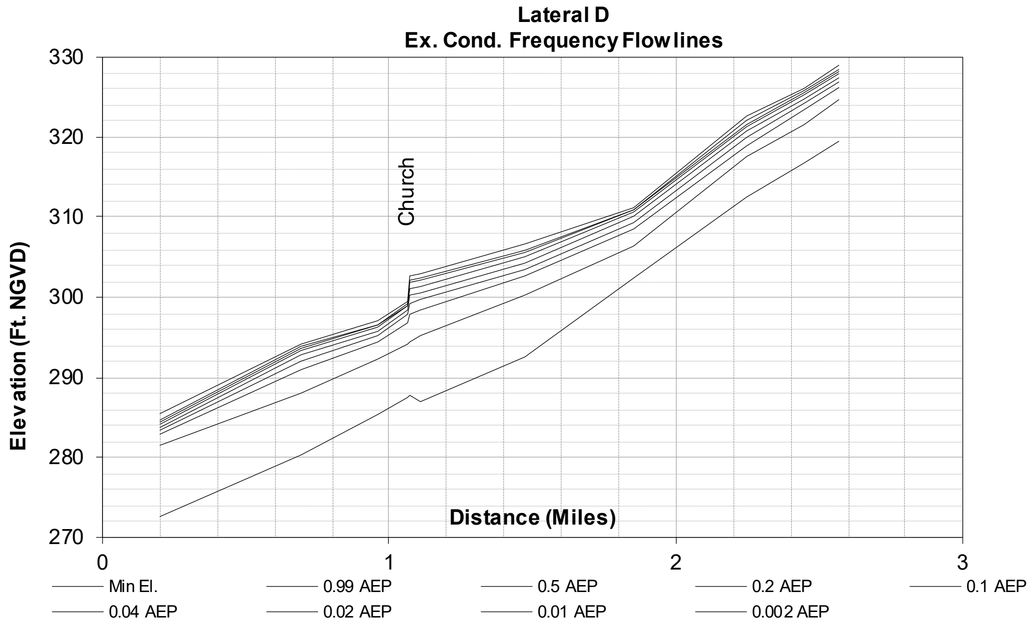

Figure 24. Lateral D Frequency Flowlines

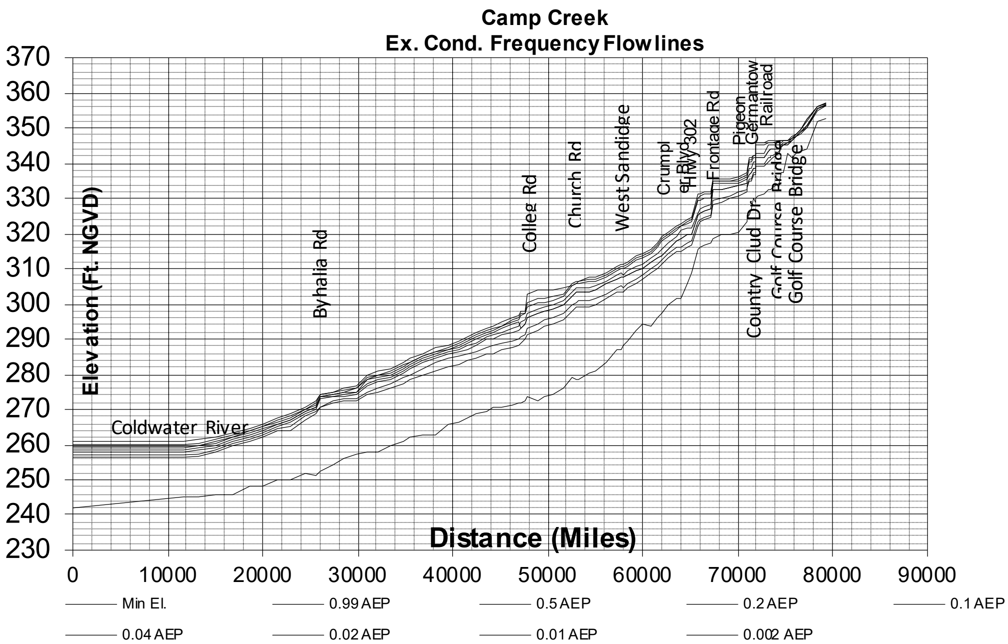

Figure 25. Camp Creek Frequency Flowlines

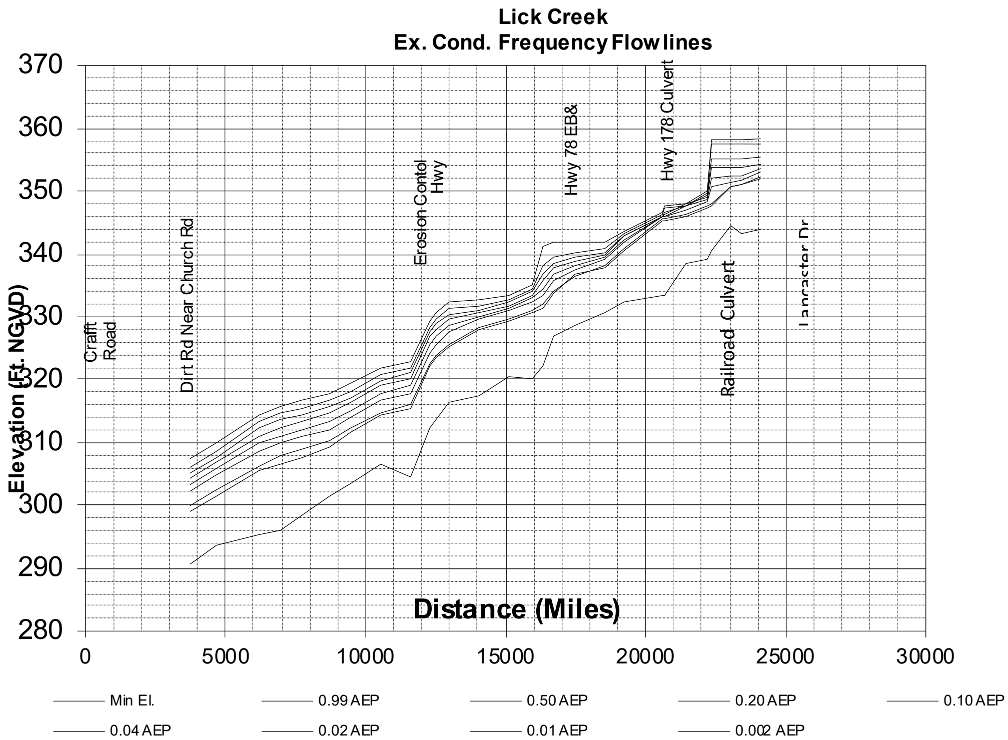

Figure 26. Lick Creek Frequency Flowlines

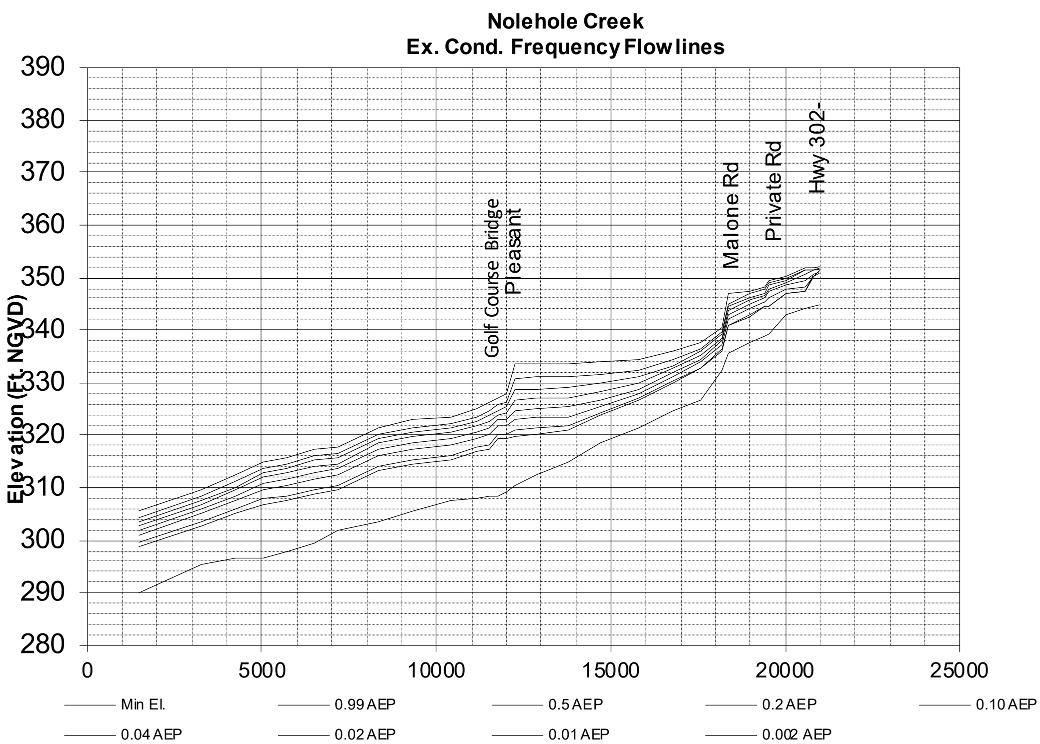

Figure 27. Nolehoe Creek Frequency Flowlines

7.3.2 Project Conditions

Several alternatives were investigated to address flood risk in the Coldwater River and Horn Lake Creek basins. The primary measures and alternatives investigated included channel enlargement, detention basins, levees, and pump stations. To assess the alternatives, modifications were made to the HEC-HMS and HEC-RAS models.

Based on the measures and alternatives examined, channel enlargement and detention basins resulted in the most feasible and economical plans in the Horn Lake Creek basin. Structural flood risk reduction measures in the Coldwater River Basin were not economically justified but non-structural alternatives were examined. Information related to non-structural