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Eric W. Olson
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RBG-47573

May 27, 2015

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: Response to Request for Additional Information on River Bend Station Recommendation 2.1 Flood Hazard Re-evaluation
River Bend Station - Unit 1
Docket No. 50-458
License No. NPF-47

Reference: 1. Entergy Letter RBG-47447, Response to Request for Information Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2014

2. River Bend Station Recommendation 2.1 Flood Hazard Re-evaluation Request for Additional Information, email dated April 27, 2015

RBF1-15-0080

Dear Sir or Madam:

In Reference (1), Entergy Operations, Inc. (Entergy) submitted a response to the Near Term Task Force Recommendation 2.1: Flooding Hazard Re-evaluation Report in response to the Nuclear Regulatory Commission's request for information pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f). In reviewing the Flooding Hazard Re-evaluation Report, NRC determined that additional information was required to complete the review (Reference 2). The attachment to this letter contains the requested information.

if you have any questions, please contact Mr. Joseph Clark at 225-381-4177. There are no new commitments contained in this submittal. I declare under penalty of perjury that the foregoing is true and correct. Executed on May 27, 2015.

Respectfully,

Eric W. Olson

EWO/dhw

Attachment: Response to Request for Additional Information
Enclosure: One (1) CD containing three data files referenced in the RAI Attachment:
- FLO-2D input / output files (no VBS)
- FLO-2D input / output files (no ARFs)
- HEC-RAS input / output files

A010
NRR

cc: Ms. Tekia Govan (w/ attachment and enclosure)
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Attachment to
RBG-47573

Response to Request for Additional Information

RAI Item 1, Local Intense Precipitation: PMP Hyetograph and Sensitivity Analysis

Background: *The LIP flood reevaluation in the FHRR used a 1-hour, front-loaded probable maximum precipitation (PMP) event based on the Hydrometeorological Report Nos. 51 and 52. For the PMP hyetograph, the FHRR extended the 1-hour event by following it with steady precipitation based on a 6-hour PMP.*

Request: *Conduct a sensitivity analysis on the LIP event duration to consider localized (one square mile) PMP events up to 72 hours in duration (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs) and various rainfall distributions (e.g., center-loaded and others in addition to a front-loaded distribution). The evaluations should identify potentially bounding scenarios with respect to flood height, event duration, and associated effects.*

Response:

NUREG/CR-7046, Section 3.2, states: "The local intense precipitation, therefore, deemed equivalent to the 1-hour, 1-square-mile PMP at the location of the site." The LIP scenario for the FHRR conservatively included the 1-hour, 1-square-mile PMP embedded within the 6-hour 10 square-mile PMP using a front-loaded distribution, following the example in Appendix B of NUREG/CR-7046. NUREG/CR-7046 does not illustrate other temporal distributions.

The bounding flood level of any duration LIP event is created by the 1-hour, 1-square-mile PMP, as indicated by the early peaks on the LIP time series plots shown in the FHRR. This makes intuitive sense since the lag time for the local plant watershed is expected to be quite short (much less than one hour). Therefore, longer duration PMPs are anticipated to be bounded the higher intensity of the 1-hour LIP. In that context, flood elevations are not expected to be significantly sensitive to the temporal distribution within the 1-hour LIP itself.

Similarly, shorter duration PMPs are also bounded by the 1-hour, 1-square-mile LIP analysis. This is because the 1-hour, 1-square mile LIP rainfall time series was developed by combining and embedding shorter duration PMPs (i.e., 5-minute, 15-minute, and 30-minute) within the same 1-hour event.

RAI Item 2, Local Intense Precipitation: West Creek Inflow

Background: *Concerning the treatment of the modeled representation of West Creek in the FLO-2D model, AREVA Document No. 32-9207353-000 section 2.1.1 states that the LIP subwatershed for West Creek was delineated at a point approximately 400 ft (131m) upstream of the mouth of the channelized portion of the creek. However, the inflow hydrograph for West Creek was added to the inflow grid element directly upstream of the channelized section in FLO-2D.*

Request: *Discuss the conservatism of locating the West Creek inflow node at the mouth of the channelized portion of West Creek as opposed to where the inflow from the creek enters the grid system, along the computational boundary. Discuss the effect that backwater from Grants Bayou into West Creek has on the model and how conservatism is employed in the model to appropriately represent this.*

Response:

The West Creek inflow node was located at the mouth of the channelized portion of West Creek to ensure that the total computed flow from the West Creek subwatershed north of the Northwest Service Road (AREVA, 2014a and AREVA, 2014b) is routed through the channelized portion of West Creek thereby maximizing the resulting water surface elevation in the channel near RBS.

Note that rainfall is simulated throughout the FLO-2D model domain and hence rain falling in the area between the computational boundary of the FLO-2D grid system where the inflow from the creek enters the FLO-2D (at the Northwest Service Road) grid system and the mouth of the channelized portion of West Creek is accounted for in the LIP analysis. See Figures 1 and 2 for the locations of the mouth of the channelized portion of West Creek and the watershed delineation point at the Northwest Service Road.

The confluence of West Creek and Grants Bayou is over 5,000 feet downstream of RBS and hence backwater effects from Grants Bayou at RBS are expected to be minimal. In addition, South Plant Road which traverses West Creek about 1,000 feet downstream of RBS was modeled as completely blocked and results in more conservative backwater conditions at RBS than any backwater from Grants Bayou.

References:

AREVA, 2014a. AREVA Document No. 32-9207350-000, "River Bend Station Flooding Hazard Re-Evaluation – Local Intense Precipitation – Generated Flood Flow and Elevations Calculations", 2014.

AREVA, 2014b. AREVA Document No. 32-9207353-000, "River Bend Station Flooding Hazard Re-Evaluation – Probable Maximum Flood on Streams and Rivers – Grants Bayou and West Creek Flow and Elevations", 2014.

Figure 1: West Creek Subwatershed LIP Configuration

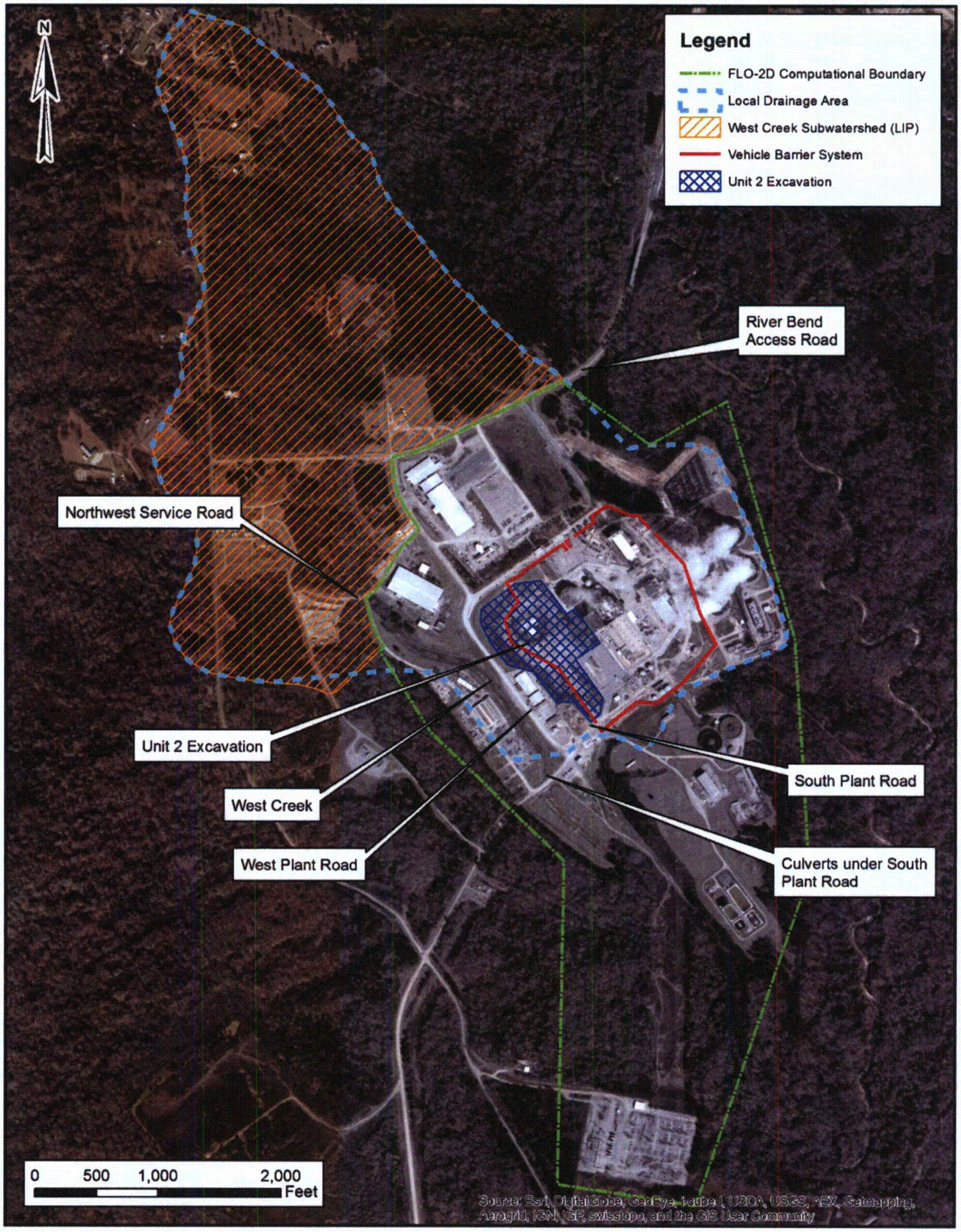
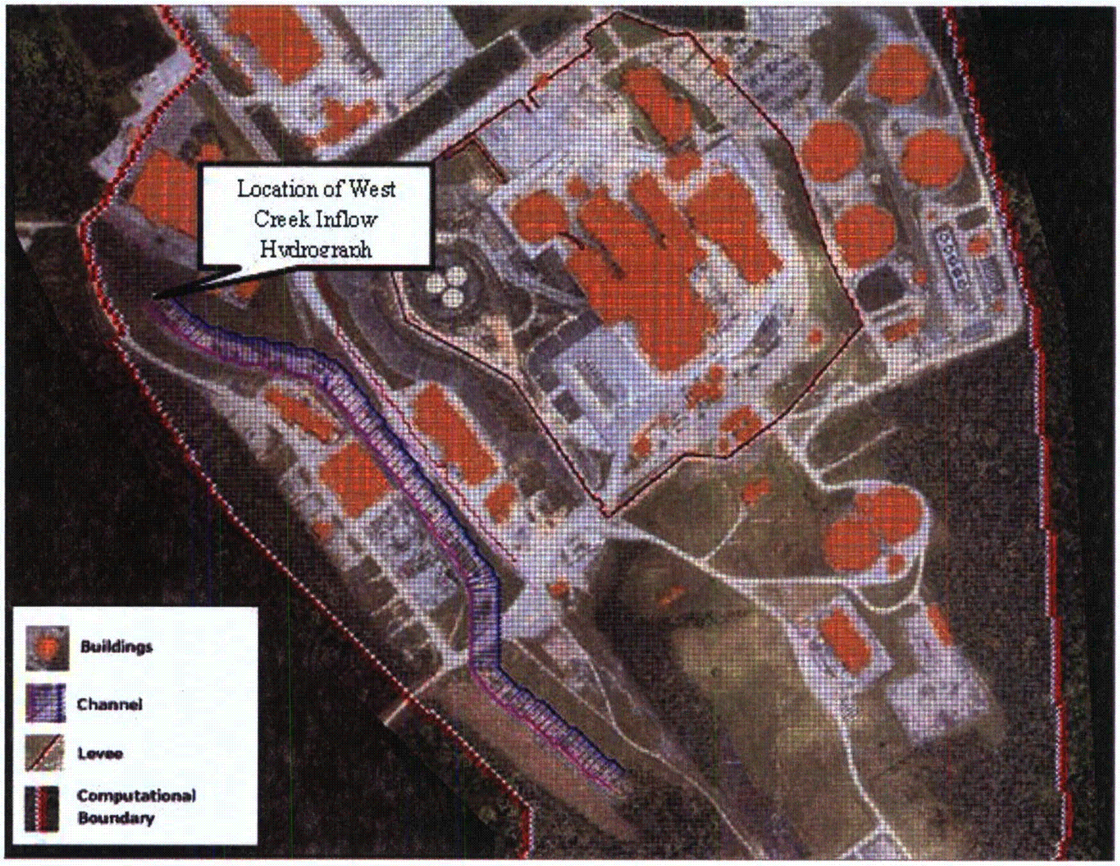


Figure 2: LIP FLO-2D Model Layout



<u>RAI Item 3, Local Intense Precipitation: Vehicle Barrier System (VBS) Simulation</u>

Background: *FHRR section 3.1.2.1.2 states that "simulation of the LIP with the VBS results in a more conservative water surface elevation than without the VBS." The staff did not find the FLO-2D model to represent a VBS within the Unit 2 Excavation.*

Request: *Provide a quantitative comparison of the peak water surface elevations at critical points. Justify the assumption that certain portions of the VBS (e.g., the pedestrian crossing along the southern edge of the VBS) remained open during the LIP event.*

Response:

The berm around the Unit 2 excavation and the VBS, with the exception of the portion in the Unit 2 excavation, at RBS was modeled in FLO-2D using the levee structures component. The portions of the VBS inside the Unit 2 excavation were not modeled in order to maintain model stability. The Unit 2 excavation is more than 20 feet deep (the ground elevation within the excavation is generally less than 70 feet NAVD88 and the general site grade is about 94 feet, NAVD88). The presence of the 4 feet high VBS has no impact on water surface elevations near safety-related SSCs or on the final maximum water surface elevation within the excavation.

The portions of the VBS that were modeled as open during the LIP event (e.g., the pedestrian crossing along the southern edge of the VBS) are passive openings that require no operation. These openings are generally more than 4 feet wide. Since the majority of the area within the VBS is paved, there are limited sources of debris that could block these openings. .

A quantitative comparison of the peak water surface elevations, with and without the VBS, at critical points has been included as Table 1: Comparison of LIP Results with and without VBS. The water surface elevations from the simulation with the VBS are higher (at most of the locations) or equal to the water surface elevations from the simulation without the VBS. The FLO-2D Input and Output files for the simulation without the VBS are included as Attachment A.

Attachment A:

FLO-2D Input and Output Files - No VBS

Table 1: Comparison of LIP Results with and without VBS

Door	Grid Element Numbers	Maximum Water Surface Elevation (ft, NAVD88)		Maximum Flood Depth in vicinity of Door (ft)	
		LIP Calculation with VBS	Simulation without VBS	LIP Calculation with VBS	Simulation without VBS
DG-098-H01	9,549	96.4	95.9	2.6	2.1
DG-098-H02	9,549	96.4	95.9	2.6	2.1
DG-098-01	9,227	96.3	95.9	2.2	1.9
DG-098-02	9,549	96.4	95.9	2.6	2.1
DG-098-03	9,711	96.4	95.9	2.5	2.0
DG-098-H03	9,711	96.4	95.9	2.5	2.0
CB-098-01	9,875	96.4	95.9	2.5	2.0
DG-098-11	9,705	96.2	96.0	1.7	1.5
JRB-D01HTCH	10,194	96.2	96.0	3.1	2.9
AB-098-03	11,036	97.5	97.5	0.5	0.5
AB-098-04	11,206	97.6	97.6	0.5	0.5
CB-098-17	11,207	97.6	97.6	0.4	0.4
FB-095-01	10,186	96.0	95.8	2.0	1.8
SP-098-01	10,348	96.0	95.8	1.8	1.6
FB-098-04	11,025	95.9	95.5	1.7	1.3
AB-098-06	11,872	96.4	96.4	0.5	0.5
AB-098-05	12,041	96.6	96.6	0.4	0.4

RAI Item 4, Local Intense Precipitation: Precipitation onto Buildings

Background: *Width Reduction Factors (WRFs) and Area Reduction Factors (ARFs) were assigned to grid elements representing buildings at RBS in the FLO-2D model. Grid elements that were completely within the extent of a building were blocked with WRFs and ARFs set equal to 1.0. Elements partially within the extent of a building were either completely blocked or completely open. FHRR section 3.1.2.1.2 states that FLO-2D calculates runoff from blocked grid elements and translates such runoff to the nearest unblocked grid element; however, it is not clear how and where rainfall onto the interior building elements is distributed to these unblocked grid elements. Previous staff experience has indicated discrepancies between how software documentation states that rainfall runoff is handled and how the selected model configuration produces those desired effects. Further clarification is required to ensure the selected model configuration matches physical characteristics at the site to ensure consistency, conservatism, and realism. The staff recognizes the coding issues for rainfall on roofs within FLO-2D for model builds before 2014. Before being re-coded in 2014, FLO-2D did not allow water to move outside the building perimeter.*

Request: *Provide a detailed description of how rainfall is routed to the nearest unblocked grid element in FLO-2D. Clarify or reanalyze how rainfall onto building roofs is physically routed at the River Bend Station and demonstrate that the model implementation accounts for roof runoff in a manner consistent with physical reality. Provide a figure showing locations of roof discharge onto the site yard. If building rainfall is routed to a concentrated discharge point, provide a discussion of how the model conservatively simulates localized flooding impacts due to concentrated discharge, and, if necessary, provide sensitivity analysis results that demonstrate the significance of localized flooding impacts from roof discharge. Describe the extent to which the model restricts building rainfall volume from entering the site yard due to the selected reduction factors (i.e., demonstrate whether there is a significant backwater effect at the building interface).*

Response:

In the RBS LIP calculation (AREVA, 2014), ARFs and WRFs were used in conjunction with elevating the grids elements representing areas occupied by buildings to model buildings. A sensitivity analysis was performed by eliminating Area Reduction Factors (ARFs) and Width Reduction Factors (WRFs) to assess if the FLO-2D model implementation at RBS accounts for roof runoff realistically. Buildings at RBS were represented as elevated grid cells based on the site survey and the high resolution orthoimagery. Elevating building grid elements allows for FLO-2D to recognize those grid elements are obstructions relative to lower ground grid elements, and results in runoff from the building rooftops to the ground surface. Grid elements that were completely within the aerial extent of a building were assigned elevations at least 5 feet higher than the surrounding topography (See Figure 3). Uniform elevations were assigned to grid elements representing a single building to ensure that runoff from rooftops are uniformly distributed to the surrounding areas. The peak 1-hour duration LIP depth of 19.4 inches is less than the assumed 5 feet height of the buildings. Therefore, water will not build up high enough to result in flow over the elevated buildings. Elevating grid elements to represent buildings has the potential to create an artificially high hydraulic gradient that may decrease flow depths and increase velocities at the intersection of building grid elements and grid elements representing the adjacent grade. The use of an assumed building height of 5 feet was minimizes this potential.

