US Army Corps
of Engineers
Baltimore District

JUNE 2006 FLOOD INVESTIGATION FOR CAMERON RUN

FAIRFAX COUNTY, VIRGINIA

FINAL REPORT
JANUARY 2007

Prepared for: **Fairfax County Stormwater Planning Division**
Department of Public Works and Environmental Services
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EXECUTIVE SUMMARY

This study was conducted by the U.S. Army Corps of Engineers (USACE), Baltimore District, Planning Division at the request of the Fairfax County Stormwater Planning Division, under the Floodplain Management Services Program (FPMS). Significant flooding occurred in the Huntington (also referred to as Arlington Terrace) Subdivision along Cameron Run in Fairfax County, Virginia on June 25 and June 26, 2006 (June 2006 flood event). Flood elevations were in excess of 2.0 feet higher than the expected county-adopted 100-year flood elevations (flood having a 1-percent chance of occurring in any given year). Factors such as the construction at the U.S. Route 1 Interchange (a component of the Woodrow Wilson Bridge Project), Lake Barcroft release rates, floodplain development, and sedimentation were thought to be potential causes of increased flood levels. The purpose of this investigation was to determine specific causes of the higher than expected flood levels experienced during the June 2006 flood event in Huntington.

During this study, it was determined that the June 2006 flood event has a recurrence interval of approximately 60 to 70 years, meaning it was between the 60 and 70-year flood event. As a result of the analysis presented in this report, it has been determined that cumulative impacts to the Cameron Run channel and floodplains have increased the flood levels in Huntington over time. At the time of the June 2006 flood event, Fairfax County and FEMA were using the 1976 USGS study for floodplain management purposes. Although the study was accurate when it was completed, it is not accurate for the Huntington area today due to significant changes in the channel and watershed. As a result, the flood levels during the June 2006 flood event were higher than the county expected.

During this study, various potential causes of the increase in flood levels in Huntington were evaluated and the following was determined:

<u>Activities that contributed to higher flood levels over time</u>

- Channel sedimentation had a considerable impact to flood elevations in Huntington during the June 2006 flood event. Based on surveys, between 1965 and 1999 nearly 5 to 6 feet of sediment accumulated between Telegraph Road and U.S. Route 1. Had the channel been at its 1965 condition (same channel depth and width as in 1965), flood elevations would have been approximately 1.2 to 2.0 feet lower in Huntington.

- The U.S. Route 1 interchange construction activity (part of the Woodrow Wilson Bridge construction project) had a lesser impact to flood elevations in Huntington during the June 2006 flood event. The temporary construction activity caused between a 0.5-foot (at the upstream end) and 0.9-foot (at the downstream end) increase in flood elevations along the Huntington area. The increase as a result of the construction activity was within the permitted limits established by the Federal Emergency Management Agency (FEMA). As a result of the overall finished construction of the U.S. Route 1 interchange, the maximum increase in the 100-year flood elevation is estimated to be 0.8 feet approximately 300 feet west of the confluence of Hoofs Run. Therefore, the temporary increase in flood levels during the construction of the interchange is similar to the expected future increase in flood levels after the project construction is complete. VDOT has stated that they will re-analyze the impacts of the new construction after it is complete to account for any design changes during construction.

- Development within the floodplain, including Jones Point and the Metro Rail and Station (as well as other commercial developments) had minimal impact to flood elevations in Huntington during the June 2006 flood event. The floodplain development caused between a 0.2 and 0.4-foot increase in flood elevations along the Huntington area. The increase as a result of the floodplain encroachments were within the permitted limits established by FEMA.

Activities that did not contribute to higher flood levels

- The barge blockage at the George Washington Memorial Parkway had no impact to flood elevations in Huntington during the June 2006 flood event.

- Lake Barcroft release rates had no impact on the flood elevations in Huntington during the June 2006 flood event. For this storm event, the peak at the USGS gage occurred nearly simultaneously with the peak exiting Lake Barcroft.

- The Potomac River tide stages had no impact to the flood elevations in Huntington during the June 2006 flood event.

Although each factor in the first list above increases flood levels to varying degrees, the cumulative increase created by adding the increases together creates a significant increase over time. It should be noted, however, that some of the houses in Huntington still would have been flooded during the June 2006 flood event even if these activities had not increased the flood levels.

Since the completion of the 1976 USGS study, several other studies, including the 1982 CDM study and the 2002 VDOT study were completed and showed a greater risk of flooding in Huntington. The 1982 CDM study may have been disputed. The 2002 VDOT study, which is the most current and accurate model, was not provided to Fairfax County staff for use in floodplain management applications; however, according to VDOT, they did provide the final study to FEMA, who produces the county Flood Insurance Rate Maps (FIRMs) that show the 100-year floodplain.

The flood levels during the June 2006 flood event were consistent with the peak flows recorded and the current condition of Cameron Run. The dramatic changes to the watershed and Cameron Run channel, along with the continued use of the 1976 USGS study for floodplain management purposes, were the reasons that flood levels during the June 2006 flood event were higher than expected.

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1.0 INTRODUCTION

1.1 STUDY PURPOSE

This study was conducted by the U.S Army Corps of Engineers (USACE), Baltimore District, Planning Division at the request of the Fairfax County Stormwater Planning Division, under the Floodplain Management Services Program (FPMS). Significant flooding occurred in the Huntington (also referred to as Arlington Terrace) Subdivision along Cameron Run in Fairfax County, Virginia on June 25 and June 26, 2006 (June 2006 flood event). Floodplain elevations were in excess of 2.0 feet higher than the expected county-adopted 100-year flood elevations (flood having a 1-percent chance of occurring in any given year). Factors such as the construction at the U.S. Route 1 Interchange (a component of the Woodrow Wilson Bridge Project), Lake Barcroft release rates, floodplain development, and sedimentation were thought to be potential causes of increased flood levels. The purpose of this investigation was to determine specific causes of the higher than expected flood levels experienced during the June 2006 flood event in Huntington.

1.2 STUDY AREA

The study area is the Huntington area along Cameron Run in Fairfax County, Virginia (Figure 1.1). Huntington is located on the south bank of Cameron Run, north of Huntington Avenue, east of Telegraph Road, and west of U.S. Route 1. The Huntington community consists of duplex residential structures, the majority of which were built in the late 1940s and early 1950s. Most of the structures have basements, with first floor elevations being roughly 5 feet above the lower lying roadways. Nearly 80 of the structures, or 160 homes, in Huntington are located in the 100-year floodplain per the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs).

Cameron Run drains 42.0 square miles of highly urbanized lands to its confluence with the Potomac River. The Cameron Run watershed includes areas within Fairfax County, the City of Alexandria, and the City of Falls Church. Tributaries such as Holmes Run, Backlick Run, Pike Branch, Tripps Run, and Taylor Run convey stormwater runoff to Cameron Run. Lake Barcroft (137 acres in size) and Fairview Lake (15 acres) are man-made reservoirs located within the watershed.

The Cameron Run watershed is considered highly urbanized due to suburban expansion and growth in the Washington, D.C. metropolitan area. According to *Urban Biodiversity in the Holmes Run/Cameron Run Watershed*, prepared by the Virginia Polytechnic Institute and State University (Virginia Tech), the growth of this watershed over time is well documented. The watershed saw its first subdivisions by 1920. In the 1950s, major sewer projects were completed, and residential subdivisions covered a substantial portion of the watershed by the end of the decade (including Huntington). With the lack of erosion and sediment control and stormwater mitigation measures at the time, the development caused significant overland erosion that washed large amounts of sediment into the streams during larger storms.

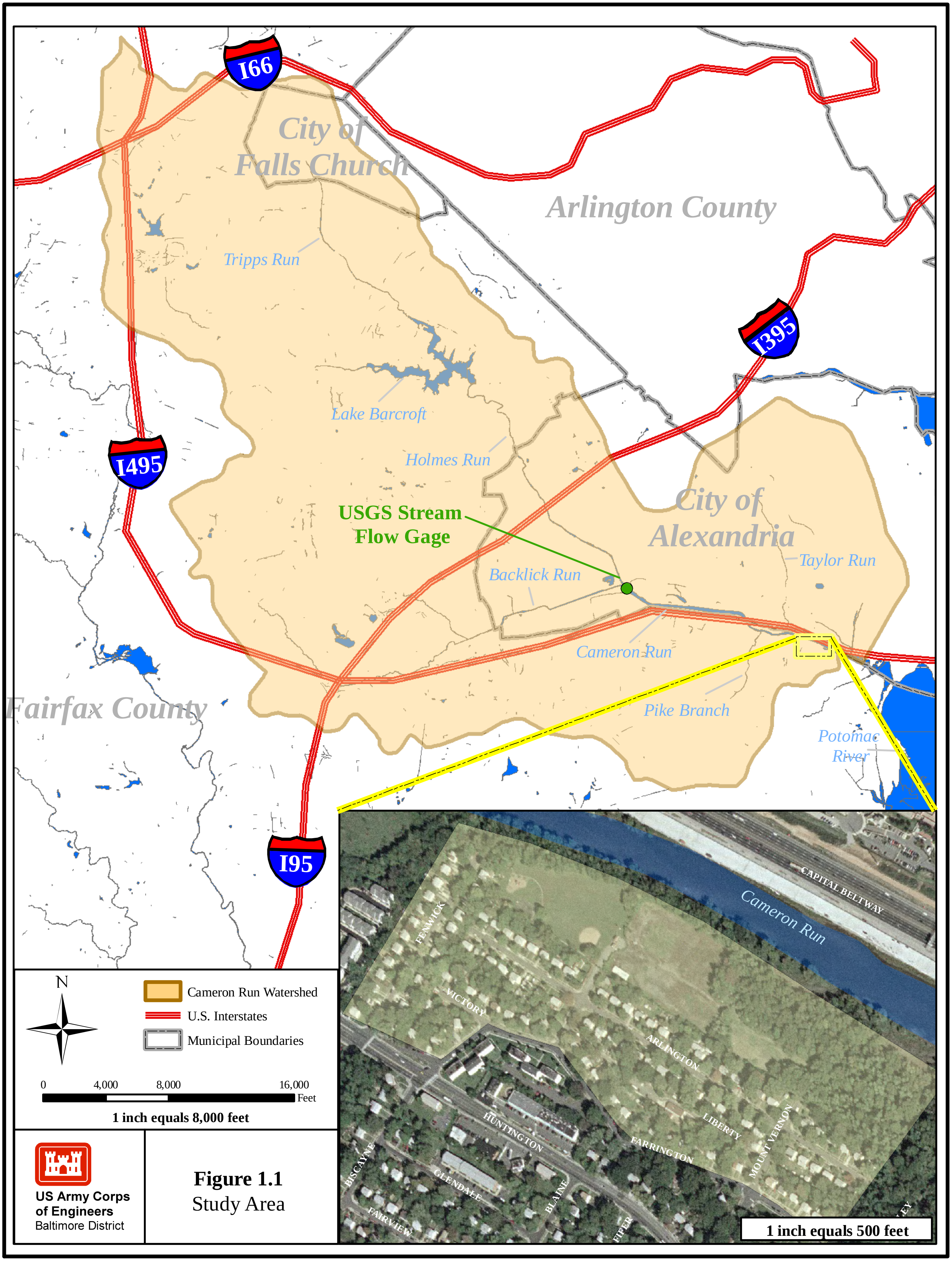


Figure 1.1
Study Area

By the 1970s, growth in the watershed continued as federal government employment and service industries expanded. Private economic growth led to unprecedented commercial growth in Fairfax County and the City of Alexandria in the 1980s. The Virginia Tech study states that in 1974, 75% of the watershed was developed; today, 95% is developed (Virginia Tech, 2003). Although erosion and sediment control and stormwater mitigation measures were in place in Virginia in the mid 1970s, the increase in development caused an increase in impervious area, which can be a major contributor to stream and channel degradation.

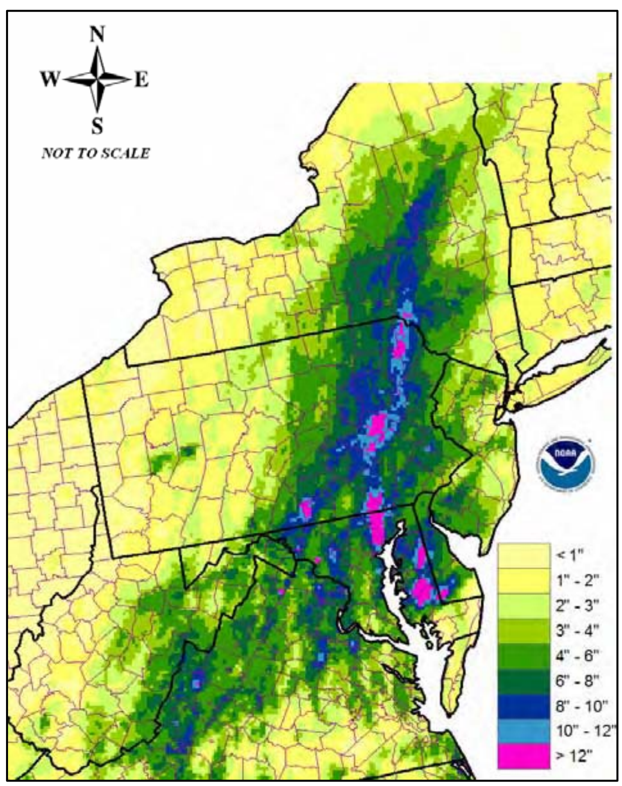
1.3 JUNE 2006 FLOOD EVENT

Across the mid-Atlantic and Northeast, exceptionally heavy rainfall occurred during June 22-28, 2006. Rain amounts exceeded 10 inches in some areas (Figure 1.2), with numerous daily and monthly rainfall records set. Flooding was widespread throughout the greater Washington, D.C. area, northward through parts of Pennsylvania and New York (National Weather Service, 2006).

In the Cameron Run Watershed, the heaviest rainfall occurred between 7:00 pm on June 25 and 1:00 am on June 26. Rainfall intensities of 1.5 to 2.0 inches per hour were recorded at the Ronald Reagan National Airport precipitation gage. Fairfax County precipitation gages recorded 1.0 to 3.5 inches per hour in some locations in or near the watershed. A United States Geological Survey (USGS) stream flow gage along Cameron Run, just downstream of the confluence of Backlick Run and Holmes Run, recorded a peak flow of 16,500 cubic feet per second (cfs), the second largest on record.

The intense runoff from the rainfall created flooding issues throughout the Cameron Run watershed. Several roadways, including Interstate 495 (Capital Beltway) and Telegraph Road were overtopped; commercial and residential structures in the City of Alexandria reported significant flooding; stormwater infrastructure was inundated with larger than design flows causing deep ponding of water on roadways; and Cameron Run, between the George Washington Memorial Highway and the Capital Beltway experienced significant flooding (Figure 1.3). Huntington is located on the southern bank of Cameron Run, and was the primary residential area in Fairfax County to receive flood damages during the June 2006 flood event. No fatalities were reported from the flooding; however, approximately 160 homes (per Fairfax County Stormwater Planning Division) suffered damages. Nearly one-third of the homes had first-floor flooding and the rest had major basement damages. News reports estimated damages at near $10 million.

Figure 1.2. Total Precipitation in the Mid-Atlantic from June 23 through June 27, 2006 (courtesy of NOAA)



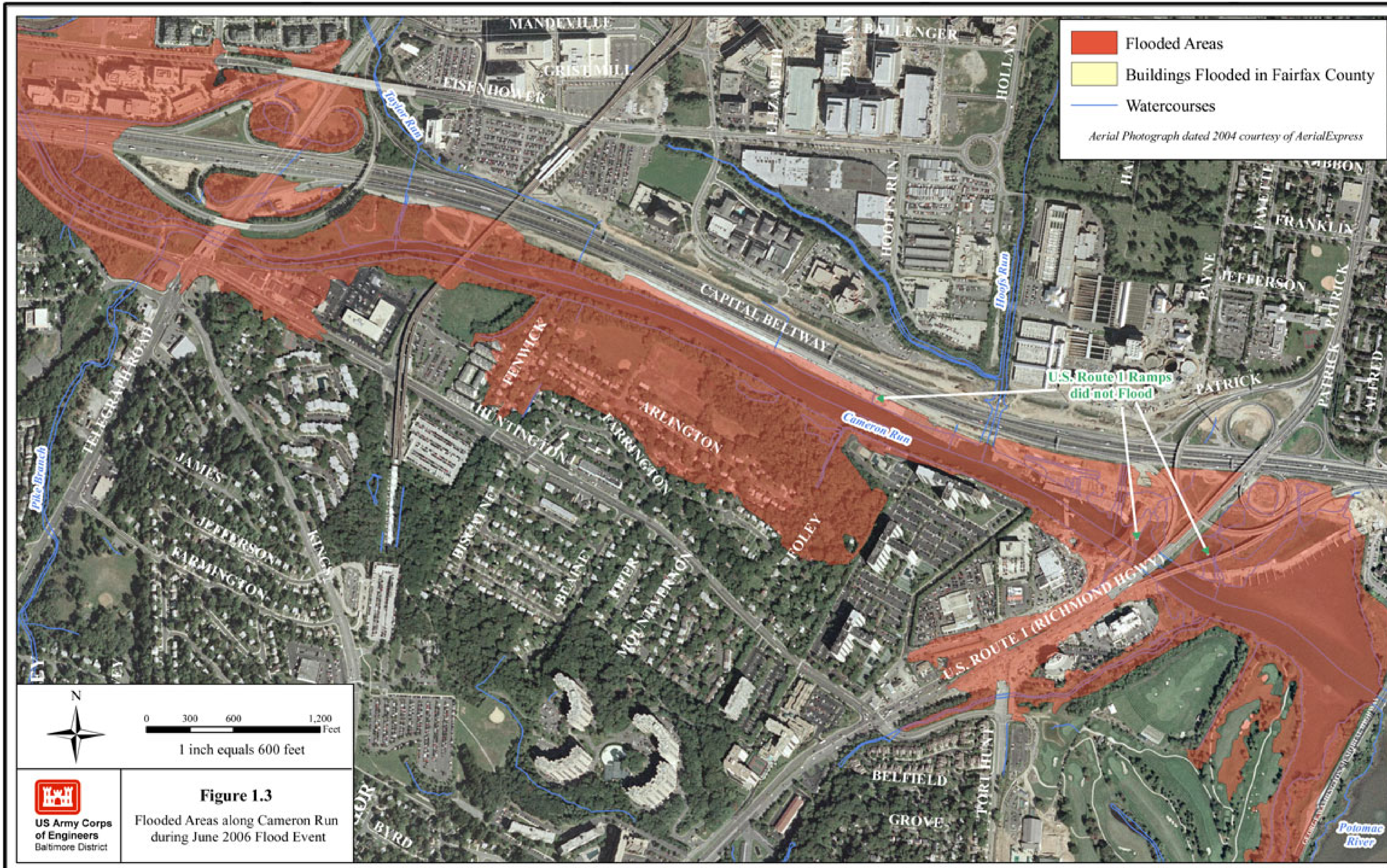


Figure 1.3

Flooded Areas along Cameron Run during June 2006 Flood Event

Although Huntington is mapped as being within the 100-year floodplain on FEMA's FIRMs, the flood levels were unexpectedly high. Existing county data showed 100-year flood elevations reaching an elevation of 10.8 feet (National Geodetic Vertical Datum of 1929 (NGVD29)) at the downstream end of Huntington, and 11.8 feet (NGVD29) at the upstream end. High water marks surveyed after the event showed that the June 2006 Flood Event was approximately 2.0 feet higher than the expected 100-year elevations. High water marks were recorded at 12.4 feet (NGVD29) at the downstream end of Huntington to 13.9 feet (NGVD29) at the upstream end.

2.0 AGENCY AND PUBLIC INVOLVEMENT AND DATA COLLECTION

2.1 AGENCY COORDINATION

Coordination with stakeholders throughout the investigation was critical in meeting the objective of the study. The following entities were identified as stakeholders in this investigation: Fairfax County Stormwater Planning Division; Virginia Department of Transportation (VDOT); and the City of Alexandria, Virginia. Multiple meetings were held between USACE and the agencies throughout the investigation. The agencies, which provided vital data and studies to USACE, were kept apprised of the study progress and findings. The agencies also coordinated other related ongoing activities.

2.2 PUBLIC INVOLVEMENT

As part of this study, a number of residents in Huntington were contacted to (1) determine the residents' perception of the flood risk at their property prior to the June 2006 flood event and (2) gather information on the history of flooding in Huntington. Approximately 30 residents were called. Of the 30 called, twelve (12) were reached and asked questions regarding flooding at their properties. Below is a list of the questions asked and a general summary of the results.

1. Did your home/property flood during the June 2006 Flood Event? To what extent? Do you know how the water entered your home (basement window, sewer)?

All residents contacted did indeed flood during the June 2006 flood event. Flooding depths ranged from 3 feet to 10 feet, which inundated all basements. One resident had flooding of the first floor. Water entered the homes through sewers, windows, doors, and walls.

2. How long have you lived in your home?

Three of the residents lived in their home less than three years and five between three and 25 years. The remaining four residents lived in their homes more than 25 years.

3. Did your home/property ever flood in the past? If so, when?

Nine of the residents stated that their homes have never flooded in the past. The other three residents, who have been living in Huntington since 1971, experienced previous flooding during Tropical Storm Agnes in 1972, which resulted in a few inches of floodwater in the basements. It was not determined how the water entered the structures that flooded during Tropical Storm Agnes.

4. Prior to the June 2006 Flood Event, did you feel your property was at risk of flooding?

Eleven of the twelve residents contacted stated that they did not feel there was a risk of flooding at their property prior to the June 2006 Flood Event. One resident stated that they felt a risk of flooding during Hurricane Isabel in 2003.

5. Did you have flood insurance?

Six of the residents contacted had flood insurance. Six of the residents did not have flood insurance.

6. Did you apply for and receive a Letter of Map Amendment (LOMA) from FEMA determining that your house is outside/above the "100-year floodplain".

Eleven of the residents contacted stated that they did not receive a LOMA from FEMA. One resident did obtain a LOMA. However, most of the residents did not know what a LOMA was.

2.3 DATA COLLECTION

Existing USACE data, along with data collected by various Federal, State, and local agencies, were used in this investigation. Data was collected from the following resources: City of Alexandria Department of Transportation and Environmental Services (Alexandria DTES); Fairfax County Stormwater Planning Division (FCSPD); Virginia Department of Transportation (VDOT); United States Geological Survey (USGS); Federal Emergency Management Agency (FEMA); National Oceanic and Atmospheric Administration (NOAA); and Lake Barcroft Watershed Improvement District (LBWID). An inventory of the data collected and used for this investigation is located in Appendix A.

3.0 FLOOD HISTORY AND PREVIOUS STUDIES

3.1 FLOOD HISTORY IN HUNTINGTON

Flooding has been a concern in Huntington for decades. As early as 1966, the Fairfax County Board of Supervisors adopted an ordinance for a regulated 100-year floodplain for Cameron Run. Previous studies and historical information confirm that the most significant type of flood event that would affect Huntington is riverine flooding from Cameron Run. Although the area is susceptible to storm surges from the Potomac River resulting from tropical systems, such as Hurricane Isabel in 2003, flood levels tend to reach higher elevations during riverine events. However, there were some complaints of houses flooding during Hurricane Isabel, however, the number is unknown. During Hurricane Isabel, 2 to 3 inches of rainfall fell in the area, and riverine flows along Cameron Run were minimal. In contrast, past riverine events along Cameron Run have produced much higher flood levels in Huntington.

The majority of the residential structures in Huntington were built in the late 1940s and early 1950's. Since that time, and prior to the June 2006 flood event, there have been two significant storm events that have created the potential for riverine flooding in Huntington: Tropical Storms (or remnants thereof) Agnes (1972) and Eloise (1975).

Tropical Storm Agnes

For many years, Tropical Storm Agnes has been the storm of record in the Cameron Run watershed, as well as other watersheds in the mid-Atlantic and Northeast regions of the United States. Tropical Storm Agnes occurred between June 20 and June 25, 1972. Flood damages were recorded throughout the central part of Virginia, but were particularly heavy in the northern part, where Fairfax County reported damages estimated at $25 million (1972 dollars). In the Four Mile Run watershed, damage was estimated at $14 million (USGS, 1975); however, no exact record of the amount of damages in the Cameron Run watershed could be found.

A rainfall gage at Washington National Airport recorded a total of 8.24 inches of rainfall over that 5-day period, with the heaviest rainfall occurring between June 21 and June 22, 1972. During that period, rainfall intensities of just over 1 inch per hour were recorded. This rainfall created a record flow of 19,900 cubic feet per second (cfs) at a USGS stream flow gage (01653000) along Cameron Run (see Figure 1.1).

This flow created flooding in Huntington, but the extent and cause is not well documented. No records of homes damaged during this event are on record with Fairfax County, FEMA, USACE, or any other entity. In a letter from a homeowner to the Fairfax County government, it is stated that "*Every home in the immediate neighborhood was flooded. Yards and streets were flooded and some homes received structural damage to their basements. One thing that did not become apparent until after the storm was the fact that not one of the homes was flooded by surface water. All flooding incidents were caused by either raw sewage backing into the basements or structural damage caused by severe water pressure upon the basements.*"

It is evident that Tropical Storm Agnes caused damages to Huntington, but the extent of flooding via overland flood flow is not apparent. It appears that the flood levels during Tropical Storm Agnes were lower than the June 2006 flood levels; however, peak flows of 19,900 cfs were recorded at the USGS stream flow gage during Tropical Storm Agnes, and the June 2006 flood event produced peak flows of 16,500 cfs at the same gage.

Tropical Storm Eloise

Rainfall associated with Tropical Storm Eloise occurred in the mid-Atlantic region between September 23 and September 27, 1975. The most significant damages as a result of Tropical Storm Eloise occurred on the tributaries to the Potomac River in and around Washington, D.C. (USACE, 1975), where nearly 400 people were evacuated along Four Mile Run. Rainfall totals of between 8 and 9 inches fell near the Cameron Run watershed. The USGS stream flow gage along Cameron Run recorded a peak flow of 14,400 cfs during the event, the third largest to date behind Tropical Storm Agnes (19,900 cfs) and the June 2006 flood event (16,500 cfs).