alternatives are shown in the Economic Section of the Report, Appendix D. The primary streams in which flood risk reduction measures were investigated are shown in Figure 28.

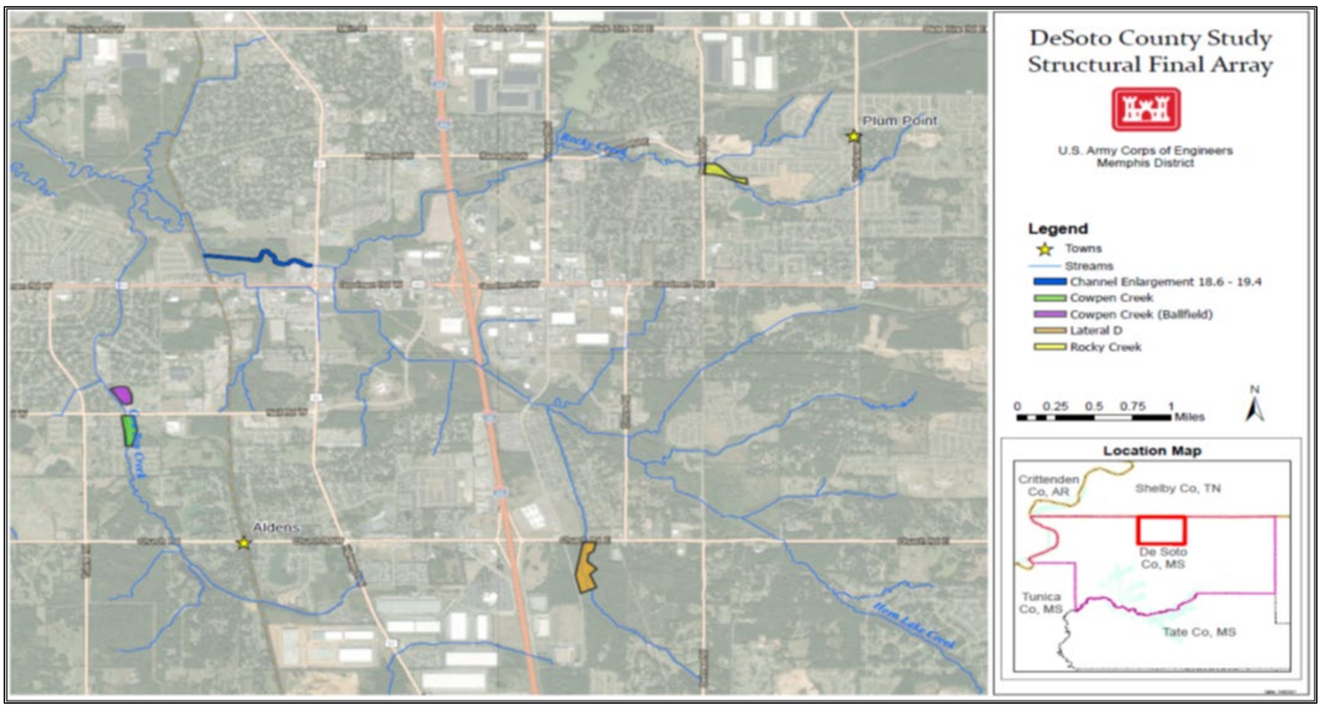

Figure 28. Flood Risk Management Streams of Interest

7.3.2.1 Horn Lake Creek Channel Enlargement

The Horn Lake Creek HEC-RAS model Creek was modified to assess the channel enlargement measure. Horn Lake Creek is currently experiencing bed degradation and channel widening. Due to this instability, the design attempted to increase conveyance but disturb the existing channel as little as possible. Channel deepening will be avoided. Channel enlargement on Horn Lake Creek will consist of a 40-foot bottom width with 1V on 3H channel side slopes and designed to the existing thalweg to avoid channel deepening. It should be noted the Modified Puls Routing relationship in HEC-HMS was altered to reflect the increase channel area and conveyance. The downstream impacts of the channel enlargement are presented section 7.3.2.4.