A comparison of the results of the sensitivity analysis without ARF/WRFs and the results of the model implementation in the RBS LIP calculation (AREVA, 2014) are shown in Table 2: Comparison of Results with and without ARFs. The results from the model implementation in the RBS LIP calculation described in the FHRR are between 0 to 0.2 feet of the results from this sensitivity analysis. No door that was previously dry became wet (flood elevation exceeds elevation at bottom of door) based on the results from the sensitivity analysis. The results of this analysis indicate that the two methodologies for modeling rooftop precipitation drainage (using FLO-2D ARFs/WRFs and using manually elevated grid cells) are in relatively close agreement. Therefore it is demonstrated through this sensitivity analysis that water falling onto buildings in the RBS LIP calculation (AREVA, 2014) was routed as runoff onto the adjacent site grades. The FLO-2D input and output files for this sensitivity run are included as Attachment B.

The more conservative flood elevations which would result from using manually elevated grid cells would not result in additional impacted areas.

Note that the version of FLO-2D used in the LIP calculation (Build No. 13.07.05) does not provide output of its internal routing from rooftops to the nearest unblocked cell when ARFs/WRFs are used. The FLO-2D, Build No.13.07.05 code does allow water to move outside the building perimeter if the water surface elevation on the building grid element is higher than that on the neighboring grid elements.

References:

AREVA, 2014. AREVA Document No. 32-9207350-000, "River Bend Station Flooding Hazard Re-Evaluation – Local Intense Precipitation – Generated Flood Flow and Elevations Calculations", 2014.

Attachment B:

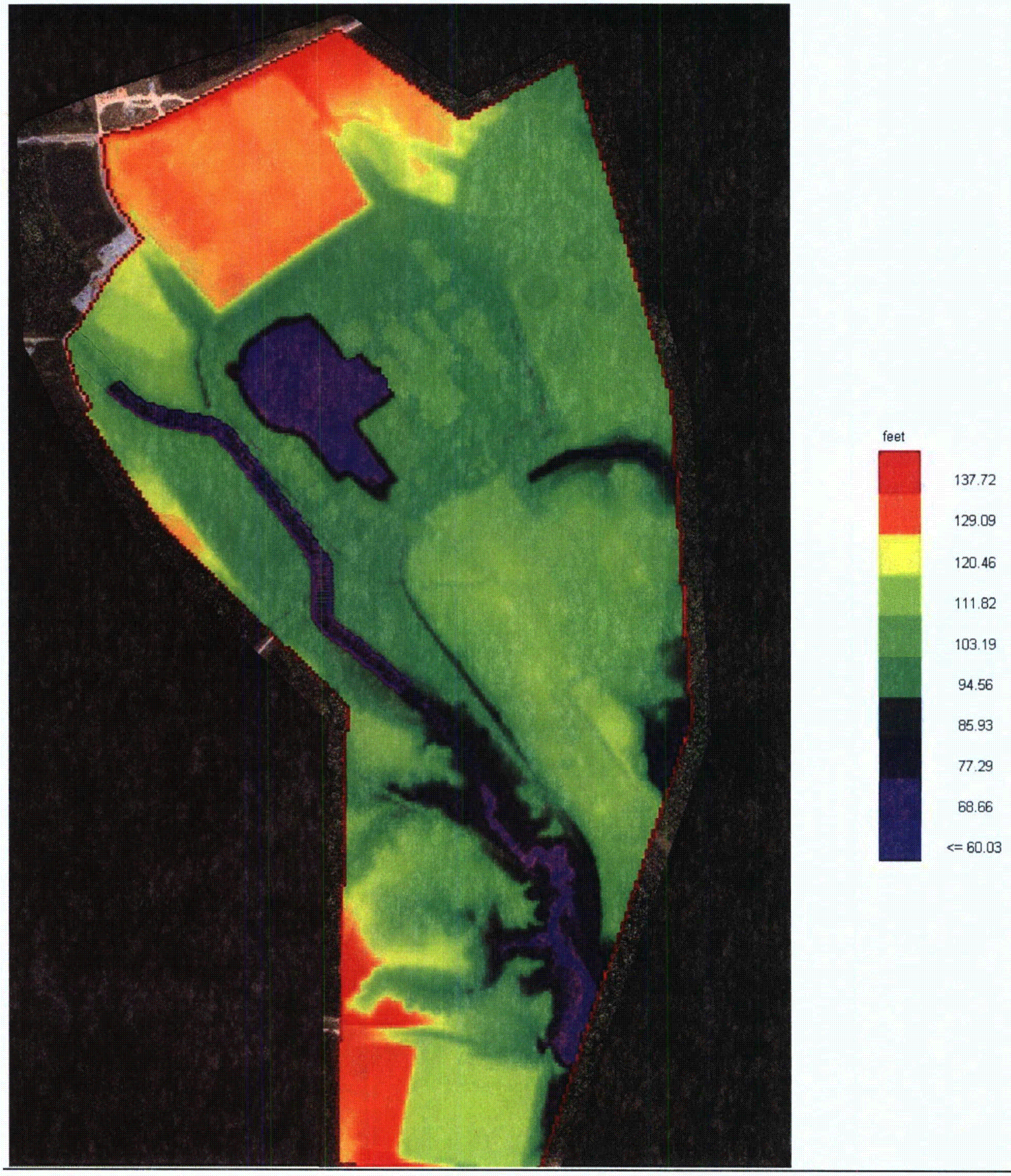
FLO-2D Input and Output Files – No ARFs

Table 2: Comparison of Results with and without ARFs

Door	Grid Element Numbers	Maximum Water Surface Elevation (ft, NAVD88)		Change in Elevation (ft)	Elevation at Bottom of Door (ft, NAVD88)	Previously Calculated Margin	Newly Calculated Margin
		LIP Calculation (Elevated Grids + ARFs)	Elevated Grids-No ARFs				
DG-098-H01	9,549	96.4	96.5	+0.1	97.3	+0.9	+0.8
DG-098-H02	9,549	96.4	96.5	+0.1	97.3	+0.9	+0.8
DG-098-01	9,227	96.3	96.4	+0.1	97.3	+1.0	+0.9
DG-098-02	9,549	96.4	96.5	+0.1	97.3	+0.9	+0.8
DG-098-03	9,711	96.4	96.5	+0.1	97.3	+0.9	+0.8
DG-098-H03	9,711	96.4	96.5	+0.1	97.3	+0.9	+0.8
CB-098-01	9,875	96.4	96.5	+0.1	97.3	+0.9	+0.8
DG-098-11	9,705	96.2	96.3	+0.1	97.4	+1.2	+1.1
JRB-D01HTCH	10,194	96.2	96.3	+0.1	93.1	-3.1	-3.2
AB-098-03	11,036	97.5	97.7	+0.2	97.2	-0.3	-0.5
AB-098-04	11,206	97.6	97.8	+0.2	97.2	-0.4	-0.6
CB-098-17	11,207	97.6	97.8	+0.2	97.4	-0.2	-0.4
FB-095-01	10,186	96.0	96.1	+0.1	94.3	-1.7	-1.8
SP-098-01	10,348	96.0	96.0	+0.0	97.7	+1.7	+1.7
FB-098-04	11,025	95.9	96.0	+0.1	97.3	+1.4	+1.3
AB-098-06	11,872	96.4	96.5	+0.1	97.3	+0.9	+0.8
AB-098-05	12,041	96.6	96.8	+0.2	97.2	+0.6	+0.4

Notes: (1) Elevations have been rounded to one decimal place. (2) Flood Margin above Elevation at Bottom of Door is the difference between LIP Peak Elevation and Elevation at Bottom of Door; negative numbers indicate water elevation is above the bottom of the door.

Figure 3: FLO-2D Grid Element Elevation Rendering - No ARF Simulation



RAI Item 5, Local Intense Precipitation: Manning's Roughness Coefficient

Background: *A Geographic Information System shapefile was created by assigning Manning's roughness coefficients to the apparent land cover classes based on visual assessment of high resolution ortho-imagery. The Manning's roughness coefficients used were based on Table 1 in the FLO-2D Reference Manual. The FHRR states that the upper range values of the Manning's Roughness Coefficients were used. Further comparison between Table 1 from the FLO-2D Reference Manual (Appendix A, Document No. 32-9207350-000) and the calculated Manning's roughness coefficients for the site (Table 3, Document No. 32-9207350-000) shows that the upper range of each roughness coefficient was not always used.*

Request: *Provide a detailed description of how Manning's roughness coefficients were selected for each land cover class. Provide a discussion on the conservatism (relative to onsite effects from LIP) of using upper or lower Manning's roughness coefficients for various land cover classes and in specific site locations.*

Response:

Manning's roughness values were assigned based on apparent land cover visible in the digital orthophotos and observations during site visits. Attachment C shows the Manning's n values selected as compared to the digital orthophoto. Manning's n values were selected after review of typical ranges from the FLO-2D manual (FLO-2D, 2013) and from "Open Channel Hydraulics" by Chow (Chow, 1959), shown in the table below. The Manning's n-values for the "forest" and "short trees" landcover type were at the upper end of the range recommended in the FLO-2D manual. The Manning's n-values for the other landcover classes were selected based on engineering judgment and generally represent the upper ends (or greater) of the Manning's n-value ranges from the open-channel reference book by Chow. In some cases, such as the concrete and brush land cover classes, a more realistic value within the range of literature values was used based on engineering judgment and site observation. Higher Manning's n-values typically result in higher water surface elevations.

Land Cover Class	Manning's n Used in Model	Manning's n Range from FLO-2D Manual	Manning's n Range from Chow
Asphalt Road	0.02	0.02 – 0.05	0.013 – 0.016
Short Grass	0.05	0.20 – 0.40	0.025 – 0.035
Forest	0.40	0.30 – 0.40	0.08 – 0.120
Concrete	0.02	0.02 – 0.05	0.011 – 0.027
Brush	0.10	0.30 – 0.40	0.035 – 0.160
Water	0.025	N/A	
Short Trees	0.20	0.10 – 0.20	0.08 – 0.120

References:

Chow, 1959. "Table 5-6: Values of the Roughness Coefficient n", Open-Channel Hydraulics, Ven Te Chow, 1959.

FLO-2D, 2013. "FLO-2D® Pro Reference Manual", FLO-2D Software Inc., Nutrioso, Arizona (www.flo-2d.com), 2013.

Attachment C:

Manning's n-values for LIP Analysis

RAI Item 6, Streams and Rivers: Probable Maximum Flooding

Background: *The licensee included in the FHRR modeling of PMF flooding at RBS using HEC-RAS (v.4.0) for three separate watersheds – the Mississippi River watershed, Grants Bayou watershed, and the West Creek watershed. The licensee modeled individual PMF scenarios for each of the three watersheds. The FHRR does not include analysis of modeling of PMF flooding considering combined watersheds.*

Request: *Demonstrate whether combined or independent analysis of the three watersheds is more conservative and appropriate.*

Response:

The peak PMF elevations in the Mississippi River was used as the downstream boundary condition in the HEC-RAS model for calculating the PMF elevation in Grants Bayou and the peak PMF elevation in the Grants Bayou was used as downstream boundary condition for the analysis of the PMF elevation in West Creek. This methodology does combine the PMFs for each watershed hydraulically. This approach is more conservative than if the watersheds were combined and treated as a single watershed, since the flood elevations in the receiving streams are likely to be less than their peak PMF elevations if the watersheds were combined, due to differences in watershed lag times due to differences in watershed sizes. The drainage area of the Mississippi River at RBS is over 1,000,000 mi^2. The drainage areas for the Grants Bayou and West Creek at RBS are 8.4 mi^2 and 0.9 mi^2 respectively (AREVA, 2014). Another layer of conservatism in the approach used compared to modeling all the watersheds as a single unit is that the effective PMP depth for a single combined watershed analysis will be less than the PMP depths used for the individual watershed analysis since the effective PMP depths would decrease with increasing drainage area.

References:

AREVA, 2014. AREVA Document No. 32-9207353-000, "River Bend Station Flooding Hazard Re-Evaluation – Probable Maximum Flood on Streams and Rivers – Grants Bayou and West Creek Flow and Elevations", 2014.

<u>RAI Item 7, Streams and Rivers: Manning's Roughness Coefficient for the Mississippi River</u>

Background: *The description of the PMF analysis in FHRR Section 3.2.2.1.2 states that Manning's roughness coefficient was adjusted during HEC-RAS hydraulic model calibrations for the Mississippi River. The staff was unable to find details in the FHRR on how the licensee performed this adjustment, which were the final coefficient values that were used, and how was the adequacy of the final coefficient values determined.*

Request: *Provide additional details on the analysis and selection of the Manning's roughness coefficient values; and, describe how those values compare with recommended values in standard references for the Mississippi River near RBS.*

Response:

The Mississippi River HEC-RAS hydraulic model was calibrated based on stage data for the Mississippi River flood in 2011. The calibrated model was then verified by comparing to the flood elevations from the Mississippi River Project Design Flood (PDF) at Baton Rouge of 1,500,000 cfs (MRC, 2007).

The parameter that was adjusted in the calibration was the Manning's Roughness Coefficient (Manning's n). The Manning's Roughness Coefficients were adjusted until the model provided a peak water surface elevation based on a target elevation difference of 0.5 feet or lower for calibration and 1 foot for verification.

Initial Manning's n-values used in initiating the model were based on literature review (Chow, 1959). The initial Manning's n-values were then adjusted in regular increments until the target elevation difference was achieved.

The final Manning's n-values used in the Mississippi River HEC-RAS model are:

Left Overbank	Channel	Right Overbank
0.10	0.0294	0.10

The calibrated Manning's n-values are within the published range of values for large rivers (Chow, 1959). Typical overbank Manning's n-values range from 0.10 to 0.16 for floodplains consisting of heavy stand of timber, a few downed trees, little undergrowth, and flood stage reaching the branches (Chow, 1959). Typical channel Manning's n-values range from 0.025 to 0.060 for major streams with regular sections and no brush (Chow, 1959). A curve of Manning's n versus flood stage for the Mississippi River is presented in Figure 5-4 (Chow, 1959) and shows that with large flood stages (i.e., the PMF), Manning's n for river channel tends to be approximately 0.030. This is consistent with calibrated Manning's n-value results.

The calibration results at HEC-RAS cross section 265.4 which is the cross section located at the Bayou Sara gage are:

Location	Model Water Surface Elevation (feet NAVD88)	Observed Water Surface Elevation (feet NAVD88)	Difference (feet)
Bayou Sara Gage	55.3	54.9	+0.4

The verification results at HEC-RAS cross section 263.9, which is the cross section located at RBS are:

Location	Model Water Surface Elevation (feet NAVD88)	USACE Reported PDF Water Surface Elevation (feet NAVD88)	Difference (feet)
RBS	55.4	54.5	+0.9

Note that the hydraulic model as calibrated and verified tends to over predict water surface elevations in the Mississippi River. The calibration and verification methodology and results are detailed in the RBS Mississippi River PMF calculation (AREVA, 2014).

References:

MRC, 2007. "The Mississippi River & Tributaries Project: Controlling the Project Flood", Mississippi River Commission, Information Paper, 2007.

RBS, 2013. RBS Updated Final Safety Analysis Report, Revision 20, 2013

AREVA, 2014. AREVA Document No. 32-9207352-001, "River Bend Station Probable Maximum Flood on Streams and Rivers – Mississippi River Flow and Elevation Calculation", 2014.

Chow, 1959. "Table 5-6 Values of Roughness Coefficient n", Open Channel Hydraulics, Ven Te Chow, 1959.

RAI Item 8, Streams and Rivers: Baseflow

Background: *The FHRR assumes that baseflow for West Creek and Grants Bayou is negligible in comparison to the peak PMF flow rates. The staff was not able to find information that the licensee modeled the baseflow for the two watersheds in HEC-RAS for the PMF water surface elevation calculations.*

Request: *Provide substantiation for the assumption that baseflow for West Creek and Grants Bayou is negligible. Demonstrate whether omission of baseflow from the PMF simulation adversely affects the conservatism of the water surface elevation estimate.*

Response:

A sensitivity analysis was performed to demonstrate that the baseflow for the West Creek and Grants Bayou watersheds is negligible under PMF conditions. There are no stream gages on West Creek or Grants Bayou. Using the stream gage records at the nearby Comite River USGS Gage (Gage 07377500) as a "surrogate," a monthly mean base flow of 3.1 cfs per square mile of watershed area was calculated based on the maximum recorded mean monthly flowrate (USGS, 2015). The Comite River gage is located approximately 17 miles east from the site. The watershed of the Comite River gage is 145 square miles. Representative mean base flows were calculated for Grants Bayou and West Creek based on the Comite River watershed and are shown in the table below (Attachment G).

Mean monthly flows are significantly smaller (0.10% or less) than the peak PMF flows. However, as an additional check, the HEC-RAS model was re-run including baseflow (Attachment G). The inclusion of baseflows into the hydraulic models had negligible effects on maximum water elevations for Grants Bayou and West Creek (See Table below and Attachment G).

Watershed	Drainage Area (square miles)	Estimated Base Flow (cfs)	Percent of Peak PMF Flow
Grants Bayou Above Confluence of West Creek	8.4	26.0	0.06%
Grants Bayou Below Confluence of West Creek	7.4	22.9	0.10%
West Creek	0.9	2.8	0.04%

Watershed	Peak PMF Elevation at RBS (ft, NAVD88)	
	Without Baseflow	With Baseflow
Grants Bayou	99.1	99.1
West Creek	94.4	94.4

References:

USGS, 2015. "USGS Surface-Water Monthly Statistics for Louisiana", USGS 0737500 Comite River near Olive Branch, LA, May 13, 2015.

Attachment G:

Baseflow Calculations

<u>RAI Item 9, Streams and Rivers: Bridges</u>

Background: *The Louisiana State Highway 10 Bridge over Grants Bayou is modeled as 50 percent blocked by debris. All other bridges downstream of RBS on Grants Bayou are assumed in the FHRR to be completely blocked. Bridges and culverts upstream of RBS are ignored and not modeled for the PMF peak water surface elevation simulation.*

Request: *Discuss the decision to exclude bridges and culverts upstream of RBS from the model and the conservatism of this approach as it relates to backwater of the river. Justify modeling the Louisiana State Highway 10 Bridge as only 50 percent blocked by debris; provide calculations showing the conservatism or need of this approach rather than modeling the bridge as 100 percent blocked by debris.*

Response:

Excluding bridges and culverts upstream of RBS is conservative since these are likely to cause backwater effects upstream of the site and effectively reduce (e.g., attenuate) the PMF flowrates downstream, leading to lower maximum water surface elevations at the site.

Louisiana State Highway 10 Bridge is over 1,000 feet long from abutment to abutment and consists of piers spaced approximately 72 feet apart. The low chord of the bridge deck is at approximately elevation 80 feet NAVD88 or 30 feet off the stream bed (see AREVA, 2014). The likelihood of significant debris blockage within this large flow conveyance area is judged to be low. Therefore, the assumption to model this bridge as 50% blocked is extremely conservative. Note that the NUREG/CR-7046 (NRC, 2011) guidance does not require hydraulic structures to be considered as blocked in PMF analysis.

References:

AREVA, 2014. AREVA Document No. 32-9207353-000, "River Bend Station Flooding Hazard Re-Evaluation – Probable Maximum Flood on Streams and Rivers – Grants Bayou and West Creek Flow and Elevations", 2014.