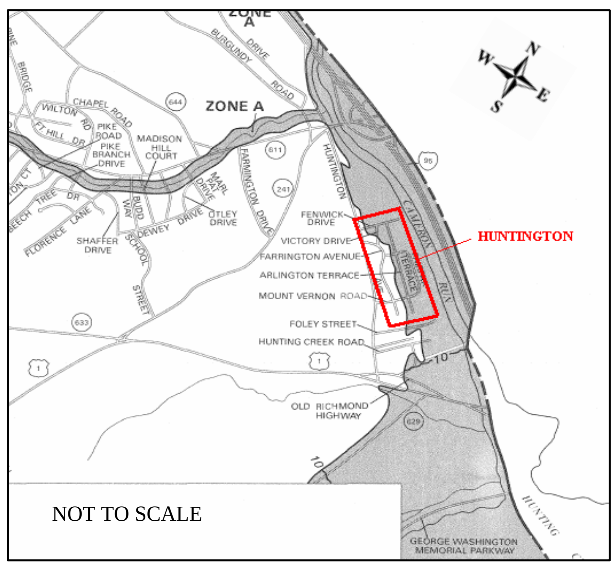
As with Tropical Storm Agnes, there is a lack of documentation of the extent of flooding in Huntington. Internal Fairfax County memos indicate that the County as a whole was hit hard by Tropical Storm Eloise, including: damage along Pike Branch; sanitary sewer line problems near Telegraph Road; outfall issues resulting in the flooding of five homes near Kathmoor Street; and storm sewer issues that resulted in homes flooding along Thornwood Drive.

Articles in local newspapers and letters from homeowners to the County verify that flooding was an issue in Huntington during Tropical Storm Eloise, especially in basements, although interviews with residents of Huntington did not confirm this. However, as with Tropical Storm Agnes, it is not apparent that the flooding of these homes was directly from overland flow from Cameron Run, or if it may have been from backed up sanitary sewer lines.

3.2 PREVIOUS STUDIES

Traditionally, the primary source for floodplain information is FEMA. FEMA publishes FIRMs and Flood Insurance Studies (FIS) that are used by local entities for floodplain management purposes. The floodplains for Cameron Run in Fairfax County are delineated as Zone A. Zone A means no detailed hydrologic and hydraulic analyses have been completed, so no exact 100-year floodplain elevations are shown for Huntington on the FEMA Fairfax County maps and study, which are dated March 5, 1990 (Figure 3.1). However, Zone A does mean that the area is in the 100-year floodplain. FEMA and Fairfax County are currently working to digitize the FIRMs and revise the FIS for Fairfax County. As part of this process, the County is in discussions with FEMA to correct the FIRMs where known inaccuracies exist.

Figure 3.1. Effective FEMA FIRM for Fairfax County, Virginia (dated March 5, 1990)

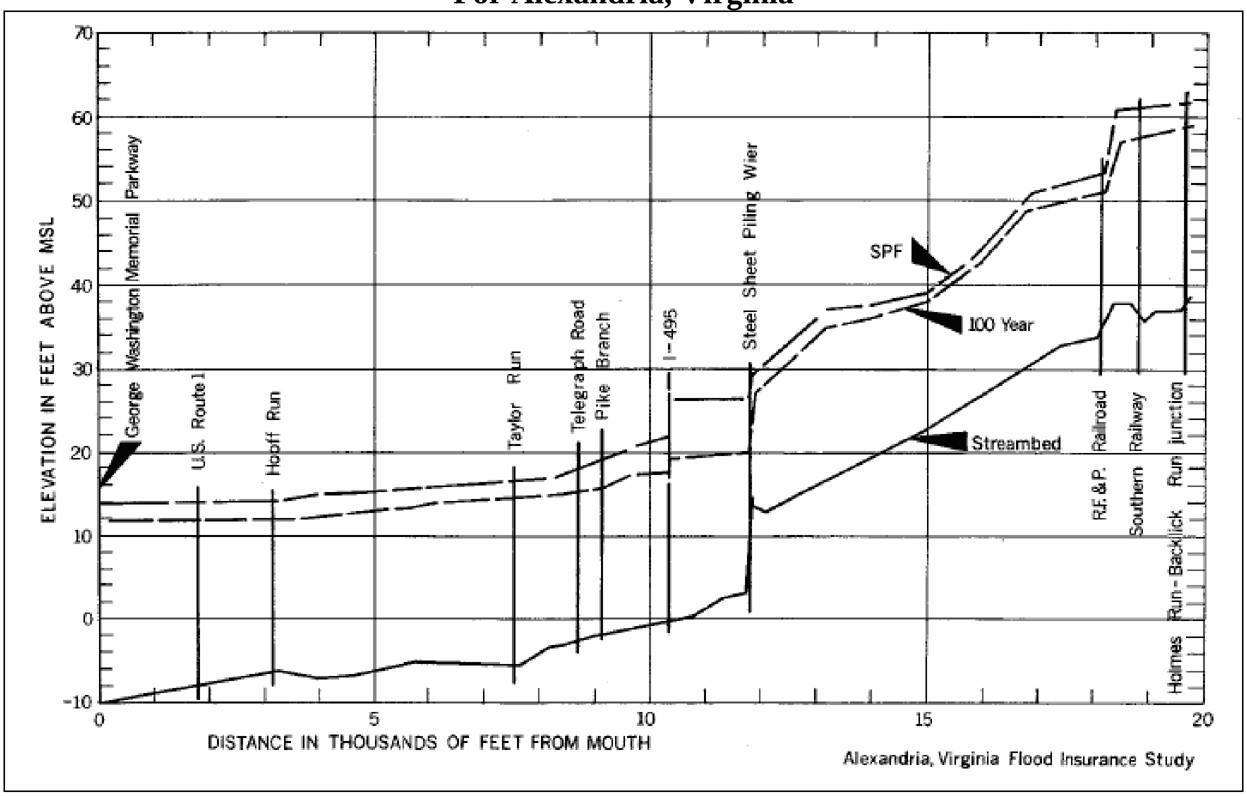


The flooding in Huntington from Cameron Run has, however, been studied in the past. The earliest documented investigation was dated December 1970, with the most recent being in February 2002. A summary of previous investigations along Cameron Run that directly impact Huntington are listed below. There have been other studies related to flooding within the Cameron Run watershed; however, the results of those investigations do not directly impact Huntington.

December 1970: Alexandria, Virginia, Flood Insurance Study, completed by the U.S. Army Corps of Engineers, Baltimore District

The purpose of this investigation was to analyze the flood potential and the damages related thereto in the City of Alexandria, Virginia. The study involved hydrologic and hydraulic studies to create elevation-frequency curves and tables, flood profiles, and floodplain maps along Cameron Run to assist in establishing flood insurance rates within the City of Alexandria. The Immediate Regional Flood elevations, which are equivalent to the 100-year flood elevations, ranged from 12.0 feet mean sea level (msl) at the confluence of Hoofs Run (just downstream of the downstream end of Huntington) to 15.0 feet msl at Telegraph Road (upstream of Huntington) as shown in Figure 3.2. It is assumed, due to the date of this study, that msl is equal to NGVD29.

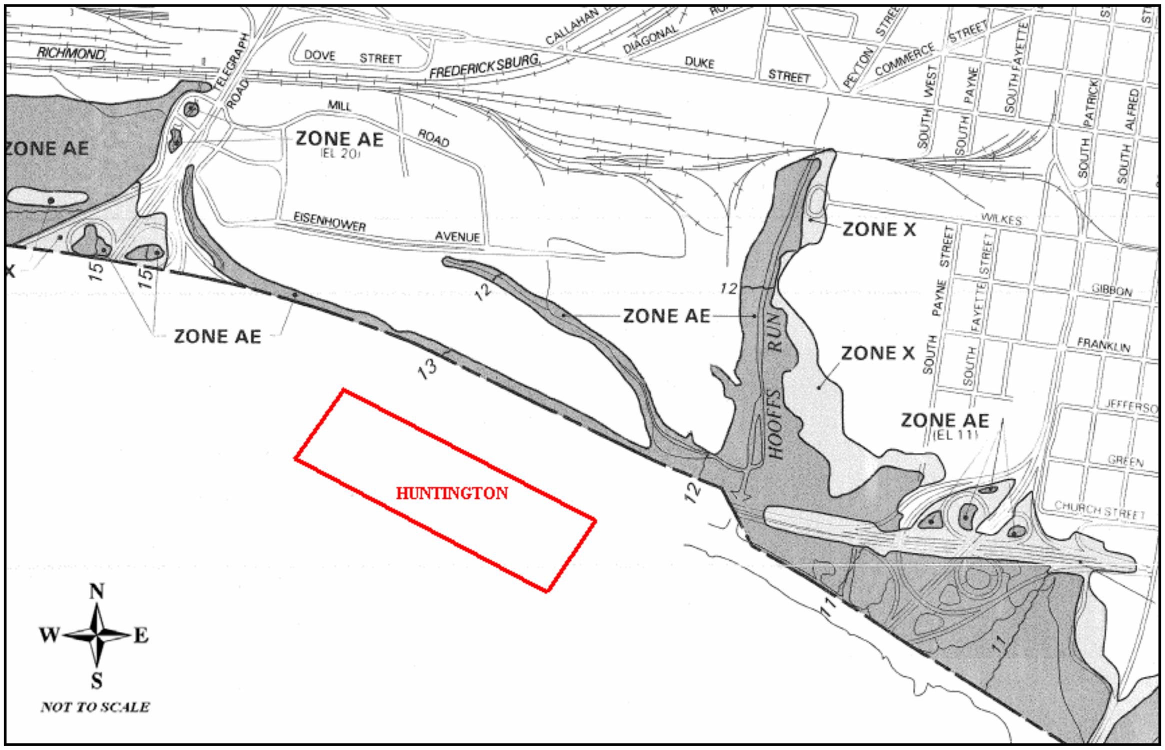
Figure 3.2. Flood Profile from December 1970 Flood Insurance Study For Alexandria, Virginia



No modeling is available from the December 1970 study. It is assumed that the results of this study were used to create the effective flood insurance rate maps for the City of Alexandria, dated May 15, 1991 (Figure 3.3). No FEMA flood insurance study is published for Alexandria;

however, floodplain elevations and flood limits on the FIRM are consistent with the results of this Corps study. Note that the FIRM maps for the City of Alexandria are currently being revised to reflect better topographic data provided by the City.

Figure 3.3. Effective FEMA FIRM for Alexandria, Virginia (dated May 15, 1991)



March 1971: Cameron Run, City of Alexandria and Fairfax County, Virginia, Review Report on Flood Control, completed by the U.S. Army Corps of Engineers, Baltimore District

The purpose of this report was to determine the feasibility of providing a project for flood damage reduction along streams that flow through the City of Alexandria, Virginia, with particular reference to Cameron Run and its tributaries. The tasks for this study included: soil surveys; elevation surveys; damage surveys to determine the extent and magnitude of damages caused by flooding; real estate investigations; economic evaluation; hydraulic studies; and analysis of flood protection measures to alleviate flood damages.

Huntington is located in Reach CA-1 in this investigation. The flood of record prior to this investigation was flash flooding that occurred September 14, 1966, which caused a peak flow of 9,300 cfs at the USGS stream gage. Based upon calculations in the investigation, only five residential structures and one commercial structure in Huntington would have been inundated by this 1966 flood, causing minimal damages. The result of this study was the recommendation of a Federal flood damage reduction project along Cameron Run to address flooding issues. However, no flood improvements were made in the Huntington area. In a USACE memo dated September 1977, Survey Report, Potomac River Streams Draining Alexandria Area, Virginia, the reason is explained:

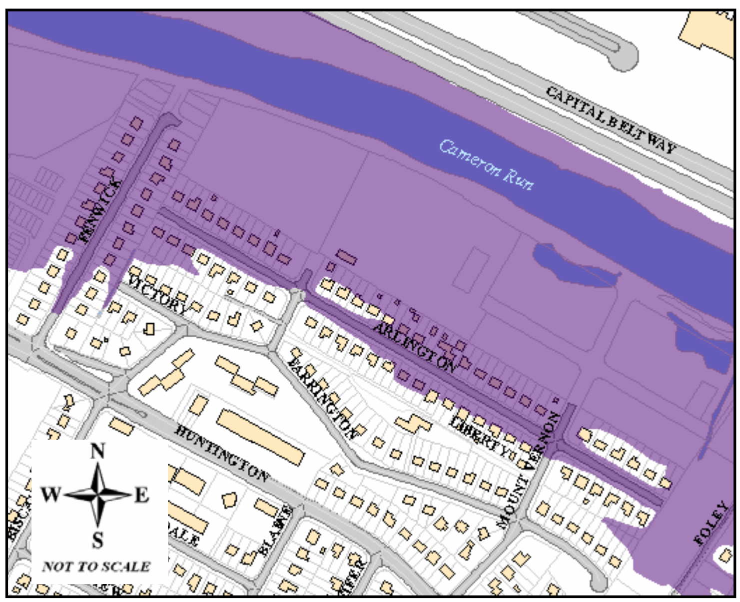
"A report on Cameron Run was prepared… which represents a positive recommendation for a Federal flood control project along Cameron, Holmes, and Backlick Runs. Because of the inability to obtain required assurances of local cooperation, the report was not processed further. In 1969, Cameron Run formed part of the boundary between Fairfax County and the City of Alexandria; thus, both jurisdictions were required to provide the local assurances. However, nearly all of the benefits of the proposed project would accrue to the City of Alexandria and, for this reason, Fairfax County would not provide their assurances. In order to overcome this problem, a land transfer was agreed to by the local jurisdictions and became effective 1 January 1973. This land transfer and boundary change placed the entire project area within the City of Alexandria limits."

Subsequently, to expedite the construction of the project, the City of Alexandria decided to implement the plan of protection recommended in this report at their own initiative and cost. The recommended plan was to channelize a portion of Cameron Run. Thus, Cameron Run is now channelized upstream of the Capital Beltway; however, it is not a Federal project.

1976: Flood-Plain Delineation for the Cameron Run Basin, Fairfax County-Alexandria City, Virginia, Open File Report 76-443, completed by USGS

The results of this investigation are currently being used by Fairfax County for the management of floodplains along Cameron Run. Floodplain mapping produced in this investigation were adopted by the County Commissioners and are still used today for floodplain information (Figure 3.4). The purpose of this investigation was to establish floodplain mapping for Cameron Run and its tributaries. It is noted, however, that although this study is dated 1976, the report documents that the field survey in the basin was done in 1961, with supplemental surveys made in 1965. The 100-year peak flows, using the Anderson method for ultimate built-out conditions, were estimated at 21,800 cfs for the Huntington area. The 100-year flood elevations ranged from 10.3 feet (NGVD29 datum) just upstream of U.S. Route 1, to 13.2 feet just downstream of Telegraph Road.

Figure 3.4. 100-year Floodplain Limits for Huntington from 1976 USGS Study



April 1977: Huntington Drainage Study (Huntington Conservation District), completed by William H. Gordon Associates

The purpose of this study was to develop an updated storm drainage master plan for the Huntington area based upon current design standards and criteria. Although this study dealt more with stormwater infrastructure rather than riverine flooding, the report contains useful information on the history of flooding in Huntington. The report notes that "The houses along Arlington Terrace and closest to Cameron Run have evidently never experienced flooding due to an overflow of the creek's banks. Any flooding of the dwellings has occurred as a direct result of the storm sewer backup or the sanitary sewer backup." Recommendations as a result of this investigation included improving the storm sewer infrastructure and installing subsurface interceptors, among others. It is unknown if any of the recommended improvements were implemented.

December 1977: Proposed Drainage Plan, Cameron Run Watershed, Task Order 3.2 Immediate Action Plan, completed by Parsons, Brinckerhoff, Quade and Douglas

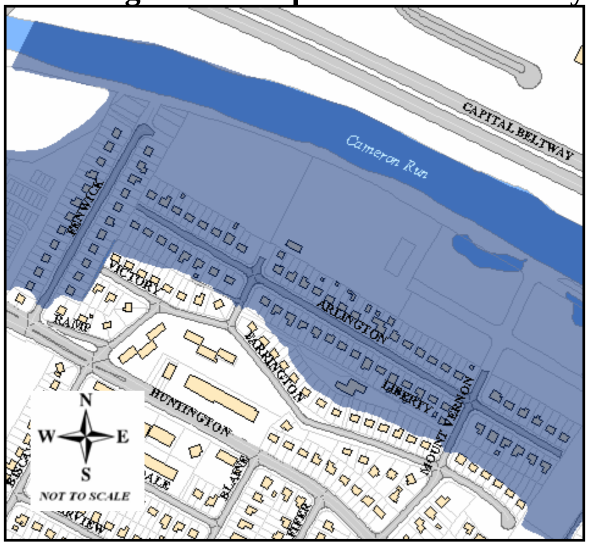
The purpose of the Immediate Action Plan (IAP) was to recommend projects to enable the drainageways in the Cameron Run Watershed to safely carry stormwater to the Potomac River with minimal disruption to areas adjacent to the streams. A total of 40 projects were recommended throughout the watershed. The study recommended the construction of an earth berm along Cameron Run to alleviate the flooding of homes and structures along Fenwick Drive and Arlington Terrace in the Huntington community. The Huntington portion of the study was never implemented.

April 1982: Arlington Terrace Storm Drainage Study, Fairfax County, Virginia, completed by Camp Dresser & McKee (CDM)

The purpose of this study was to perform a comprehensive flood drainage feasibility study for the Huntington community. It includes a detailed definition of the flooding problem in the Huntington community caused by Cameron Run flood flows and Potomac River high tides, and the development of alternate flood control solutions with cost estimates to resolve the flooding problems in the Huntington area. Initial analysis during the investigation concluded that although tidal surge was a flood risk in Huntington, the type of flooding that would cause the most significant damage was riverine flooding from the Cameron Run watershed.

The hydrology for the project was completed using the MIT Catchment Computer Model (MITCAT) and "other well-supported methodology," with peak flows for a 100-year flood event estimated to be 37,785 cfs. The hydraulic analysis was completed using the USACE HEC-2 program, with the following computed flood elevations for the Huntington community: 10-year flood elevation of 8.63 feet; 25-year elevation of 10.38 feet; 50-year elevation of 11.86 feet; and 100-year elevation of 14.34 feet (all elevations are NGVD29 datum). The study concluded that a 100-year flood event at elevation 14.34 feet would inundate approximately 167 homes in Huntington (Figure 3.5).

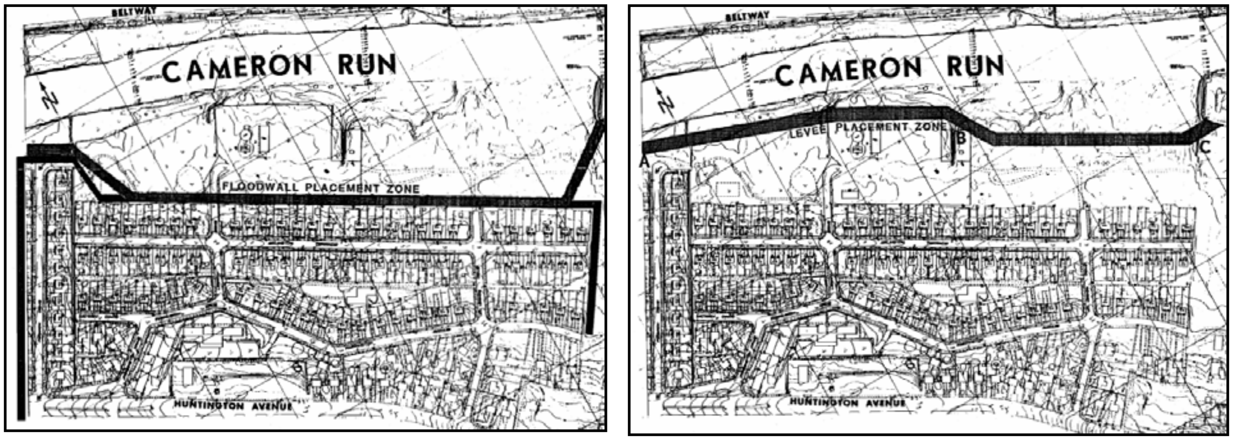
Figure 3.5. 100-year Floodplain Limits for Huntington from April 1982 CDM Study



The 1982 CDM study provides a great deal of flood information for Huntington, and outlined potential flood damage reduction measures such as channelization, levees, floodwalls, floodproofing, dredging, and constriction relief. The following is a list of the recommendations made in this investigation:

- No protection is required for a 10-year flood, and a levee would provide complete protection from a 25-year event at a lower cost than other alternatives.
- For a 50-year flood, a levee provides complete protection at a lower cost than other alternatives.
- A floodwall is the only single flood control measure that performs satisfactorily during a 100-year flood, at a 1982 cost of $3,537,000. However, other viable options would be a floodwall and dredging the reach to a width of 100 feet, at a 1982 cost of $3,987,000, and a levee plus dredging to a 200 foot width, at a 1982 cost of $3,206,000 (Figure 3.6).
- Under any plans a channel maintanence program must be established to clear sediment from Cameron Run.

Figure 3.6. Potential Floodwall and Levee Placement Zones from April 1982 CDM Study



Although options for flood damage mitigation were presented in this report, none were implemented. The reason they were not implemented is uncertain. Regardless of the baseline analysis and calculated flows, the types of alternatives recommended in this report may be viable and should be evaluated in further detail.

February 2002: Hydrologic and Hydraulic Analysis of Cameron Run, completed by Potomac River Consultants (PCC) for Virginia Department of Transportation

The purpose of this study was to examine the impact that the proposed improvements associated with the Woodrow Wilson Bridge replacement project would have on the existing flood stages and profiles, and to provide necessary hydraulic data for scour computations at proposed bridges and crossings. The study was a compilation of results presented in the following reports: *I-95/Route 1 Interchange Improvement Project, Cameron Run Hydraulic Study Report*, prepared by HNTB in November 2001; and *Interstate 95/495/Telegraph Road Interchange, County of Fairfax/City of Alexandria, Project #0095-96A-105, Hydrologic and Hydraulic Analysis of Cameron Run*, prepared by Dewberry & Davis, LLC, in December 2001.

The report outlines results of a one-dimensional HEC-RAS hydraulic model that starts at the confluence of Cameron Run at the Potomac River and extends upstream to approximately 400 feet west of the Capital Beltway bridge over Cameron Run. All field-surveyed cross-sections for the study were completed in 1999.

The study completed two separate HEC-RAS models. The existing-conditions model reflects the conditions of Cameron Run in 1999, before any improvements to U.S. Route 1, Telegraph Road, or the Woodrow Wilson Bridge were made (Figure 3.7). The proposed-conditions model reflects the conditions of Cameron Run once the entire project is completed.

Figure 3.7. Existing-Conditions 100-year Floodplain Limits for Huntington from 2002 VDOT Study

The hydrology for this study was based on the Anderson method, per FEMA guidance. The Anderson method computed a 100-year peak flow of 25,525 cfs at the U.S. Route 1 Interchange; 23,845 cfs at Telegraph Road; and 22,625 cfs at the Capital Beltway bridge. The hydraulic model was developed using HEC-RAS version 2.2, and the results were verified by other agencies using two-dimensional and three-dimensional modeling.

The results of the modeling showed 100-year flood elevations ranging from 10.8 feet (NGVD29) just upstream of U.S. Route 1 to 18.4 feet just downstream of Telegraph Road; however, the results for Huntington in this study showed much higher 100-year elevations for Huntington than the 1976 USGS investigation. The 1976 USGS investigation computed 100-year flood elevations ranging from 10.8 feet (NGVD29) at the downstream end to 11.7 feet at the upstream end. The VDOT existing-conditions model computed 100-year flood elevations of 13.7 feet at the downstream end to 14.6 feet at the upstream end. This is an increase of nearly 3 feet. It is noted that the USGS investigation used a 100-year peak discharge of 21,800 cfs, where the VDOT study used a peak discharge of 23,845 cfs.

Based upon the proposed design and construction, the maximum increase in the 100-year flood elevation as a result of the construction of the new U.S. Route 1 bridges is 0.8 feet approximately 300 feet west of the confluence of Hoofs Run. On average, the project will increase flood elevations by roughly 0.5 feet throughout this reach of Cameron Run and within Huntington. VDOT will re-analyze the impacts of the project when construction is complete to account for any design changes during construction.

The February 2002 study and associated modeling are considered the best available data that represents existing-conditions for Cameron Run (pre-Woodrow Wilson Bridge activity). Copies of this report and modeling were not sent to Fairfax County. However, through written correspondence, it is evident that VDOT initiated tremendous coordination efforts with the Federal Highway Administration (FHWA), FEMA, and the City of Alexandria through the process. VDOT submitted their final model results to FEMA in December 2001. USACE and USGS were also contacted throughout the process for data coordination efforts.