The enlargement will start at River Station 18.6 and extend to 19.4. Currently, both banks of the improved channel are based on a 3H to 1V slope for stability but one-sided enlargement is the desired plan and will investigated in the detailed analysis. A riprap “blanket” is needed on the lower channel to prevent erosion. The riprap blanket will be placed in a three-foot deep layer on the bottom and extend 5 feet up both banks. The upper banks will be protected with turf reinforcing mat. Figure 29 shows a plan view of the enlargement reach.

Figure 29. Horn Lake Creek Channel Enlargement

7.3.2.2 Horn Lake Creek Enlargement-Frequency vs. Elevation Curves

Frequency/probability water surface elevations were also developed for all measures investigated as needed for economic analysis. Water surface elevations vs probability curves provide a simple comparison of existing conditions with project alternatives and conditions. These comparisons are shown in Figures 30 to 32.

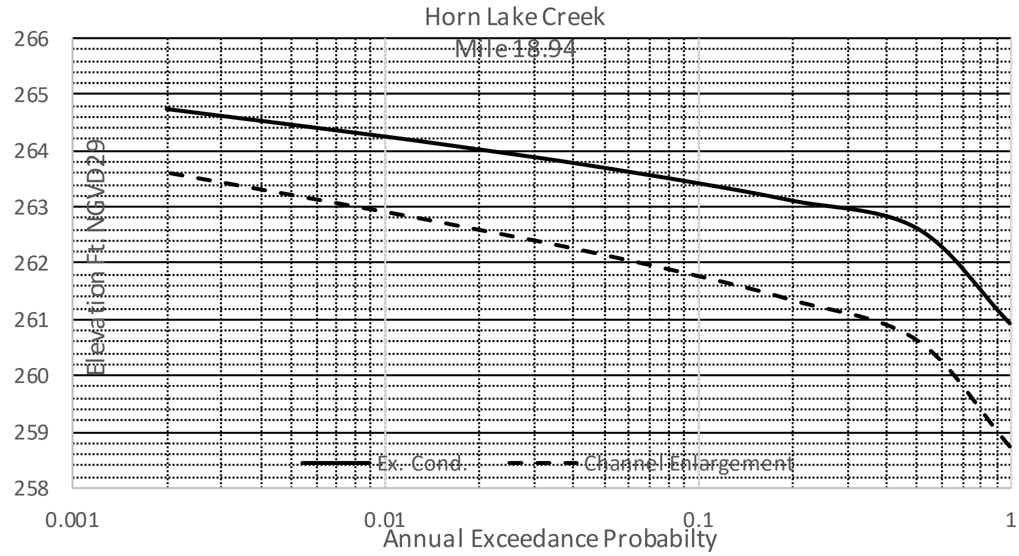

Figure 30- Water Surface Elev. Vs. Probability Curve

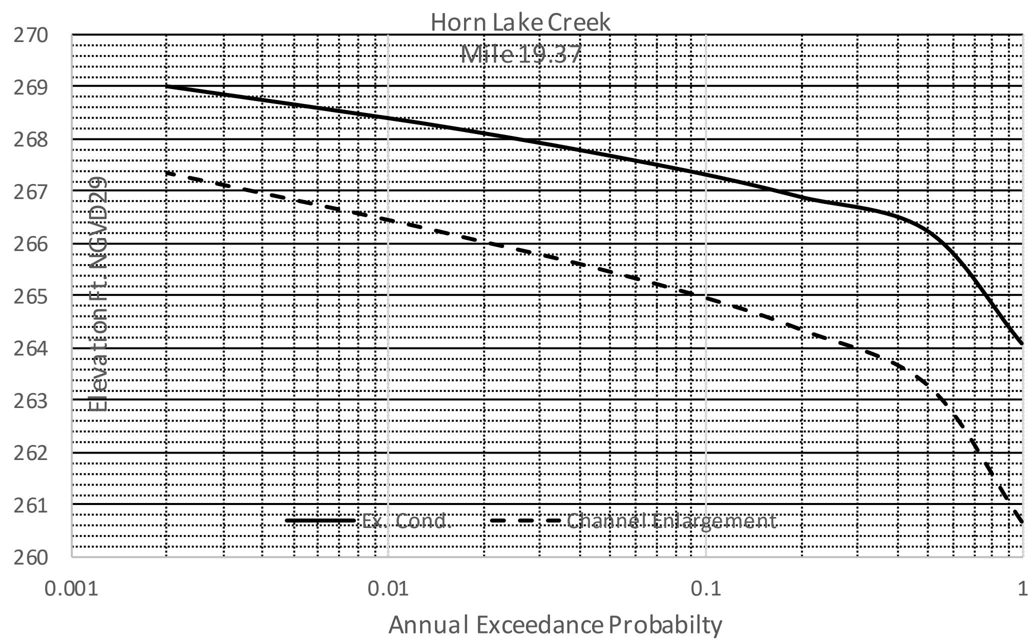

Figure 31- Water Surface Elev. Vs. Probability Curve

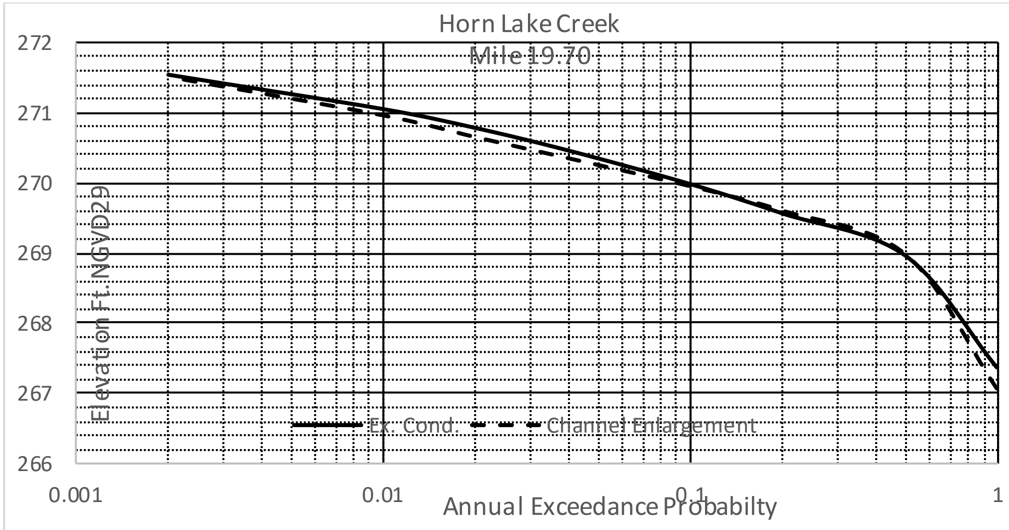

Figure 32-Water Surface Elev. Vs. Probability Curve

7.3.2.4 Horn Lake Creek Downstream Impacts

The channel enlargement reach extends from Mile 18.6 to 19.4. Peak discharges downstream of the enlargement reach will increase, due the improved conveyance and increased capacity. The HEC-HMS routing information was altered to reflect the improved conditions and the resulting increased peak flows were input into the HEC-RAS model. The relative impacts to existing conditions are shown in Figure 33. The TSP is composed of the subject channel enlargement combined with a detention basin on Lateral D at Church Road. It should be noted the TSP did not eliminate the downstream impacts but reduced the average increase in frequency flood elevations from an average of 0.2 feet to 0.1 feet. The LPP did not induce damages. Downstream induced damages, resulting from the Horn Lake Creek enlargement alternative, are mitigated as a project cost and are explained in the Economic Appendix.