NRC, 2011. NUREG/CR-7046: Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America", U.S. Nuclear Regulatory Commission, Springfield, VA, National Technical Information Service, 2011.

RAI Item 10, General: Unit 2 Excavation during PMF

Background: *In the FHRR analysis of the site LIP and PMF, the Unit 2 Excavation is modeled as a storage area in HEC-RAS and acts as a receiving area for flow that overtops West Plant Road (FHRR Section 3.2.2.3.3), which decreases the effective flood depth on site. Examination of the HEC-RAS files for the West Creek shows that the Unit 2 Excavation is considered dry at the beginning of the model (i.e., there is no standing water in the area to add to the PMF water level). This is also stated in the FHRR (Section 3.1.2.1.2) for the FLO-2D analysis. The FHRR mentions RBS Procedure OSP-0031 as the basis for this initial dry setting. Since the PMF is a flood resulting from the PMP, it is possible that water will accumulate within the Unit 2 Excavation prior to the start of the PMF, therefore affecting the final flood elevation due to PMF at RBS.*

Request: *Justify modeling the Unit 2 Excavation with no initial standing water conditions. Provide documentation that supports the Unit 2 Excavation being credited as a flood protection feature in the design basis. Provide information on whether the feature is considered permanent or whether its relevant characteristics and/or function could change in the future.*

Response:

RBS Procedure OSP-0031 requires that equipment located at the base of the Unit 2 Excavation be inspected daily (RBS, 2013, Items 29 and 30). If there are accessibility issues due to flooding, pumps will be used to dewater the excavation as needed.

A 40% antecedent PMP event prior to the PMP induced PMF on West Creek would potentially result in standing water in the Unit 2 Excavation. The amount of water ponding in the Excavation is expected to be relatively low, due to the surrounding elevated berm, and the lack of overtopping from West Creek. Additionally, the 72-hour dry period between the antecedent rain event and the PMF, as well as the lag between the onset of the PMF and actual overtopping of West creek into the Unit 2 Excavation, is considered sufficient to dewater to allow for daily equipment inspection per RBS procedures.

The Unit 2 Excavation is not, however, being credited as a flood protection feature in the design basis. The Unit 2 Excavation is a site topographic feature which influences RBS site drainage and flood inundation. The impacts to flood propagation caused by potential future site topographic changes would be assessed on an "as needed" basis.

Reference:

RBS, 2013. "River Bend Station Operating Manual, Operations Section Procedure", Procedure Number OSP-0031, Revision 063, 2013.

RAI Item 11, Dam Failures: Total Volume Storage Methodology

Background: *The FHRR adopted methodology from the Guidance for Assessment of Flooding Hazards Due to Dam Failure Report (NRC, 2013) for use in the RBS dam failure analysis (FHRR Section 3.3.2). The ISG presents three simplified dam failure modeling approach methods: 1) volume, 2) peak outflow without attenuation, and 3) peak outflow with attenuation. The FHRR models dam failure using suggested steps outlined from both the volume and peak outflow without attenuation methods. The FHRR approach uses the total upstream reservoir volume approach (as outlined for the volume method) but uses regression equations to calculate breach outflow (as outlined for the peak outflow method). Following the peak outflow method by summing individual peak outflows from each upstream dam may provide more conservative results than the FHRR approach of calculating peak outflow for a single "combined" dam breach failure.*

Request: *Justify combining concepts from the two recommended ISG dam failure analysis methods. Discuss conservatism relative to modeling a dam breach outflow based on the total storage volume of a hypothetical dam versus modeling the cumulative outflow resulting from individual upstream dam peak breach outflows. Describe whether the limit to which the regression equations are applicable applies to a dam of the size assumed in this analysis. Provide any supporting calculations and sensitivity analysis.*

Response:

Concepts from two recommended ISG dam failure analysis methods were not combined in the analysis of upstream dam failures at RBS. The "peak outflow without attenuation" method was primarily used in the analysis of dam failure at RBS. The first step of the "peak outflow without attenuation" method outlined in the ISG states that "*...Because of the potentially large number of dams at this stage of the analysis, justification of applicability for individual dams will not be practical.*" Furthermore, the final paragraph of Section 3.2 discusses clustering of dams in general (below the fourth simplified dam failure approach of using hydrologic routing techniques): *"For watersheds with many dams, setting up a single hypothetical dam to conservatively represent multiple dams in a rainfall-runoff-routing model involves much less effort than modeling actual dams. The hypothetical dam(s) should include representative situations of dams in series and cascading failures (see example illustration in Figure 16). The hypothetical dams should conserve the impounded volume of the dams they represent."* This information appears to acknowledge the practicalities of working in a large watershed with a large number of dams and allows for the use of the representative dam concept in general in combination with simplified modeling approaches (with sufficient justification).

There were 114 major dams (dams 50 feet or more in height, dams with a normal storage capacity of 5,000 acre-feet or more, and dams with a maximum storage capacity of 25,000 acre-feet or more) identified for use in the analysis. The dams were justifiably represented as a single large hypothetical dam following the approach described in Section 3.2.1 of the ISG for representing clusters of dams.

The analysis presented in the dam failure analysis is very conservative since it does not consider attenuation of the breach outflow as it travels along the river to the site. Peak breach outflow is generally halved every 10 miles traveled downstream (Reed, 2011).

The regression equation that resulted in the most conservative estimate of the breach outflow at RBS was the Froehlich equation (Froehlich, 1995). The historical dam breach outflow data used in developing the Froehlich regression equation included the Teton Dam in Idaho, which is over 285 feet tall. The height of the single hypothetical dam for RBS is 243 feet. The Froehlich regression equation is therefore appropriate for use in the RBS dam failure analysis.

References:

Reed, 2011. "Validation of a new GIS tool to rapidly develop simplified dam break models" Seann Reed and James Halgren. 2011.

Froehlich, 1995. Peak Outflow from Breached Embankment Dam. Froehlich, D.C. 1995. Journal of Water Resources Planning and Management, vol. 121, no. 1, p. 90-97.

RAI Item 12, Dam Failures: Antecedent Conditions

Background: *The ISG volume and peak outflow without attenuation methods for analyzing dam failure recommend setting antecedent conditions at the site equal to the water surface elevation caused by a 500-year flood. Since the FHRR conservatively modeled the dam failure analysis during the PMF rather than the 500-year flood, the initial conditions at River Bend presumably should be the water surface elevation calculated during the PMF analysis, but the staff did not find the FHRR information to indicate what was used. The staff did not find that the HEC-RAS dam failure input/output files show any assumed conditions at the site.*

Request: *Provide clarification of the antecedent conditions at RBS implemented in the dam failure analysis model.*

Response:

The computed peak PMF flowrate of 5,580,000 cfs (AREVA, 2014a) was added to the peak dam breach outflow of 5,510,000 cfs (AREVA, 2014b) and the sum of the flows (11,090,000 cfs) was input to the HEC-RAS model to calculate the peak flood elevation resulting from upstream dam failures combined with the PMF. The HEC-RAS analysis used a steady state approach based on the combined maximum (11,090,000 cfs) flow rate, which does not require input of initial conditions at the site.

References:

AREVA, 2014a. AREVA Document No. 32-9207352-001, "River Bend Station Probable Maximum Flood on Streams and Rivers – Mississippi River Flow and Elevation Calculation", 2014.

AREVA, 2014b. AREVA Document No. 32-9207355-000, "River Bend Station Flooding Hazard Re-evaluation – Dam Failures", 2014.

Attachment D:

HEC-RAS Input and Output Files for RBS Dam Failure Calculation

RAI Item 13, Combined Effects: Wind Speed

Background: *A Gumbel Distribution was applied to the 2-minute wind speed data from the National Climatic Data Center (NCDC) to determine the 2-year return period wind speed.*

Request: *Discuss the decision to apply the Gumbel Distribution to wind speed data. Compare the results from the Gumbel distribution to other widely used distributions such as the Weibull Distribution.*

Response:

A comparison of the results of the 2-year wind speed calculation using the Gumbel (Maidment, 1993), Weibull (Maidment, 1993), and Log Pearson III (USGS, 1982) distributions are shown in the table below. The distribution fits were assessed by calculating the Pearson r correlation coefficient for each method. The 2-year wind speed calculated using the Weibull distribution is higher, but also a significantly worse fit. The 2-year wind speed using the Log Pearson III distribution has a better fit but yields a less conservative wind speed value. Therefore, the 2-year wind speed calculated using the Gumbel distribution represents an appropriate estimate that both fits the data well and is also conservative. MathCAD and Excel calculation sheets are presented in Attachment E.

Distribution	2-Year Wind Speed (mph)	Pearson r
Gumbel	43.4	0.906
Weibull	45.9	0.799
Log Pearson III	41.0	0.965

References:

Maidment, 1993. "Frequency Analysis of Extreme Events", Handbook of Hydrology, David R. Maidment, 1993.

USGS, 1982. "Guidelines for Determining Flood Flow Frequency", Bulletin 17B of the Hydrology Subcommittee, U.S. Department of the Interior, Geologic Survey, March, 1982.

Attachment E:

2-Year Wind Speed Calculation using other Distributions

RAI Item 14: General: CLB and CDB

Background: *The FHRR refers to the current licensing basis (CLB) and the current design basis (CDB) variously and in some instances without reference. For example, FHRR Tables 4.1-1, 4.1-2, and 4.1-4 refer to the CLB and compare the CLB to the reevaluated flood hazard. A comparison between the CDB and the reevaluated flood hazard is described in the instructions that are provided in the 50.54(f) letter. It is not clear to the staff whether the CLB and CDB are the same or different, and if different, what distinguishes them in the way that they are used in the FHRR.*

Request: *Provide clarification for the inconsistencies identified in the FHRR with regard to the comparison of the reevaluated flood hazard to the current design bases and submit a revised hazard comparison consistent with the instructions provided in the 50.54(f) letter.*

Response:

The Design Basis Flood Level at RBS is 96.0 ft MSL, and is caused by PMP runoff at the site (generally comparable to an LIP event). The Design Basis for flooding at RBS requires protection to a minimum elevation of 98.0 ft MSL. Evaluation of flooding events as documented in the RBS USAR represent plant-specific design bases information. Discussions in the FHRR which include the terminology "design basis" indicates information developed to determine flooding hazard and requirements for flood protection, as indicated in Section 2.4 of the RBS USAR (RBS, 2013).

By definition, CLB (per 10CFR54.3(a)) includes any NRC requirements, current and effective licensee commitments, operation, and any design basis information for the site as documented in the most recent final safety analysis report.

For the purposes of the RBS FHRR, the two terms can be considered to have the same meaning.

RAI Item 15, General: Integrated Assessment Hazard Input

Background: *The FHRR identified local intense precipitation and PMF from streams and rivers (West Creek due to PMP) as flooding causing mechanisms that could potentially expose flood hazard to RBS. The staff did not find the FHRR to provide warning times, duration of inundation of the site, or time for flooding water to recede from the site (see definition and Figure 6 of the NRC interim staff guidance document JLD-ISG-2012-05, "Guidance for Performing an Integrated Assessment," November 2012, ADAMS Accession No. ML12311A214). This includes (as applicable) the warning time the site will have to prepare for the event (e.g., the time between notification of an impending flood event and arrival of floodwaters on site) and the period of time the site is inundated for the mechanisms that are not bounded by the current design basis.*

Request: *Clarify which flood causing mechanism and associated effects, if applicable, will be included in the Integrated Assessment. Provide the applicable flood event duration parameters associated with each mechanism that triggers an integrated assessment using the results of the flood hazard reevaluation. Provide the basis or source of information for the flood event duration, which may include a description of relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and/or timing information derived from the hazard analysis.*

Response:

The Integrated Assessment for RBS will include evaluation of impacts and associated protection/mitigation measures for Local Intense Precipitation and for Probable Maximum Flooding on West Creek. Per the FHRR, Local Intense Precipitation generates the bounding flood elevations and exceeds the design basis flood protection elevation of 98.0 ft MSL in the vicinity of RBS SSCs important to safety. West Creek does not create the bounding flood elevation for the RBS site, but does result in inundation of the Unit 2 Excavation. Inundation of the Unit 2 Excavation due to PMF on West Creek is below the elevation where flooding in the Unit 2 Excavation could impact RBS SSCs important to safety.

The RBS Integrated Assessment will address specific flood durations for the LIP flood scenario, based on time series hydrographs at RBS exterior entrances. Flood protection features credited during the LIP event are passive and in place during normal operations, and no specific manual actions are required prior to the onset of the LIP event. As a result, specific forecast tools and methodologies are not discussed as part of the RBS Integrated Assessment.

RAI Item 16, General: Drainage Divides

Background: *In Table 4.1-1, based on elevation alone, the Grants Bayou PMF water level would trigger inclusion in the Integrated Assessment. The text on FHRR Section 4.1.9 (page 4-5) provides partial explanation of this as a non-issue; and, the elevation of a "drainage divide" that prevents the Grants Bayou PMF from reaching the site is mentioned earlier in FHHR Section 3.2.2.2.3 (page 3-12). This elevation is discussed in a calculation package, but is needed relative to the FHRR. Also, with respect to West Creek (FHRR Section 3.2.2.3.3), "[t]he top elevation of West Plant Road [WPR] drainage divide at the lowest point is 93.5 ft NAVD88 (AREVA, 2013a)." It is not clear to staff whether this is a single point or a length of road.*

Request: *Provide delineation of site drainage divides, with pertinent elevation information, important to the reevaluation; and, where appropriate, whether each drainage divide provides a protected level in the design basis. Provide a figure to include visual reference to drainage divides mentioned in the text; and, clarify in Table 4.1-1 whether the Grants Bayou PMF, with and without wind and wave effects, is separated from the site by a drainage divide with a stated elevation or range thereof. Provide a figure showing the WPR drainage divide low point. Provide clarity to staff whether the WPR low-point this is a single point or a length of the road.*

Response:

While the PMF on Grants Bayou generates the bounding flood elevation at RBS, it does not trigger an integrated assessment. The re-evaluated flood elevation for PMF on Grants Bayou is 2.0 ft lower than the same flood level reported in the RBS USAR. Including wind-generated waves, the re-evaluated flood level for PMF on Grants Bayou is 1.7 ft lower than the Grants Bayou PMF flood level reported in the RBS USAR. The topographic layout of the RBS site prevents any Grants Bayou flooding from impacting SSCs important to safety.

Ground surface elevation profiles along the site drainage divides have been included as Attachment F. Low points referenced in the FHRR are called out along these drainage divides. The lowest point of West Plant Road, which is noted as 93.5 ft NAVD88, is a single point along the divide. The ground surface profile varies along West Plant Road (Drainage Divide 1) as shown in Figure F-1. The West Creek PMF overtops the divide along a distance of approximately 900 feet (Figure F-1). A map showing the drainage divide between West Creek and the RBS site is provided as Figure 4.

Two drainage divides exist between RBS and the Grants Bayou floodplain. Two low areas, less than the Grants Bayou peak PMF elevation, are present along the first berm northeast of the site (Drainage Divide 3 in Attachment F). Drainage Divide 3 would effectively block wave action (i.e. waves would break) that develops along the longest straight line fetch presented in the FHRR. A second divide is located south of the berm near the center of the parking lot (Drainage Divide 4 in Attachment F) with a minimum elevation of approximately 100 feet NAVD88 along the profile. This is above the maximum PMF water surface elevation of 99.1 feet NAVD88 (AREVA, 2014a) and above the maximum combined water surface elevation of 99.4 feet NAVD88 (AREVA, 2014b) in Grants Bayou (including wave-runup). A map showing the drainage divides between Grants Bayou and the RBS site is provided as Figure 5.

References:

AREVA, 2014a. AREVA Document No. 32-9207353-000, "River Bend Station Probable Maximum Flood on Streams and Rivers – Grants Bayou and West Creek Flow and Elevation Calculation", 2014.

AREVA, 2014b. AREVA Document No. 32-9207357-000, "River Bend Station Flooding Hazard Re-evaluation – Combined Events Flood Analysis", 2014.

Attachment F:

Drainage Divide Profiles

Figure 4: Southeast Drainage Divides

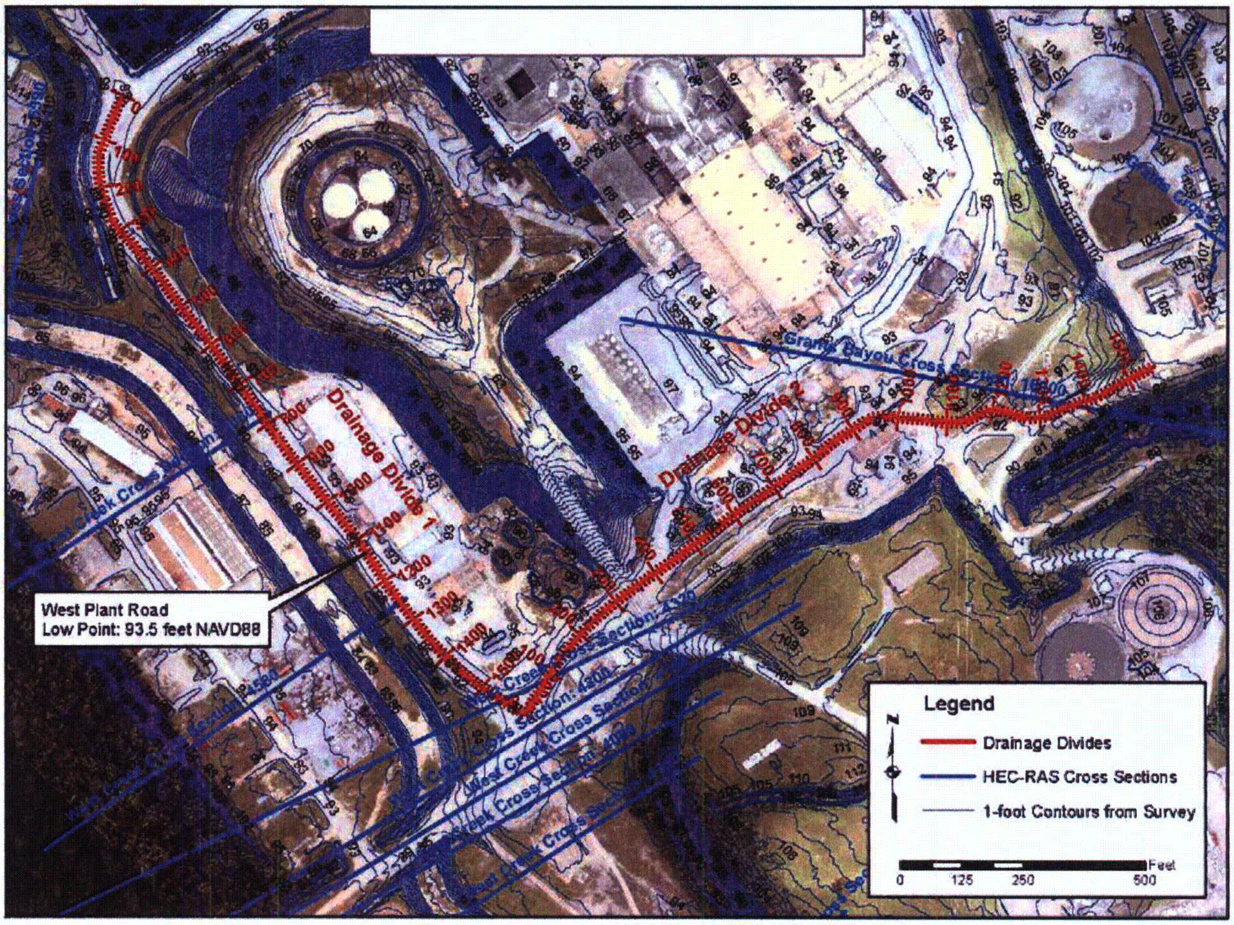
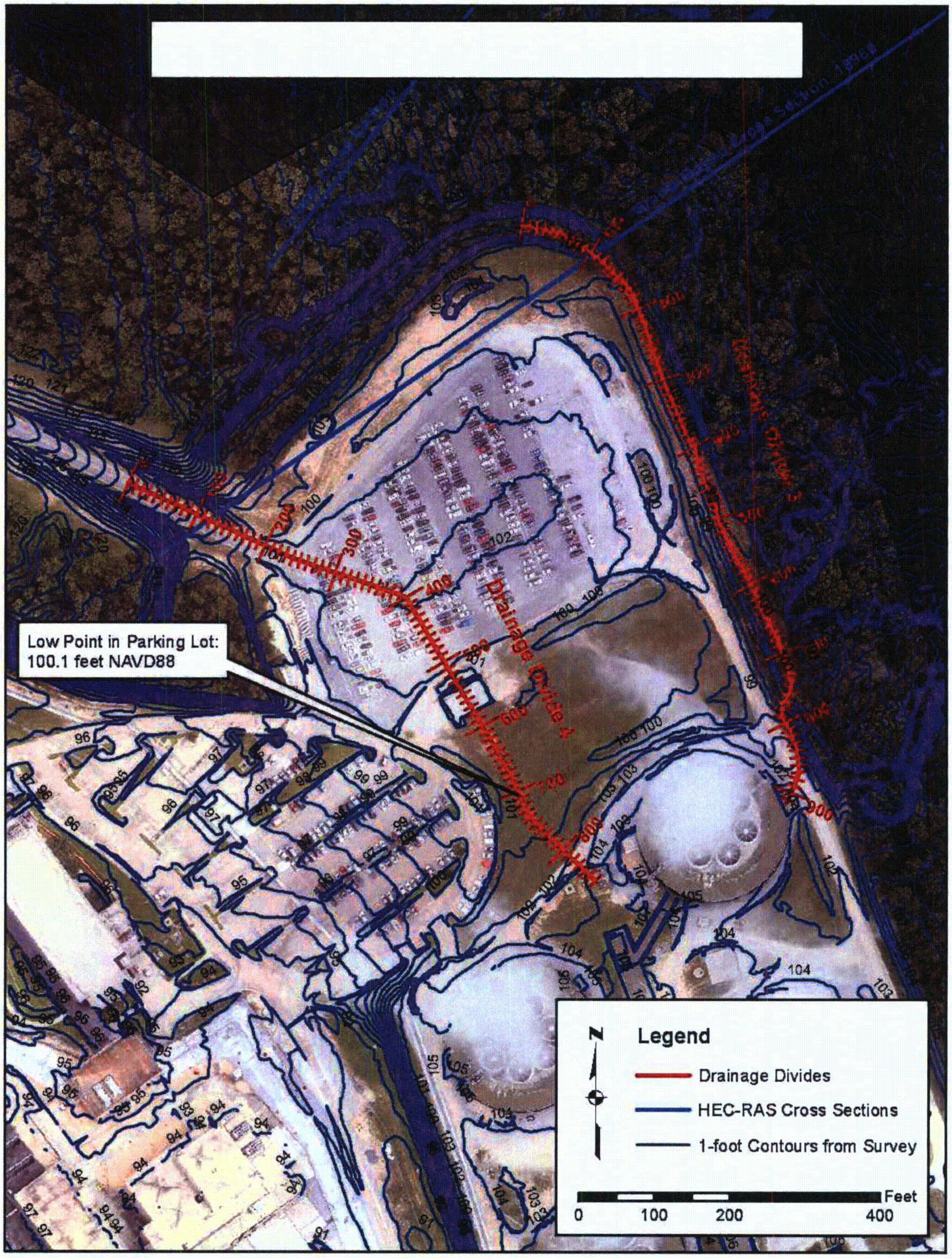


Figure 5: Northeast Drainage Divides




Legend
Computational Boundary
Land Cover
Asphalt
Short Grass
Forest
Concrete
Concrete
Brush
Asphalt
Water
Short Trees
N
0
350
700
1,400
Feet

Attachment D – HEC-RAS Input and Output Files for RBS Dam Failure Calculation

HEC-RAS input and output files have been attached electronically.

Attachment E – 2-Year Wind Speed Calculation using other Distributions

Gumbel Distribution

Step 1: Maximum Wind Speeds from each year for the period of record

Year	Max (.1m/s)	Max (m/s)
1993	179	17.9
1994	161	16.1
1995	174	17.4
1996	443	44.3
1997	165	16.5
1998	174	17.4
1999	174	17.4
2000	165	16.5
2001	174	17.4
2002	268	26.8
2003	174	17.4
2004	161	16.1
2005	183	18.3
2006	174	17.4
2007	295	29.5
2008	273	27.3
2009	228	22.8
2010	161	16.1
2011	219	21.9
2012	201	20.1
2013	161	16.1

Row Labels	Max of WSF2
1993	179
1994	161
1995	174
1996	443
1997	165
1998	174
1999	174
2000	165
2001	174
2002	268
2003	174
2004	161
2005	183
2006	174
2007	295
2008	273
2009	228
2010	161
2011	219
2012	201
2013	161
Grand Total	**443**

Step 2: Determine the 2 year return period wind speed using the Gumbel Distribution

Year	Peak Wind Speed (m/s)	Rank	Gringorten	X_{est}
1994	16.1	1	0.03	10.6
2004	16.1	2	0.07	12.4
2010	16.1	3	0.12	13.5
2013	16.1	4	0.17	14.4
1997	16.5	5	0.22	15.2
2000	16.5	6	0.26	15.9
1995	17.4	7	0.31	16.6
1998	17.4	8	0.36	17.3
1999	17.4	9	0.41	18.0
2001	17.4	10	0.45	18.7
2003	17.4	11	0.50	19.4
2006	17.4	12	0.55	20.1
1993	17.9	13	0.59	20.9
2005	18.3	14	0.64	21.8
2012	20.1	15	0.69	22.7
2011	21.9	16	0.74	23.7
2009	22.8	17	0.78	24.9
2002	26.8	18	0.83	26.4
2008	27.3	19	0.88	28.3
2007	29.5	20	0.93	31.0
1996	44.3	21	0.97	36.6

Gumbel Distribution

Period of Record	21
Mean	20.51
Standard Deviation	6.78
α	5.29
ξ	17.46

$$\alpha = \frac{s\sqrt{6}}{\pi} \qquad \xi = \bar{x} - 0.5772\alpha \qquad x_p = \xi - \alpha \ln(-\ln(p))$$

Return Period (years)	Nonexceedance Probability	Exceedance Probability	Wind Speed (m/s)	Wind Speed (mph)
500	0.998	0.002	50.3	112.53
200	0.995	0.005	45.5	101.68
100	0.99	0.01	41.8	93.45
50	0.98	0.02	38.1	85.20
25	0.96	0.04	34.4	76.88
10	0.9	0.1	29.4	65.67
5	0.8	0.2	25.4	56.79
2	0.5	0.5	**19.4**	43.39

Pearson r Coefficient	0.905457757

Reads in wind speed values from Excel File

data := sort(READEXCEL("J:\170,000-179,999\171705\171705-11.KDH\Work Files\Responses to RA

Number of wind speed values (n) and index number for wind speed (i)

$n := 21$

$i := 1 .. n$

Calculates mean, standard deviation and skew from data set and assigns these values to μx, σ: and γx respectively.

mean(data) = 20.51 stdev(data) = 6.617 skew(data) = 2.4975

$\mu_x := \text{mean(data)}$ $\sigma_x := \text{stdev(data)}$ $\gamma_x := \text{skew(data)}$

A "solve block" is used for the lower bound of the the shape parameter (κ) and the scale parameter (α)

The parameters are initialized:

$\alpha := 0.1$ $\kappa := -0.3$

Given

The equations to solve for each of the parameters are used as constraints using the boolean equals

$$\mu_x = \alpha \cdot \Gamma\left(1 + \frac{1}{\kappa}\right) \qquad \sigma_x^2 = \alpha^2 \cdot \left[\Gamma\left(1 + \frac{2}{\kappa}\right) - \left(\Gamma\left(1 + \frac{1}{\kappa}\right)\right)^2\right]$$

The "find" function can solve linear and nonlinear problems. For these equations the nonlinear solver is the Levenberg-Marquardt Algorithm

$$x(\mu_x, \sigma_x) := \text{Find}(\alpha, \kappa) \qquad x(\mu_x, \sigma_x) = \begin{pmatrix} 22.8205 \\ 3.4257 \end{pmatrix}$$

Assigns the solutions found through the solve block to α, κ, and ξ

$\alpha 1 := x(\mu_x, \sigma_x)_1$ $\kappa 1 := x(\mu_x, \sigma_x)_2$

$\alpha 1 = 22.8205$ $\kappa 1 = 3.4257$

The quantile function is used to solve storm surge height at a specified nonexceedance probability

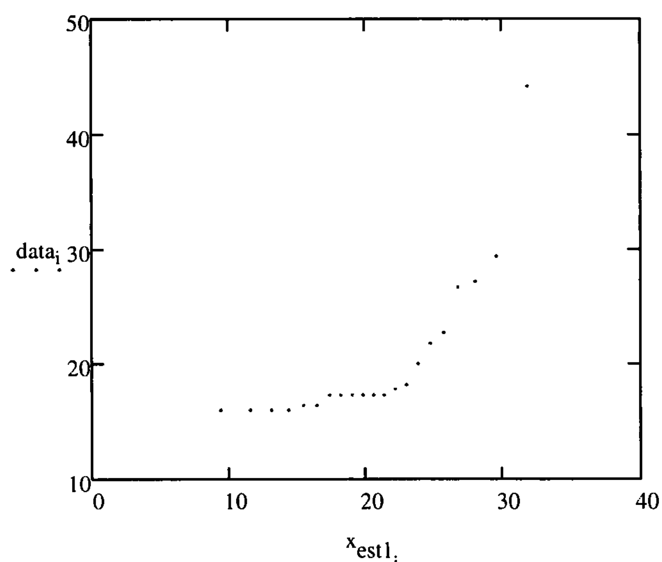
$$x_p(p, \alpha 1, \kappa 1) := \alpha 1 \left(-\ln(1-p)\right)^{\frac{1}{\kappa 1}}$$

$x_p(0.5, \alpha 1, \kappa 1) = 20.505$ $xmph := x_p(0.5, \alpha 1, \kappa 1) \cdot 2.23694 = 45.8684$

The Weibull plotting position is substituted for the nonexceedance probability in the quantile function to create a probability plot

$$x_{est}(\alpha 1, \kappa 1, i) := \alpha 1 \left(-\ln\left(1 - \frac{i}{n+1}\right)\right)^{\frac{1}{\kappa 1}}$$

$$x_{est1_i} := x_{est}(\alpha 1, \kappa 1, i)$$



The "corr" function calculates the Pearson's r correlation coefficient between the wind speed data values and the wind speed values calculated using the Weibull Distribution. Pearson's r is a measure of the linear dependence between two variables and ranges between +1 and -1.

$$\mathrm{corr}\left(\mathrm{data}, x_{est1}\right) = 0.7989$$

Log Pearson Type III Distribution

Step 1: Maximum Wind Speeds from each year for the period of record

Year	Max (.1m/s)	Max (m/s)
1993	179	17.9
1994	161	16.1
1995	174	17.4
1996	443	44.3
1997	165	16.5
1998	174	17.4
1999	174	17.4
2000	165	16.5
2001	174	17.4
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2003	174	17.4
2004	161	16.1
2005	183	18.3
2006	174	17.4
2007	295	29.5
2008	273	27.3
2009	228	22.8
2010	161	16.1
2011	219	21.9
2012	201	20.1
2013	161	16.1

Row Labels	Max of WSF2
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1996	443
1997	165
1998	174
1999	174
2000	165
2001	174
2002	268
2003	174
2004	161
2005	183
2006	174
2007	295
2008	273
2009	228
2010	161
2011	219
2012	201
2013	161
Grand Total	**443**

Step 2: Determine the 2 year return period wind speed using the Log Pearson Type III Distribution

Year	Peak Wind Speed (m/s)	Rank	Log Peak Wind Speed	Weibull Plotting Position	K	X_{est}
1996	44.3	1	1.65	0.05	1.982804	1.52212
2007	29.5	2	1.47	0.09	1.427291	1.45859
2008	27.3	3	1.44	0.14	1.070301	1.41777
2002	26.8	4	1.43	0.18	0.762943	1.38262
2009	22.8	5	1.36	0.23	0.53016	1.35600
2011	21.9	6	1.34	0.27	0.347092	1.33507
2012	20.1	7	1.30	0.32	0.181901	1.31618
2005	18.3	8	1.26	0.36	0.043523	1.30036
1993	17.9	9	1.25	0.41	-0.0869	1.28544
1995	17.4	10	1.24	0.45	-0.18549	1.27417
1998	17.4	11	1.24	0.50	-0.28409	1.26289
1999	17.4	12	1.24	0.55	-0.3717	1.25287
2001	17.4	13	1.24	0.59	-0.45931	1.24286
2003	17.4	14	1.24	0.64	-0.53791	1.23387
2006	17.4	15	1.24	0.68	-0.61427	1.22514
1997	16.5	16	1.22	0.73	-0.6862	1.21691
2000	16.5	17	1.22	0.77	-0.75519	1.20902
1994	16.1	18	1.21	0.82	-0.82265	1.20131
2004	16.1	19	1.21	0.86	-0.88781	1.19386
2010	16.1	20	1.21	0.91	-0.95204	1.18651
2013	16.1	21	1.21	0.95	-1.01255	1.17959

Log Pearson Type III Distribution

Period of Record	21
Average Peak Wind Speed	20.51
Avereage Log Peak Wind Speed	1.30
Variance LogV	0.01
Skew LogV	1.82
Standard Deviation	0.11

Return Period (years)	Exceedance Probability	K	Log V (m/s)	Wind Speed (m/s)	Wind Speed (mph)
500	0.002	5.021032	1.869547704	74.1	165.65
200	0.005	4.162272	1.771346239	59.1	132.13
100	0.01	3.51007	1.696765225	49.7	111.28
50	0.02	2.854966	1.621852359	41.9	93.65
25	0.04	2.195996	1.546497406	35.2	78.73
10	0.1	1.316188	1.445889046	27.9	62.45
5	0.2	0.640004	1.368565627	23.4	52.27
2	0.5	-0.28409	1.262893047	**18.3**	40.98

Goodness of Fit Test

Pearson r Coefficient	0.965

Attachment F – Drainage Divide Profiles

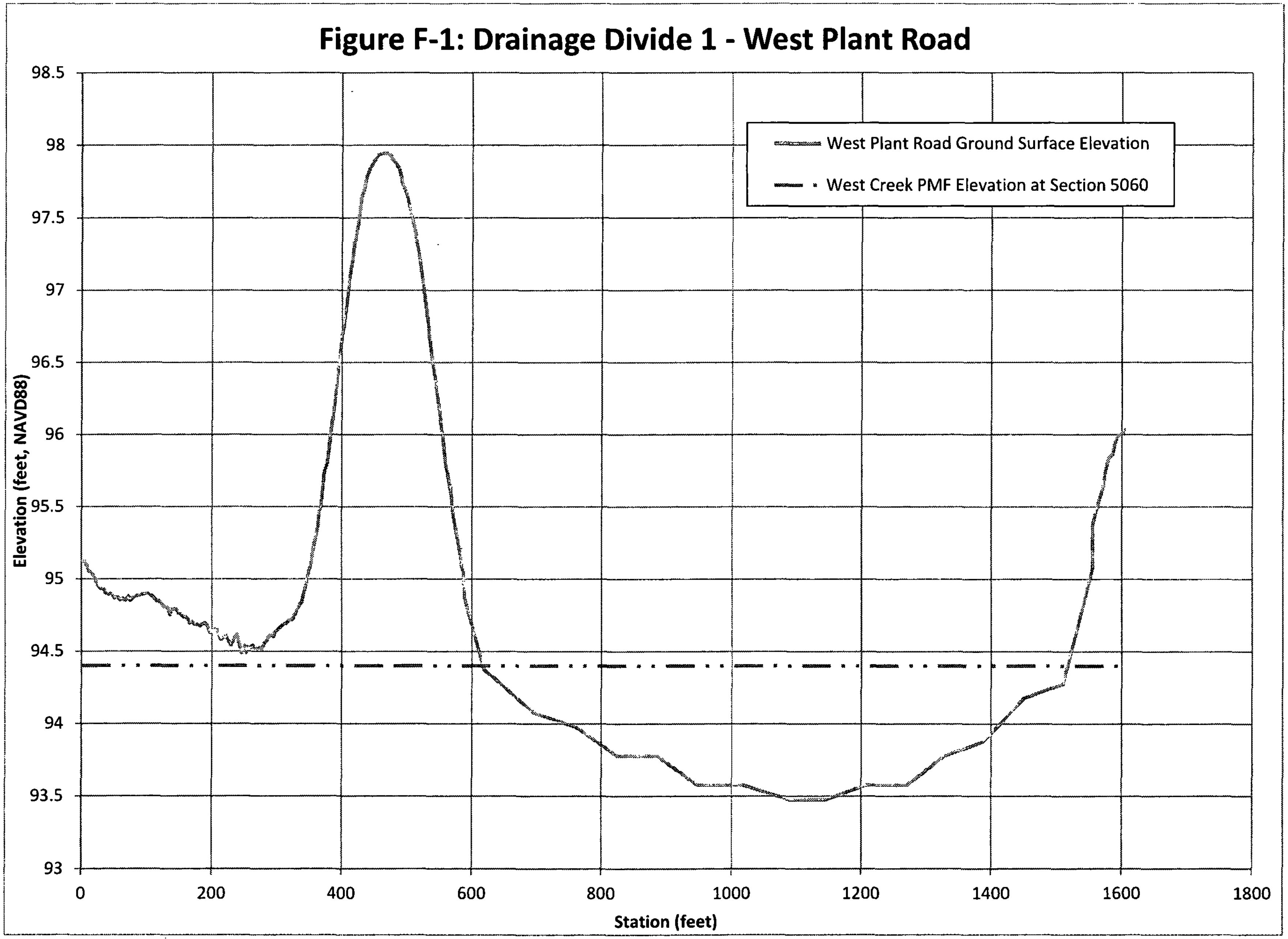


Figure F-1: Drainage Divide 1 - West Plant Road
West Plant Road Ground Surface Elevation
West Creek PMF Elevation at Section 5060
Elevation (feet, NAVD88)
Station (feet)
98.5
98
97.5
97
96.5
96
95.5
95
94.5
94
93.5
93
0
200
400
600
800
1000
1200
1400
1600
1800