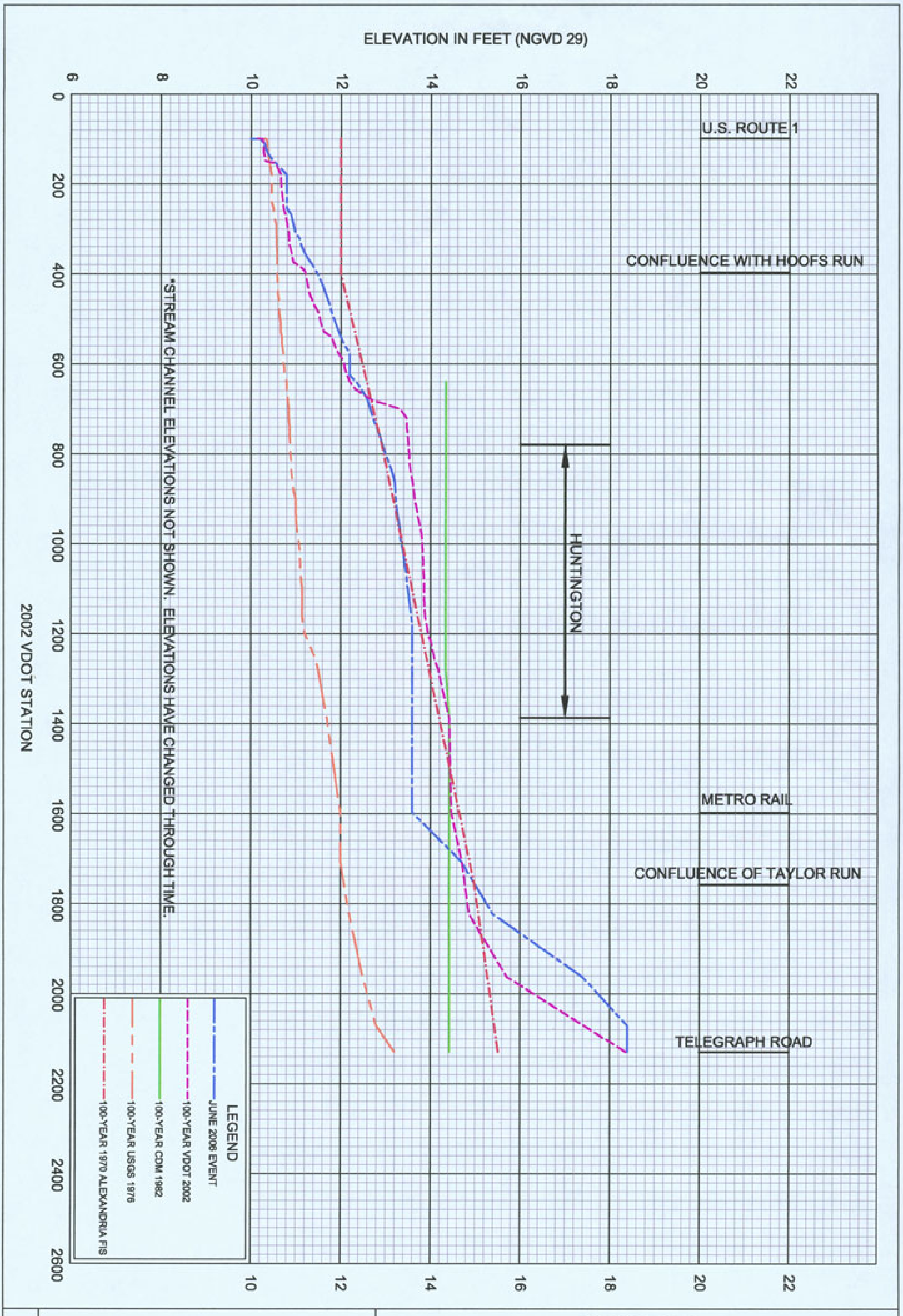
September 2006: Woodrow Wilson Bridge Project Report on Impacts on Cameron Run Flood Event of June 25, 2006, prepared by Potomac Crossing Consultants (PCC) for Virginia Department of Transportation

Concurrent with this investigation, the PCC conducted an examination of the severe flooding experienced June 25, 2006 in the Huntington/Arlington Terrace area of Fairfax County. The purpose of the report was to investigate the possibility that the construction activities associated with the Woodrow Wilson Bridge (WWB) Project caused the flooding conditions on June 25 and 26, 2006 in the Huntington area. The study determined that the total impact of the WWB construction attributed to a 5 to 10 inch increase in peak flow elevation in Huntington.

3.3 COMPARISON OF PREVIOUS STUDIES

Based upon the amount of previous hydrologic and hydraulic investigations along Cameron Run, flooding was an issue in the past and continues to be an issue today. There have been various peak flow calculations completed by various entities throughout the years, using a variety of techniques, and these results have been compared and disputed in past investigations. What is evident from compiling and comparing these previous studies is that calculated floodplain elevations, using hydraulic calculations and modeling, have increased over time and the floodplain limits have expanded in Huntington.

Figure 3.8 shows a comparison of floodplain profiles for the studies listed in this section. Figure 3.9 shows the difference in delineated 100-year floodplain limits for the various investigations.



U.S. ARMY CORPS OF ENGINEERS	FIGURE 3.8
BALTIMORE DISTRICT	CAMERON RUN

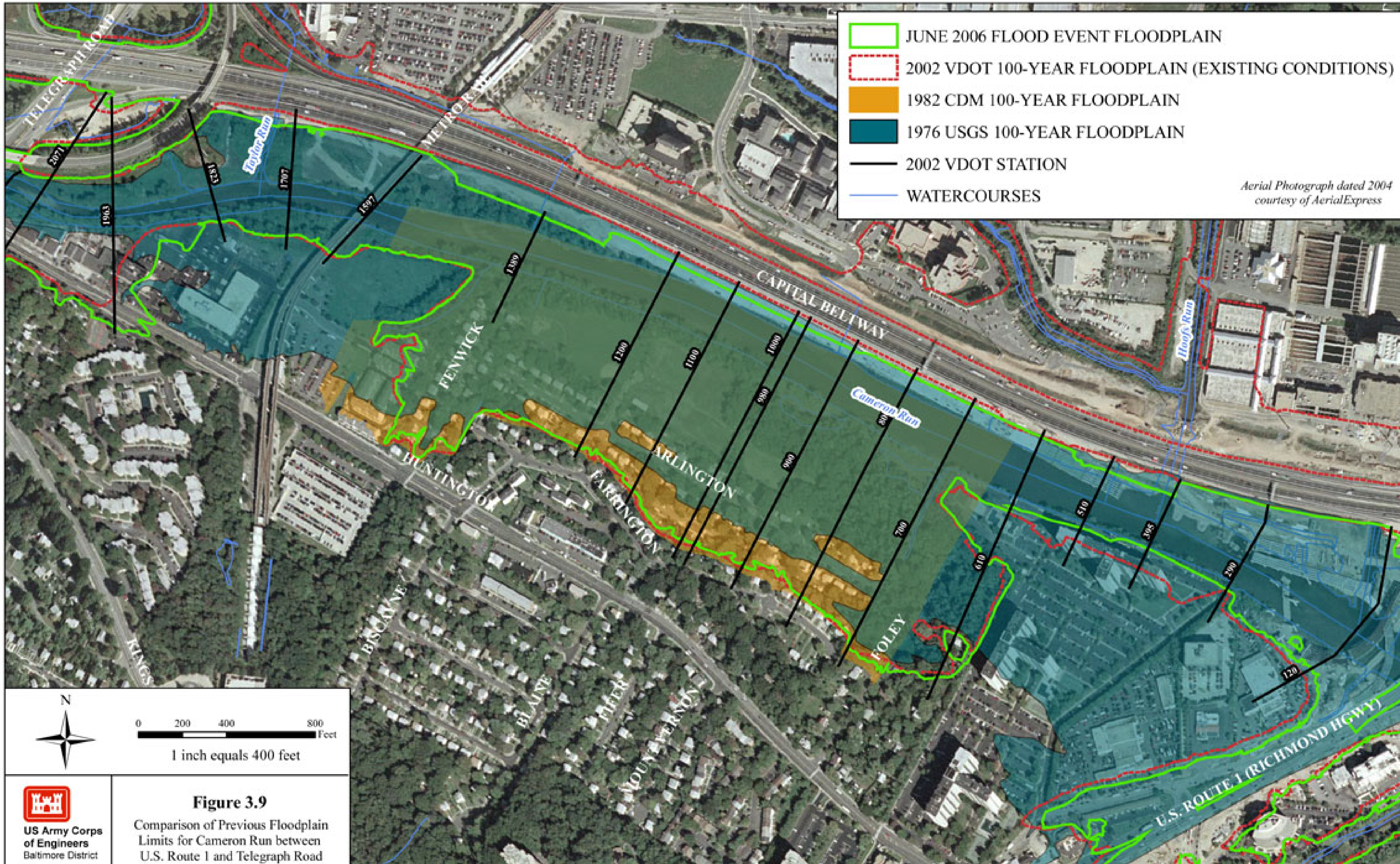


Figure 3.9

Comparison of Previous Floodplain Limits for Cameron Run between U.S. Route 1 and Telegraph Road

4.0 PRE-EVENT PERCEPTION OF FLOOD RISK

4.1 FAIRFAX COUNTY GOVERNMENTAL STAFF

Fairfax County has been a participating member of FEMA's National Flood Insurance Program (NFIP) since January 7, 1972. Since the adoption of their floodplain ordinance soon after membership into NFIP, Fairfax County has instituted sound floodplain management practices. The county currently requires a minimum vertical elevation of 18 inches above the base flood (100-year) elevation, and a 15-foot horizontal setback from the floodplain is required for new construction. The county also has a more restrictive 0.1-foot allowable rise in base flood elevation for new fill placed anywhere in the floodplain, rather than the 1.0-foot allowable rise criteria set by FEMA. Finally, FEMA guidelines currently direct that floodplains be regulated for watersheds that are one square mile (640 acres) in area or larger; Fairfax County, on the other hand, regulates watershed development and establishes floodplains for watersheds 70 acres in area or larger (FEMA, March 2006).

For floodplain management purposes in Huntington, Fairfax County adopted and uses floodplain maps and elevations that were produced by the USGS in 1976. The study, although dated 1976, consists of surveyed cross-sections and calculations that were completed in 1961, with supplemental survey data in 1965. This 1976 study is being used for Cameron Run in Huntington as the floodplain and is delineated as Zone A on FEMA's FIRM maps, meaning, no detailed flood elevation data is available from FEMA.

Huntington has been a priority area for Fairfax County staff, as it is one of the few areas of significant residential areas in the floodplain within the County. The history of the flood studies conducted in this area is also confirmation that flooding has happened, and is a concern of County officials. Significant changes to not only the watershed but the stretch of Cameron Run near Huntington have occurred since the 1976 USGS study, such as development in the watershed, development within the Cameron Run floodplain, channel sedimentation at rates of 0.2 feet per year (CDM, 1982), and roadway construction. The 1976 USGS study was useful for the time it was completed; however, due to the significant changes noted above, the results in the 1976 USGS study have proven to be invalid for Huntington in present day conditions.

4.2 RESIDENTS OF HUNTINGTON SUBDIVISION

As discussed in Section 3.1, residents of the Huntington community have been dealing with flooding issues for decades. However, based upon a letter from a homeowner to Fairfax County following Tropical Storm Eloise, the majority of complaints from homeowners regarding flooding prior to the June 2006 flood event was from backed up storm and sanitary sewer lines rather than overland, riverine flooding from Cameron Run. Although the majority of homes in Huntington were mapped in FEMA's 100-year floodplain, a number of them were removed from the floodplain limits via the FEMA letter of map amendment (LOMA) process.

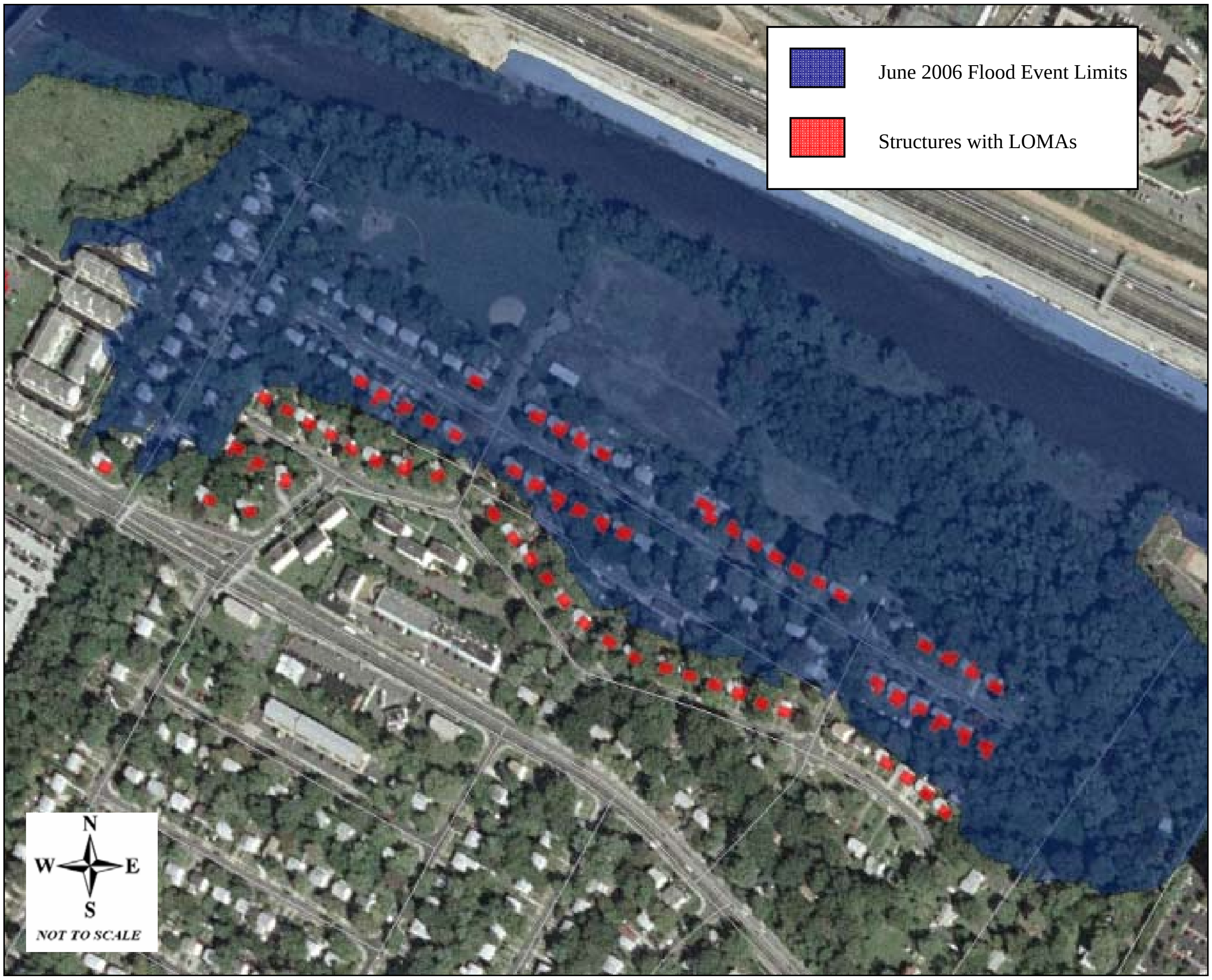
If a residential structure is located in a floodplain on FEMA's FIRMs, the homeowner is required to purchase flood insurance through NFIP for any Federally-backed loan. Although FEMA uses the most accurate flood hazard information available, limitations of scale or topographic definition of the source maps used to prepare the FIRM may cause small areas that are at or above the 100-year flood elevation to be inadvertently shown within the floodplain boundaries. When this happens, structures or parcels of land may be inadvertently included in the 100-year floodplain on the FIRM. For such situations, the property owner or lessee may apply for a LOMA with FEMA. LOMAs are documents issued by FEMA that officially remove a property and/or structures from the 100-year floodplain limits. The issuance of a LOMA determines that the property/structures is not located in the 100-year floodplain, and eliminates the Federal flood insurance purchase requirement as a condition of Federal or Federally-backed financing; however, ultimately the mortgage lender retains the prerogative to require flood insurance as a condition of any loan. In addition, although a structure is removed from the floodplain, flood insurance may still be purchased by the homeowner at reduced costs.

For structures placed on natural ground or constructed prior to the issuance of the first FEMA maps (as are all structures in Huntington), the determination as to whether a structure will be removed from the floodplain is based upon the comparison of the 100-year flood elevation to the lowest adjacent grade (LAG) elevation. The LAG is the lowest ground touching the outside of the structure, including attached decks and garages. If the LAG is at or above the 100-year flood elevation, the structure may be removed from the floodplain. Note that for structures with basements built on natural ground, such as those in Huntington, the basement elevation is not used in the determination.

The procedure used by FEMA for issuing LOMAs involves obtaining a LAG elevation for the structure from a licensed land surveyor or professional engineer, or in some cases, using community-approved topographic mapping. Next, a 100-year flood elevation is determined at the property. If a 100-year flood elevation is published on the FIRM map or FIS, it will be used for the determination. If the floodplain is delineated as Zone A, meaning no detailed study was completed by FEMA, a 100-year flood elevation must be obtained from other sources. Note that the floodplain for Cameron Run at Huntington is delineated as Zone A.

Nearly 130 property owners in Huntington (note that many structures in Huntington are duplexes) applied for and were granted LOMAs between 1997 and 2000 (Figure 4.1). For these LOMAs, FEMA used the 1976 USGS study results as the source of 100-year flood elevations for the structures in Huntington, with flood elevations ranging from 10.9 feet to 11.8 feet (NGVD29). This was determined to be the best available data at the time for Cameron Run.

Figure 4.1. Structures in Huntington with FEMA Letters of Map Amendment (LOMAs)



The application for LOMAs shows that although residents of Huntington knew that the risk of flooding in the community was present, some did not feel the flooding would cause damages to their structures. Note that although officially many applied for LOMAs, it is clear from the interviews with some of the residents that they were not familiar with what a LOMA is. This may be due to (1) the current tenant was not in residence at the time of the LOMA, as the LOMA may have been granted to the previous owner or (2) the LOMA was submitted for them by another entity, such as the County, lending institution, or homeowners association.

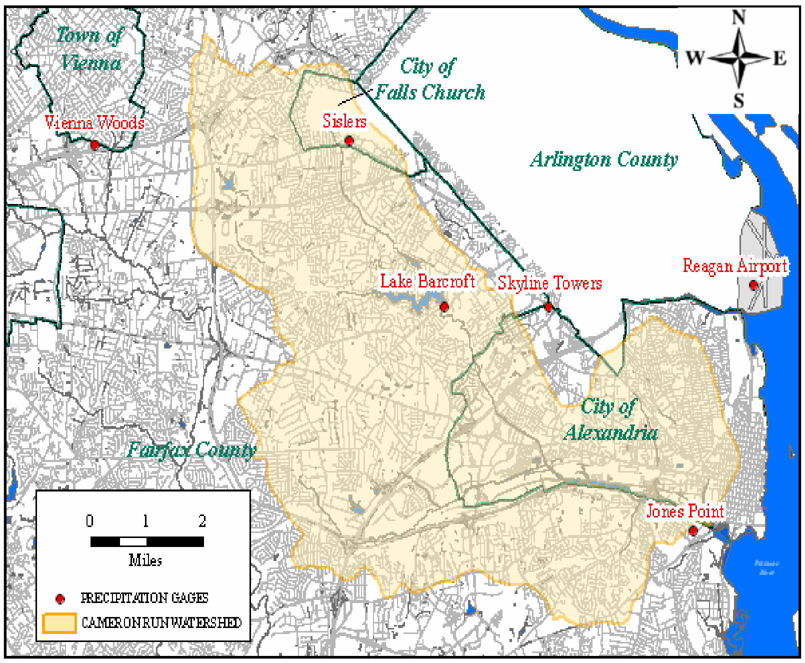
Certainly many residents were taken by surprise by the extent of flooding during the June 2006 flood event as many were removed from the floodplain limits and were then flooded significantly. Many residents did not carry flood insurance and thus incurred significant financial hardships as a result of the June 2006 flood event.

5.0 HYDROLOGIC ANALYSIS

5.1 PRECIPITATION DATA

There are six precipitation gages located in or within close proximity of the Cameron Run watershed (Figure 5.1). The Ronald Reagan National Airport precipitation gage is operated by NOAA's National Climatic Data Center (NCDC). The following gages are owned and operated by Fairfax County: Sislers, Skyline Towers, Jones Point, and Vienna Woods. The Lake Barcroft precipitation gage is owned and operated by LBWID.

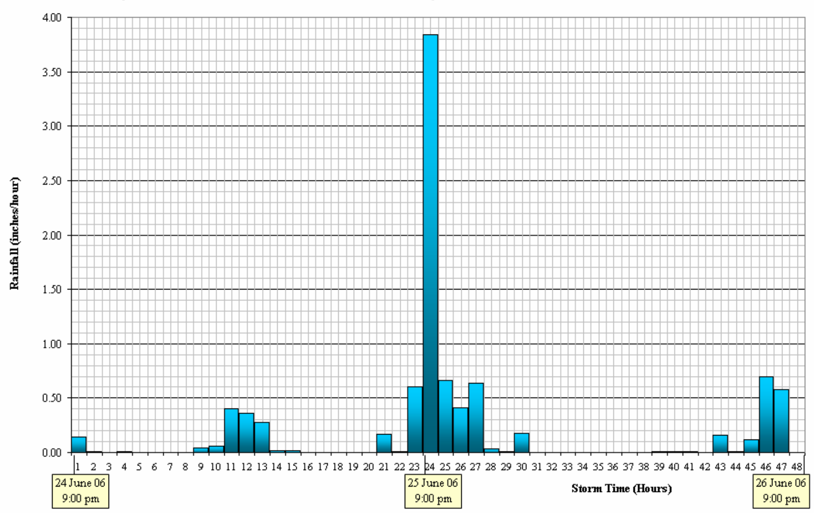
Figure 5.1. Precipitation Gages in or near the Cameron Run Watershed



During the June 2006 flood event, all gages shown in Figure 5.1 were functional and recorded precipitation data. The storm duration was approximately 48 hours in length, starting at roughly 9:00 pm on June 24, 2006 and ending at approximately 9:00 pm on June 26, 2006. Hyetographs and total precipitation curves for each gage are located in Appendix B.

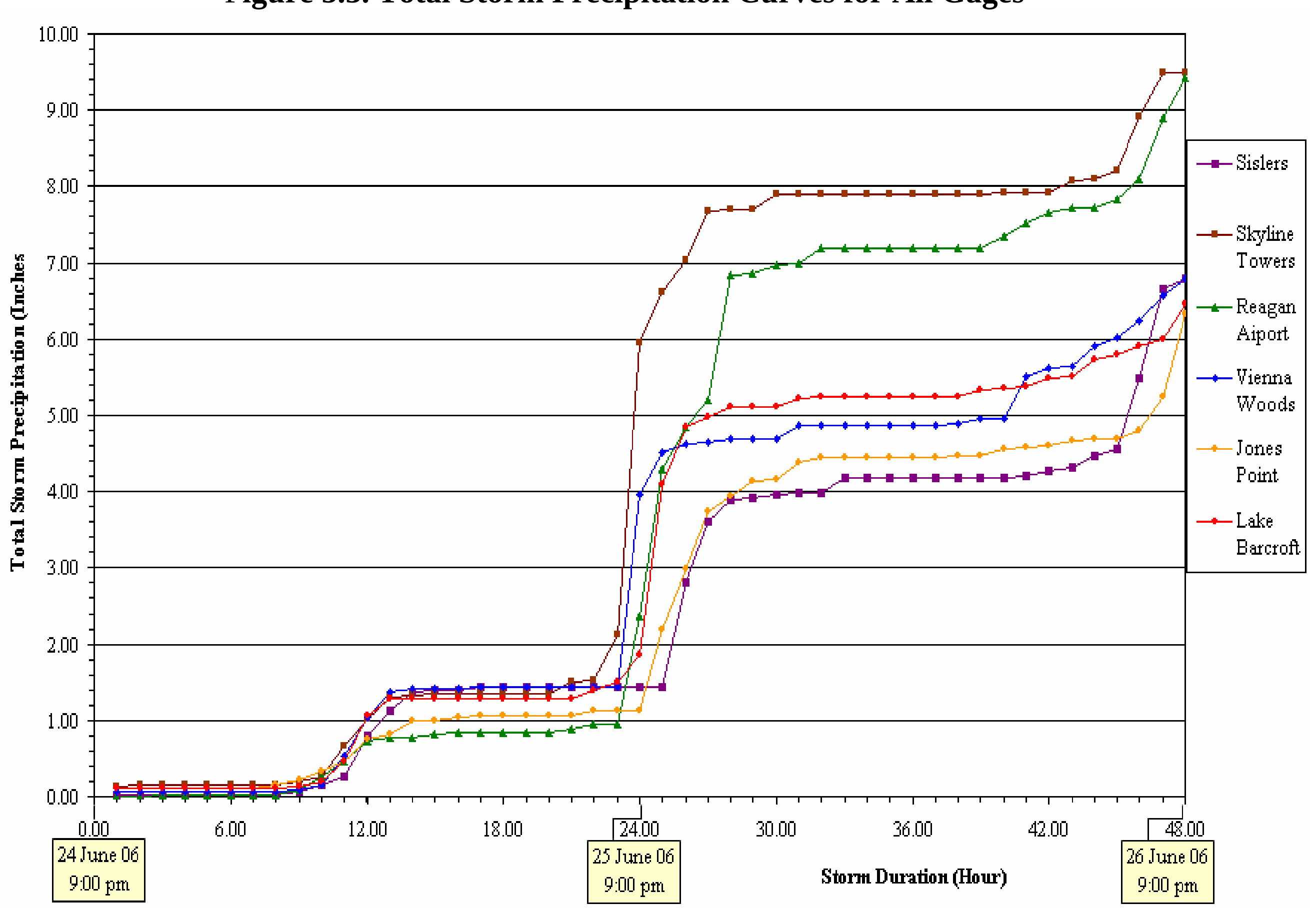
The precipitation gages recorded the same pattern of precipitation: low rainfall totals from the beginning of the storm to about hour 22 of the storm (approximately 7:00 pm on June 25, 2006). At approximately 7:00 pm on June 25, 2006, rainfall intensities began to increase. The Skyline Towers gage located in the Four Mile Run watershed recorded approximately 3.8 inches of rainfall between 8:00 pm and 9:00 pm on June 25, 2006 (Figure 5.2). Vienna Woods recorded over 2.5 inches of rain in the same time period. Overall, the heaviest rains occurred between 7:00 pm on June 25, 2006 and 1:00 am on June 26, 2006.

Figure 5.2. Storm Hyetograph for Skyline Towers



Precipitation totals over the 48-hour storm duration were nine to ten inches in some areas (Figure 5.3). The Skyline Towers and Ronald Reagan National Airport gages recorded between 9 and 10 inches of total rainfall over the 48-hour period. The other four precipitation gages recorded rainfall totals between 6 and 7 inches.