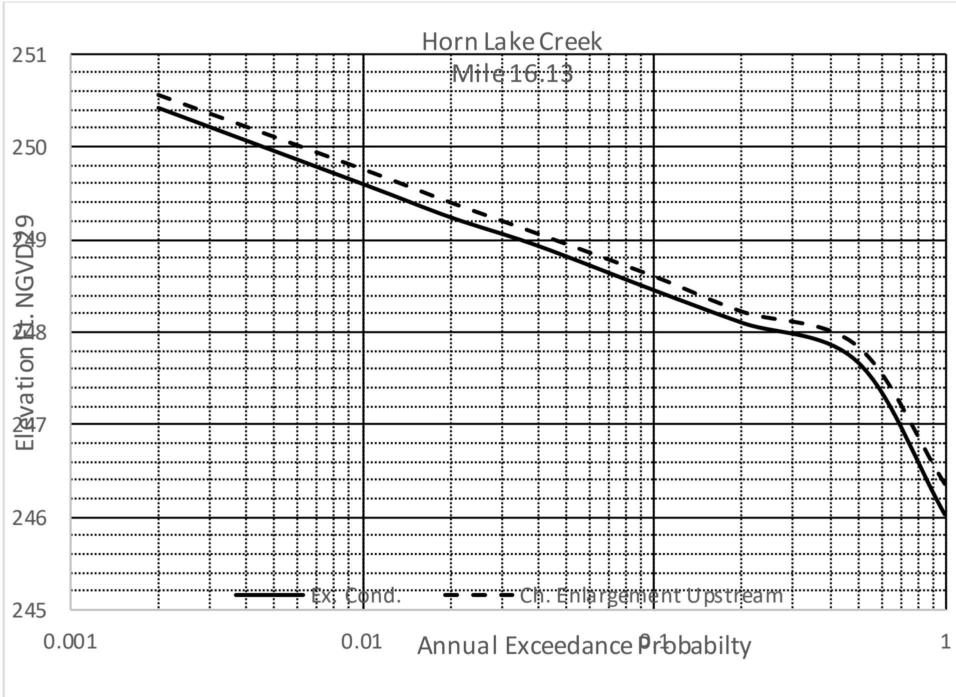

Figure 33-Water Surface Elev. Vs. Probability Curve

7.3.2.5 Cow Pen Creek Basin Detention Analysis

As stated in Section 7.3.2, HEC-HMS was used to model detention ponds. The acres and sites to where detention basins could be constructed were provided by the sponsor. This therefore determined the streams analyze for potential sites. Depths of the detention pond(s) and bottom elevations are based on the approximate elevations of the outlet ditches and/or adjacent detention ponds. Basin storage will be provided primarily by excavation and berms/embankments construction will kept to a minimum. Pond embankments or berms could induce a project risk downstream but could be considered in detained design. It should be noted overflow spillway design combined with other outlet considerations could require additional adjustments to basin volumes that can be addressed in additional analysis.

Cowpen Creek Detention South- A 12-acre inline detention basin will be located on Cowpen Creek south of Nail Road (River Station 2.5). in Horn Lake, MS. The dry detention basin will have a bottom elevation of 262.0, bottom area of 10 acres, and shall be sloped back up to grade at 3H to 1V. A 500-foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100-foot-wide overflow spillway. The maximum storage of 108 acre-feet requires approx. 175,000 cubic yards of excavation. The detention design will be optimized during feasibility-level design.

Cowpen Creek Detention North- An 8-acre offline detention basin will be located adjacent to Cowpen Creek north of Nail Rd. in Horn Lake, MS. The dry detention basin will have a bottom elevation of 258.0, bottom area of 6 acres, and shall be sloped back up to grade at 3H to 1V. A 500 foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100 foot-wide overflow spillway armored with riprap on the downstream side. The 100 foot-wide spillway will operate at elevation 268.0, approx. at the 0.50 ACE event. The maximum storage of 68 acre-feet requires approx. 115,000 cubic yards of excavation. The locations of detention basins are shown in Figure 34.

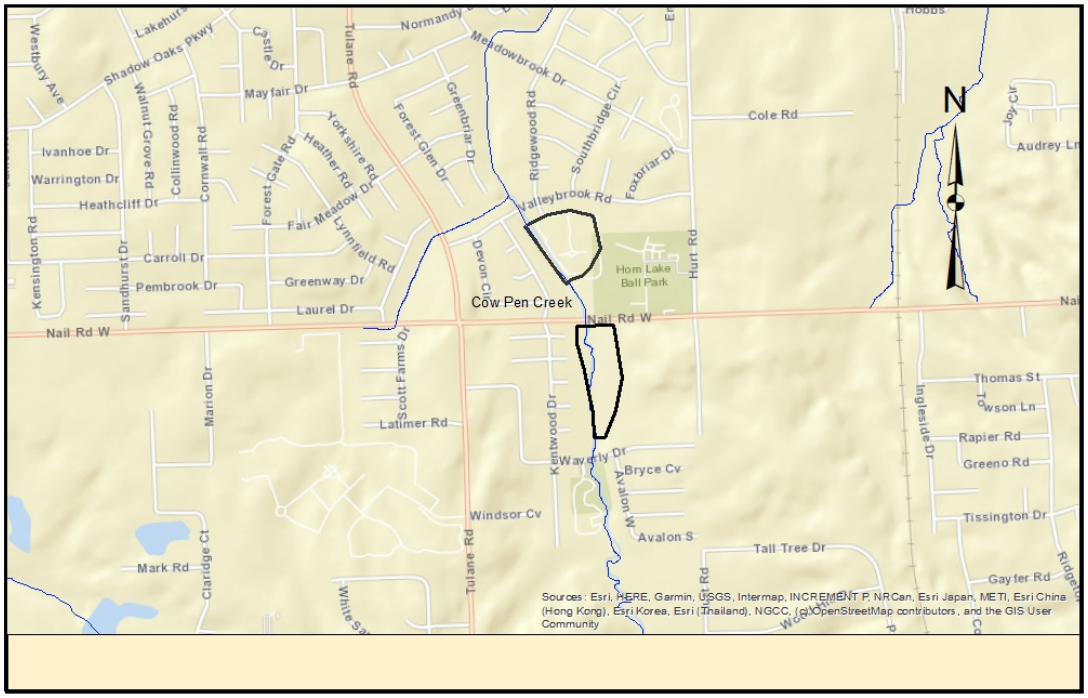

Figure 34- Cow Pen Creek Detention Basins

7.3.2.6 Cow Pen Creek Frequency vs. Elevation Curves

The reduction in flows are primarily a benefit to Cow Pen Creek. The HEC-HMS flows were adjusted for the entire Horn Lake Basin and the corresponding water surfaces on the Cow Pen Creek were computed. Comparisons of the results are shown below.