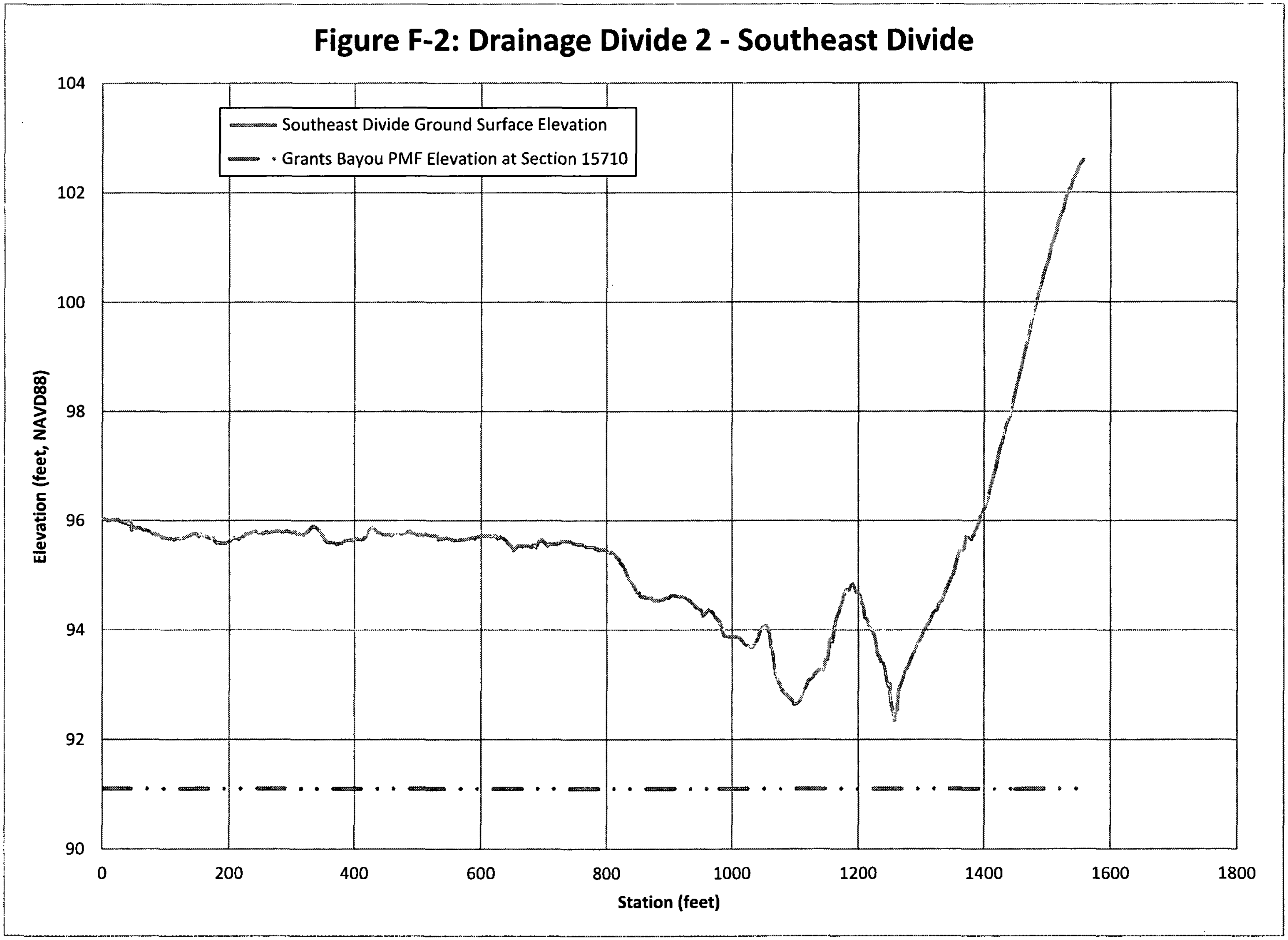


Figure F-2: Drainage Divide 2 - Southeast Divide
Southeast Divide Ground Surface Elevation
Grants Bayou PMF Elevation at Section 15710
Elevation (feet, NAVD88)
Station (feet)
104
102
100
98
96
94
92
90
0
200
400
600
800
1000
1200
1400
1600
1800

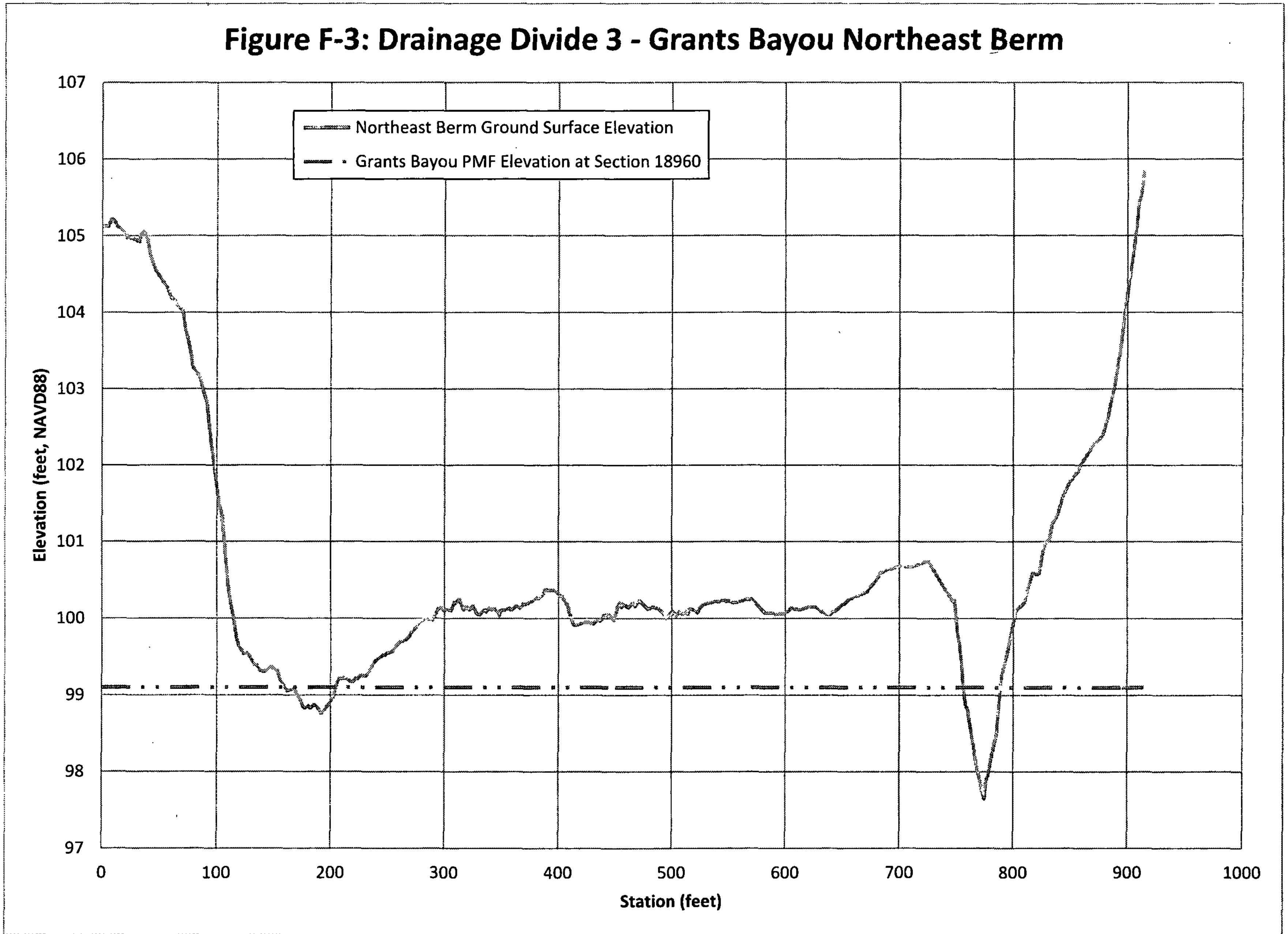
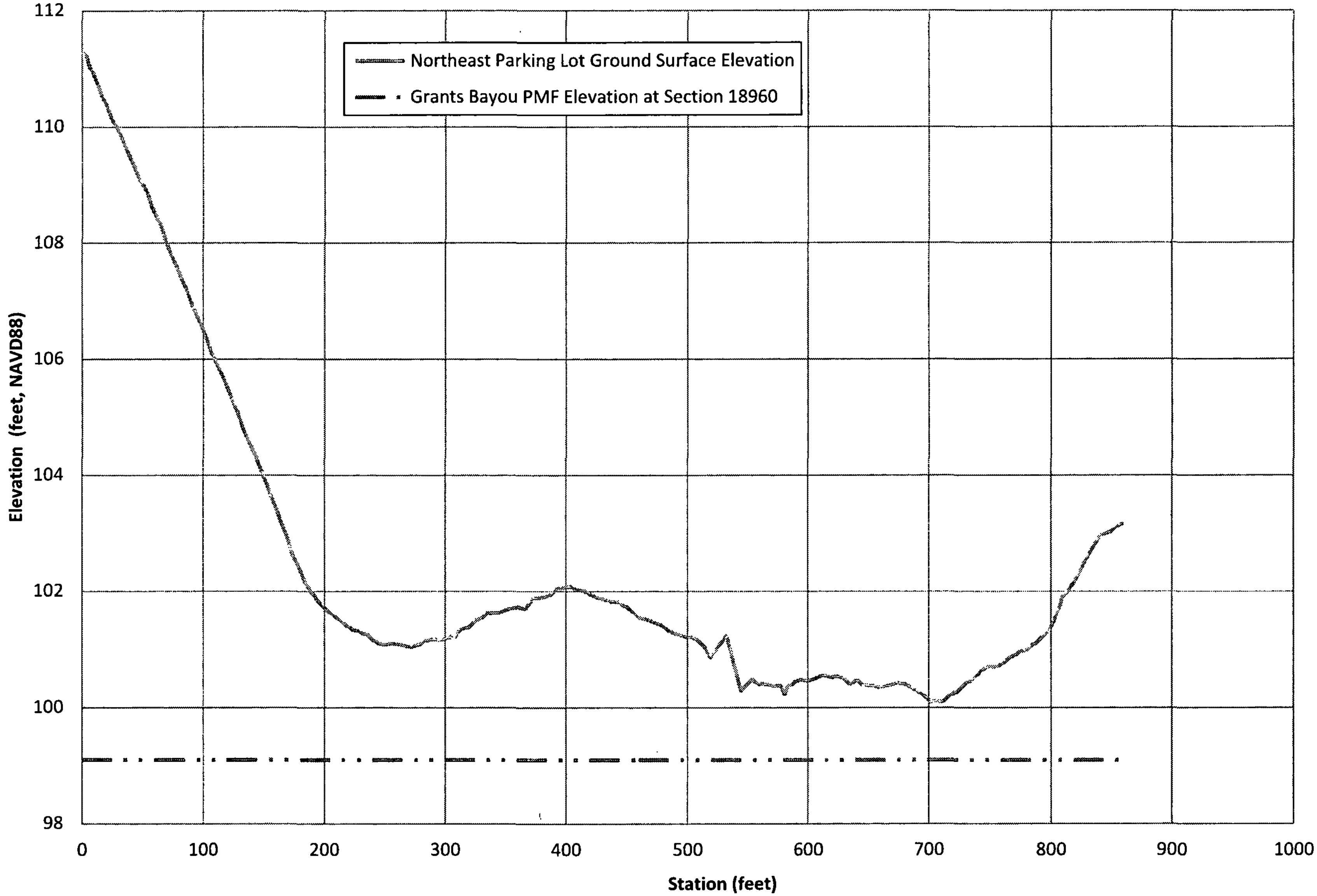


Figure F-3: Drainage Divide 3 - Grants Bayou Northeast Berm
Northeast Berm Ground Surface Elevation
Grants Bayou PMF Elevation at Section 18960
Elevation (feet, NAVD88)
107
106
105
104
103
102
101
100
99
98
97
0
100
200
300
400
500
600
700
800
900
1000
Station (feet)

Figure F-4: Drainage Divide 4 - Grants Bayou Northeast Parking Lot



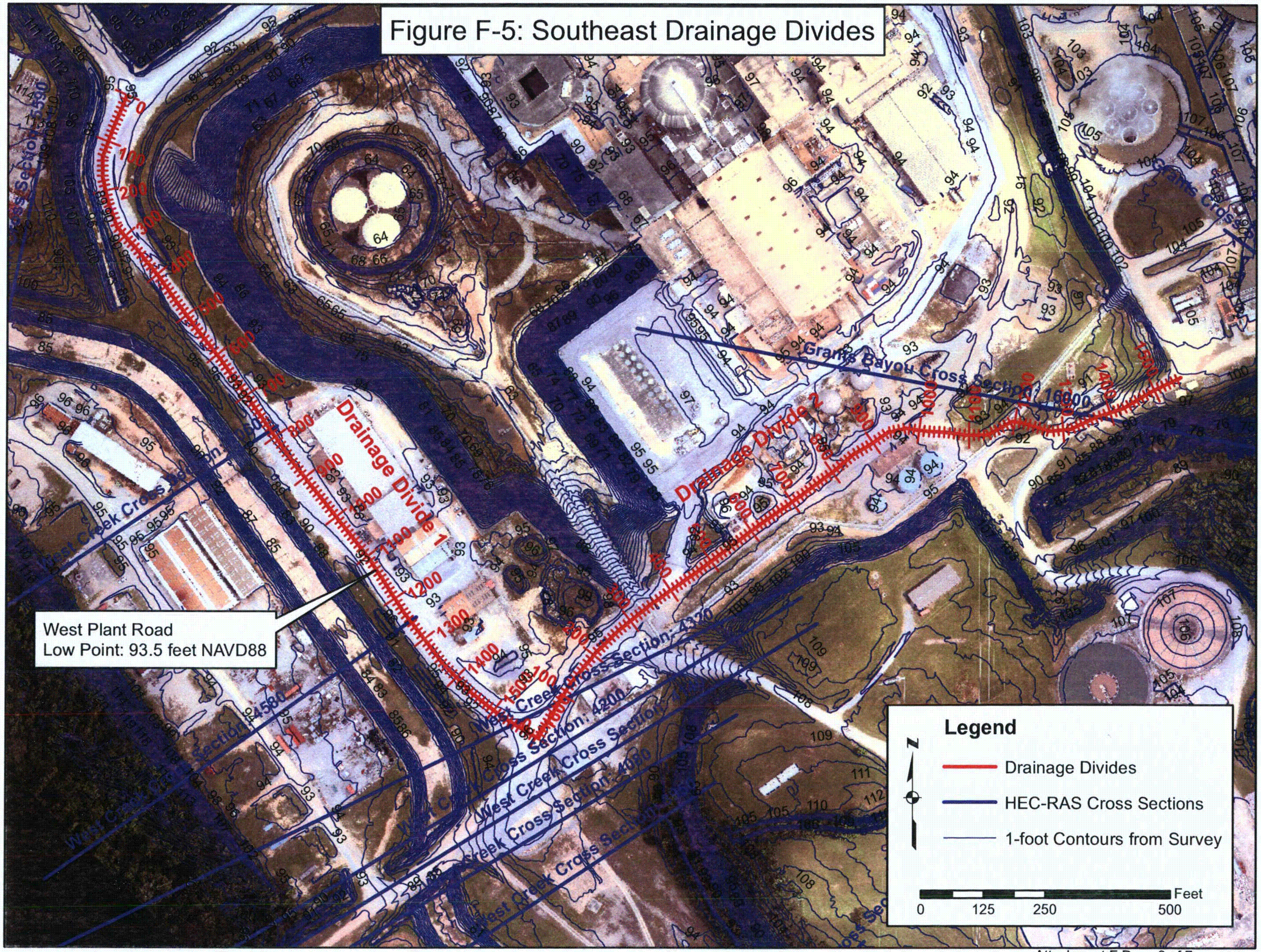


Figure F-5: Southeast Drainage Divides
Drainage Divide 1
Drainage Divide 2
Grand Bayou Cross Section
West Plant Road
Low Point: 93.5 feet NAVD88
West Creek Cross Section
Legend
Drainage Divides
HEC-RAS Cross Sections
1-foot Contours from Survey
0
125
250
500
Feet