Figure 5.3. Total Storm Precipitation Curves for All Gages

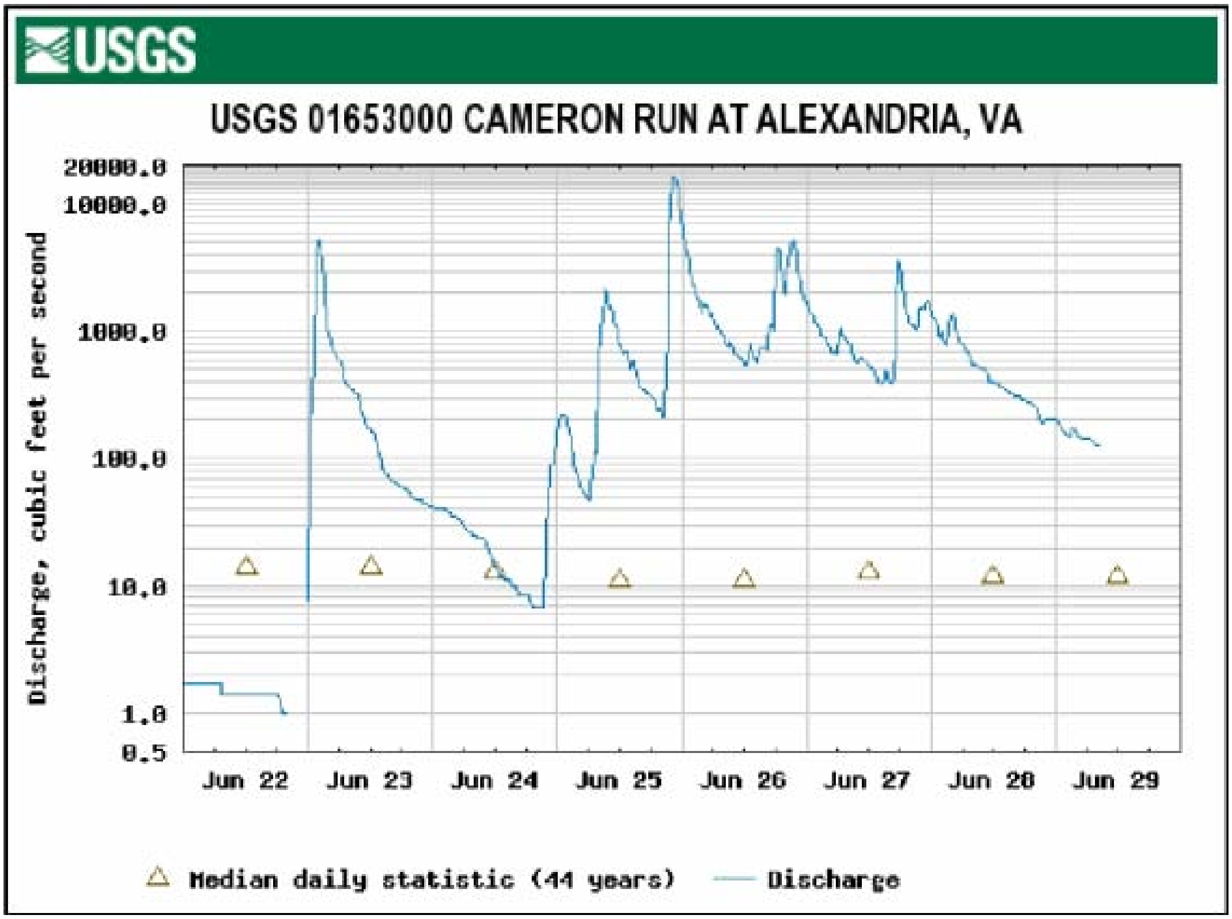


5.2 USGS GAGE DATA

USGS operates a continuous streamflow measurement gage along Cameron Run in the City of Alexandria; the gage location is shown in Figure 1.1. The gage, identified as USGS 01653000, has a record of flows from 1955 to present, and was functional during the June 2006 flood event. The drainage area to the gage is 33.7 square miles and the base gage elevation is 31.74 feet NGVD29.

The USGS gage recorded a peak discharge of 16,500 cfs for Cameron Run at 10:15 pm on June 25, 2006 (Figure 5.4). The stage at the gage for this peak flow was 15.52 feet (elevation 47.26 feet NGVD29). The peak discharge of 16,500 cfs was the second highest recorded at the gage. On June 22, 1972, the gage recorded a peak flow of 19,900 cfs, which was flow associated with rainfall from remnants of Tropical Storm Agnes. A table showing the recorded peak flows for the entire June 2006 flood event is located in Appendix C.

Figure 5.4. Observed Hydrograph for June 2006 Flood Event at USGS 01653000



5.3 LAKE BARCROFT RELEASE

Lake Barcroft is a man-made reservoir that is operated and managed by the Lake Barcroft Watershed Improvement District (LBWID). The LBWID is governed by the Commonwealth of Virginia via the Northern Virginia Soil and Water Conservation District, and is regulated, monitored, and inspected by the Virginia Dam Safety Board. The drainage area to the 135-acre Lake Barcroft is 14.5 square miles (approximately 35% of the entire Cameron Run watershed). The LBWID published a report titled "*Report on the Response of Lake Barcroft Dam to Heavy Rains during the Period of June 23 through June 29, 2006.*" This report is located in Appendix D.

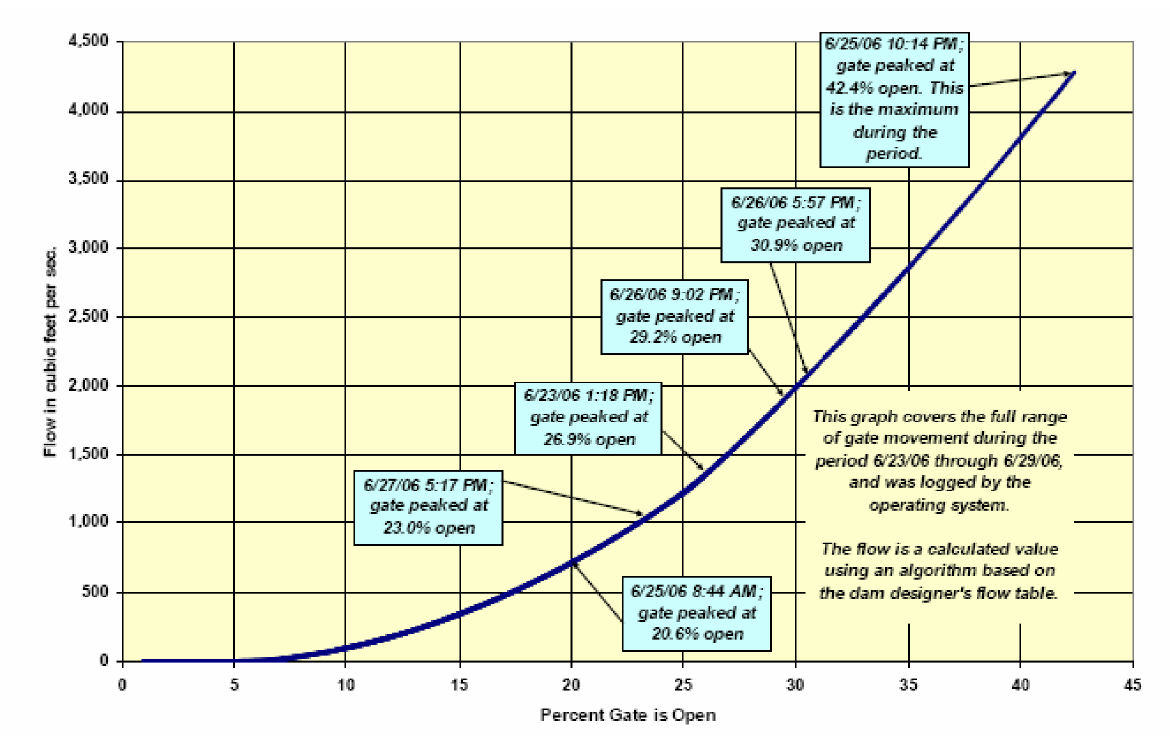
The dam that impounds the water in Lake Barcroft was originally constructed as a masonry dam with earthen embankments at the sides in the early 1900s as a water supply reservoir for the City of Alexandria. The lake and adjoining land was sold in the 1950s, when residential development of the land began. In 1972, during Tropical Storm Agnes, the earthen embankment of the dam eroded at the western end due to the high water in the lake; the erosion scoured the embankment and drained the lake. The dam was rebuilt after this event and was fitted with a 151-foot wide by

12-foot high bascule gate on top of the original masonry. Four hydraulic rams open and close the gate in response to a computer-operated monitoring control system. The system was designed to maintain the lake at a constant level (208.5 to 209.0 feet, NGVD29) to remove the risk of the dam failing.

The control systems for the gates include sensors that measure the water level accurately to the nearest 0.01-foot. The control system updates its readings every second, so as inflowing water begins to increase the elevation of Lake Barcroft, the computer begins the process of sending instructions to the gates to open the specific amount to allow the desired lake level to be maintained. Therefore, by design, Lake Barcroft is an inflow-outflow facility. Hydrologically, it provides minimal storage of excess runoff, and also will not, barring failure, release more water than is entering the lake.

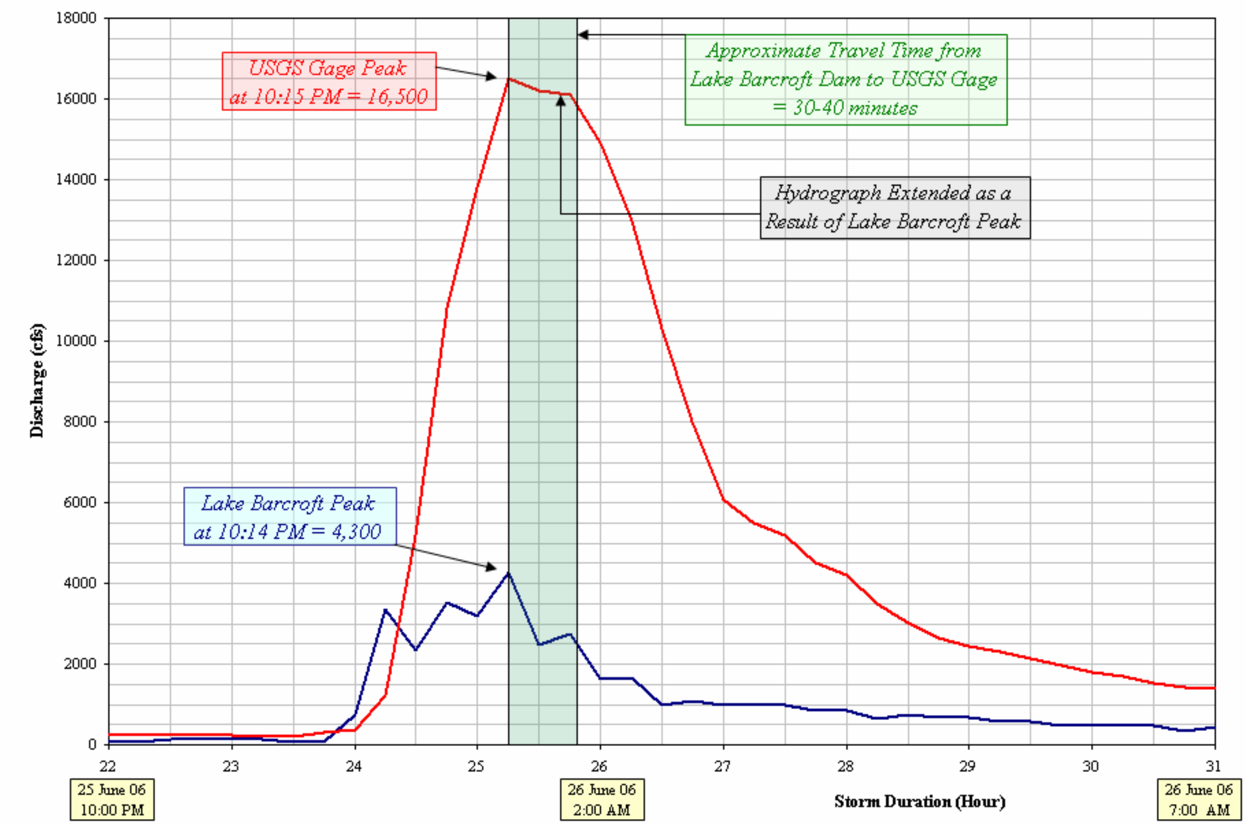
During the June 2006 flood event, the maximum peak discharge exiting the Lake Barcroft facility was 4,300 cfs at 10:14 pm on June 25, 2006. This release rate was based upon the gates being 42.4% open (Figure 5.5).

Figure 5.5. Relationship to Gate Opening to Flow over Lake Barcroft Dam during June 2006 Flood Event



Based upon Manning's equation, the estimated channel flow time from the outlet of Lake Barcroft to the USGS gage location is 30 to 40 minutes, depending on exact velocities. For the June 2006 flood event, the peak flow of 16,500 cfs at the USGS stream flow gage was measured at 10:15 PM on June 25, 2006. The peak flow from Lake Barcroft of 4,300 cfs was released between 10:11 and 10:15 PM on June 25, 2006. Therefore, the peak flow from Lake Barcroft did not contribute to the peak flow measured at the USGS gage, as the peaks occurred nearly simultaneously. Lake Barcroft was releasing approximately 3,700 cfs at roughly 9:45 PM on June 25, 2006, about 30 minutes prior to the peak at the USGS gage. The flows from Lake Barcroft obviously contribute to the peak flows recorded in downstream areas; however, for this storm event, the peak from Lake Barcroft only extended the hydrograph at the USGS gage (Figure 5.6), rather than being the contributing factor to the actual peak recorded at the USGS gage. Based upon the available data, it appears that Lake Barcroft was operating normally, maintaining its design function, and did not release a wave of water that may have intensified the peak flows in Huntington.

Figure 5.6. Comparison of USGS Gage and Lake Barcroft Hydrographs for June 2006 Flood Event



5.4 DEVELOPMENT OF JUNE 2006 PEAK FLOW ESTIMATES

At the present time, there is no hydrologic model that covers the entire Cameron Run watershed. An Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) was prepared by Versar, Inc. for the Fairfax County Stormwater Planning Division in June 2005; however, this model only includes portions of the watershed upstream of the USGS gage as well as the Pike Branch watershed; it does not include areas downstream of the USGS gage or the Taylor Run watershed, which drains approximately 1.6 square miles of the highly urbanized City of Alexandria. Therefore, the model could not be utilized for this investigation. Thus, the USGS steamflow gage data was relied on exclusively to estimate peak flows for the June 2006 flood event.

The ideal situation for estimating the peak flows for Huntington for the June 2006 flood event would be to have a streamflow gage upstream and downstream of the study area in order to produce a peak flow discharge curve between the two gages. Unfortunately, only one gage exists. Therefore, in order to estimate the peak flows in the study area, three commonly used methods were used and compared. These are the drainage area ratio method, the Anderson method, and USGS regression analysis.

For the purpose of this investigation, four "hydrologic study points" were identified. These points are the Capital Beltway (U.S. Route 495) crossing, Telegraph Road crossing along Cameron Run, the upstream end of Huntington, and the U.S. Route 1 crossing.

5.4.1 DRAINAGE AREA RATIO METHOD

This method is widely used by the U.S. Army Corps of Engineers and other agencies throughout the country to estimate peak flows for ungaged sites that lie upstream or downstream of a gaged site. It assumes a homogenious watershed in which the drainage area to the ungaged site responds to hydrologic factors in the same fashion as the gaged site. Typically, the drainage area of the ungaged site must be within 50 to 150 percent of the gaged site. This method was deemed reasonable for this investigation because nearly 95 percent of the watershed is highly urbanized (Virginia Tech, 2003), with little land use variability between sub-watersheds. The equation used to estimate the peak flows to the hydrologic study points is:

$$\mathbf{Q}_{\text{ungaged}} = \mathbf{Q}_{\text{gaged}} \left(\mathbf{A}_{\text{ungaged}}/\mathbf{A}_{\text{gaged}}\right)^{\mathbf{0.8}}$$

Where:

$\mathbf{Q}_{\text{ungaged}}$ = Peak discharge of ungaged site in cubic feet per second
$\mathbf{Q}_{\text{gaged}}$ = Peak discharge of gaged site in cubic feet per second
$\mathbf{A}_{\text{ungaged}}$ = Drainage area of ungaged site in square miles
$\mathbf{A}_{\text{gaged}}$ = Drainage area of gaged site in square miles

The drainage area to the gaged site, USGS 01653000, is 33.7 square miles, with a June 2006 flood event peak flow of 16,500 cubic feet per second. This method was considered valid for the area in question because (1) the majority of the watershed to the gage and the ungaged site is relatively urbanized evenly across the entire watershed, and (2) Lake Barcroft is an inflow-outflow facility and does not cause bias in the results. An exponent of 1.0 in the equation would imply that the streamflow at the ungaged site is the same per unit area as the gaged site. However, it is characteristic of river basins that discharge of any flood frequency will increase less rapidly than drainage area. Therefore, an exponent of 0.8 was applied to the equation. The results of the analysis using this method are shown in Table 5.1.

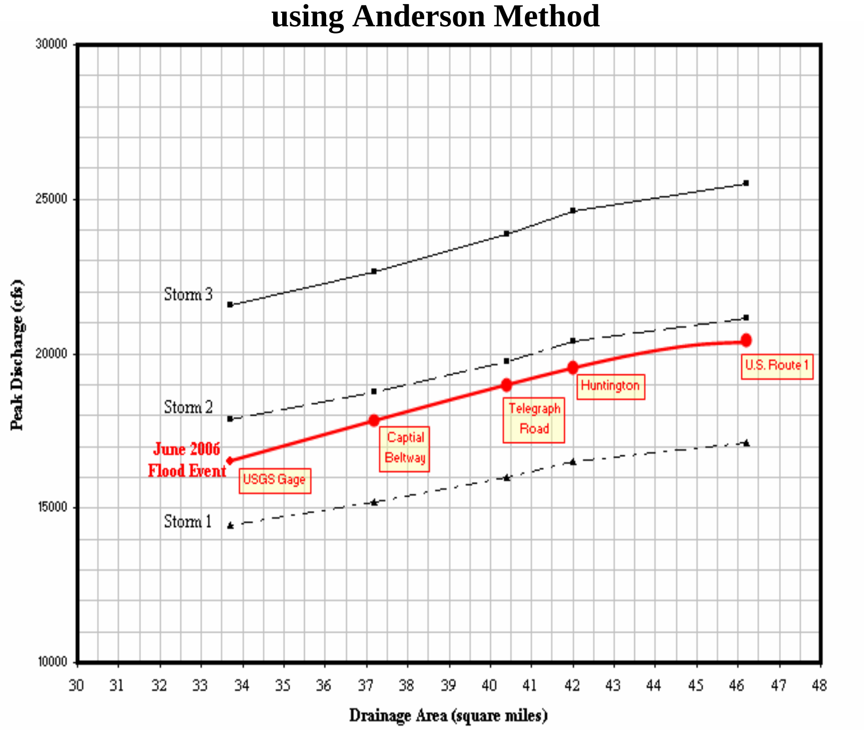
Table 5.1. Estimation of Peak Flows for the June 2006 Flood Event using the Drainage Area Ratio Method

Hydrologic Point	Drainage Area (square miles)	Estimated Peak Flow Using Drainage Area Ratio Method (cfs)
Capital Beltway	37.2	17,900
Telegraph Road	40.4	19,100
Huntington	42.0	19,700
U.S. Route 1	46.2	21,200

5.4.2 ANDERSON METHOD

The Anderson method, outlined in USGS Water Supply Paper 2001, utilizes five independent variables to perform peak flow calculations: the size, length, and slope of the watershed, and the percentage of impervious area and type of drainage system. This method was used by the USGS in Fairfax County's initial flood insurance studies to produce flood maps in the 1970's, as well as in the VDOT Woodrow Wilson Bridge Study (at the direction of FEMA).

Figure 5.7. Peak Discharge vs. Drainage Area Relationship using Anderson Method



For the purposes of estimating the peak flows for the June 2006 flood event, relationships were established for the hydrologic study points along the study reach, based upon the size of the drainage area. The Anderson method was used to estimate flood events of different frequency at each hydrologic study point. The results for each hydrologic study point using the Anderson method were used to develop a graphical peak discharge vs. drainage area relationship. The known flow at the USGS gage for the June 2006 Flood Event was plotted as well, and a curve was interpolated following the relationship established using the Anderson method. Peak discharge estimates for the June 2006 flood event were then estimated for each hydrologic study point using the developed curve (Figure 5.7). The results of the analysis using the Anderson Method are shown in Table 5.2.

Table 5.2. Estimation of Peak Flows for the June 2006 Flood Event using the Anderson Method

Hydrologic Point	Drainage Area (square miles)	Estimated Peak Flow Using Anderson Method (cfs)
Capital Beltway	37.2	17,800
Telegraph Road	40.4	19,000
Huntington	42.0	19,500
U.S. Route 1	46.2	20,400

5.4.3 REGRESSION ANALYSIS

A regional method for estimating peak discharge at ungaged sites located on a gaged stream is described in *USGS Water-Resources Investigations Report 94-4148, Methods for Estimating the Magnitude and Frequency of Peak Discharges for Rural, Unregulated Streams in Virginia.* This method involves the following steps: (1) estimating the peak discharge of the ungaged site using a regression equation; (2) computation of a correction factor for the gaged site using weighted peak discharge and regional regression peak charge data; (3) computation of a correction factor for the ungaged site using drainage area relationships; and (4) estimation of the peak discharge at the ungaged site using the data developed in previous steps. This method also requires the drainage area of the ungaged site must be within 50 to 150 percent of the gaged site's drainage area, and the watershed be homogenous in nature.

Typically this method is applied when a specific frequency peak discharge is needed, as the regression equations are developed for the 2- through 500-year flood event. However, for this investigation, the frequency storm does not correspond to a defined regression event. In order to develop a reasonable estimation of the peak discharge at the hydrologic study points, a relationship of the overall drainage area was developed using this method. The technique was used to develop peak discharges for floods of various frequencies for Lake Barcroft, the USGS gage, and the hydrologic study points. The results were plotted to develop a relationship between the drainage areas at each site to the peak flows for each frequency storm. This relationship was then used with observed peak flows (16,500 cfs at the USGS gage and 4,300 cfs at Lake Barcroft) to estimate the peak flows for the hydrologic study points (Figure 5.8). The results of the analysis using USGS regression analysis are shown in Table 5.3.

Figure 5.8. Peak Discharge vs. Drainage Area Relationship using Regression Analysis

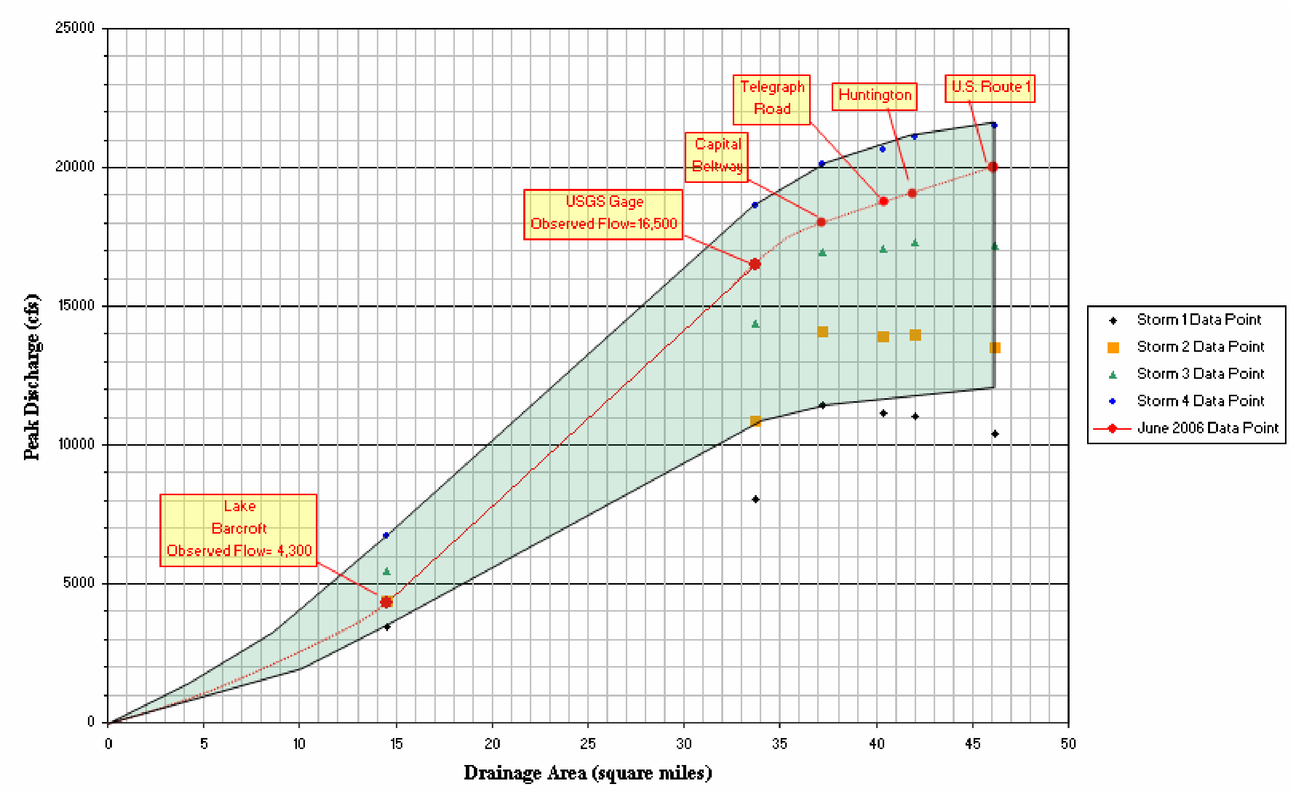


Table 5.3. Estimation of Peak Flows for the June 2006 Flood Event using Regression Analysis

Hydrologic Point	Drainage Area (square miles)	Estimated Peak Flow Using Regression Analysis (cfs)
Capital Beltway	37.2	17,900
Telegraph Road	40.4	18,800
Huntington	42.0	19,100
U.S. Route 1	46.2	20,000

5.4.4 COMPARISON OF RESULTS

A comparison of June 2006 peak flows estimated using the three outlined methods is shown in Table 5. 4.

Table 5.4. Comparison of Peak Flow Results for June 2006 Flood Event

Hydrologic Point	Estimated Peak Flow (cfs)		
	Drainage Area Ratio Method	Anderson Method	Regression Analysis
Capital Beltway	17,900	17,800	17,900
Telegraph Road	19,100	19,000	18,800
Huntington	19,700	19,500	19,100
U.S. Route 1	21,200	20,400	20,000

For the purposes of this investigation, the flows calculated using the drainage area ratio method were used for the hydraulic analysis. The results of the Anderson method and USGS regression analysis confirm that the estimation of peak flows using the drainage area ratio method is reasonable for this highly urbanized watershed.

6.0 HYDRAULIC ANALYSIS

6.1 DEVELOPMENT OF JUNE 2006 HYDRAULIC MODEL

A hydraulic model that simulates the June 2006 flood event was developed. This was done in order to establish baseline conditions for which comparisons can be made during the sensitivity analysis.