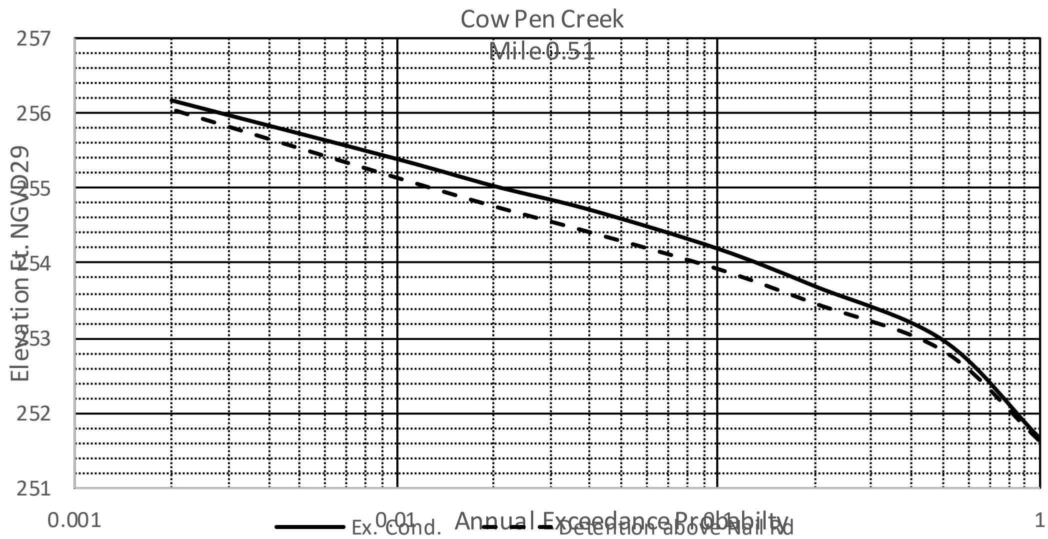

Figure 35-Water Surface Elev. Vs. Probability Curve

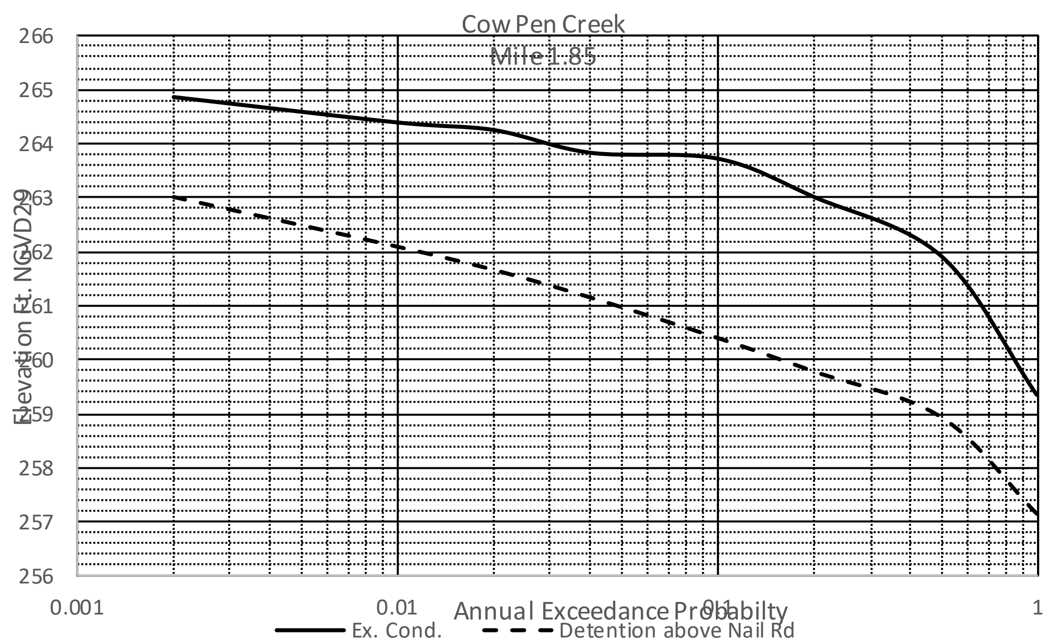

Figure 36-Water Surface Elev. Vs. Probability Curve

7.3.2.7 Rocky Creek Basin Detention Analysis

A nine-acre inline detention basin will be located on Rocky Creek (River Station 3.42) east of Swinnea Road in Southaven, MS. The dry detention basin will have a single pool elevation 302.0. The pool bottom area is six acres. All slopes back up to grade shall be 3H to 1V. Downstream embankment is 500 linear feet and will include a 48 in. Reinforced Concrete Pipe outlet and 100 foot-wide overflow spillway armored with riprap on the downstream side the 100 foot-wide spillway will operate at elevation 312.0 at the 0.50 ACE event. The maximum storage is 72 acre-feet. The site is shown in Figure 37.

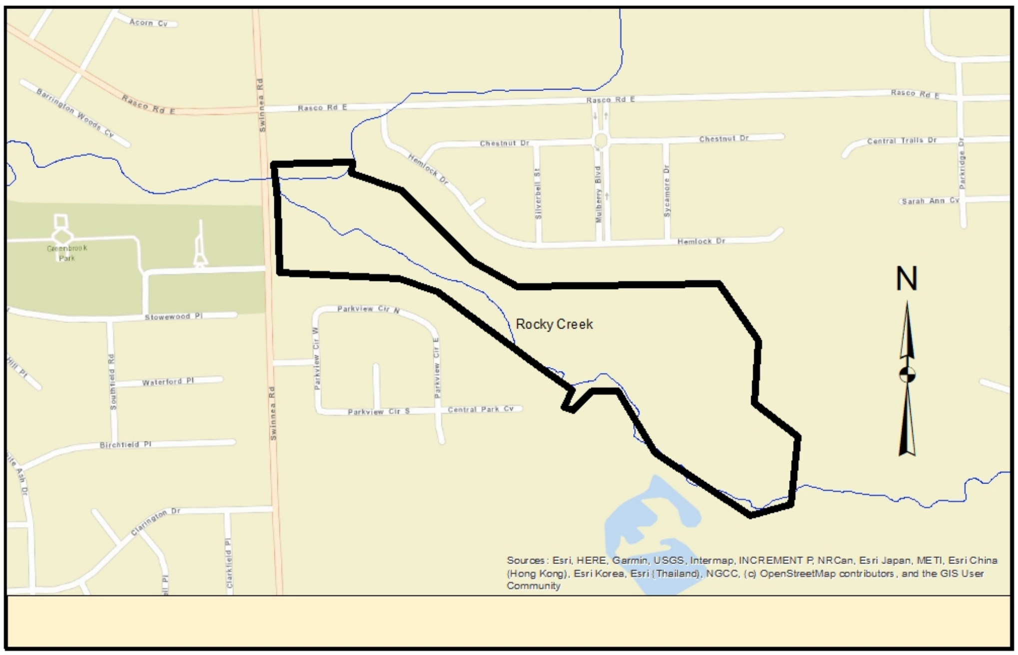

Figure 37- Rocky Creek Detention Basin

7.3.2.8 Rocky Creek Frequency vs. Elevation Curves

Simulated flows, after the detention, were input in the HEC-RAS models for Rocky Creek and project water surface profiles were developed. The following Elevation vs. Probabilities relationships are shown for existing conditions and projection conditions.