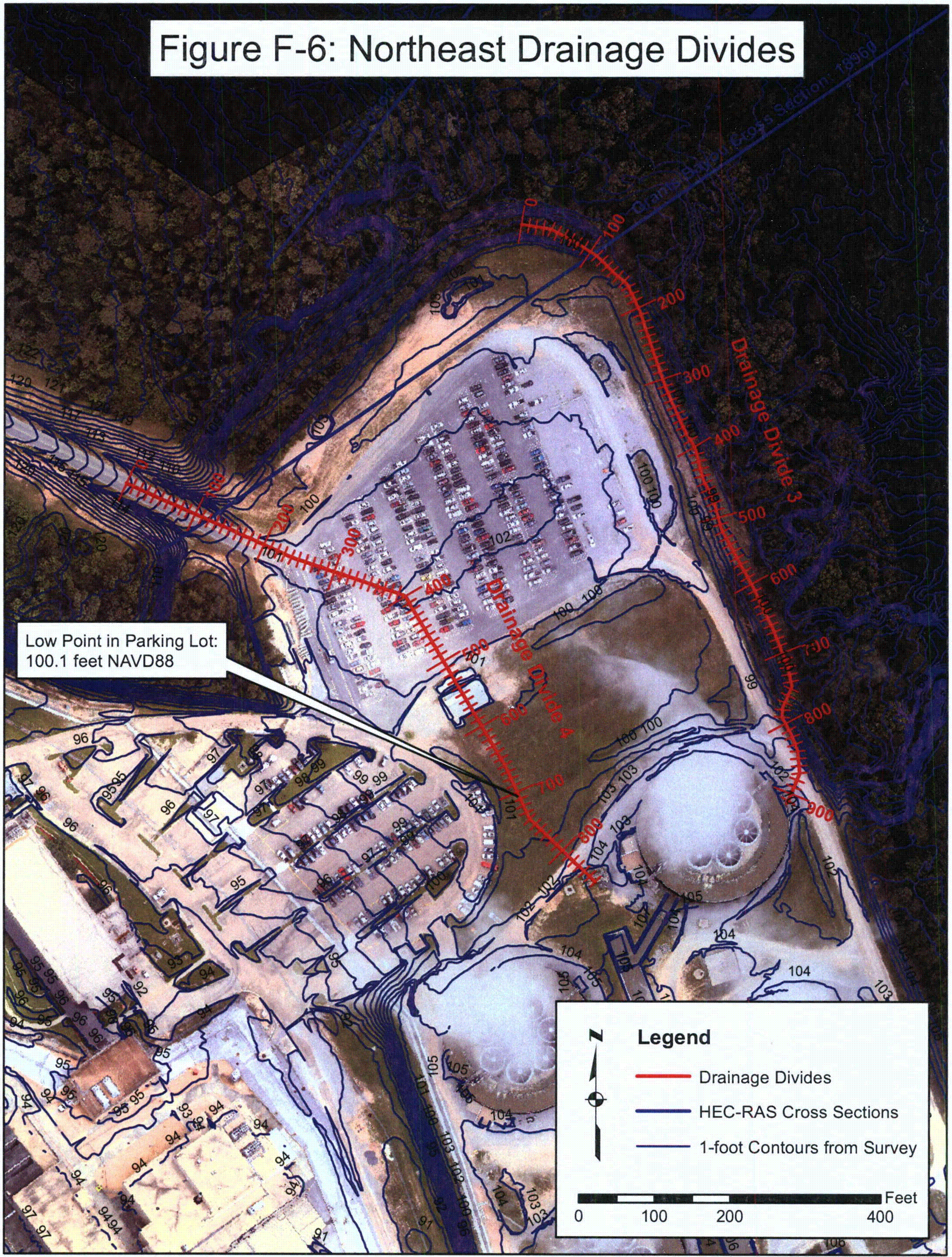


Figure F-6: Northeast Drainage Divides

Attachment G – Grants Bayou and West Creek Baseflow Results and HEC-RAS Input and Output Files

```
#
#
# US Geological Survey, Water Resources Data
# retrieved: 2015-05-13 11:55:22 EDT      (vaww02)
#
# This file contains USGS Surface-Water Monthly Statistics
#
# Note:The statistics generated from  this site are based on approved daily-
mean data and may not match those published by the USGS in official
publications.
# The user is responsible for assessment and use of statistics from this site.
# For more details on why the statistics may not match, visit
http://waterdata.usgs.gov/la/nwis/?dv_statistics_disclaimer.
#
# ** No Incomplete data have been used for statistical calculation
#
# This file includes the following columns:
#
#
# agency_cd    agency code
# site_no USGS site number
# parameter_cd
# dd_nu
# year_nu Calendar year for value
# month_nu     Month for value
# mean_va monthly-mean value.
#         if there is not complete record
#         for a month this field is blank
#
#
# Sites in this file include:
# USGS 07377500 Comite River near Olive Branch, LA
#
# Explanation of Parameter Code and dd_nu used in the Statistics Data
# parameter_cd  Parameter Name                                  dd_nu
Location Name
# 00060         Discharge, cubic feet per second                2
#
#
agency_cd       site_no parameter_cd    dd_nu   year_nu month_nu
mean_va
5s      15s     5s      3n      4s      2s      12n
USGS    07377500        00060   2       1942    10      81.0
USGS    07377500        00060   2       1942    11      75.0
USGS    07377500        00060   2       1942    12      337.5
USGS    07377500        00060   2       1943    1       159.3
USGS    07377500        00060   2       1943    2       689.1
USGS    07377500        00060   2       1943    3       987.2
USGS    07377500        00060   2       1943    4       194.8
USGS    07377500        00060   2       1943    5       77.7
USGS    07377500        00060   2       1943    6       105.5
USGS    07377500        00060   2       1943    7       97.4
USGS    07377500        00060   2       1943    8       54.0
USGS    07377500        00060   2       1943    9       156.1
USGS    07377500        00060   2       1943    10      54.5
USGS    07377500        00060   2       1943    11      237.7
USGS    07377500        00060   2       1943    12      409.9
USGS    07377500        00060   2       1944    1       379.7
USGS    07377500        00060   2       1944    2       269.4
USGS    07377500        00060   2       1944    3       464.7
USGS    07377500        00060   2       1944    4       330.0
USGS    07377500        00060   2       1944    5       158.6
USGS    07377500        00060   2       1944    6       73.8
USGS    07377500        00060   2       1944    7       73.6
```

USGS	07377500	00060	2	1944	8	177.9
USGS	07377500	00060	2	1944	9	197.8
USGS	07377500	00060	2	1944	10	65.6
USGS	07377500	00060	2	1944	11	127.4
USGS	07377500	00060	2	1944	12	243.7
USGS	07377500	00060	2	1945	1	458.6
USGS	07377500	00060	2	1945	2	510.2
USGS	07377500	00060	2	1945	3	158.1
USGS	07377500	00060	2	1945	4	544.7
USGS	07377500	00060	2	1945	5	170.9
USGS	07377500	00060	2	1945	6	97.2
USGS	07377500	00060	2	1945	7	80.8
USGS	07377500	00060	2	1945	8	87.6
USGS	07377500	00060	2	1945	9	71.1
USGS	07377500	00060	2	1945	10	183.9
USGS	07377500	00060	2	1945	11	78.1
USGS	07377500	00060	2	1945	12	253.9
USGS	07377500	00060	2	1946	1	584.0
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USGS	07377500	00060	2	1946	3	377.7
USGS	07377500	00060	2	1946	4	76.8
USGS	07377500	00060	2	1946	5	513.7
USGS	07377500	00060	2	1946	6	274.4
USGS	07377500	00060	2	1946	7	250.3
USGS	07377500	00060	2	1946	8	97.0
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USGS	07377500	00060	2	1946	10	62.1
USGS	07377500	00060	2	1946	11	316.3
USGS	07377500	00060	2	1946	12	202.7
USGS	07377500	00060	2	1947	1	873.5
USGS	07377500	00060	2	1947	2	123.8
USGS	07377500	00060	2	1947	3	796.4
USGS	07377500	00060	2	1947	4	560.7
USGS	07377500	00060	2	1947	5	147.7
USGS	07377500	00060	2	1947	6	208.8
USGS	07377500	00060	2	1947	7	63.8
USGS	07377500	00060	2	1947	8	67.4
USGS	07377500	00060	2	1947	9	86.4
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USGS	07377500	00060	2	1947	11	159.7
USGS	07377500	00060	2	1947	12	451.1
USGS	07377500	00060	2	1948	1	404.8
USGS	07377500	00060	2	1948	2	376.4
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USGS	07377500	00060	2	1948	4	240.1
USGS	07377500	00060	2	1948	5	169.1
USGS	07377500	00060	2	1948	6	67.7
USGS	07377500	00060	2	1948	7	65.3
USGS	07377500	00060	2	1948	8	56.6
USGS	07377500	00060	2	1948	9	79.7
USGS	07377500	00060	2	1948	10	57.9
USGS	07377500	00060	2	1948	11	528.5
USGS	07377500	00060	2	1948	12	634.9
USGS	07377500	00060	2	1949	1	293.1
USGS	07377500	00060	2	1949	2	666.2
USGS	07377500	00060	2	1949	3	931.3
USGS	07377500	00060	2	1949	4	586.1
USGS	07377500	00060	2	1949	5	515.1
USGS	07377500	00060	2	1949	6	187.0
USGS	07377500	00060	2	1949	7	294.2
USGS	07377500	00060	2	1949	8	166.0
USGS	07377500	00060	2	1949	9	95.9
USGS	07377500	00060	2	1949	10	191.5
USGS	07377500	00060	2	1949	11	106.8

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USGS	07377500	00060	2	1950	3	467.1
USGS	07377500	00060	2	1950	4	230.2
USGS	07377500	00060	2	1950	5	123.2
USGS	07377500	00060	2	1950	6	246.7
USGS	07377500	00060	2	1950	7	110.8
USGS	07377500	00060	2	1950	8	78.3
USGS	07377500	00060	2	1950	9	62.2
USGS	07377500	00060	2	1950	10	58.2
USGS	07377500	00060	2	1950	11	60.2
USGS	07377500	00060	2	1950	12	215.9
USGS	07377500	00060	2	1951	1	360.5
USGS	07377500	00060	2	1951	2	437.1
USGS	07377500	00060	2	1951	3	770.2
USGS	07377500	00060	2	1951	4	201.4
USGS	07377500	00060	2	1951	5	78.6
USGS	07377500	00060	2	1951	6	152.8
USGS	07377500	00060	2	1951	7	164.7
USGS	07377500	00060	2	1951	8	65.9
USGS	07377500	00060	2	1951	9	50.0
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USGS	07377500	00060	2	1951	11	56.5
USGS	07377500	00060	2	1951	12	175.1
USGS	07377500	00060	2	1952	1	76.1
USGS	07377500	00060	2	1952	2	285.1
USGS	07377500	00060	2	1952	3	123.8
USGS	07377500	00060	2	1952	4	243.4
USGS	07377500	00060	2	1952	5	133.6
USGS	07377500	00060	2	1952	6	60.7
USGS	07377500	00060	2	1952	7	61.1
USGS	07377500	00060	2	1952	8	54.6
USGS	07377500	00060	2	1952	9	46.4
USGS	07377500	00060	2	1952	10	38.8
USGS	07377500	00060	2	1952	11	57.3
USGS	07377500	00060	2	1952	12	142.2
USGS	07377500	00060	2	1953	1	234.5
USGS	07377500	00060	2	1953	2	632.5
USGS	07377500	00060	2	1953	3	541.0
USGS	07377500	00060	2	1953	4	260.6
USGS	07377500	00060	2	1953	5	1232
USGS	07377500	00060	2	1953	6	106.1
USGS	07377500	00060	2	1953	7	180.0
USGS	07377500	00060	2	1953	8	97.1
USGS	07377500	00060	2	1953	9	53.2
USGS	07377500	00060	2	1953	10	46.3
USGS	07377500	00060	2	1953	11	56.9
USGS	07377500	00060	2	1953	12	276.8
USGS	07377500	00060	2	1954	1	247.8
USGS	07377500	00060	2	1954	2	153.9
USGS	07377500	00060	2	1954	3	121.6
USGS	07377500	00060	2	1954	4	97.2
USGS	07377500	00060	2	1954	5	198.9
USGS	07377500	00060	2	1954	6	50.3
USGS	07377500	00060	2	1954	7	97.8
USGS	07377500	00060	2	1954	8	45.6
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USGS	07377500	00060	2	1954	10	70.9
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USGS	07377500	00060	2	1955	3	77.2

USGS	07377500	00060	2	1955	4	845.2
USGS	07377500	00060	2	1955	5	128.6
USGS	07377500	00060	2	1955	6	101.2
USGS	07377500	00060	2	1955	7	280.3
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USGS	07377500	00060	2	1955	9	59.1
USGS	07377500	00060	2	1955	10	50.0
USGS	07377500	00060	2	1955	11	61.7
USGS	07377500	00060	2	1955	12	554.5
USGS	07377500	00060	2	1956	1	93.9
USGS	07377500	00060	2	1956	2	898.2
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USGS	07377500	00060	2	1956	10	38.5
USGS	07377500	00060	2	1956	11	42.4
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USGS	07377500	00060	2	1957	6	368.4
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USGS	07377500	00060	2	1958	3	340.0
USGS	07377500	00060	2	1958	4	195.0
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USGS	07377500	00060	2	1958	6	148.2
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USGS	07377500	00060	2	1958	9	315.3
USGS	07377500	00060	2	1958	10	63.6
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USGS	07377500	00060	2	1961	2	787.0
USGS	07377500	00060	2	1961	3	1266
USGS	07377500	00060	2	1961	4	183.3
USGS	07377500	00060	2	1961	5	88.5
USGS	07377500	00060	2	1961	6	59.5
USGS	07377500	00060	2	1961	7	107.5
USGS	07377500	00060	2	1961	8	83.4
USGS	07377500	00060	2	1961	9	210.0
USGS	07377500	00060	2	1961	10	58.3
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USGS	07377500	00060	2	1962	4	968.9
USGS	07377500	00060	2	1962	5	147.8
USGS	07377500	00060	2	1962	6	221.4
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USGS	07377500	00060	2	1962	8	76.0
USGS	07377500	00060	2	1962	9	50.6
USGS	07377500	00060	2	1962	10	53.6
USGS	07377500	00060	2	1962	11	51.4
USGS	07377500	00060	2	1962	12	63.1
USGS	07377500	00060	2	1963	1	251.8
USGS	07377500	00060	2	1963	2	161.9
USGS	07377500	00060	2	1963	3	112.7
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USGS	07377500	00060	2	1963	5	47.5
USGS	07377500	00060	2	1963	6	48.7
USGS	07377500	00060	2	1963	7	60.3
USGS	07377500	00060	2	1963	8	60.7
USGS	07377500	00060	2	1963	9	42.5
USGS	07377500	00060	2	1963	10	39.9
USGS	07377500	00060	2	1963	11	46.7
USGS	07377500	00060	2	1963	12	70.8
USGS	07377500	00060	2	1964	1	241.6
USGS	07377500	00060	2	1964	2	164.3
USGS	07377500	00060	2	1964	3	999.2
USGS	07377500	00060	2	1964	4	467.5
USGS	07377500	00060	2	1964	5	86.0
USGS	07377500	00060	2	1964	6	54.1
USGS	07377500	00060	2	1964	7	277.6
USGS	07377500	00060	2	1964	8	52.0
USGS	07377500	00060	2	1964	9	42.3
USGS	07377500	00060	2	1964	10	700.8
USGS	07377500	00060	2	1964	11	165.2
USGS	07377500	00060	2	1964	12	270.8
USGS	07377500	00060	2	1965	1	106.6
USGS	07377500	00060	2	1965	2	423.8
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USGS	07377500	00060	2	1965	5	49.8
USGS	07377500	00060	2	1965	6	48.9
USGS	07377500	00060	2	1965	7	52.9
USGS	07377500	00060	2	1965	8	70.8
USGS	07377500	00060	2	1965	9	116.4
USGS	07377500	00060	2	1965	10	47.2
USGS	07377500	00060	2	1965	11	83.8

USGS	07377500	00060	2	1965	12	214.3
USGS	07377500	00060	2	1966	1	527.3
USGS	07377500	00060	2	1966	2	1454
USGS	07377500	00060	2	1966	3	298.1
USGS	07377500	00060	2	1966	4	385.9
USGS	07377500	00060	2	1966	5	138.1
USGS	07377500	00060	2	1966	6	63.2
USGS	07377500	00060	2	1966	7	99.4
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USGS	07377500	00060	2	1966	9	49.4
USGS	07377500	00060	2	1966	10	46.9
USGS	07377500	00060	2	1966	11	56.1
USGS	07377500	00060	2	1966	12	53.1
USGS	07377500	00060	2	1967	1	97.6
USGS	07377500	00060	2	1967	2	177.8
USGS	07377500	00060	2	1967	3	105.0
USGS	07377500	00060	2	1967	4	800.3
USGS	07377500	00060	2	1967	5	504.6
USGS	07377500	00060	2	1967	6	56.8
USGS	07377500	00060	2	1967	7	92.0
USGS	07377500	00060	2	1967	8	90.2
USGS	07377500	00060	2	1967	9	49.0
USGS	07377500	00060	2	1967	10	41.2
USGS	07377500	00060	2	1967	11	42.3
USGS	07377500	00060	2	1967	12	193.7
USGS	07377500	00060	2	1968	1	166.1
USGS	07377500	00060	2	1968	2	80.3
USGS	07377500	00060	2	1968	3	133.5
USGS	07377500	00060	2	1968	4	177.7
USGS	07377500	00060	2	1968	5	152.7
USGS	07377500	00060	2	1968	6	70.7
USGS	07377500	00060	2	1968	7	53.6
USGS	07377500	00060	2	1968	8	57.0
USGS	07377500	00060	2	1968	9	42.2
USGS	07377500	00060	2	1968	10	38.4
USGS	07377500	00060	2	1968	11	35.7
USGS	07377500	00060	2	1968	12	352.2
USGS	07377500	00060	2	1969	1	84.0
USGS	07377500	00060	2	1969	2	427.3
USGS	07377500	00060	2	1969	3	422.3
USGS	07377500	00060	2	1969	4	549.4
USGS	07377500	00060	2	1969	5	319.9
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USGS	07377500	00060	2	1969	8	46.1
USGS	07377500	00060	2	1969	9	45.0
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USGS	07377500	00060	2	1969	11	42.2
USGS	07377500	00060	2	1969	12	148.0
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USGS	07377500	00060	2	1970	2	77.2
USGS	07377500	00060	2	1970	3	167.0
USGS	07377500	00060	2	1970	4	90.3
USGS	07377500	00060	2	1970	5	51.6
USGS	07377500	00060	2	1970	6	106.0
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USGS	07377500	00060	2	1970	9	59.9
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USGS	07377500	00060	2	1971	1	148.5
USGS	07377500	00060	2	1971	2	271.4
USGS	07377500	00060	2	1971	3	279.7

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USGS	07377500	00060	2	1971	7	94.1
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USGS	07377500	00060	2	1971	9	353.3
USGS	07377500	00060	2	1971	10	52.7
USGS	07377500	00060	2	1971	11	59.3
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USGS	07377500	00060	2	1972	1	456.2
USGS	07377500	00060	2	1972	2	258.6
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USGS	07377500	00060	2	1972	4	68.3
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USGS	07377500	00060	2	1972	6	57.7
USGS	07377500	00060	2	1972	7	61.1
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USGS	07377500	00060	2	1972	9	38.5
USGS	07377500	00060	2	1972	10	63.3
USGS	07377500	00060	2	1972	11	111.0
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USGS	07377500	00060	2	1973	1	225.1
USGS	07377500	00060	2	1973	2	319.3
USGS	07377500	00060	2	1973	3	984.0
USGS	07377500	00060	2	1973	4	934.7
USGS	07377500	00060	2	1973	5	234.9
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USGS	07377500	00060	2	1973	7	74.6
USGS	07377500	00060	2	1973	8	57.7
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USGS	07377500	00060	2	1973	11	595.6
USGS	07377500	00060	2	1973	12	325.6
USGS	07377500	00060	2	1974	1	911.9
USGS	07377500	00060	2	1974	2	425.6
USGS	07377500	00060	2	1974	3	158.6
USGS	07377500	00060	2	1974	4	263.9
USGS	07377500	00060	2	1974	5	187.5
USGS	07377500	00060	2	1974	6	72.1
USGS	07377500	00060	2	1974	7	67.2
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USGS	07377500	00060	2	1974	12	238.9
USGS	07377500	00060	2	1975	1	549.0
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USGS	07377500	00060	2	1975	3	277.2
USGS	07377500	00060	2	1975	4	208.8
USGS	07377500	00060	2	1975	5	628.4
USGS	07377500	00060	2	1975	6	609.3
USGS	07377500	00060	2	1975	7	248.5
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USGS	07377500	00060	2	1975	12	130.3
USGS	07377500	00060	2	1976	1	177.0
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USGS	07377500	00060	2	1976	3	398.1
USGS	07377500	00060	2	1976	4	96.0
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USGS	07377500	00060	2	1976	7	158.8