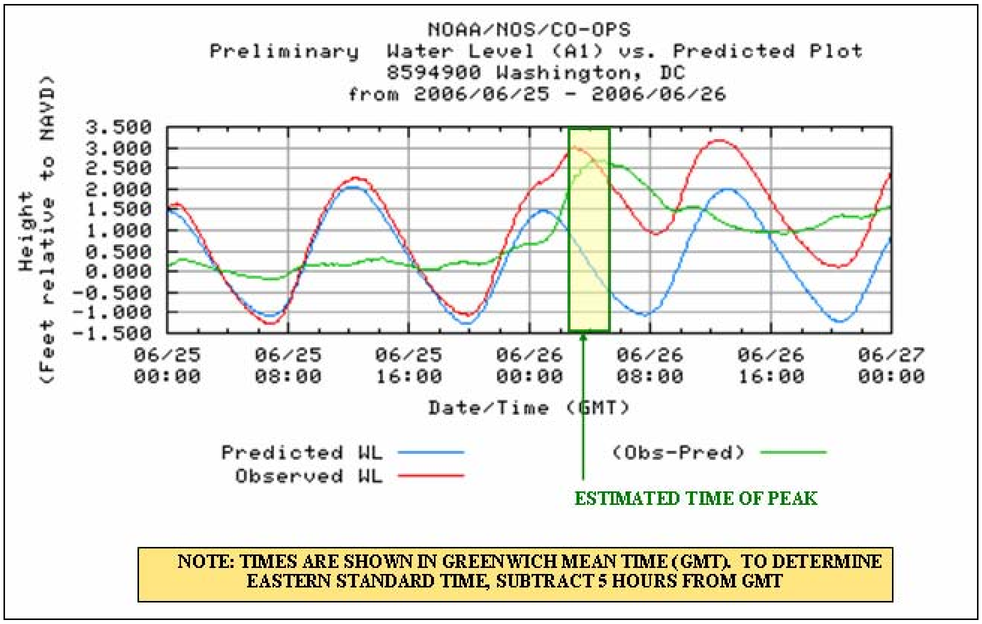
For the purposes of this investigation, the VDOT HEC-RAS steady-state models (existing and proposed conditions), dated 2002, was assumed to be the most recent and accurate reflection of the hydraulic condition of Cameron Run within the study area. Both the existing and proposed-conditions models were reviewed for accuracy, and found to be scientifically sound in most areas; however, adjustments to Manning's "n" values were made prior to using this model to develop a June 2006 flood event model. The VDOT models estimate a Manning's "n" value of 0.05 for the entire Huntington overbank area. Due to the significant amount of blockages, such as houses, large trees, etc… the "n" values were increased to 0.08 or 0.1. Therefore, the VDOT existing-conditions model was modified, and the geometric file is called "MODIFIED VDOT EXISTING".

Next, the modified VDOT existing data and VDOT proposed conditions models were merged to reflect conditions during the June 2006 flood event, as the U.S. Route 1 interchange was near completion, and the Telegraph Road interchange was not started. Manning's "n" values for near the U.S. Route 1 interchange were adjusted based upon the narrative of the construction project provided by VDOT (located in Appendix E). Values were increased from .035 (rip-rap conditions) to 0.072 to account for stockpiles, constructions materials, construction vehicles, and cofferdams. The barge blockage was input into the model to simulate the approximate 15-percent blockage that was created during the event. The geometric file for the June 2006 flood event was identified as "JUNE 2006 CONDITIONS."

6.2 JUNE 2006 MODEL RUN AND COMPARISON TO HIGH WATER MARKS

The June 2006 flood event model (JUNE 2006 CONDITIONS) was run with the peak flows estimated and discussed in Section 5 (flow file named "JUNE 2006 FLOW (TIDE)"). The plan file was named "JUNE 2006 FLOOD EVENT PLAN." A known water surface elevation of 2.0 feet (NGVD29 datum) was used as the starting water surface elevation. As noted earlier, the estimated time of peak of the flood event at the Potomac River was between 10:00 pm and 12:00 am on June 25 and June 26, 2006. At 10:00 pm on June 25, the tidal stage was roughly 3.0 feet National Adjusted Vertical Datum of 1988 (NAVD88) (which is 2.2 feet NGVD29). At 12:00 am on June 26, the tidal stage was approximately 2.2 feet NAVD88 datum (1.4 feet NGVD29) (Figure 6.1). Because the exact time of peak was unknown, the starting water surface elevation was estimated at 2.0 feet NGVD29.

Figure 6.1. NOAA Tidal Data at 8594900, Washington, D.C. for the June 2006 Flood Event



The HEC-RAS steady-state model was run in a sub-critical flow regime using the June 2006 geometric data with the June 2006 flow data. The results of the HEC-RAS run were compared to surveyed high water marks of the June 2006 flood event provided by VDOT and Fairfax County Stormwater Planning Division. This comparison is shown in Table 6.1. VDOT cross-section and high water mark locations are shown in Figure 6.2. A complete HEC-RAS output table for the June 2006 flood event is located in Appendix F.

Table 6.1. June 2006 Flood Event Model Results compared to High Water Marks

Cross-Section	June 2006 Flood Event HEC-RAS Model (feet NGVD29)	High Water Marks (feet NGVD29)
2752	23.8	22.6-25.8
2169	19.8	19.8-20.3
2071	16.3	18.4
1963	15.1	17.4
1823	14.5	15.4
1707	14.3	14.7
1389	13.9	13.2-13.9
1180	13.4	13.4-13.7
860	12.9	12.9-13.4
640	12.1	12.4
99	9.6	9.0-10.4

HUNTINGTON

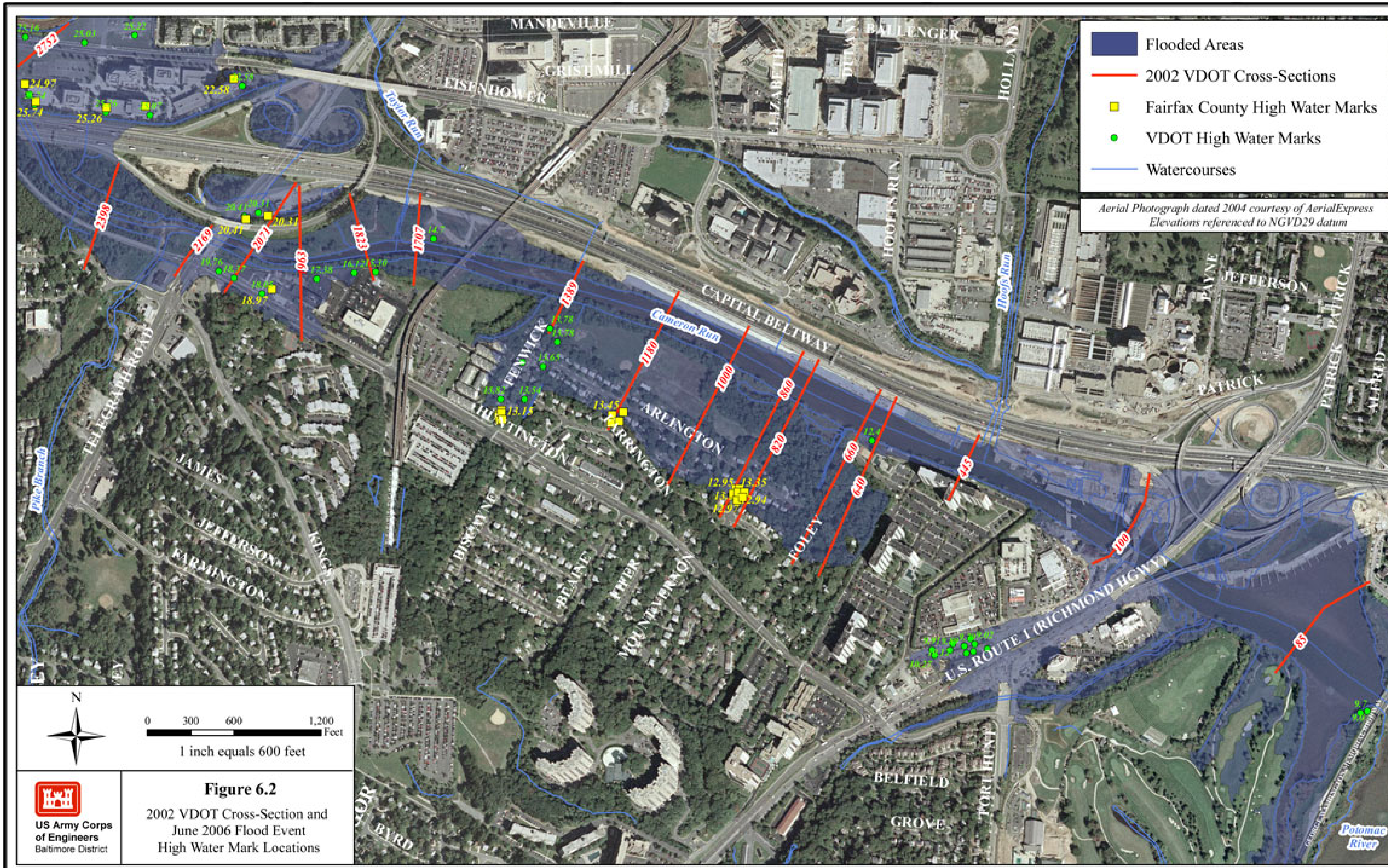


Figure 6.2

2002 VDOT Cross-Section and June 2006 Flood Event High Water Mark Locations

For the majority of Cameron Run, the June 2006 flood event model results match quite well with the high water marks recorded by VDOT and Fairfax County. In Huntington in particular, the model results were within the range of recorded high water marks, or within 0.3 feet. The modeling results also matched well with recorded high water marks near the Capital Beltway. The results, however, varied near Telegraph Road, as the modeling results were over 2 feet lower than the recorded high water marks. Although the exact cause of this is unknown at this point in time, resolving this issue is outside the scope of this investigation. VDOT also experienced similar discrepancies when comparing information. Since the modeling results simulate the flooding in Huntington during the June 2006 flood event well, it was deemed acceptable to conduct a sensitivity analysis to meet the objectives of the investigation.

7.0 SENSITIVITY ANALYSIS

The purpose of the sensitivity analysis was to determine how Cameron Run flooding is impacted as a result of given scenarios such as construction activities, barge blockages, floodplain development, channel sedimentation, and Potomac River tidal influence. For the sensitivity analysis, several geometric files, flow files, and plan files were created in HEC-RAS (version 2.2) in order to simulate the effects of certain factors on the system. Table 7.1 lists the created files and provides a brief explanation of each.

Table 7.1. HEC-RAS Files Developed for the Sensitivity Analysis

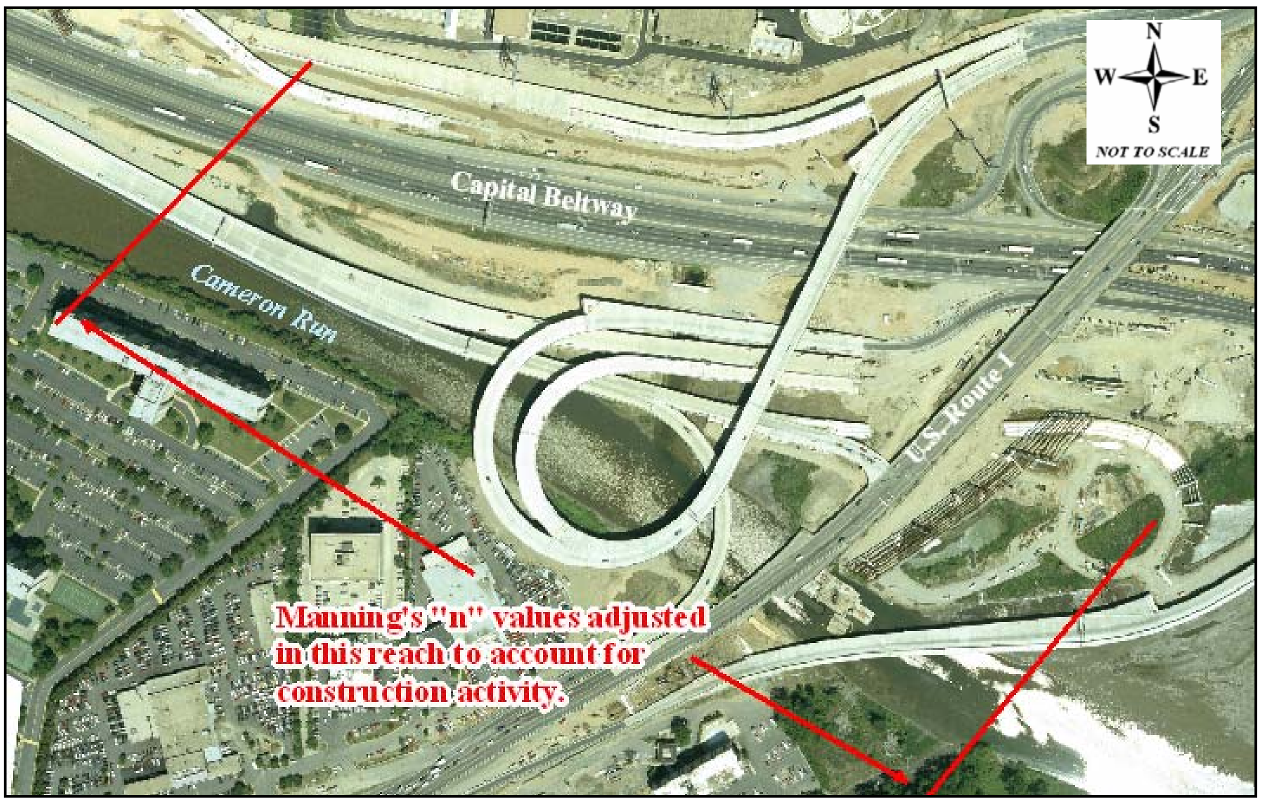
Plan	Geometric File	Flow File	Explanation
JUNE 2006 FLOOD EVENT PLAN	*JUNE 2006 CONDITIONS*	*JUNE 2006 FLOOD EVENT (TIDE)*	Discussed in Section 6.2. The June 2006 flood event
JUNE 2006 (WITHOUT BRIDGE ACTIVITY)	MODIFIED VDOT EXISTING	*JUNE 2006 FLOOD EVENT (TIDE)*	If the June 2006 flood event occurred in 1999, prior to Woodrow Wilson Bridge and U.S. Route 1 interchange construction activity
JUNE 2006 FLOOD EVENT PLAN (NO BARGE)	JUNE 2006 CONDITIONS (NO BARGE)	*JUNE 2006 FLOOD EVENT (TIDE)*	The June 2006 flood event if the barge blockage did not occur
1965 WITH JUNE 2006 FLOWS	1965 CONDITIONS	*JUNE 2006 FLOOD EVENT (TIDE)*	If the June 2006 flood event occurred in 1965. Reflects surveyed cross-sections dated 1961 and 1966 that were used in the 1976 USGS study. Survey prior to the construction of Jones Point (1971 construction date).
1972 WITH JUNE 2006 FLOWS	1972 CONDITIONS	*JUNE 2006 FLOOD EVENT (TIDE)*	If the June 2006 flood event occurred in 1972. Reflects surveyed cross-sections after the construction of Jones Point (1971 construction date).
POTOMAC 5.0	*JUNE 2006 CONDITIONS*	JUNE 2006 FLOOD EVENT (POTOMAC 5)	If the Potomac River was at tidal stage 5.0 during the June 2006 flood event
POTOMAC 7	*JUNE 2006 CONDITIONS*	JUNE 2006 FLOOD EVENT (POTOMAC 7)	If the Potomac River was at tidal stage 7.0 during the June 2006 flood event
POTOMAC 11	*JUNE 2006 CONDITIONS*	JUNE 2006 FLOOD EVENT (POTOMAC 11)	If the Potomac River was at tidal stage 11.0 during the June 2006 flood event

The HEC-RAS files listed in Table 7.1 were used to compute water surface elevations for the given scenarios, and then the scenario results were compared to the June 2006 flood event results in order to determine the impact each factor has or had on the system. Detailed HEC-RAS output tables are located in Appendix G.

7.1 U.S. ROUTE 1 INTERCHANGE CONSTRUCTION ACTIVITY

There was significant construction activity at the U.S. Route 1 interchange during the June 2006 flood event. This activity is outlined by VDOT in *"Narrative Summary of the Woodrow Wilson Bridge Project Status near Cameron Run on June 25, 2006,"* which is located in Appendix E. As discussed in Section 6.0, Manning's "n" values for near the U.S. Route 1 interchange were adjusted based upon the narrative (Figure 7.1). Values were increased from 0.035 (rip-rap conditions) to 0.072 to account for stockpiles, constructions materials, construction vehicles, and cofferdams. All construction activity at the U.S. Route 1 interchange was permitted by the applicable entities and/or agencies.

Figure 7.1. Construction Activity at Route 1 Interchange during June 2006 Flood Event (aerial photograph courtesy of VDOT, dated 23 May 2006).



The results of the JUNE 2006 FLOOD EVENT plan were compared to the results of the JUNE 2006 (WITHOUT BRIDGE ACTIVITY) plan to determine the impact the construction activity had on the water surface elevations during the flood event. The objective was to determine how severe the flooding would have been during the June 2006 flood event if the Woodrow Wilson Bridge construction activity would not have been occurring. The results are listed in Table 7.2

Table 7.2. Increase in Flood Elevations as a Result of U.S. Route 1 Interchange Construction Activity

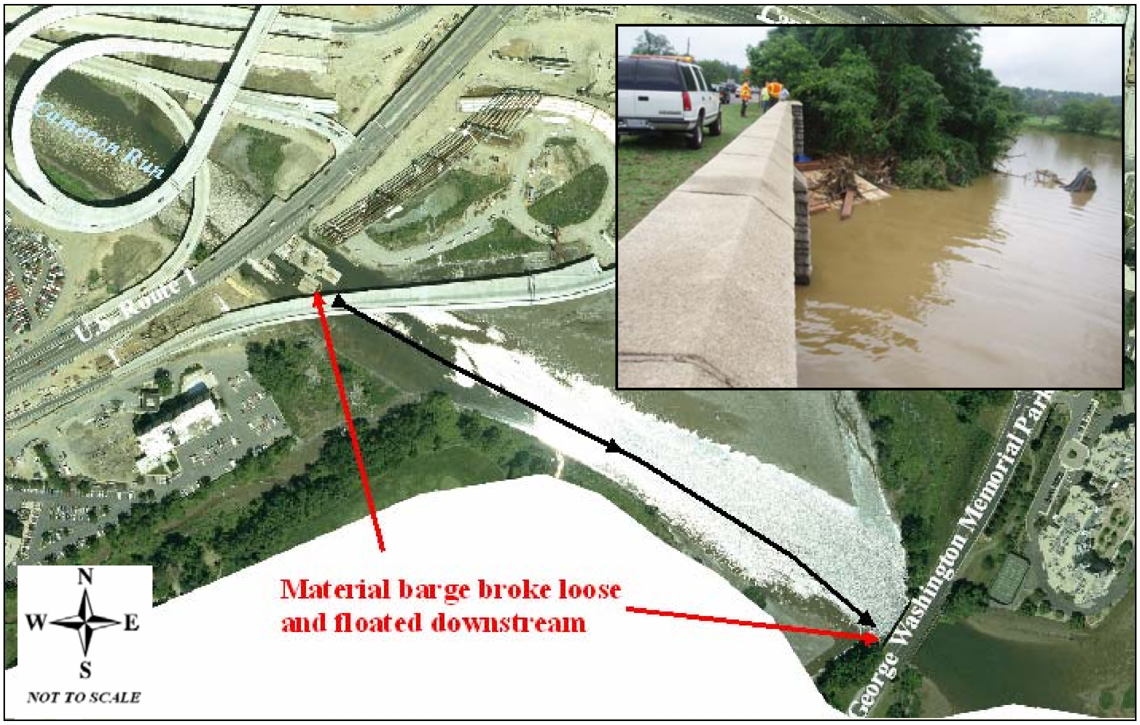
SECTION	*JUNE 2006 FLOOD EVENT PLAN*	*JUNE 2006 (WITHOUT BRIDGE ACTIVITY)*	*INCREASE AS A RESULT OF U.S. ROUTE 1 INTERCHANGE ACTIVITY*
2752	23.8	23.6	0.2
2398	21.0	20.7	0.2
2071	16.3	16.2	0.2
1389	13.9	13.4	0.5
1180	13.4	12.7	0.7
1000	13.2	12.6	0.6
820	12.8	12.1	0.7
660	12.2	11.3	0.9
445	11.2	10.3	0.8
100	9.7	9.4	0.3
85	9.0	8.8	0.2
	HUNTINGTON		

The maximum increase in Huntington as a result of the construction activity at the U.S. Route 1 interchange at the time of the June 2006 flood event is 0.9 feet at cross-section 660 (downstream end of Huntington), and decreasing upstream from that point. *This increase is from the temporary activity associated with construction*. As a result of the overall finished construction of the U.S. Route 1 interchange, the projected maximum increase in the 100-year flood elevation as a result of the finished construction is 0.8 feet approximately 300 feet west of the confluence of Hoofs Run. On average, the completed project will increase flood elevations by roughly 0.5 feet throughout this reach of Cameron Run (VDOT, 2002). VDOT will re-analyze the impacts of the project when construction is complete to account for any design changes during construction. The increases associated with the temporary construction activity are within the bounds of the anticipated increase for the finished project, which is acceptable per FEMA as they are less than 1.0 feet.

7.2 BARGE BLOCKAGE AT GEORGE WASHINGTON MEMORIAL PARKWAY

During the June 2006 flood event, a 40-foot x 40-foot material barge associated with the U.S. Route interchange construction activity broke loose and floated downstream (Figure 7.2). At 6:00 am on June 26, 2006, a VDOT project manager observed the material barge located at the George Washington Memorial Parkway stone arch bridge over Cameron Run. No structural damage to the bridge was observed by VDOT and FHWA experts; however, it is estimated that the barge blocked approximately 15 percent of the total flow capacity of the arch bridge (VDOT, July 2006).

Figure 7.2. Barge Blockage at the George Washington Memorial Parkway



The results of the JUNE 2006 FLOOD EVENT plan were compared to the results of the JUNE 2006 FLOOD EVENT (NO BARGE) plan to determine the impact the barge blockage had on the water surface elevations during the flood event. The objective was to determine how severe the flooding would have been during the June 2006 flood event if the barge blockage did not occur. The results are shown in Table 7.3. As shown in the table, the impact was negligible.

Table 7.3. Increase in Flood Elevations as a Result of the Barge Blockage

SECTION	WATER SURFACE ELEVATION (FEET NGVD29)		
	JUNE 2006 FLOOD EVENT PLAN	*JUNE 2006 FLOOD EVENT PLAN (NO BARGE)*	*INCREASE AS A RESULT OF BARGE BLOCKAGE*
2752	23.8	23.8	0.0
2398	21.0	21.0	0.0
2071	16.3	16.3	0.0
1389	13.9	13.8	0.1
1180	13.4	13.3	0.1
1000	13.2	13.2	0.0
820	12.8	12.8	0.0
660	12.2	12.1	0.1
445	11.2	11.1	0.1
100	9.7	9.5	0.2
85	9.0	8.8	0.2

HUNTINGTON

The barge blockage at the George Washington Memorial Parkway had minimal effect on the severity of flooding in Huntington during the June 2006 Flood Event. The blockage caused less than a 0.1-foot. increase (1 to 2 inches) in flood elevations in Huntington.

7.3 FLOODPLAIN DEVELOPMENT

The floodplain of Cameron Run between U.S. Route 1 upstream to Telegraph Road has changed considerably throughout time. Developments have occurred that have placed significant amount of fill in the original 1976 USGS delineated floodplains (based on surveys from 1961 and 1965). The fill in the floodplain is considered a floodplain encroachment. A floodplain encroachment is defined as the placing of material (fill, buildings, etc…) in a floodplain in a manner that potentially obstructs or increases the depth of flow of a watercourse. Typically, under NFIP regulations, encroachments in the floodplain may take place if the development does not increase water surface elevations by more than 1 foot. Engineering calculations are usually required with such developments to demonstrate that the guidelines are being met.

Two large developments, along with several smaller commercial developments, were constructed within the 1976 USGS delineated floodplains since 1965. The large developments include Jones Point and the Huntington Metro Rail and Station (Figure 7.3).

The Huntington Metro Rail and Station was opened for riders in 1983. It is estimated that construction activity associated with the station was taking place around 1980. The rail runs over Cameron Run just downstream of the confluence of Taylor Run. The rail is elevated more than 20 feet above Cameron Run, and is supported by concrete piers. However, the most significant fill in the floodplain is not associated with the rail itself; it is from an abandoned dirt stockpile located west of Fenwick Drive and east of the rail. A large mound of grassed land exists on the right bank of Cameron Run, which contains over 13 feet of fill. Preliminary analyses using HEC-RAS showed that the development upstream of Huntington, which was the Huntington Metro Rail and Station and commercial developments, had no impact to flood levels in Huntington. This is expected as typically, floodplain encroachments affect areas upstream rather than downstream. Subsequently, the Huntington Metro Rail and Station and the commercial developments did increase flood levels by approximately 0.5 feet near Telegraph Road. The impact of this development is outside the scope of this investigation as it does not impact Huntington; therefore, results are not presented in this report.

Based upon preliminary analyses, the floodplain development downstream of Huntington, Jones Point, does impact the flood levels in Huntington. The Jones Point development, which is approximately 100 acres in size, is located adjacent to the right bank of Cameron Run and the west side of the U.S. Route 1 interchange. The plans for the development were approved by Fairfax County governmental agencies in 1967, with construction being completed in 1971. The development contains residential apartment towers along with several commercial buildings. A metal retaining wall was constructed along Cameron Run for the development, with a large amount of fill brought in to elevate the development out of the floodplain. As much as 14 feet of fill was placed in some locations, and a large portion of the floodplain was filled in as a result (Figures 7.4 and 7.5).