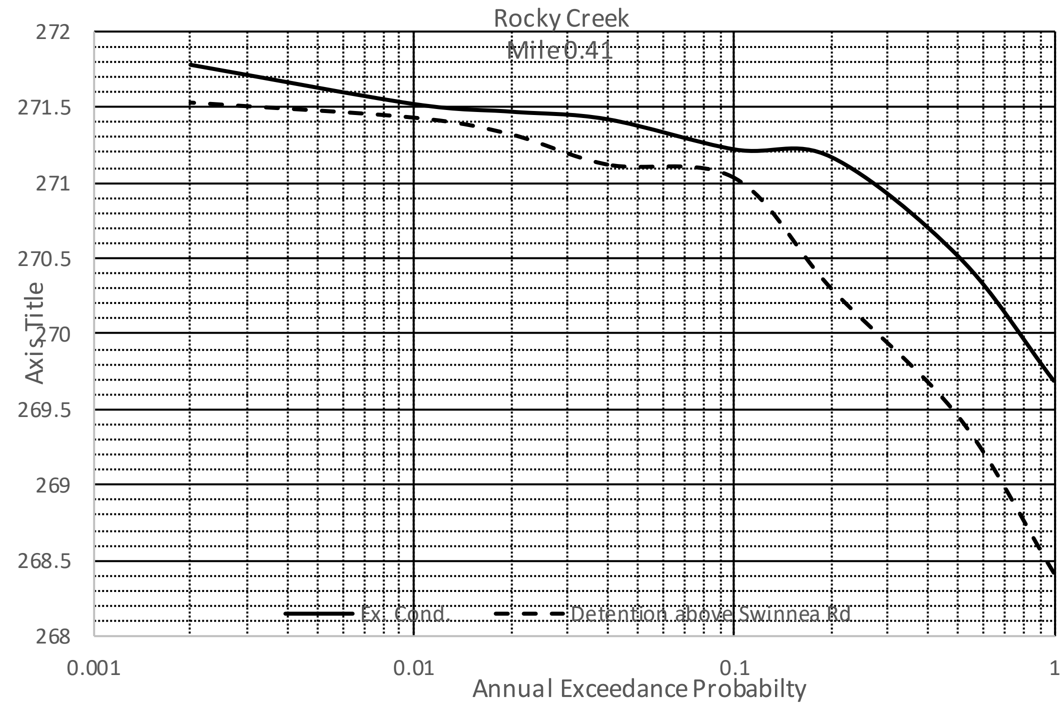

Figure 38-Water Surface Elev. Vs. Probability Curve

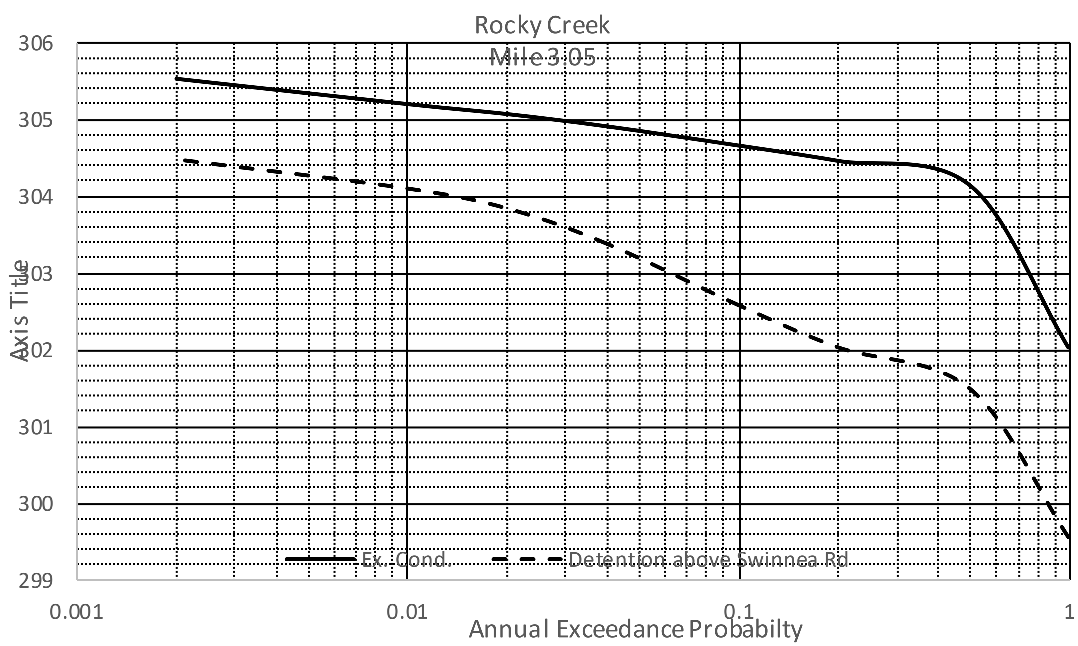

Figure 39-Water Surface Elev. Vs. Probability Curve

7.3.2.2 Lateral D Detention Basin

A 22-acre inline detention basin will be located on Lateral D (River Station 1.06) south of Church Rd. The dry detention basin will have a bottom elevation of 290.0, bottom area of 16 acres, and shall be sloped back up to grade at 3H to 1V. A 500 foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100 foot-wide overflow spillway armored with approx. 2,000 tons riprap on the downstream side. The 100 foot-wide spillway will operate at elevation 300.0, at the 0.50 ACE event. The maximum storage of 177 acre-feet requires approx. 350,000 CY of excavation. The site is shown in Figure 40.

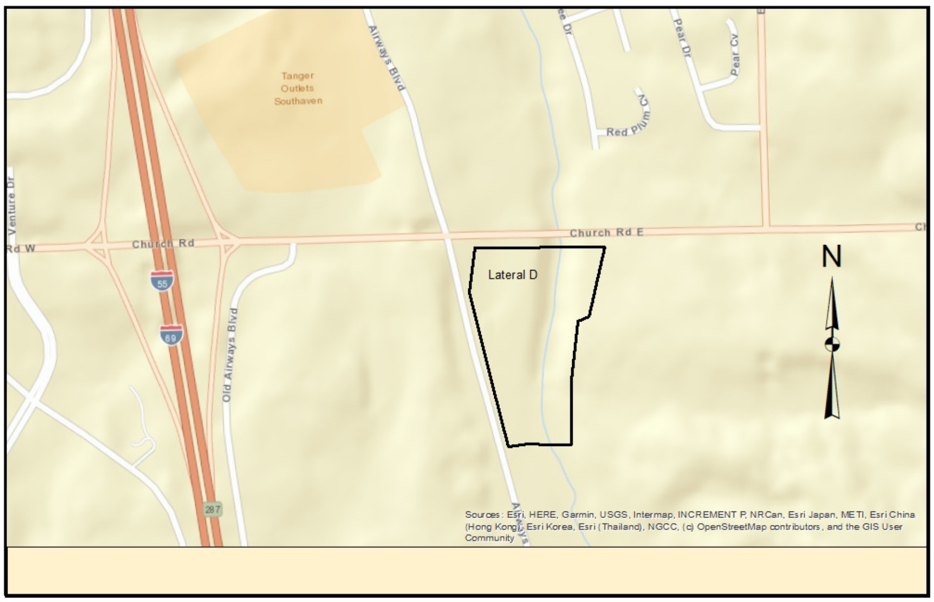

Figure 40- Lateral D Detention Basin

Simulated flows after the detention were input in the HEC-RAS models for Lateral D and project water surface profiles were developed. The following Elevation vs. Probabilities relationships are shown for existing conditions and projection conditions.