USGS	07377500	00060	2	1976	8	47.0
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USGS	07377500	00060	2	1976	11	78.3
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USGS	07377500	00060	2	1977	2	272.4
USGS	07377500	00060	2	1977	3	448.5
USGS	07377500	00060	2	1977	4	1010
USGS	07377500	00060	2	1977	5	67.0
USGS	07377500	00060	2	1977	6	47.4
USGS	07377500	00060	2	1977	7	58.5
USGS	07377500	00060	2	1977	8	271.0
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USGS	07377500	00060	2	1977	10	85.8
USGS	07377500	00060	2	1977	11	757.6
USGS	07377500	00060	2	1977	12	445.2
USGS	07377500	00060	2	1978	1	495.8
USGS	07377500	00060	2	1978	2	245.6
USGS	07377500	00060	2	1978	3	172.9
USGS	07377500	00060	2	1978	4	105.1
USGS	07377500	00060	2	1978	5	225.3
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USGS	07377500	00060	2	1978	7	68.3
USGS	07377500	00060	2	1978	8	351.0
USGS	07377500	00060	2	1978	9	118.8
USGS	07377500	00060	2	1978	10	51.0
USGS	07377500	00060	2	1978	11	63.1
USGS	07377500	00060	2	1978	12	133.3
USGS	07377500	00060	2	1979	1	427.8
USGS	07377500	00060	2	1979	2	1168
USGS	07377500	00060	2	1979	3	303.6
USGS	07377500	00060	2	1979	4	1248
USGS	07377500	00060	2	1979	5	119.3
USGS	07377500	00060	2	1979	6	65.2
USGS	07377500	00060	2	1979	7	122.0
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USGS	07377500	00060	2	1979	9	114.3
USGS	07377500	00060	2	1979	10	55.8
USGS	07377500	00060	2	1979	11	117.5
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USGS	07377500	00060	2	1980	1	478.1
USGS	07377500	00060	2	1980	2	271.5
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USGS	07377500	00060	2	1980	4	915.6
USGS	07377500	00060	2	1980	5	532.0
USGS	07377500	00060	2	1980	6	132.9
USGS	07377500	00060	2	1980	7	84.0
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USGS	07377500	00060	2	1980	9	57.5
USGS	07377500	00060	2	1980	10	115.1
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USGS	07377500	00060	2	1980	12	204.3
USGS	07377500	00060	2	1981	1	71.0
USGS	07377500	00060	2	1981	2	188.6
USGS	07377500	00060	2	1981	3	130.3
USGS	07377500	00060	2	1981	4	84.3
USGS	07377500	00060	2	1981	5	193.7
USGS	07377500	00060	2	1981	6	131.5
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USGS	07377500	00060	2	1981	9	78.3
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USGS	07377500	00060	2	1982	2	552.8
USGS	07377500	00060	2	1982	3	126.8
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USGS	07377500	00060	2	1982	5	98.2
USGS	07377500	00060	2	1982	6	64.0
USGS	07377500	00060	2	1982	7	72.5
USGS	07377500	00060	2	1982	8	155.3
USGS	07377500	00060	2	1982	9	46.8
USGS	07377500	00060	2	1982	10	46.4
USGS	07377500	00060	2	1982	11	96.3
USGS	07377500	00060	2	1982	12	1137
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USGS	07377500	00060	2	1983	2	1378
USGS	07377500	00060	2	1983	3	366.3
USGS	07377500	00060	2	1983	4	1445
USGS	07377500	00060	2	1983	5	329.8
USGS	07377500	00060	2	1983	6	318.4
USGS	07377500	00060	2	1983	7	144.8
USGS	07377500	00060	2	1983	8	441.8
USGS	07377500	00060	2	1983	9	72.6
USGS	07377500	00060	2	1983	10	49.3
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USGS	07377500	00060	2	1983	12	298.2
USGS	07377500	00060	2	1984	1	191.7
USGS	07377500	00060	2	1984	2	557.0
USGS	07377500	00060	2	1984	3	215.5
USGS	07377500	00060	2	1984	4	150.3
USGS	07377500	00060	2	1984	5	61.3
USGS	07377500	00060	2	1984	6	80.8
USGS	07377500	00060	2	1984	7	87.1
USGS	07377500	00060	2	1984	8	89.0
USGS	07377500	00060	2	1984	9	91.9
USGS	07377500	00060	2	1984	10	608.3
USGS	07377500	00060	2	1984	11	62.7
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USGS	07377500	00060	2	1985	3	267.5
USGS	07377500	00060	2	1985	4	118.5
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USGS	07377500	00060	2	1985	7	85.7
USGS	07377500	00060	2	1985	8	53.9
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USGS	07377500	00060	2	1985	10	773.6
USGS	07377500	00060	2	1985	11	142.0
USGS	07377500	00060	2	1985	12	255.5
USGS	07377500	00060	2	1986	1	131.8
USGS	07377500	00060	2	1986	2	188.0
USGS	07377500	00060	2	1986	3	199.9
USGS	07377500	00060	2	1986	4	107.7
USGS	07377500	00060	2	1986	5	260.1
USGS	07377500	00060	2	1986	6	208.0
USGS	07377500	00060	2	1986	7	70.9
USGS	07377500	00060	2	1986	8	68.9
USGS	07377500	00060	2	1986	9	44.8
USGS	07377500	00060	2	1986	10	54.8
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USGS	07377500	00060	2	1986	12	365.3
USGS	07377500	00060	2	1987	1	741.4
USGS	07377500	00060	2	1987	2	759.5
USGS	07377500	00060	2	1987	3	691.9

USGS	07377500	00060	2	1987	4	111.9
USGS	07377500	00060	2	1987	5	107.3
USGS	07377500	00060	2	1987	6	220.1
USGS	07377500	00060	2	1987	7	115.5
USGS	07377500	00060	2	1987	8	176.4
USGS	07377500	00060	2	1987	9	52.1
USGS	07377500	00060	2	1987	10	44.9
USGS	07377500	00060	2	1987	11	61.7
USGS	07377500	00060	2	1987	12	74.8
USGS	07377500	00060	2	1988	1	96.9
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USGS	07377500	00060	2	1988	3	508.1
USGS	07377500	00060	2	1988	4	710.5
USGS	07377500	00060	2	1988	5	50.0
USGS	07377500	00060	2	1988	6	55.1
USGS	07377500	00060	2	1988	7	58.0
USGS	07377500	00060	2	1988	8	78.2
USGS	07377500	00060	2	1988	9	446.4
USGS	07377500	00060	2	1988	10	106.8
USGS	07377500	00060	2	1988	11	163.4
USGS	07377500	00060	2	1988	12	417.2
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USGS	07377500	00060	2	1989	3	333.0
USGS	07377500	00060	2	1989	4	116.7
USGS	07377500	00060	2	1989	5	491.5
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USGS	07377500	00060	2	1989	8	89.4
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USGS	07377500	00060	2	1989	11	161.7
USGS	07377500	00060	2	1989	12	376.0
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USGS	07377500	00060	2	1990	2	987.8
USGS	07377500	00060	2	1990	3	249.0
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USGS	07377500	00060	2	1990	5	137.5
USGS	07377500	00060	2	1990	6	132.3
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USGS	07377500	00060	2	1990	9	78.4
USGS	07377500	00060	2	1990	10	63.5
USGS	07377500	00060	2	1990	11	92.5
USGS	07377500	00060	2	1990	12	333.8
USGS	07377500	00060	2	1991	1	1029
USGS	07377500	00060	2	1991	2	939.3
USGS	07377500	00060	2	1991	3	203.0
USGS	07377500	00060	2	1991	4	932.2
USGS	07377500	00060	2	1991	5	823.9
USGS	07377500	00060	2	1991	6	141.3
USGS	07377500	00060	2	1991	7	112.8
USGS	07377500	00060	2	1991	8	134.5
USGS	07377500	00060	2	1991	9	104.9
USGS	07377500	00060	2	1991	10	62.1
USGS	07377500	00060	2	1991	11	67.1
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USGS	07377500	00060	2	1992	1	611.3
USGS	07377500	00060	2	1992	2	635.0
USGS	07377500	00060	2	1992	3	952.3
USGS	07377500	00060	2	1992	4	102.0
USGS	07377500	00060	2	1992	5	100.1
USGS	07377500	00060	2	1992	6	183.4
USGS	07377500	00060	2	1992	7	145.4

USGS	07377500	00060	2	1992	8	358.3
USGS	07377500	00060	2	1992	9	95.3
USGS	07377500	00060	2	1992	10	52.3
USGS	07377500	00060	2	1992	11	258.2
USGS	07377500	00060	2	1992	12	157.3
USGS	07377500	00060	2	1993	1	1039
USGS	07377500	00060	2	1993	2	131.0
USGS	07377500	00060	2	1993	3	457.5
USGS	07377500	00060	2	1993	4	706.0
USGS	07377500	00060	2	1993	5	151.0
USGS	07377500	00060	2	1993	6	93.2
USGS	07377500	00060	2	1993	7	87.9
USGS	07377500	00060	2	1993	8	68.0
USGS	07377500	00060	2	1993	9	58.0
USGS	07377500	00060	2	1993	10	61.8
USGS	07377500	00060	2	1993	11	361.5
USGS	07377500	00060	2	1993	12	152.7
USGS	07377500	00060	2	1994	1	731.7
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USGS	07377500	00060	2	1994	3	185.2
USGS	07377500	00060	2	1994	4	498.0
USGS	07377500	00060	2	1994	5	241.7
USGS	07377500	00060	2	1994	6	185.1
USGS	07377500	00060	2	1994	7	459.8
USGS	07377500	00060	2	1994	8	93.7
USGS	07377500	00060	2	1994	9	113.7
USGS	07377500	00060	2	1994	10	149.1
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USGS	07377500	00060	2	1994	12	139.5
USGS	07377500	00060	2	1995	1	534.1
USGS	07377500	00060	2	1995	2	166.2
USGS	07377500	00060	2	1995	3	924.9
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USGS	07377500	00060	2	1995	6	92.9
USGS	07377500	00060	2	1995	7	101.5
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USGS	07377500	00060	2	1995	9	61.6
USGS	07377500	00060	2	1995	10	70.3
USGS	07377500	00060	2	1995	11	182.3
USGS	07377500	00060	2	1995	12	543.2
USGS	07377500	00060	2	1996	1	320.8
USGS	07377500	00060	2	1996	2	157.4
USGS	07377500	00060	2	1996	3	150.1
USGS	07377500	00060	2	1996	4	194.0
USGS	07377500	00060	2	1996	5	86.6
USGS	07377500	00060	2	1996	6	88.3
USGS	07377500	00060	2	1996	7	60.5
USGS	07377500	00060	2	1996	8	72.8
USGS	07377500	00060	2	1996	9	82.3
USGS	07377500	00060	2	1996	10	173.2
USGS	07377500	00060	2	1996	11	81.0
USGS	07377500	00060	2	1996	12	86.0
USGS	07377500	00060	2	1997	1	311.4
USGS	07377500	00060	2	1997	2	1055
USGS	07377500	00060	2	1997	3	169.4
USGS	07377500	00060	2	1997	4	1507
USGS	07377500	00060	2	1997	5	171.3
USGS	07377500	00060	2	1997	6	500.7
USGS	07377500	00060	2	1997	7	113.6
USGS	07377500	00060	2	1997	8	68.2
USGS	07377500	00060	2	1997	9	49.4
USGS	07377500	00060	2	1997	10	51.3
USGS	07377500	00060	2	1997	11	98.7

USGS	07377500	00060	2	1997	12	253.9
USGS	07377500	00060	2	1998	1	1268
USGS	07377500	00060	2	1998	2	450.1
USGS	07377500	00060	2	1998	3	285.8
USGS	07377500	00060	2	1998	4	265.6
USGS	07377500	00060	2	1998	5	88.3
USGS	07377500	00060	2	1998	6	61.6
USGS	07377500	00060	2	1998	7	55.8
USGS	07377500	00060	2	1998	8	53.1
USGS	07377500	00060	2	1998	9	88.7
USGS	07377500	00060	2	1998	10	82.7
USGS	07377500	00060	2	1998	11	61.6
USGS	07377500	00060	2	1998	12	100.7
USGS	07377500	00060	2	1999	1	365.6
USGS	07377500	00060	2	1999	2	171.5
USGS	07377500	00060	2	1999	3	596.7
USGS	07377500	00060	2	1999	4	75.7
USGS	07377500	00060	2	1999	5	61.4
USGS	07377500	00060	2	1999	6	78.1
USGS	07377500	00060	2	1999	7	76.8
USGS	07377500	00060	2	1999	8	54.9
USGS	07377500	00060	2	1999	9	69.2
USGS	07377500	00060	2	1999	10	103.4
USGS	07377500	00060	2	1999	11	46.2
USGS	07377500	00060	2	1999	12	67.6
USGS	07377500	00060	2	2000	1	70.9
USGS	07377500	00060	2	2000	2	43.9
USGS	07377500	00060	2	2000	3	65.5
USGS	07377500	00060	2	2000	4	111.0
USGS	07377500	00060	2	2000	5	43.9
USGS	07377500	00060	2	2000	6	49.4
USGS	07377500	00060	2	2000	7	56.3
USGS	07377500	00060	2	2000	8	44.5
USGS	07377500	00060	2	2000	9	42.7
USGS	07377500	00060	2	2000	10	33.5
USGS	07377500	00060	2	2000	11	155.6
USGS	07377500	00060	2	2000	12	62.5
USGS	07377500	00060	2	2001	1	338.1
USGS	07377500	00060	2	2001	2	138.0
USGS	07377500	00060	2	2001	3	736.5
USGS	07377500	00060	2	2001	4	61.2
USGS	07377500	00060	2	2001	5	41.8
USGS	07377500	00060	2	2001	6	1406
USGS	07377500	00060	2	2001	7	161.2
USGS	07377500	00060	2	2001	8	114.5
USGS	07377500	00060	2	2001	9	228.7
USGS	07377500	00060	2	2001	10	128.2
USGS	07377500	00060	2	2001	11	45.4
USGS	07377500	00060	2	2001	12	75.7
USGS	07377500	00060	2	2002	1	115.7
USGS	07377500	00060	2	2002	2	146.5
USGS	07377500	00060	2	2002	3	335.2
USGS	07377500	00060	2	2002	4	315.2
USGS	07377500	00060	2	2002	5	59.8
USGS	07377500	00060	2	2002	6	60.4
USGS	07377500	00060	2	2002	7	93.5
USGS	07377500	00060	2	2002	8	607.0
USGS	07377500	00060	2	2002	9	167.7
USGS	07377500	00060	2	2002	10	519.0
USGS	07377500	00060	2	2002	11	455.8
USGS	07377500	00060	2	2002	12	252.9
USGS	07377500	00060	2	2003	1	144.1
USGS	07377500	00060	2	2003	2	1119
USGS	07377500	00060	2	2003	3	372.6

USGS	07377500	00060	2	2003	4	455.3
USGS	07377500	00060	2	2003	5	81.9
USGS	07377500	00060	2	2003	6	86.2
USGS	07377500	00060	2	2003	7	85.6
USGS	07377500	00060	2	2003	8	54.6
USGS	07377500	00060	2	2003	9	48.2
USGS	07377500	00060	2	2003	10	48.5
USGS	07377500	00060	2	2003	11	52.6
USGS	07377500	00060	2	2003	12	67.5
USGS	07377500	00060	2	2004	1	110.1
USGS	07377500	00060	2	2004	2	939.0
USGS	07377500	00060	2	2004	3	92.2
USGS	07377500	00060	2	2004	4	88.7
USGS	07377500	00060	2	2004	5	971.9
USGS	07377500	00060	2	2004	6	584.8
USGS	07377500	00060	2	2004	7	117.2
USGS	07377500	00060	2	2004	8	71.8
USGS	07377500	00060	2	2004	9	54.6
USGS	07377500	00060	2	2004	10	140.9
USGS	07377500	00060	2	2004	11	107.5
USGS	07377500	00060	2	2004	12	190.8
USGS	07377500	00060	2	2005	1	161.6
USGS	07377500	00060	2	2005	2	448.5
USGS	07377500	00060	2	2005	3	114.9
USGS	07377500	00060	2	2005	4	167.0
USGS	07377500	00060	2	2005	5	73.3
USGS	07377500	00060	2	2005	6	100.6
USGS	07377500	00060	2	2005	7	90.4
USGS	07377500	00060	2	2005	8	105.3
USGS	07377500	00060	2	2005	9	107.4
USGS	07377500	00060	2	2005	10	56.7
USGS	07377500	00060	2	2005	11	77.4
USGS	07377500	00060	2	2005	12	141.7
USGS	07377500	00060	2	2006	1	102.3
USGS	07377500	00060	2	2006	2	187.9
USGS	07377500	00060	2	2006	3	93.2
USGS	07377500	00060	2	2006	4	59.8
USGS	07377500	00060	2	2006	5	51.4
USGS	07377500	00060	2	2006	6	42.2
USGS	07377500	00060	2	2006	7	92.3
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USGS	07377500	00060	2	2006	9	45.1
USGS	07377500	00060	2	2006	10	678.1
USGS	07377500	00060	2	2006	11	142.0
USGS	07377500	00060	2	2006	12	239.8
USGS	07377500	00060	2	2007	1	481.2
USGS	07377500	00060	2	2007	2	118.3
USGS	07377500	00060	2	2007	3	81.7
USGS	07377500	00060	2	2007	4	74.9
USGS	07377500	00060	2	2007	5	110.8
USGS	07377500	00060	2	2007	6	59.9
USGS	07377500	00060	2	2007	7	67.5
USGS	07377500	00060	2	2007	8	44.6
USGS	07377500	00060	2	2007	9	52.2
USGS	07377500	00060	2	2007	10	55.2
USGS	07377500	00060	2	2007	11	61.3
USGS	07377500	00060	2	2007	12	112.9
USGS	07377500	00060	2	2008	1	275.7
USGS	07377500	00060	2	2008	2	301.1
USGS	07377500	00060	2	2008	3	207.7
USGS	07377500	00060	2	2008	4	75.3
USGS	07377500	00060	2	2008	5	96.6
USGS	07377500	00060	2	2008	6	51.5
USGS	07377500	00060	2	2008	7	38.2