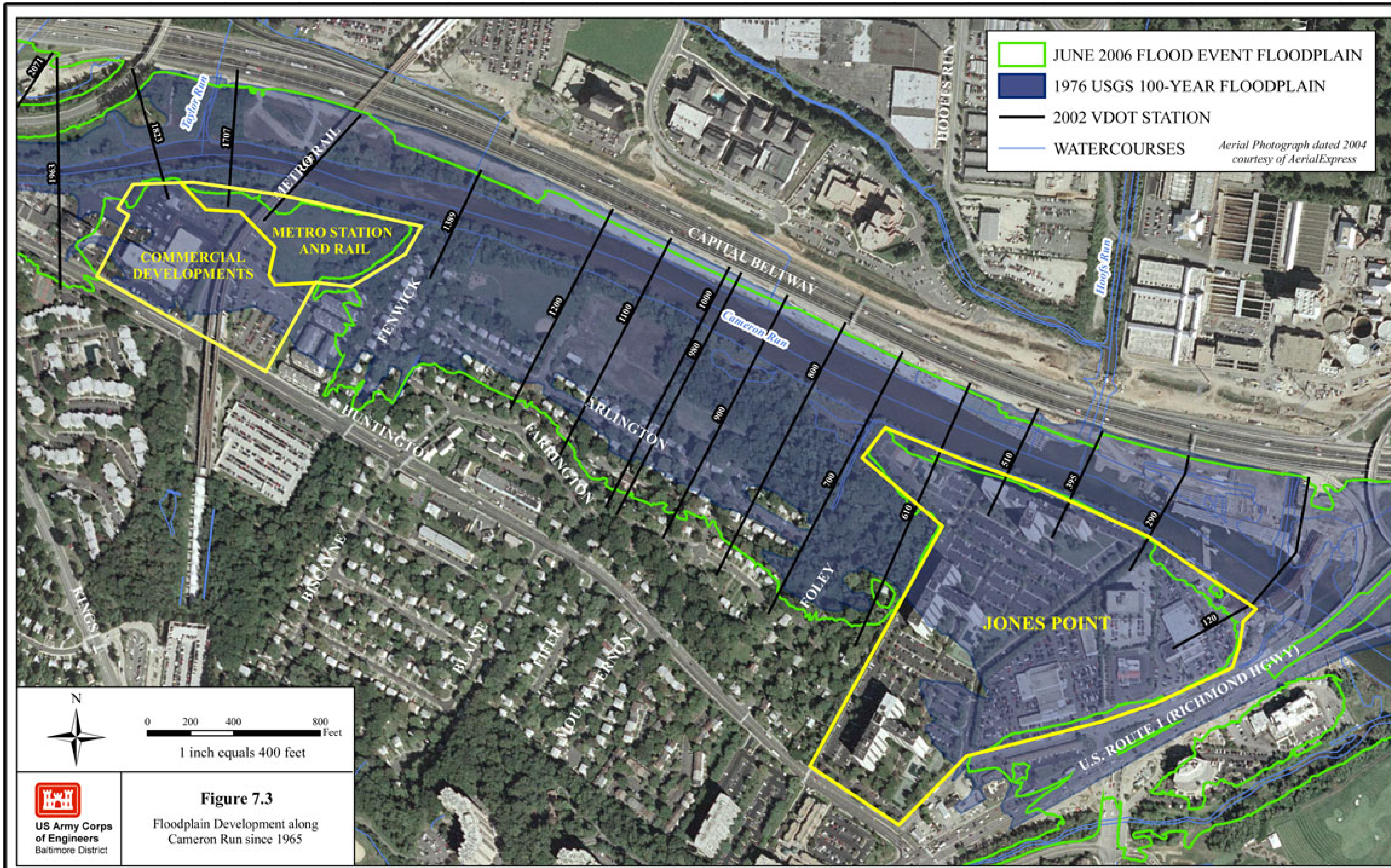


Figure 7.3

Floodplain Development along Cameron Run since 1965

Figure 7.4. Depth of Fill for Jones Point

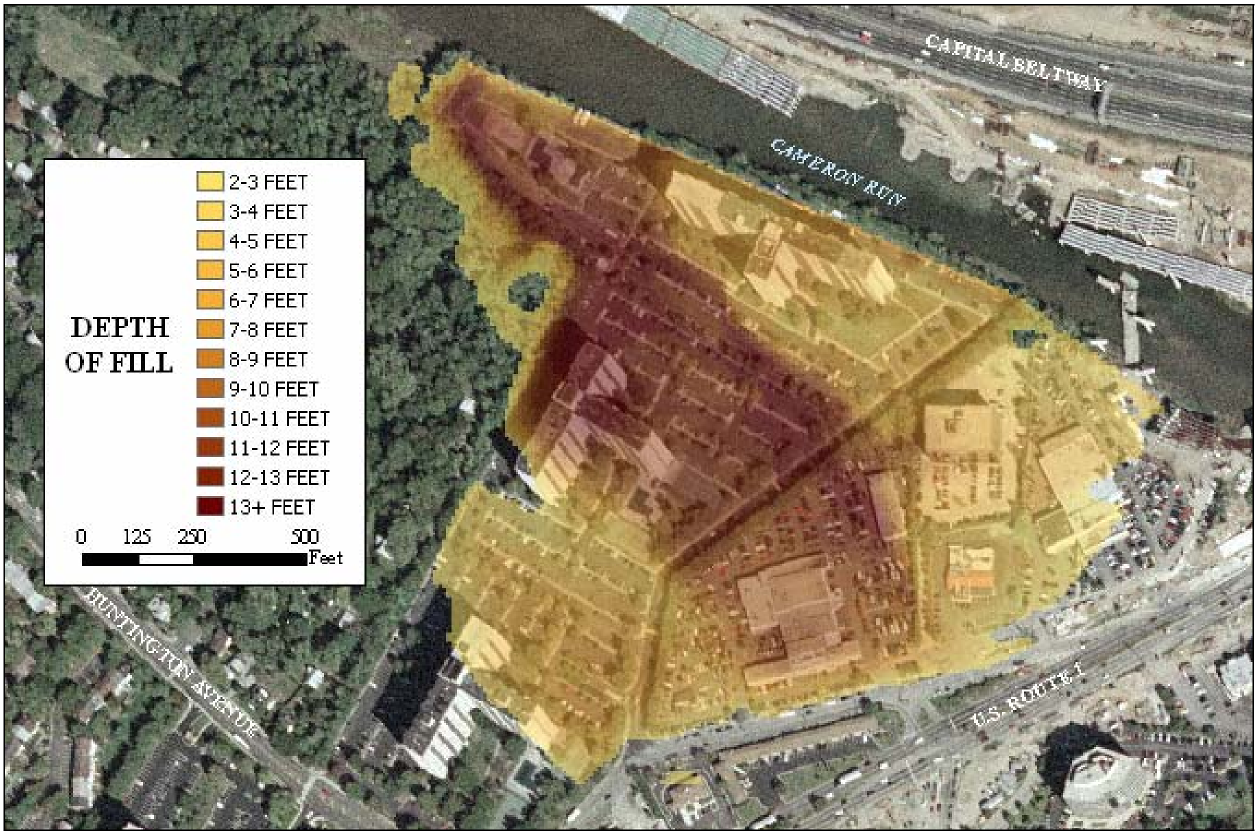


Figure 7.5. Comparison of Typical Cross-Section for Jones Point

The results of the 1965 WITH JUNE 2006 FLOWS plan were compared to the results of the 1972 WITH JUNE 2006 FLOWS plan to determine the impact that the Jones Point development had on the water surface elevations in Huntington (Table 7.4).

Table 7.4. Increase in Flood Elevations as a Result of Jones Point Floodplain Development

VDOT CROSS-SECTION	WATER SURFACE ELEVATION (FEET NGVD29)		
	1965 WITH JUNE 2006 FLOWS	*1972 WITH JUNE 2006 FLOWS*	*INCREASE AS A RESULT OF JONES POINT DEVELOPMENT*
2752	22.0	22.6	0.6
2398	19.3	19.3	0.0
2071	14.5	14.6	0.1
1389	11.1	11.4	0.3
1180	10.7	11.0	0.3
1000	10.5	10.9	0.4
820	10.2	10.6	0.4
660	9.9	10.1	0.2
445	9.7	9.4	-0.3
100	8.9	8.9	0.0
85	8.6	8.6	0.0
	HUNTINGTON		

The impact of the Jones Point development on the flood elevations of Huntington is minimal. Although a significant amount of fill was placed in the floodplain, there was less than 0.5 feet of impact in Huntington as a result.

7.4 CHANNEL SEDIMENTATION

Sedimentation is one of the greatest water quality and reduction in channel capacity problems facing the lower reaches of the Cameron Run watershed. Some of the sedimentation in the watershed comes from construction activities, but a substantial amount comes from streambank erosion from excessive stormwater flows caused by high amounts of impervious surfaces (Virginia Tech, 2003). The draft 1982 CDM report states that "*from the USGS data and our survey it is known that there has been an estimated three feet of sediment accumulation along this reach of Cameron Run in the past fifteen years* (which is 1967-1982). *On this basis, it is expected that sediment accumulation rates approaching .20 feet per year may be possible, and a maintenance dredging plan is in order.*"

Surveyed cross-sections were first taken on Cameron Run in 1961 and 1965 as part of the 1976 USGS study. The next documented survey occurred in 1982 as part of the CDM study; however, detailed survey information was not included in the report and therefore the data was not available for this investigation. The most recent survey was in 1999 as part of the 2002 VDOT study. Several of the 1965 USGS cross-sections and 1999 VDOT cross-sections are located in the same location (Figure 7.6). Therefore, a comparison could be made to the amount of sedimentation that has occurred within the Cameron Run channel between 1965 and 1999. As part of this analysis, the Fairfax County Stormwater Planning Division has confirmed that no dredging of this stretch of Cameron Run has occurred.

Figure 7.6. Location of 1965 USGS Cross-Sections Compared to 1999 VDOT Cross-Sections

A detailed comparison of these cross-sections is located in Appendix H. Overall, there has been a significant amount of sedimentation within the Cameron Run channel between 1965 and 1999. The comparison between the 1965 data and the 1999 data indicates that nearly 5 to 6 feet of sediment has accumulated in Cameron Run between Telegraph Road and U.S. Route 1. Figure 7.7 shows two cross-sections and the difference in stream channel elevation between 1965 and 1999.

Figure 7.7. Comparison of 1965 USGS Cross-Sections with 1999 VDOT Cross-Sections

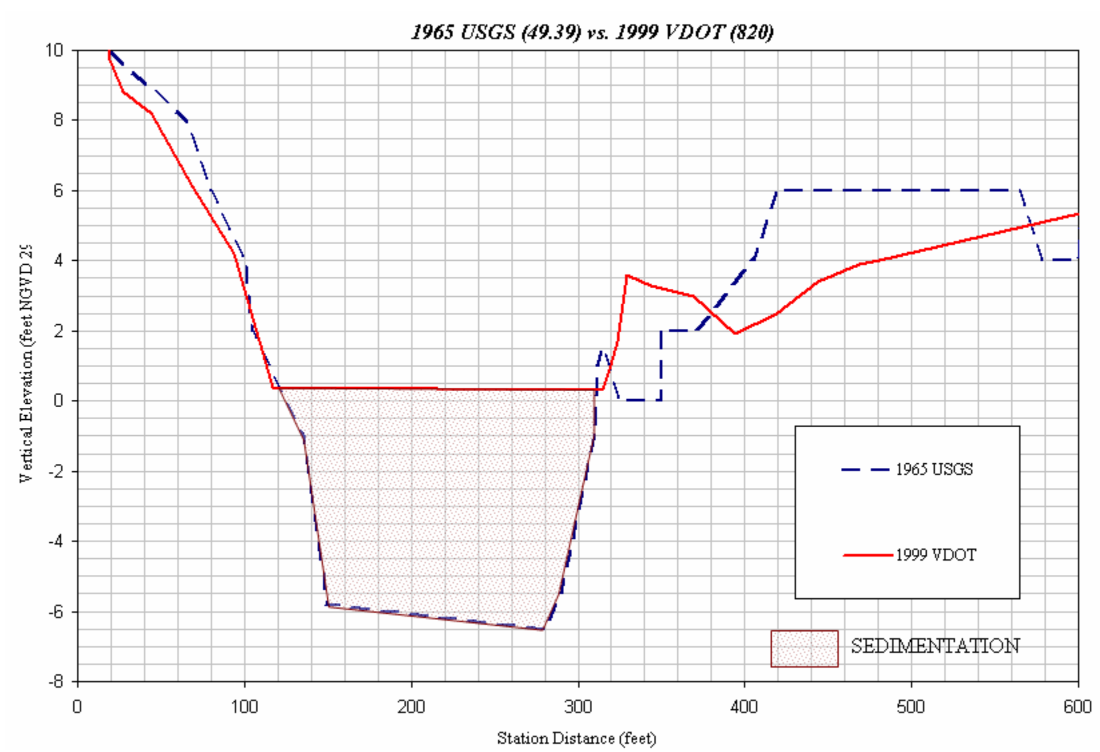
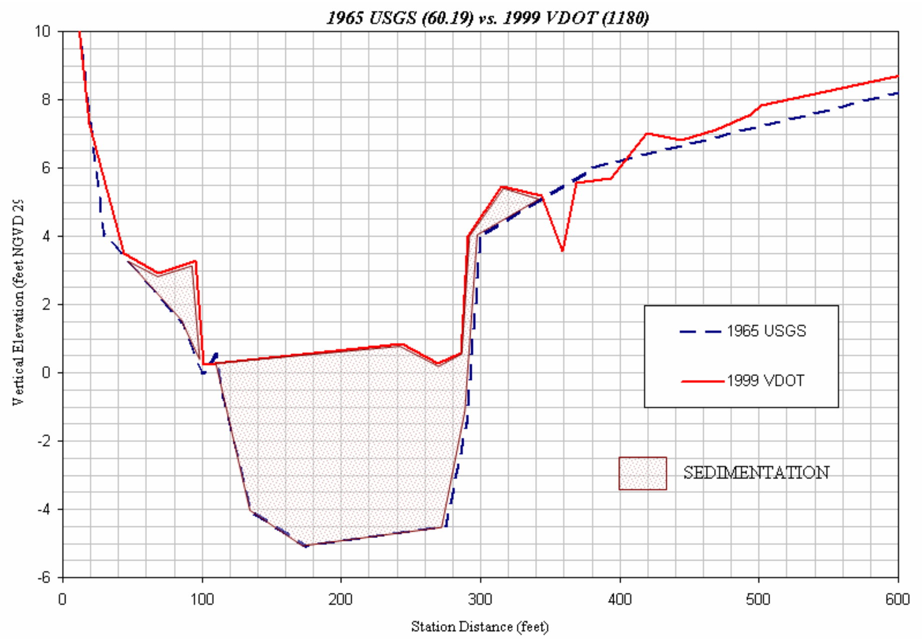
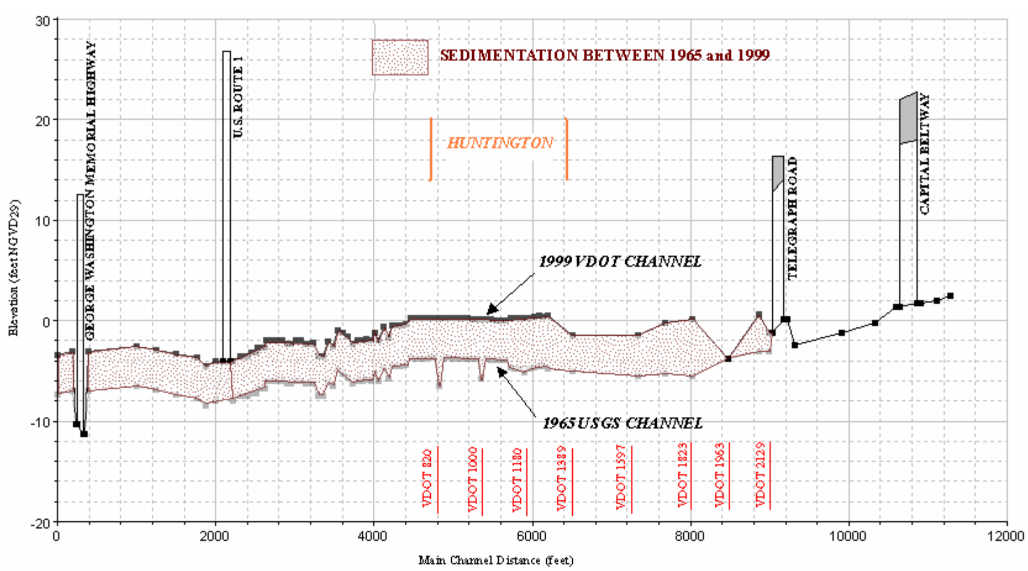


Figure 7.7. Comparison of 1965 USGS Cross-Sections with 1999 VDOT Cross-Sections (Continued)



The sedimentation amounts determined from the comparison between the 1965 USGS cross-sections and the 1999 VDOT cross-sections were applied to the entire stretch between Telegraph Road and the George Washington Memorial Highway. In the intervening interpolated area, a constant value was subtracted (usually 5 or 6 feet) from the 1999 VDOT cross-sections to get an assumed 1965 stream channel elevation. A profile was thus created simulating the channel geometry of Cameron Run in 1965 (Figure 7.8), which is known as the 1965 CONDITIONS geometry file.

Figure 7.8. Profile Showing Sedimentation on Cameron Run between 1965 and 1999



The results of the 1972 WITH JUNE 2006 FLOWS plan were compared to the results of the 1999 WITH JUNE 2006 FLOWS plan to determine the impact that sedimentation over time has had on floodplain elevations (Table 7.4). For comparative purposes, the 1972 CONDITIONS geometric file was used rather than the 1965 CONDITIONS geometric file. This was done in order to determine the true impact of sedimentation without influence from floodplain development. The 1972 CONDITIONS geometric file reflects the channel in 1965, but with the Jones Point development included. The results are shown in Table 7.5.

Table 7.5. Increase in Flood Elevations as a Result of Sedimentation

VDOT CROSS-SECTION	WATER SURFACE ELEVATION (FEET NGVD29)		
	1999 WITH JUNE 2006 FLOWS	*1972 WITH JUNE 2006 FLOWS*	*INCREASE AS A RESULT OF SEDIMENTATION BETWEEN 1965 and 1999*
2752	23.6	22.6	1.0
2398	20.7	19.3	1.4
2071	16.2	14.6	1.6
1389	13.4	11.4	2.0
1180	12.7	11.0	1.7
1000	12.6	10.9	1.7
820	12.1	10.6	1.5
660	11.3	10.1	1.2
445	10.3	9.4	0.9
100	9.4	8.9	0.5
85	8.8	8.6	0.2
		HUNTINGTON	

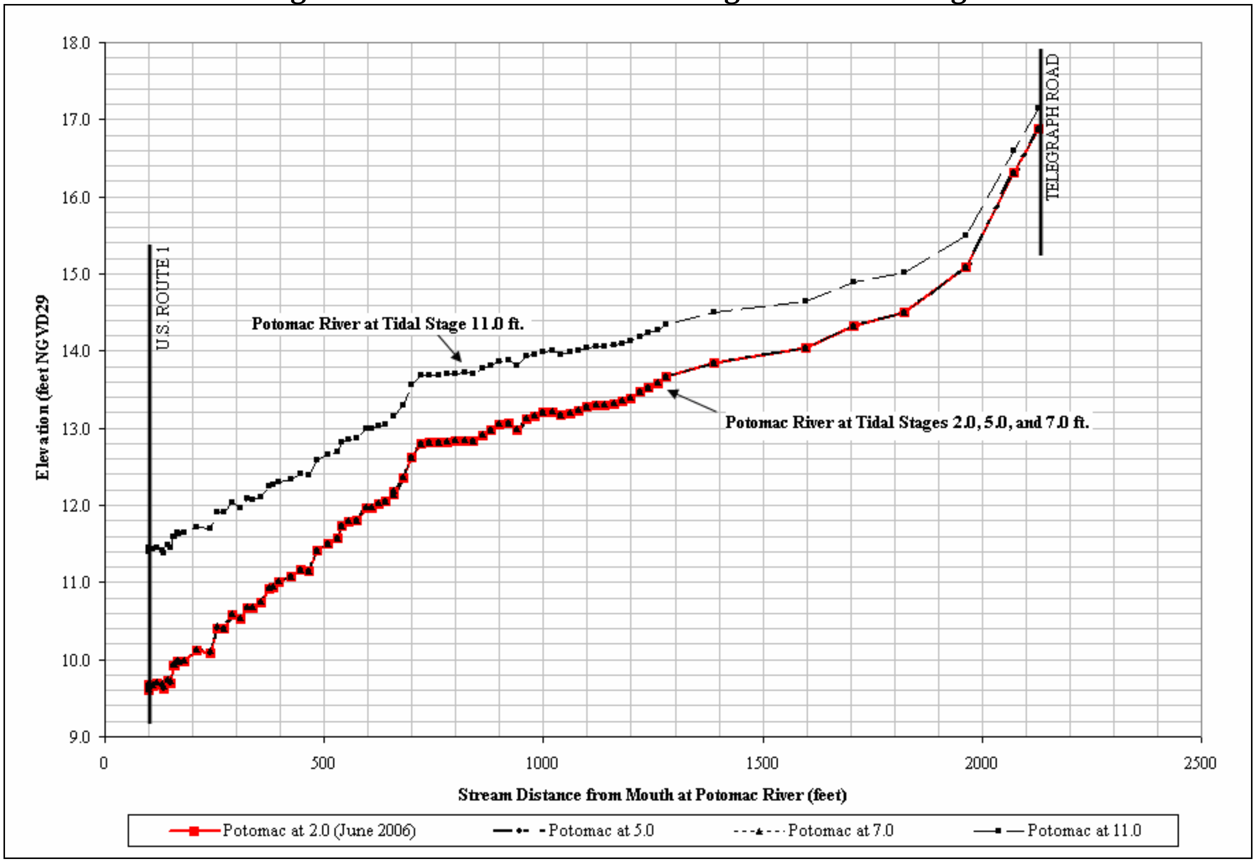
The impact of sedimentation over time is significant to the flood elevations in Huntington. Flood elevations in Huntington for the June 2006 flood event would have been 1.2 to 2.0 feet lower had the channel been at the 1965 condition. In addition, the results reflect sedimentation that has occurred up to and including 1999. Further accumulation of sediment may have occurred since 1999, which may have accounted for additional increases in water surface elevation.

7.5 POTOMAC INFLUENCE

Cameron Run outfalls into the Potomac River which is influenced by tides. Huntington is located at or near the boundary line along Cameron Run where tidal waters influence the hydraulics of Cameron Run. As discussed in Section 6.2, during the June 2006 flood event, it is estimated that the tide during the peak of the flood was at or near 2.0 feet (NGVD29). However, since the tide elevation at the time of influence of the June 2006 flood event could not be definitely determined, an analysis was completed in order to determine the influence that the tide stage would have on the June 2006 flood event.

The starting water surface elevation in the HEC-RAS model was adjusted to tide stages 5.0 feet, 7.0 feet, and 11.0 feet, to determine the influence these stages would have on the flood elevations. Three separate flow files and plan files were created (see Table 7.1). The results of the HEC-RAS runs, between U.S. Route 1 and Telegraph Road, are shown in Figure 7.9.

Figure 7.9. Profile of Results using Select Tide Stages



The HEC-RAS results clearly show that if the June 2006 Flood Event would have occurred with a tide stage of 5.0 or 7.0 feet, that the flood elevations in Huntington and along Cameron Run would have been the same. The run at tidal stage 11.0, which is near the 100-year storm surge elevation for the Potomac River, would have increased flood elevations significantly along Cameron Run. However, during the June 2006 Flood Event, the tide stage was estimated to be at 2.0 feet, and was certainly no more than 3.0 feet at the most based upon NOAA tidal data. A tide stage of 11.0 feet and a peak flow that occurred in the June 2006 flood event occurring simultaneously would be considered a highly improbable event. Previous studies have shown that the primary risk of flooding in Huntington is riverine flooding from Cameron Run.

8.0 FLOOD FREQUENCY ANALYSIS

A flood frequency analysis for Cameron Run was performed using existing stream gage data recorded at the USGS stream flow gage discussed in Section 5.2 and shown in Figure 1.1. This analysis follows the federally recommended guidelines described in Bulletin 17B, "*Guidelines for Determining Flood Flow Frequency*" published by the Interagency Advisory Committee on Water Data.

Annual peak flow data collected at the USGS stream flow gage were compiled for water years 1953 through 2006. Using the methodologies prescribed by Bulletin 17B, generally conforming to a Log Pearson Type III distribution, a frequency curve was developed with the data. During the analysis, several issues regarding the data set arose. These issues included: intended use of the frequency data; validation of the June 25, 2006 flood event; gage placement; minor gaps in the data set; management of the Lake Barcroft dam; and urbanization of the watershed during the period of record. Discussion of the resolution of these issues and other technical data is located in the Flood Frequency Analysis Report located in Appendix I.