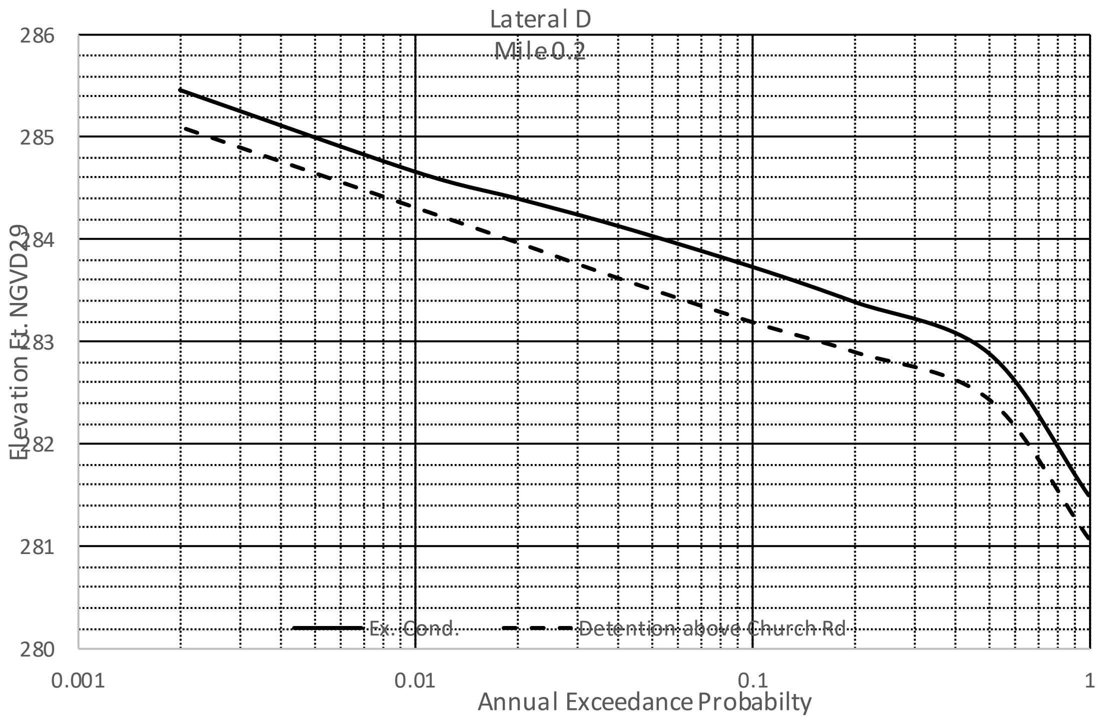

Figure 41-Water Surface Elev. Vs. Probability Curve

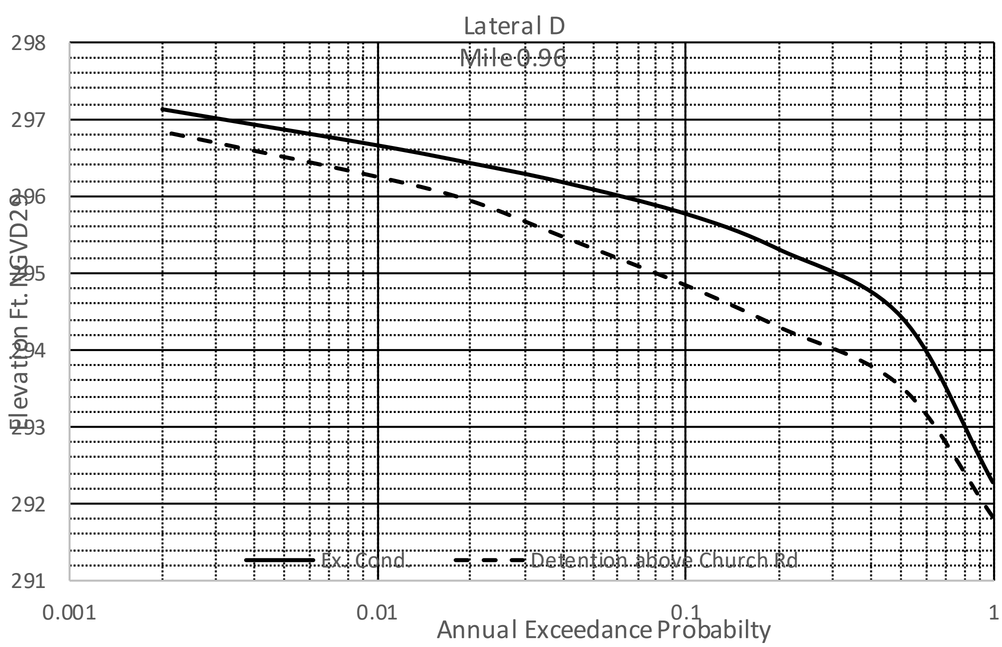

Figure 42- Water Surface Elev. Vs. Probability Curve

7.3.2.3 Frequency vs. Elevation Curves Tentatively Selected Plan (TSP)

The National Economic Development Plan (NED) identified from the final array of Flood Risk Management alternatives is a combination of the Horn Lake Creek Channel Enlargement (RM 18.6-19.4) combined with the Lateral D Detention basin, and an optimized nonstructural plan aggregated by floodplain. This is explained in more detail in the Economic section.

The TSP is not the National Economic Development (NED) Plan. The non-federal sponsor has identified a combination of the above measures as the locally preferred plan. This plan includes all component measures included in the NED plan (Horn Lake Creek Channel Enlargement (RM 18.6-19.4) combined with the Lateral D Detention basin, as well as two additional detention basins (Cow Pen and Rocky Creek Detention basins). Stage vs. Frequency curves on Horn Lake Creek are shown on Figures 43 to 45.