USGS	07377500	00060	2	2008	8	62.2
USGS	07377500	00060	2	2008	9	958.9
USGS	07377500	00060	2	2008	10	49.3
USGS	07377500	00060	2	2008	11	51.2
USGS	07377500	00060	2	2008	12	120.1
USGS	07377500	00060	2	2009	1	127.2
USGS	07377500	00060	2	2009	2	107.6
USGS	07377500	00060	2	2009	3	613.0
USGS	07377500	00060	2	2009	4	197.8
USGS	07377500	00060	2	2009	5	83.8
USGS	07377500	00060	2	2009	6	43.7
USGS	07377500	00060	2	2009	7	43.7
USGS	07377500	00060	2	2009	8	42.9
USGS	07377500	00060	2	2009	9	61.5
USGS	07377500	00060	2	2009	10	278.9
USGS	07377500	00060	2	2009	11	92.1
USGS	07377500	00060	2	2009	12	621.4
USGS	07377500	00060	2	2010	1	147.0
USGS	07377500	00060	2	2010	2	385.2
USGS	07377500	00060	2	2010	3	198.5
USGS	07377500	00060	2	2010	4	73.9
USGS	07377500	00060	2	2010	5	69.0
USGS	07377500	00060	2	2010	6	80.6
USGS	07377500	00060	2	2010	7	60.2
USGS	07377500	00060	2	2010	8	57.1
USGS	07377500	00060	2	2010	9	41.9
USGS	07377500	00060	2	2010	10	38.5
USGS	07377500	00060	2	2010	11	44.4
USGS	07377500	00060	2	2010	12	76.3
USGS	07377500	00060	2	2011	1	133.8
USGS	07377500	00060	2	2011	2	112.3
USGS	07377500	00060	2	2011	3	378.9
USGS	07377500	00060	2	2011	4	59.3
USGS	07377500	00060	2	2011	5	44.6
USGS	07377500	00060	2	2011	6	40.9
USGS	07377500	00060	2	2011	7	54.3
USGS	07377500	00060	2	2011	8	39.7
USGS	07377500	00060	2	2011	9	88.2
USGS	07377500	00060	2	2011	10	33.6
USGS	07377500	00060	2	2011	11	49.0
USGS	07377500	00060	2	2011	12	82.4
USGS	07377500	00060	2	2012	1	341.0
USGS	07377500	00060	2	2012	2	663.0
USGS	07377500	00060	2	2012	3	411.0
USGS	07377500	00060	2	2012	4	271.8
USGS	07377500	00060	2	2012	5	71.6
USGS	07377500	00060	2	2012	6	72.6
USGS	07377500	00060	2	2012	7	69.1
USGS	07377500	00060	2	2012	8	182.2
USGS	07377500	00060	2	2012	9	136.8
USGS	07377500	00060	2	2012	10	52.6
USGS	07377500	00060	2	2012	11	40.9
USGS	07377500	00060	2	2012	12	279.8
USGS	07377500	00060	2	2013	1	738.8
USGS	07377500	00060	2	2013	2	594.5
USGS	07377500	00060	2	2013	3	190.7
USGS	07377500	00060	2	2013	4	423.9
USGS	07377500	00060	2	2013	5	243.5
USGS	07377500	00060	2	2013	6	83.7
USGS	07377500	00060	2	2013	7	61.2
USGS	07377500	00060	2	2013	8	106.2
USGS	07377500	00060	2	2013	9	118.5
USGS	07377500	00060	2	2013	10	46.8
USGS	07377500	00060	2	2013	11	67.1

USGS	07377500	00060	2	2013	12	118.1
USGS	07377500	00060	2	2014	1	70.4
USGS	07377500	00060	2	2014	2	767.7
USGS	07377500	00060	2	2014	3	244.1
USGS	07377500	00060	2	2014	4	148.1
USGS	07377500	00060	2	2014	5	177.9
USGS	07377500	00060	2	2014	6	196.4
USGS	07377500	00060	2	2014	7	92.8
USGS	07377500	00060	2	2014	8	117.3
USGS	07377500	00060	2	2014	9	84.1

East Feliciana Parish, Louisiana
Hydrologic Unit Code 08070202
Latitude 30°45'23", Longitude 91°02'38"
NAD27
Drainage area 145.00 square miles
Gage datum 113.15 feet above NAVD88

Maximum Mean Monthly Flow (1942-2014) (cfs)	449
Drainage Area (sq. mi.)	145
Baseflow per square mile (cfsm)	3.10

Watershed	**Drainage Area (sq. mi)**	**Baseflow (cfs)**	**PMF Peak Flow (cfs)**	**Percent of Peak Flow**
Grants Bayou Above	8.4	26.0	44900	0.06%
Grants Bayou Below	7.4	22.9	22700	0.10%
West Creek	0.9	2.8	6900	0.04%

HEC-RAS River: Grants Bayou Reach: Upper Profile: Max WS

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	23320	Max WS	PMF	44791.86	86.45	113.39		114.74	0.001903	10.00	6587.40	507.88	0.38
Upper	23320	Max WS	PMFBaseflow	44817.86	86.45	113.40		114.75	0.001903	10.01	6590.45	508.01	0.38
Upper	22150	Max WS	PMF	44752.71	83.11	110.86		112.16	0.002632	11.40	7820.56	590.10	0.44
Upper	22150	Max WS	PMFBaseflow	44778.26	83.11	110.87		112.16	0.002632	11.40	7824.27	590.20	0.44
Upper	21450	Max WS	PMF	44613.63	82.15	106.24		109.96	0.006625	16.95	4227.92	435.73	0.68
Upper	21450	Max WS	PMFBaseflow	44638.16	82.15	106.25		109.97	0.006619	16.95	4232.14	435.95	0.68
Upper	20790	Max WS	PMF	44581.86	78.67	105.26		106.57	0.001925	9.74	6332.84	473.26	0.38
Upper	20790	Max WS	PMFBaseflow	44604.73	78.67	105.27		106.58	0.001923	9.74	6338.24	473.46	0.38
Upper	20280	Max WS	PMF	44565.17	76.21	104.27		105.43	0.002320	11.49	8282.38	551.73	0.42
Upper	20280	Max WS	PMFBaseflow	44571.88	76.21	104.29		105.44	0.002315	11.48	8290.00	551.89	0.42
Upper	19560	Max WS	PMF	44476.78	73.65	101.44		103.79	0.004331	15.96	6921.06	752.51	0.57
Upper	19560	Max WS	PMFBaseflow	44472.36	73.65	101.47		103.80	0.004307	15.93	6940.43	754.45	0.57
Upper	18960	Max WS	PMF	44298.43	72.73	99.07		100.64	0.003191	12.32	8261.76	930.11	0.48
Upper	18960	Max WS	PMFBaseflow	44221.93	72.73	99.14		100.68	0.003130	12.23	8320.23	931.71	0.48
Upper	17780	Max WS	PMF	44039.70	71.04	95.78		97.02	0.002698	11.34	8234.01	694.87	0.44
Upper	17780	Max WS	PMFBaseflow	43900.97	71.04	95.93		97.13	0.002598	11.18	8337.74	698.05	0.44
Upper	16900	Max WS	PMF	43879.20	69.28	94.00		95.02	0.001631	9.29	8182.16	602.11	0.35
Upper	16900	Max WS	PMFBaseflow	43715.50	69.28	94.23		95.22	0.001551	9.12	8321.44	604.82	0.34
Upper	16460	Max WS	PMF	43600.74	69.81	92.08		94.05	0.004276	13.69	5975.03	480.10	0.55
Upper	16460	Max WS	PMFBaseflow	43449.14	69.81	92.46		94.31	0.003943	13.32	6158.38	488.02	0.53
Upper	15710	Max WS	PMF	43462.16	65.38	91.13		91.58	0.001184	7.54	13526.21	1084.20	0.29
Upper	15710	Max WS	PMFBaseflow	43339.97	65.38	91.63		92.04	0.001056	7.23	14067.41	1091.62	0.28
Upper	14920	Max WS	PMF	43373.59	63.56	90.25		90.58	0.000872	7.18	15484.55	1101.15	0.26
Upper	14920	Max WS	PMFBaseflow	43274.10	63.56	90.85		91.15	0.000784	6.92	16149.46	1131.00	0.25
Upper	14050	Max WS	PMF	43308.79	61.66	89.07		89.79	0.001253	7.98	9064.16	570.02	0.31
Upper	14050	Max WS	PMFBaseflow	43234.93	61.66	89.80		90.46	0.001101	7.65	9485.69	576.82	0.29
Upper	12930	Max WS	PMF	43251.90	59.22	87.60		88.42	0.001257	9.19	9332.41	530.01	0.32
Upper	12930	Max WS	PMFBaseflow	43221.52	59.22	88.52		89.26	0.001096	8.78	9827.30	539.82	0.30
Upper	12050	Max WS	PMF	43232.68	56.29	87.17		87.42	0.000436	5.24	16541.83	933.98	0.18

HEC-RAS River: Grants Bayou Reach: Upper Profile: Max WS (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	12050	Max WS	PMFBaseflow	43218.17	56.29	88.17		88.39	0.000374	4.98	17480.88	948.51	0.17
Upper	11500	Max WS	PMF	65687.44	55.07	85.86		86.61	0.001289	9.22	16164.92	1226.85	0.32
Upper	11500	Max WS	PMFBaseflow	72140.90	55.07	86.73		87.58	0.001401	9.83	17295.05	1392.77	0.34
Upper	11400	Max WS	PMF	65686.27	55.04	85.83	73.43	86.40	0.001114	8.61	17840.45	1183.44	0.30
Upper	11400	Max WS	PMFBaseflow	72140.88	55.04	86.71	73.95	87.35	0.001197	9.12	18919.98	1269.67	0.31
Upper	11330			Inl Struct									
Upper	11300	Max WS	PMF	65672.79	55.04	85.72		86.29	0.001135	8.66	17708.60	1176.26	0.30
Upper	11300	Max WS	PMFBaseflow	72140.88	55.04	86.59		87.22	0.001198	9.10	18768.80	1259.16	0.31
Upper	10230	Max WS	PMF	65657.79	51.96	84.47		84.95	0.000873	7.72	18670.17	1260.30	0.26
Upper	10230	Max WS	PMFBaseflow	72122.58	51.96	85.29		85.82	0.000935	8.15	19741.94	1316.17	0.28
Upper	9910	Max WS	PMF	65656.83	51.75	84.25	70.62	84.59	0.000739	7.27	21428.23	1106.17	0.24
Upper	9910	Max WS	PMFBaseflow	72121.60	51.75	85.05	71.18	85.43	0.000790	7.66	22322.88	1112.86	0.25
Upper	9870			Bridge									
Upper	9840	Max WS	PMF	65640.81	51.03	79.46		80.11	0.001696	9.70	15462.52	951.57	0.36
Upper	9840	Max WS	PMFBaseflow	72108.86	51.03	80.25		80.97	0.001786	10.18	16221.99	963.31	0.37
Upper	9420	Max WS	PMF	65639.39	50.76	78.38		79.46	0.002345	11.58	12627.01	819.07	0.42
Upper	9420	Max WS	PMFBaseflow	72098.80	50.76	79.10		80.28	0.002490	12.18	13221.51	827.80	0.44
Upper	8330	Max WS	PMF	65627.84	48.12	76.07		76.85	0.002118	10.78	14045.68	862.66	0.40
Upper	8330	Max WS	PMFBaseflow	72084.78	48.12	76.61		77.49	0.002321	11.46	14513.06	867.16	0.42
Upper	7640	Max WS	PMF	65626.09	47.34	75.55	63.89	75.92	0.000797	7.17	21370.42	1251.71	0.25
Upper	7640	Max WS	PMFBaseflow	72083.34	47.34	76.04	64.34	76.46	0.000886	7.65	21987.24	1257.58	0.27
Upper	7600			Inl Struct									
Upper	7580	Max WS	PMF	65450.96	45.73	71.90		73.17	0.002246	10.94	11841.89	945.01	0.41
Upper	7580	Max WS	PMFBaseflow	71855.04	45.73	72.79		74.13	0.002280	11.31	12693.42	963.40	0.42
Upper	7430	Max WS	PMF	65425.51	45.29	71.58		72.90	0.003017	12.06	11384.67	927.40	0.47
Upper	7430	Max WS	PMFBaseflow	71821.88	45.29	72.47		73.86	0.003026	12.43	12155.31	939.12	0.47
Upper	5800	Max WS	PMF	65272.45	42.50	69.31		69.70	0.000832	6.51	19399.67	1215.14	0.25
Upper	5800	Max WS	PMFBaseflow	71625.05	42.50	70.20		70.62	0.000853	6.77	20481.57	1221.27	0.25

HEC-RAS River: Grants Bayou Reach: Upper Profile: Max WS (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	4160	Max WS	PMF	65227.76	40.58	67.05		67.82	0.001437	8.56	13390.94	841.12	0.33
Upper	4160	Max WS	PMFBaseflow	71580.71	40.58	67.83		68.67	0.001511	8.99	14049.69	855.32	0.34
Upper	2020	Max WS	PMF	65210.71	37.82	61.83		62.88	0.002726	10.71	11548.63	798.84	0.44
Upper	2020	Max WS	PMFBaseflow	71550.28	37.82	62.25		63.45	0.003011	11.43	11887.35	801.57	0.46
Upper	740	Max WS	PMF	65209.76	35.05	59.71		60.00	0.001125	7.26	21648.55	1428.52	0.29
Upper	740	Max WS	PMFBaseflow	71548.85	35.05	59.85		60.18	0.001317	7.89	21842.90	1429.25	0.31
Upper	0	Max WS	PMF	150.06	34.22	59.00	35.55	59.00	0.000000	0.01	29720.66	2270.14	0.00
Upper	0	Max WS	PMFBaseflow	150.06	34.22	59.00	35.55	59.00	0.000000	0.01	29720.66	2270.14	0.00

HEC-RAS River: West Creek Reach: Main Profile: Max WS

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	8300	Max WS	WCPMF	6877.60	112.75	120.57		121.54	0.006923	9.05	1346.63	351.40	0.60
Main	8300	Max WS	PMFBaseflow	6880.40	112.75	120.57		121.54	0.006923	9.05	1347.16	351.62	0.60
Main	7520	Max WS	WCPMF	6836.80	105.24	115.51		116.31	0.004298	7.81	1367.60	296.51	0.48
Main	7520	Max WS	PMFBaseflow	6839.62	105.24	115.51		116.32	0.004298	7.81	1368.08	296.56	0.48
Main	6550	Max WS	WCPMF	6808.07	103.07	111.63		112.10	0.003615	6.48	2002.10	520.71	0.43
Main	6550	Max WS	PMFBaseflow	6810.89	103.07	111.63		112.10	0.003615	6.48	2002.83	520.79	0.43
Main	6450	Max WS	WCPMF	6807.88	101.85	111.22		111.67	0.003874	5.44	1382.33	443.86	0.43
Main	6450	Max WS	PMFBaseflow	6810.69	101.85	111.22		111.68	0.003874	5.45	1382.91	444.08	0.43
Main	6320	Max WS	WCPMF	6807.61	99.65	109.66	109.49	111.39	0.013647	11.48	956.07	300.46	0.82
Main	6320	Max WS	PMFBaseflow	6810.43	99.65	109.66	109.49	111.39	0.013647	11.48	956.46	300.50	0.82
Main	6210	Max WS	WCPMF	6807.41	100.66	107.34	108.11	110.39	0.030531	14.35	589.25	219.75	1.18
Main	6210	Max WS	PMFBaseflow	6810.22	100.66	107.34	108.11	110.39	0.030529	14.35	589.49	219.79	1.18
Main	6060	Max WS	WCPMF	6807.17	95.87	100.32	102.16	106.13	0.088430	19.35	351.85	107.98	1.89
Main	6060	Max WS	PMFBaseflow	6809.98	95.87	100.32	102.16	106.13	0.088423	19.35	351.95	107.99	1.89
Main	5960	Max WS	WCPMF	6523.27	85.91	94.30		95.78	0.001591	9.77	667.48	109.09	0.70
Main	5960	Max WS	PMFBaseflow	6526.09	85.91	94.30		95.79	0.001592	9.78	667.50	109.09	0.70
Main	5590	Max WS	WCPMF	6800.45	83.81	94.56		95.48	0.000694	7.70	890.00	128.48	0.48
Main	5590	Max WS	PMFBaseflow	6803.27	83.81	94.57		95.49	0.000695	7.70	890.05	128.49	0.48
Main	5250			Lat Struct									
Main	5060	Max WS	WCPMF	6750.92	83.11	94.38		95.14	0.000640	7.01	974.77	141.01	0.45
Main	5060	Max WS	PMFBaseflow	6753.66	83.11	94.38		95.14	0.000641	7.01	974.81	141.01	0.45
Main	4580	Max WS	WCPMF	5972.22	82.11	94.60		95.06	0.000273	5.50	1220.04	309.17	0.31
Main	4580	Max WS	PMFBaseflow	5974.44	82.11	94.60		95.06	0.000273	5.50	1220.20	309.31	0.31
Main	4320	Max WS	WCPMF	5647.05	81.71	94.68		95.02	0.000195	4.79	1584.47	479.11	0.26
Main	4320	Max WS	PMFBaseflow	5648.87	81.71	94.68		95.02	0.000195	4.80	1584.80	479.41	0.26
Main	4200	Max WS	WCPMF	5646.60	82.11	94.76	88.14	94.97	0.000147	3.82	1849.07	435.07	0.23
Main	4200	Max WS	PMFBaseflow	5648.43	82.11	94.76	88.14	94.97	0.000147	3.82	1849.38	435.11	0.23
Main	4140			Inl Struct									

HEC-RAS River: West Creek Reach: Main Profile: Max WS (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	4080	Max WS	WCPMF	5644.90	81.61	90.01		91.03	0.001328	8.07	699.38	134.29	0.62
Main	4080	Max WS	PMFBaseflow	5646.71	81.61	90.01		91.03	0.001328	8.07	699.54	134.32	0.62
Main	3950	Max WS	WCPMF	5644.86	80.91	89.84		90.89	0.001025	8.23	685.64	103.57	0.56
Main	3950	Max WS	PMFBaseflow	5646.67	80.91	89.84		90.89	0.001025	8.23	685.75	103.58	0.56
Main	3390	Max WS	WCPMF	5644.56	79.61	89.67		90.43	0.000648	7.00	806.49	112.12	0.46
Main	3390	Max WS	PMFBaseflow	5646.37	79.61	89.67		90.43	0.000648	7.00	806.61	112.16	0.46
Main	3220	Max WS	WCPMF	5644.41	76.09	89.45		89.97	0.003411	5.78	977.28	158.09	0.41
Main	3220	Max WS	PMFBaseflow	5646.23	76.09	89.45		89.97	0.003412	5.78	977.45	158.11	0.41
Main	2960	Max WS	WCPMF	5643.37	74.67	88.16		88.87	0.005214	6.76	835.18	144.78	0.50
Main	2960	Max WS	PMFBaseflow	5645.19	74.67	88.16		88.87	0.005216	6.76	835.26	144.79	0.50
Main	2210	Max WS	WCPMF	5628.74	69.58	87.34		87.51	0.000455	3.58	2266.75	252.97	0.17
Main	2210	Max WS	PMFBaseflow	5630.56	69.58	87.34		87.51	0.000456	3.58	2266.78	252.97	0.17
Main	1250	Max WS	WCPMF	5448.02	62.88	87.20		87.25	0.000084	1.83	4233.53	348.66	0.08
Main	1250	Max WS	PMFBaseflow	5449.84	62.88	87.20		87.25	0.000084	1.83	4233.54	348.66	0.08
Main	570	Max WS	WCPMF	3680.78	62.84	87.17		87.18	0.000021	1.01	7091.39	469.10	0.04
Main	570	Max WS	PMFBaseflow	3682.95	62.84	87.17		87.18	0.000021	1.01	7091.39	469.10	0.04
Main	0	Max WS	WCPMF	199.91	59.47	87.17	61.58	87.17	0.000000	0.02	24024.09	1468.77	0.00
Main	0	Max WS	PMFBaseflow	199.91	59.47	87.17	61.58	87.17	0.000000	0.02	24024.09	1468.77	0.00

HEC-RAS input and output files have been attached electronically.