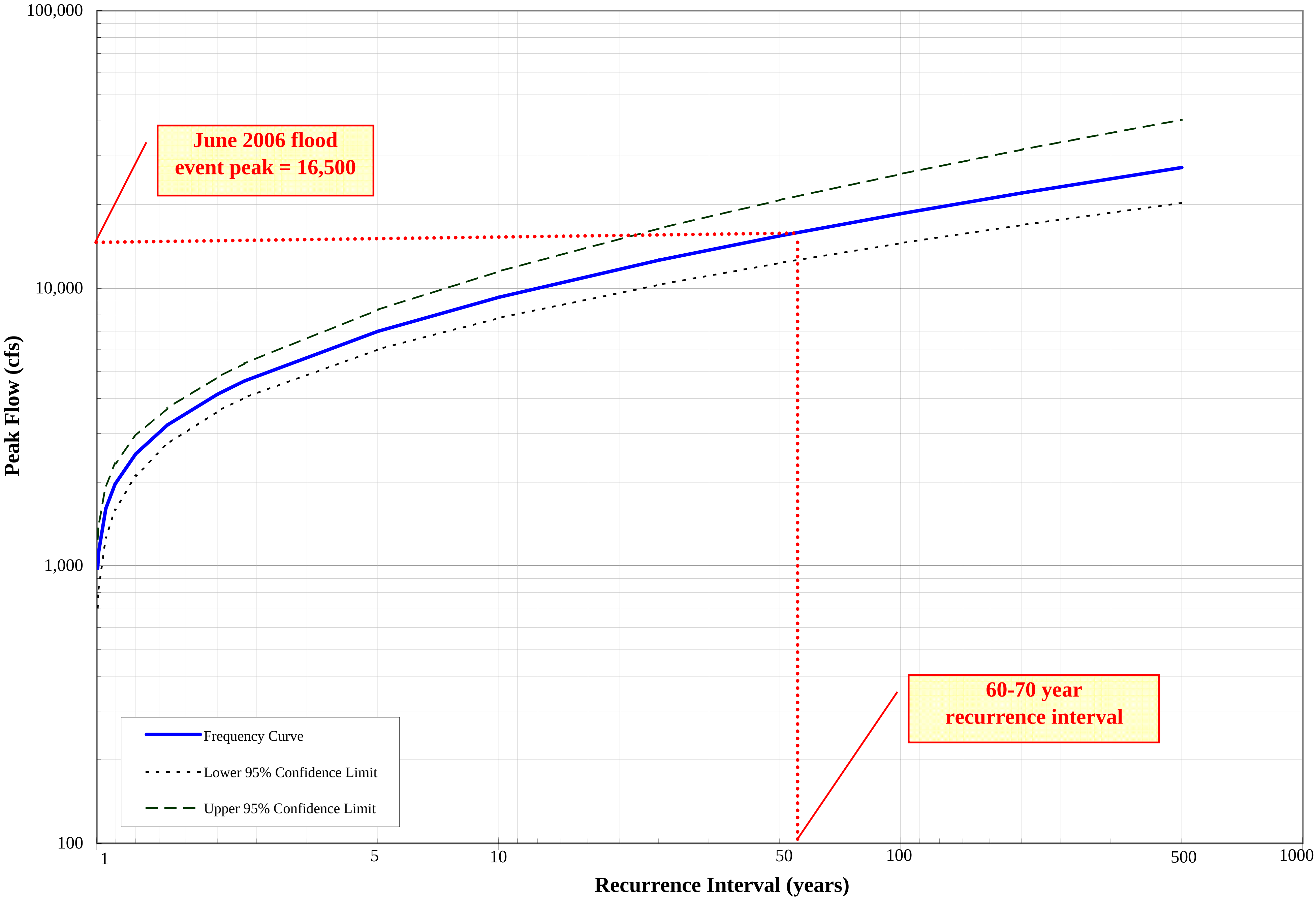
The final flow frequency relationship at the USGS stream flow gage, presented in Table 8.1, was generated using industry standard techniques including the statistical modeling package PeakFQ developed by the USGS and adhering to the guidelines of Bulletin 17B.

Table 8.1. 2006 Flood Frequency Analysis Based on 1956 thru 2006 Data Set

Recurrence Interval (years)	Probability	Peak Flow (cfs)
2	0.5	4,157
5	0.2	6,993
10	0.1	9,266
25	0.04	12,600
50	0.02	15,430
100	0.01	18,570
500	0.002	27,210

The data presented in Table 8.1 was used to develop the frequency curve shown in Figure 8.1. The plots depicted in Figure 8.1 include the best fit frequency curve and the upper and lower 95% confidence limits. As shown on Figure 8.1, it was determined that the peak flows associated with the June 2006 flood event have a recurrence interval of approximately 60 to 70 years.

Figure 8.1. Frequency Curve for USGS Gaging Station 01653000 , Water Years 1956 - 2006



9.0 CONCLUSIONS

The purpose of this investigation was to determine specific causes of the higher than expected flood levels experienced during the June 2006 flood event in Huntington. During this study, it was determined that the June 2006 flood event has a recurrence interval of approximately 60 to 70 years, meaning it was between the 60 and 70-year flood event. As a result of the analysis presented in this report, it has been determined that cumulative impacts to the Cameron Run channel and floodplains have increased the flood levels in Huntington over time. At the time of the June 2006 flood event, Fairfax County and FEMA were using the 1976 USGS study for floodplain management purposes. Although the study was accurate when it was completed, it is not accurate for the Huntington area today due to significant changes in the channel and watershed. As a result, the flood levels during the June 2006 flood event were higher than the county expected.

During this study, various potential causes of the increase in flood levels were evaluated and the following was determined:

<u>Activities that contributed to higher flood levels over time</u>

- Channel sedimentation had a considerable impact to flood elevations in Huntington during the June 2006 flood event. Had the channel been at its 1965 condition (same channel depth and width as in 1965), flood elevations would have been approximately 1.2 to 2 feet lower in Huntington.

- The U.S. Route 1 interchange construction activity (part of the Woodrow Wilson Bridge construction project) had a lesser impact to flood elevations in Huntington during the June 2006 flood event. The temporary construction activity caused between a 0.5 and 0.9-foot increase in flood elevations along the Huntington area. The increase as a result of the construction activity was within the permitted limits established by FEMA. As a result of the overall finished construction of the U.S. Route 1 interchange, the projected maximum increase in the 100-year flood elevation is estimated to be 0.8 feet approximately 300 feet west of the confluence of Hoofs Run. Therefore, the temporary increase in flood levels during the construction of the interchange is similar to the expected future increase in flood levels after the project construction is complete.

- The floodplain development, including Jones Point and the Metro Rail and Station (as well as other commercial developments) had minimal impact to flood elevations in Huntington during the June 2006 flood event. The floodplain development caused between a 0.2 and 0.4-foot increase in flood elevations along the Huntington area. The increase as a result of the floodplain encroachments were within the permitted limits established by FEMA.

Activities that did not contribute to higher flood levels

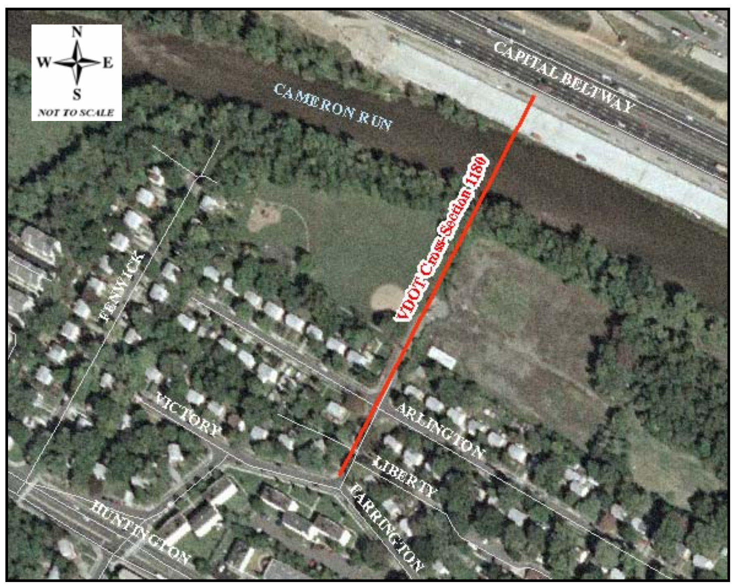
- The barge blockage at the George Washington Memorial Parkway had no impact to flood elevations in Huntington during the June 2006 flood event.

- Lake Barcroft release rates had no impact on the flood elevations in Huntington during the June 2006 flood event. For this storm event, the peak at the USGS gage occurred nearly simultaneously with the peak exiting Lake Barcroft.

- The Potomac River tide stages had no impact to the flood elevations in Huntington during the June 2006 flood event.

Although each factor in the first list above increases flood levels to varying degrees, the cumulative increase created by adding the increases together creates a significant increase over time. This is explained below for one area within Huntington, VDOT Cross-Section 1180 (Figure 9.1). During the June 2006 flood event, the flood elevation was 13.4 feet at VDOT Cross-Section 1180.

Figure 9.1. Location of VDOT Cross-Section 1180



If the peak flows from the June 2006 flood event would have occurred in 1965 at VDOT Cross-Section 1180, the flood elevation would have reached 10.7 feet (NGVD29). At this same location (USGS Cross-Section 60.19) the 100-year flood elevation per the 1976 USGS study was 11.2 feet with a flow of 21,800 cfs. The flow for the June 2006 flood event at this location was estimated to be 19,700 cfs. A flood at this stage would have caused minimal damages to residences, as floodwater would remain mostly in yards and in streets.

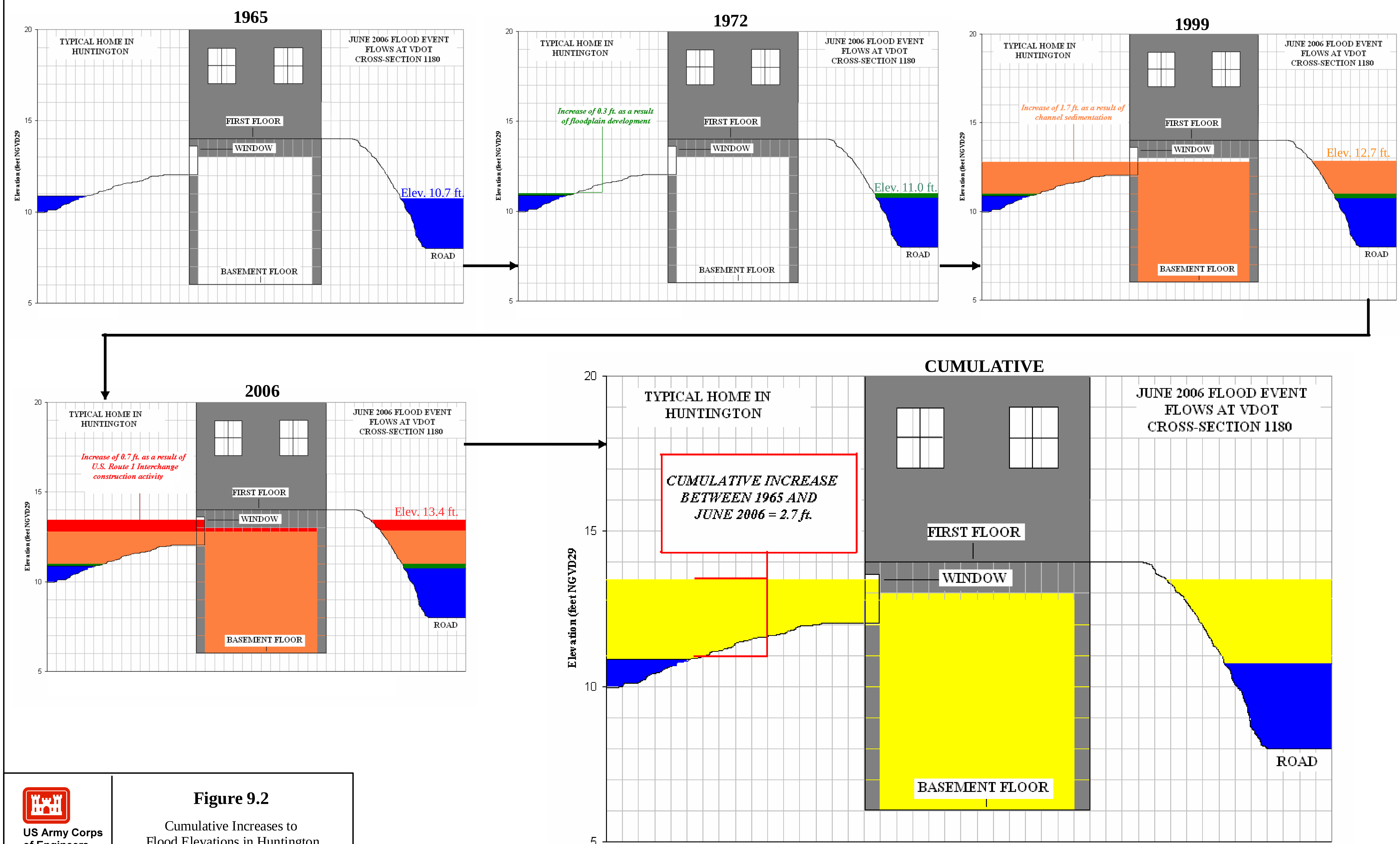
The floodplain development that occurred, in particular Jones Point, caused a 0.3 feet increase in flood elevations at VDOT Cross-Section 1180. Thus, if the June 2006 flood event would have occurred in 1972, the flood elevation would have reached 11.0 feet. Again, a flood at this stage would have caused minimal damages to residences, as floodwater would remain mostly in yards and in streets. Tropical Storm Agnes, which recorded higher flows than the June 2006 flood event, caused some damages to homes; however, most of the damages were associated with sewer back-ups.

Sedimentation throughout time decreased the channel capacity in Cameron Run, especially between 1972 and 1999. If the June 2006 flood event would have occurred in 1999, flood elevations at VDOT Cross-Section 1180 would have reached 12.7 feet, nearly 1.7 feet higher than the same flood in 1972. A flood of this magnitude would have caused significant damages to many of the structures in Huntington. Channel sedimentation had the greatest impact to the increases in flood levels in Huntington over time.

The changes that occurred to Cameron Run between 1999 and the June 2006 flood event were related to the construction activity associated with the U.S. Route 1 interchange and the barge blockage at the George Washington Memorial Parkway during the June 2006 flood event. This activity increased flood elevations by 0.7 feet at VDOT Cross-Section 1180, which results in the June 2006 flood event elevation at this location of 13.4 feet. Approximately 160 homes suffered damages, with one-third of the homes having first-floor flooding and the rest having major basement damages. Thus, the cumulative impacts to the floodplain between 1965 and June 2006 increased flood elevations by 2.7 feet at VDOT Cross-Section 1180 (Figure 9.2). Similar cumulative increases occur at other cross-sections within Huntington as well.

It should be noted, however, that some of the houses in Huntington still would have been flooded during the June 2006 flood event even if these activities had not increased the flood levels.

Since the completion of the 1976 USGS study, several other studies, including the 1982 CDM study and the 2002 VDOT study were completed and showed a greater risk of flooding in Huntington. The 1982 CDM study may have been disputed. The 2002 VDOT study, which is the most current and accurate model, was not provided to Fairfax County staff for use in floodplain management applications; however, according to VDOT, they did provide the final study to FEMA, who produces the county Flood Insurance Rate Maps (FIRMs) that show the 100-year floodplain. The flood levels during the June 2006 flood event were consistent with the peak flows recorded and the current condition of Cameron Run. The dramatic changes to the watershed and Cameron Run channel, along with the continued use of the 1976 USGS study for floodplain management purposes, were the reasons that flood levels during the June 2006 flood event were higher than expected.



US Army Corps of Engineers
Baltimore District

Figure 9.2

Cumulative Increases to Flood Elevations in Huntington

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APPENDIX A

INVENTORY OF COLLECTED DATA

Inventory of Collected Data

Data	Source	Date or Date Received
GIS Data for Fairfax County, VA	USACE PAS Belle Haven Watershed Study	2005
GIS Data for the City of Alexandria	USACE GI Four Mile Run Study	2004
Fairfax County Rain Gage Data for June 2006	Fairfax County Stormwater Planning	July 7, 2006
Letter of Map Amendments (LOMAs) for Arlington Terrace Area	FEMA	Several
Precipitation Data for the National Airport Gage	NWS NCDC	June 2006
USGS Cameron Gage Data, Historical and 25 June 06 Storm Stages and Discharges	USGS	June 2006
High Water Marks for the 25 June 06 Event for areas in Farifax County and Alexandria	VDOT	August 1, 2006
Aerial Photography flown 23 May 06	VDOT	May 23, 2006
Aerial Photography flown July 1, 2006	VDOT	July 1, 2006
High Water Marks for the 25 June 06 Event for areas in Farifax County	Fairfax County Stormwater Planning	June 26, 2006
Digital Photographs of Post-Flood Situation	Fairfax County Stormwater Planning	June 26, 2006
Digital Photographs of Post-Flood Situation	USACE HQ	June 26, 2006
GIS Polygon of Approximate 25 June 06 Flooding Limits	Fairfax County Stormwater Planning	June 26, 2006
Site Plans for Jones Point Apartments in Fairfax County	Fairfax County Stormwater Planning	1972
Board Approved Floodplain Mapping for Cameron Run	Fairfax County Stormwater Planning	1969
Report on the Responses of Lake Barcroft Dam to Heavy Rains during the period of June 23 through June 29, 2006	LBWID	July 23, 2006
Narrative of Status of WWBP and Rainbow Charts of Project Status	VDOT	August 1, 2006

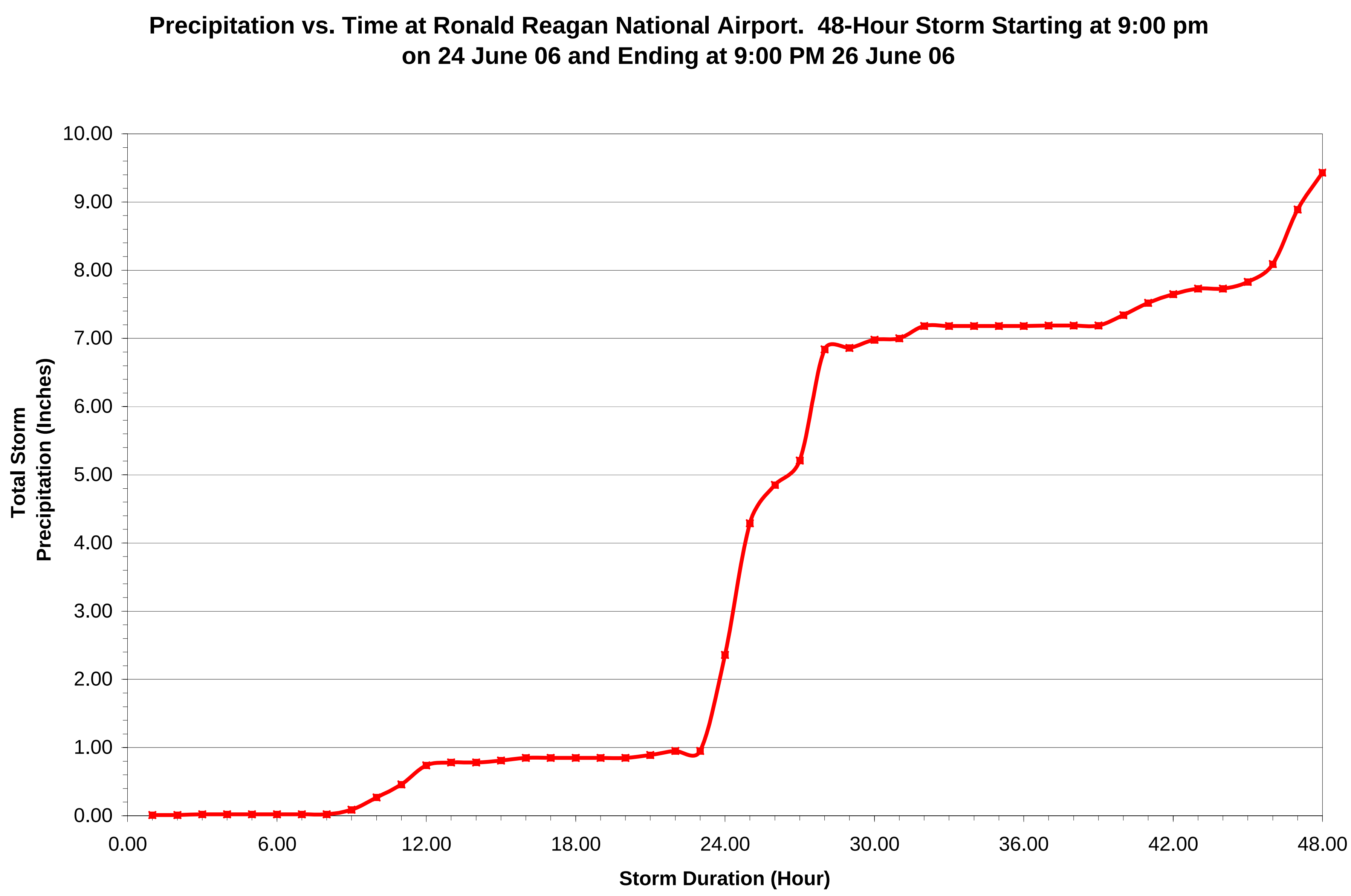
Inventory of Collected Data

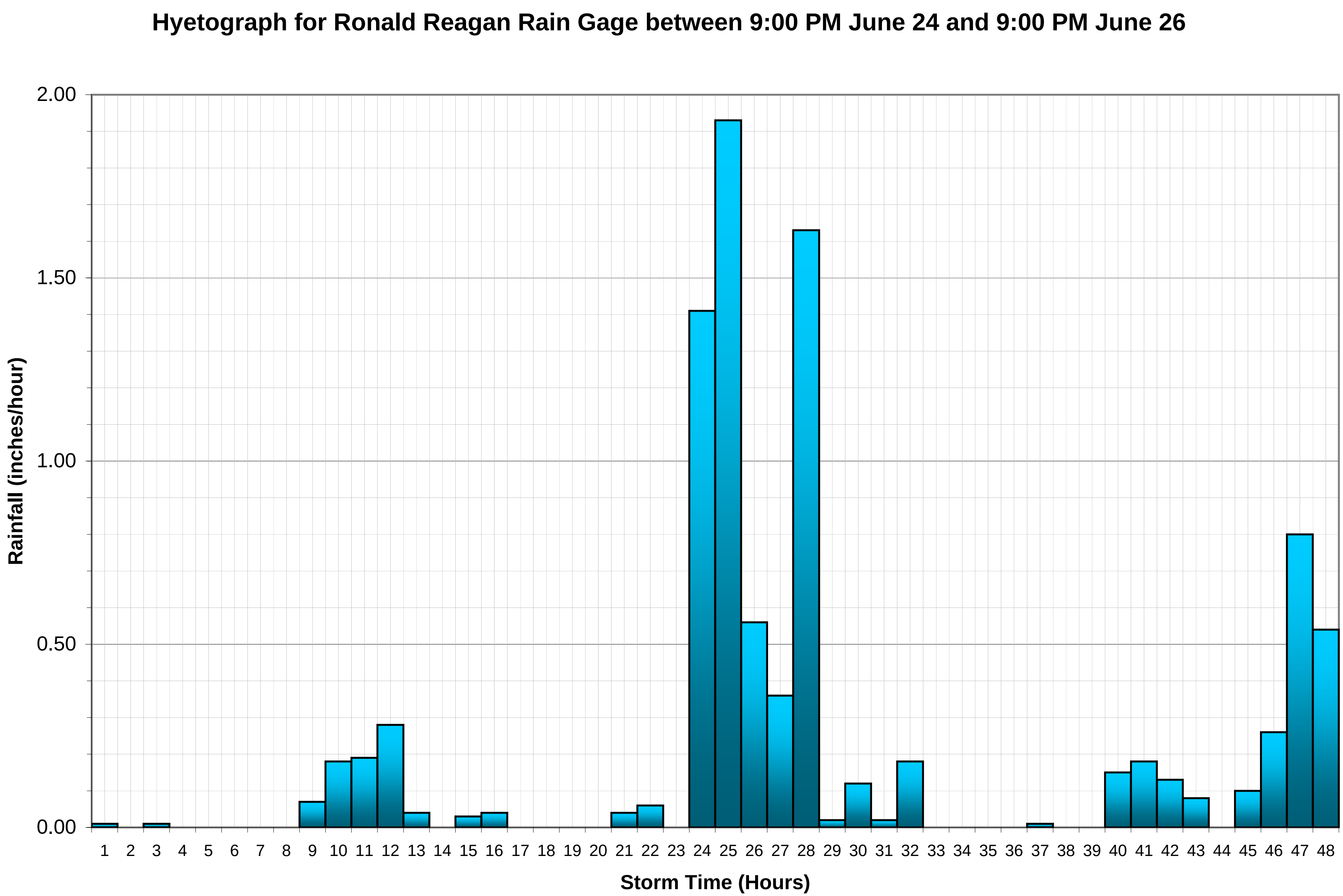
Data	Source	Date or Date Received
HEC-RAS Modeling for Cameron Run Watershed	USACE GI Four Mile Run Study	2005
SWMM Modeling for Cameron Run Watershed	USACE GI Four Mile Run Study	2005
Plan of Improvement, Cameron Run in Alexandria and Fairfax County	USACE	1979
List of homes flooded during June 2006 event	Fairfax County Stormwater Planning	August 1, 2006
Urban Biodiversity in the Holmes Run/Cameron Run Watershed	Virginia Tech Dept. of Landscape Architecture and Uraban Affairs and Planning	March 2003
Arlington Terrace Storm Drainage Study, Fairfax County, Virginia	Camp Dresser & McKee	April 1982
Cameron Run, City of Alexandria and Fairfax County, Virginia, Review Report on Flood Control	USACE-Baltimore	March 1971
Alexandria, Virginia Flood Insurance Study	USACE-Baltimore	December 1970
Cameron Station Military Installation Flood Damage Reduction Study	USACE-Baltimore	1985
Open File Report 76-443	USGS	1976
Cameron Run Hydrologic and Hydraulic Study for Fairfax County/City of Alexandria, Virginia	Potomac Crossing Consultants (PCC) for VDOT	February 2002
Cameron Run Hydraulic Study Report for I-95/Route 1 Interchange Improvement Project	HNTB for VDOT	November 2001
Hydrologic and Hydraulic Analysis of Cameron Run	Dewberry for VDOT	December 2001