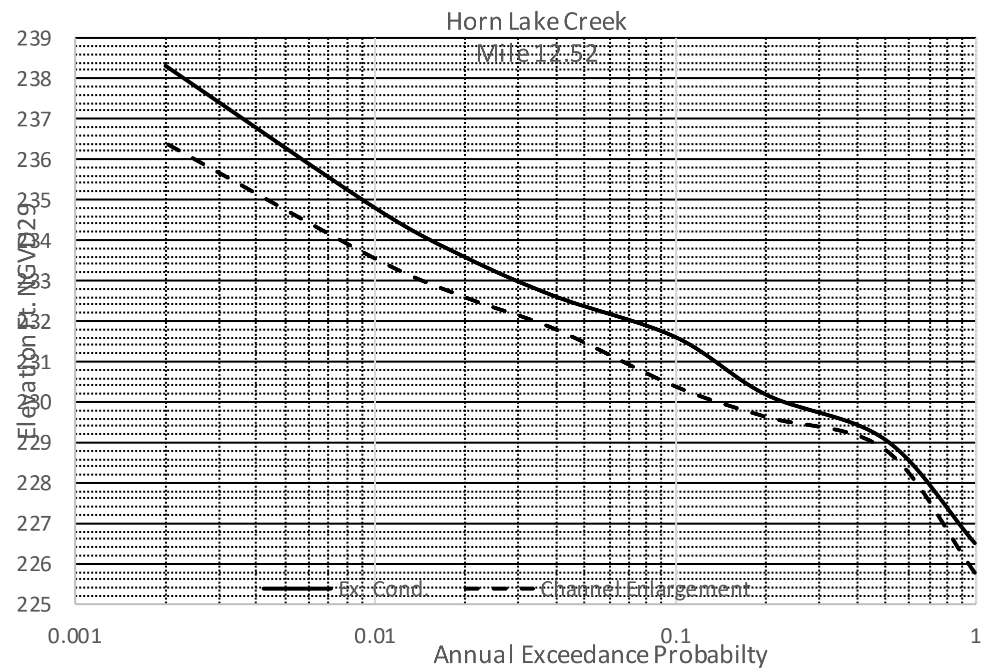

Figure 43-Water Surface Elev. Vs. Probability Curve

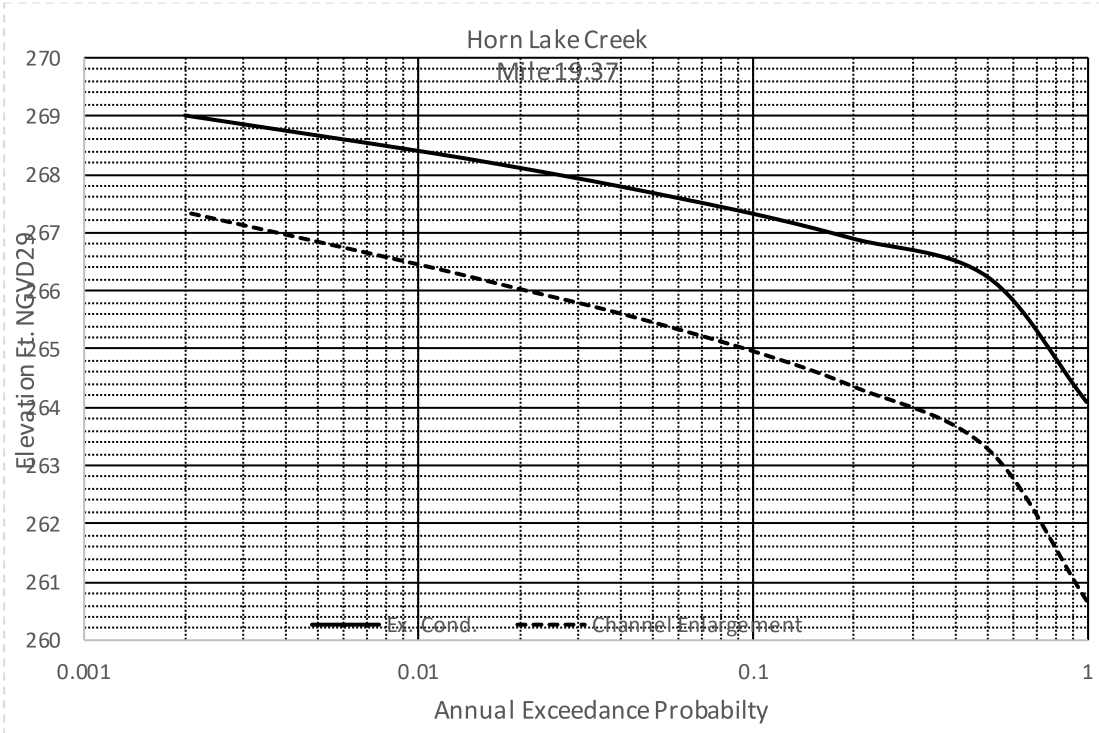

Figure 44-Water Surface Elev. Vs. Probability Curve

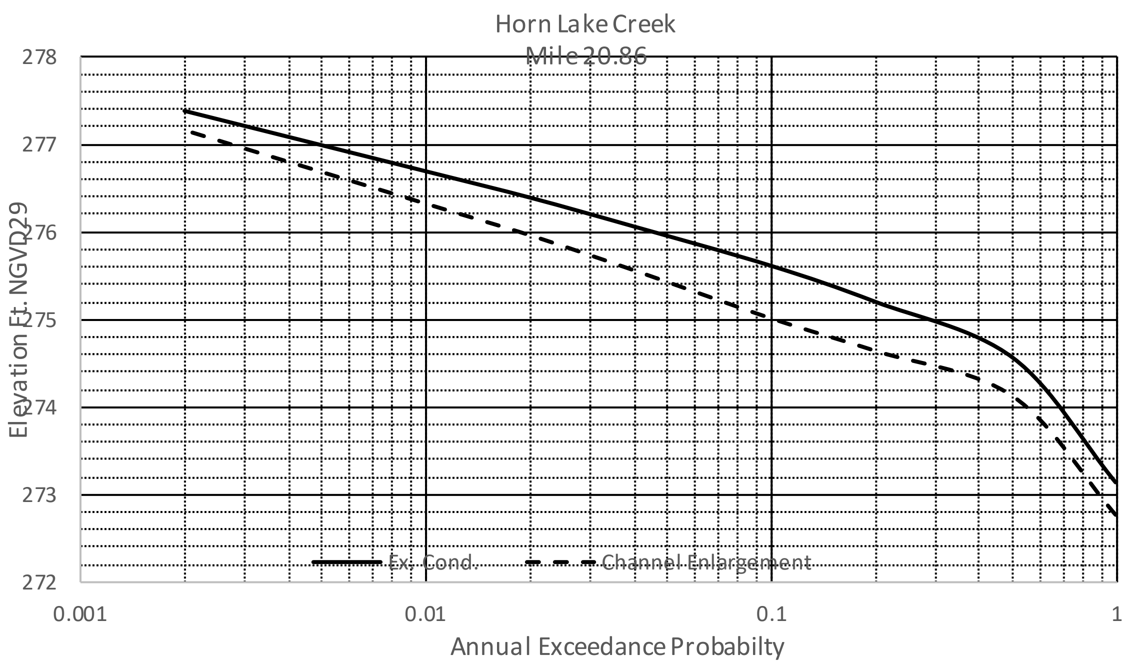

Figure 45-Water Surface Elev. Vs. Probability Curve