APPENDIX B

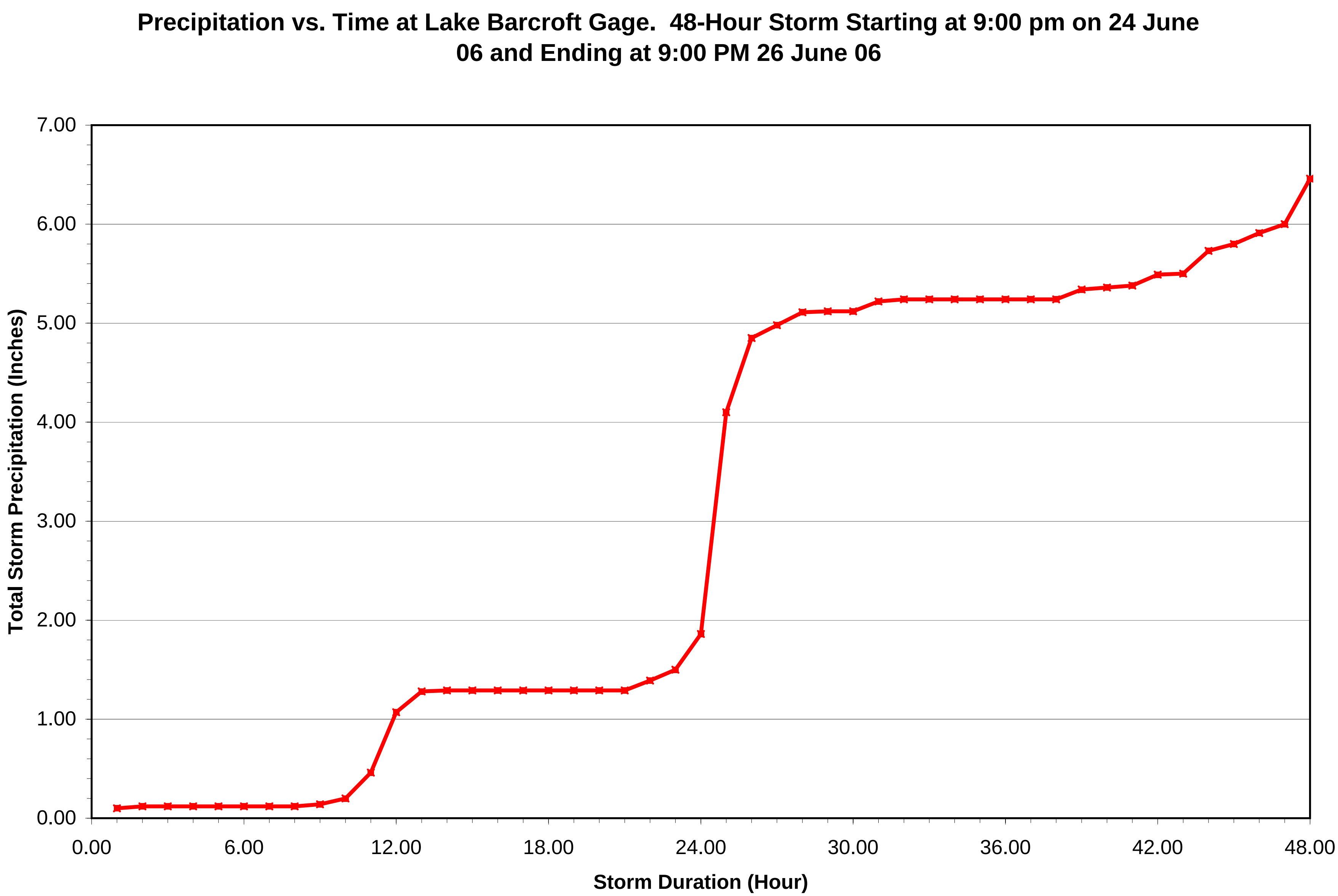
RAINFALL DATA FOR THE JUNE 2006 FLOOD EVENT

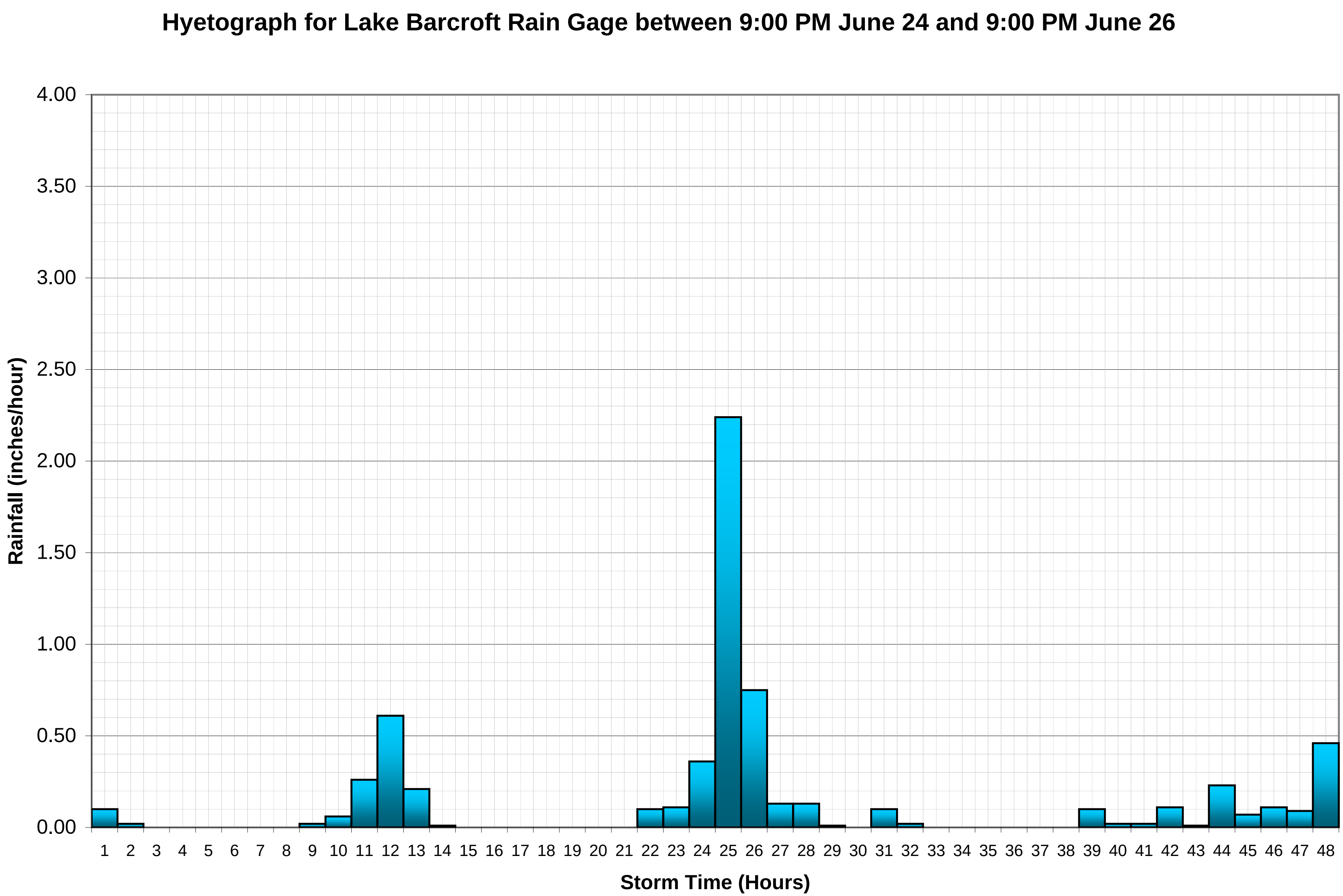
RONALD REAGAN WASH NATIONAL AIRPORT (13743) 48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06		
Hour	**Rainfall Measured**	**Cumulative**
1.00	0.01	0.01
2.00	0.00	0.01
3.00	0.01	0.02
4.00	0.00	0.02
5.00	0.00	0.02
6.00	0.00	0.02
7.00	0.00	0.02
8.00	0.00	0.02
9.00	0.07	0.09
10.00	0.18	0.27
11.00	0.19	0.46
12.00	0.28	0.74
13.00	0.04	0.78
14.00	0.00	0.78
15.00	0.03	0.81
16.00	0.04	0.85
17.00	0.00	0.85
18.00	0.00	0.85
19.00	0.00	0.85
20.00	0.00	0.85
21.00	0.04	0.89
22.00	0.06	0.95
23.00	0.00	0.95
24.00	1.41	2.36
25.00	1.93	4.29
26.00	0.56	4.85
27.00	0.36	5.21
28.00	1.63	6.84
29.00	0.02	6.86
30.00	0.12	6.98
31.00	0.02	7.00
32.00	0.18	7.18
33.00	0.00	7.18
34.00	0.00	7.18
35.00	0.00	7.18
36.00	0.00	7.18
37.00	0.01	7.19
38.00	0.00	7.19
39.00	0.00	7.19
40.00	0.15	7.34
41.00	0.18	7.52
42.00	0.13	7.65
43.00	0.08	7.73
44.00	0.00	7.73
45.00	0.10	7.83
46.00	0.26	8.09
47.00	0.80	8.89
48.00	0.54	9.43


Precipitation vs. Time at Ronald Reagan National Airport. 48-Hour Storm Starting at 9:00 pm
on 24 June 06 and Ending at 9:00 PM 26 June 06
Total Storm
Precipitation (Inches)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
Storm Duration (Hour)


Hyetograph for Ronald Reagan Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

LAKE BARCROFT RAIN GAGE 48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06		
Hour	**Rainfall Measured**	**Cumulative**
1.00	0.10	0.10
2.00	0.02	0.12
3.00	0.00	0.12
4.00	0.00	0.12
5.00	0.00	0.12
6.00	0.00	0.12
7.00	0.00	0.12
8.00	0.00	0.12
9.00	0.02	0.14
10.00	0.06	0.20
11.00	0.26	0.46
12.00	0.61	1.07
13.00	0.21	1.28
14.00	0.01	1.29
15.00	0.00	1.29
16.00	0.00	1.29
17.00	0.00	1.29
18.00	0.00	1.29
19.00	0.00	1.29
20.00	0.00	1.29
21.00	0.00	1.29
22.00	0.10	1.39
23.00	0.11	1.50
24.00	0.36	1.86
25.00	2.24	4.10
26.00	0.75	4.85
27.00	0.13	4.98
28.00	0.13	5.11
29.00	0.01	5.12
30.00	0.00	5.12
31.00	0.10	5.22
32.00	0.02	5.24
33.00	0.00	5.24
34.00	0.00	5.24
35.00	0.00	5.24
36.00	0.00	5.24
37.00	0.00	5.24
38.00	0.00	5.24
39.00	0.10	5.34
40.00	0.02	5.36
41.00	0.02	5.38
42.00	0.11	5.49
43.00	0.01	5.50
44.00	0.23	5.73
45.00	0.07	5.80
46.00	0.11	5.91
47.00	0.09	6.00
48.00	0.46	6.46


Precipitation vs. Time at Lake Barcroft Gage. 48-Hour Storm Starting at 9:00 pm on 24 June 06 and Ending at 9:00 PM 26 June 06
Total Storm Precipitation (Inches)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
Storm Duration (Hour)

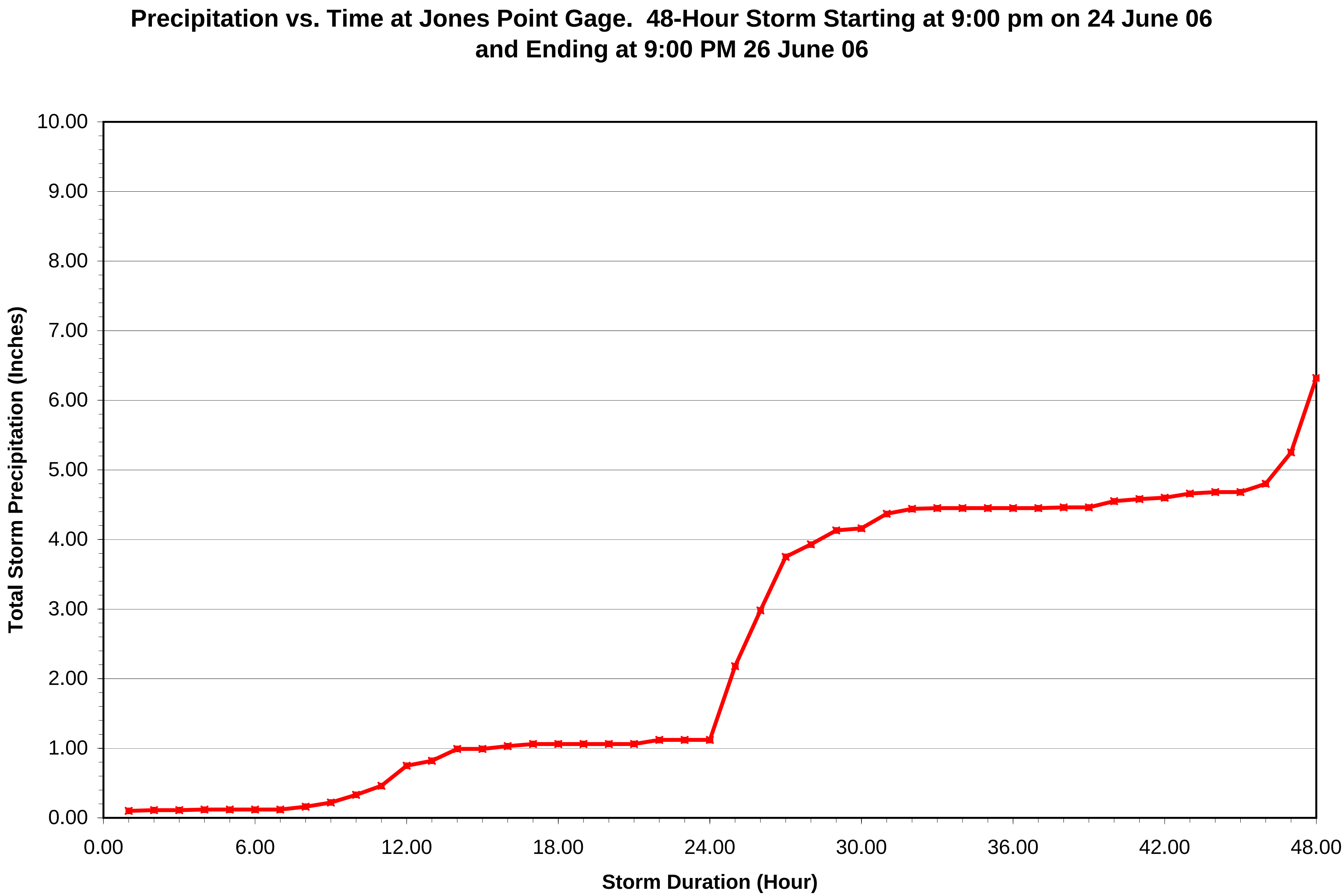


Hyetograph for Lake Barcroft Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

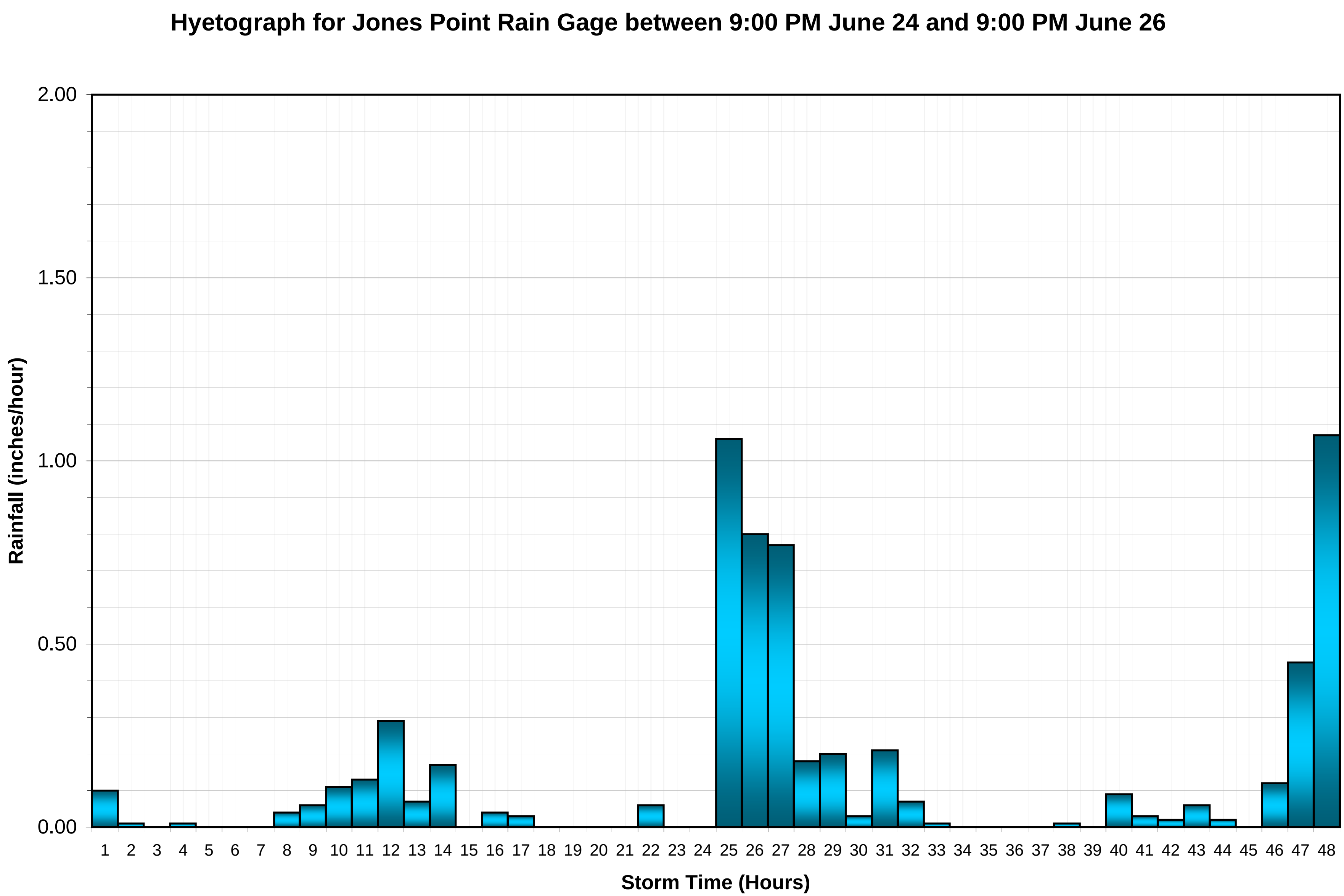
JONES POINT RAIN GAGE (I3020)

48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06

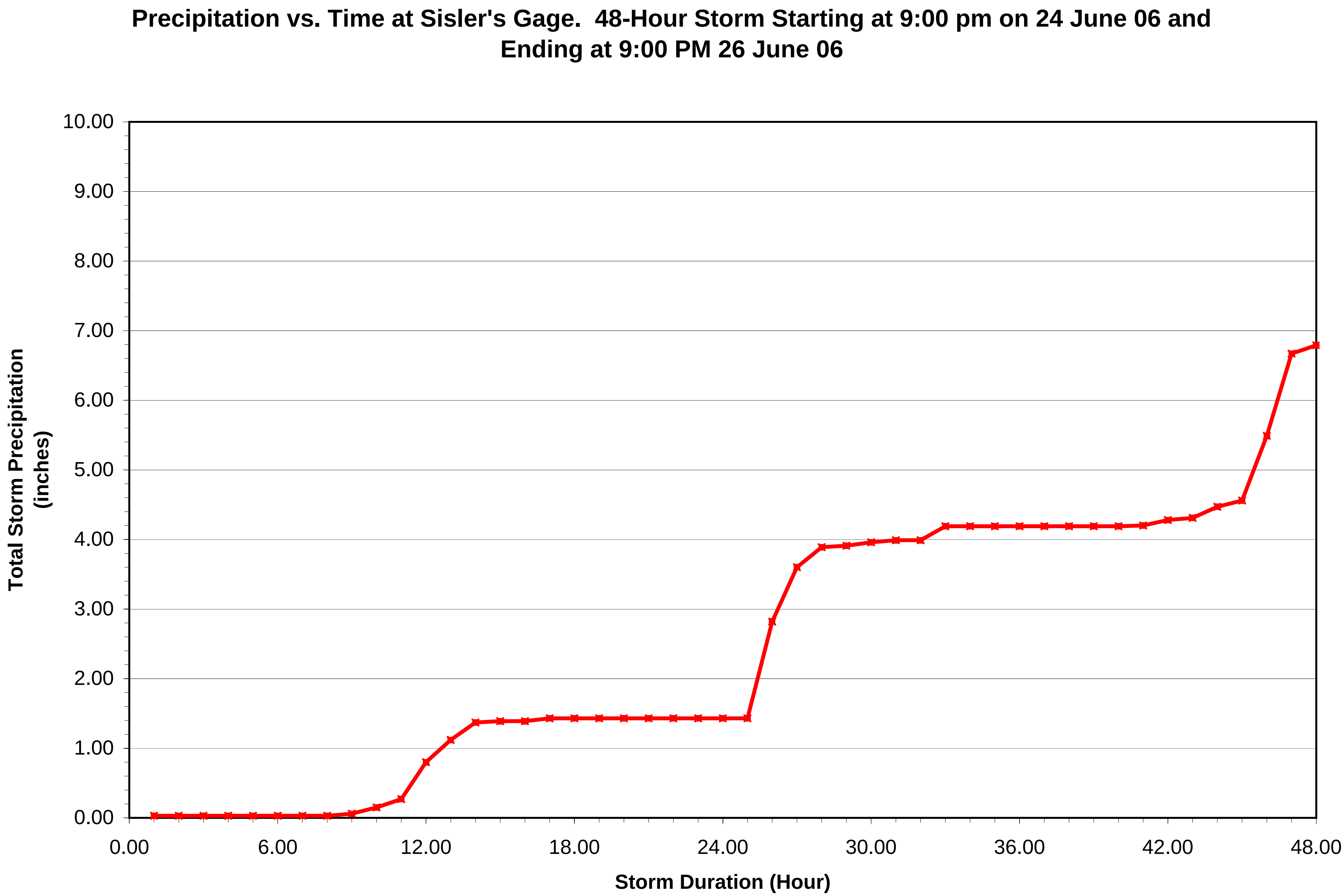
Hour	Rainfall Measured	Cumulative
1.00	0.10	0.10
2.00	0.01	0.11
3.00	0.00	0.11
4.00	0.01	0.12
5.00	0.00	0.12
6.00	0.00	0.12
7.00	0.00	0.12
8.00	0.04	0.16
9.00	0.06	0.22
10.00	0.11	0.33
11.00	0.13	0.46
12.00	0.29	0.75
13.00	0.07	0.82
14.00	0.17	0.99
15.00	0.00	0.99
16.00	0.04	1.03
17.00	0.03	1.06
18.00	0.00	1.06
19.00	0.00	1.06
20.00	0.00	1.06
21.00	0.00	1.06
22.00	0.06	1.12
23.00	0.00	1.12
24.00	0.00	1.12
25.00	1.06	2.18
26.00	0.80	2.98
27.00	0.77	3.75
28.00	0.18	3.93
29.00	0.20	4.13
30.00	0.03	4.16
31.00	0.21	4.37
32.00	0.07	4.44
33.00	0.01	4.45
34.00	0.00	4.45
35.00	0.00	4.45
36.00	0.00	4.45
37.00	0.00	4.45
38.00	0.01	4.46
39.00	0.00	4.46
40.00	0.09	4.55
41.00	0.03	4.58
42.00	0.02	4.60
43.00	0.06	4.66
44.00	0.02	4.68
45.00	0.00	4.68
46.00	0.12	4.80
47.00	0.45	5.25
48.00	1.07	6.32

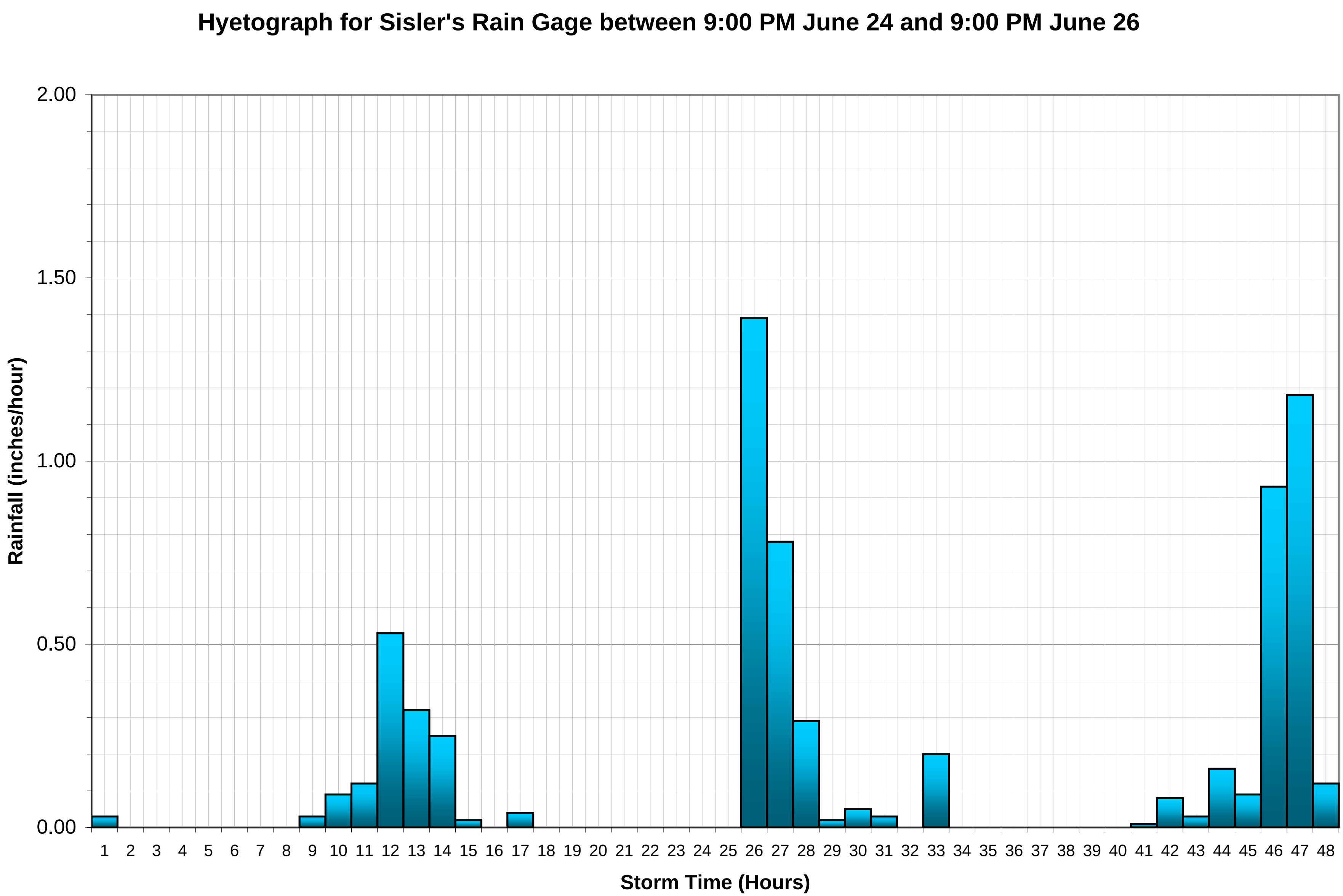


Precipitation vs. Time at Jones Point Gage. 48-Hour Storm Starting at 9:00 pm on 24 June 06
and Ending at 9:00 PM 26 June 06
Total Storm Precipitation (Inches)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
Storm Duration (Hour)


Hyetograph for Jones Point Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

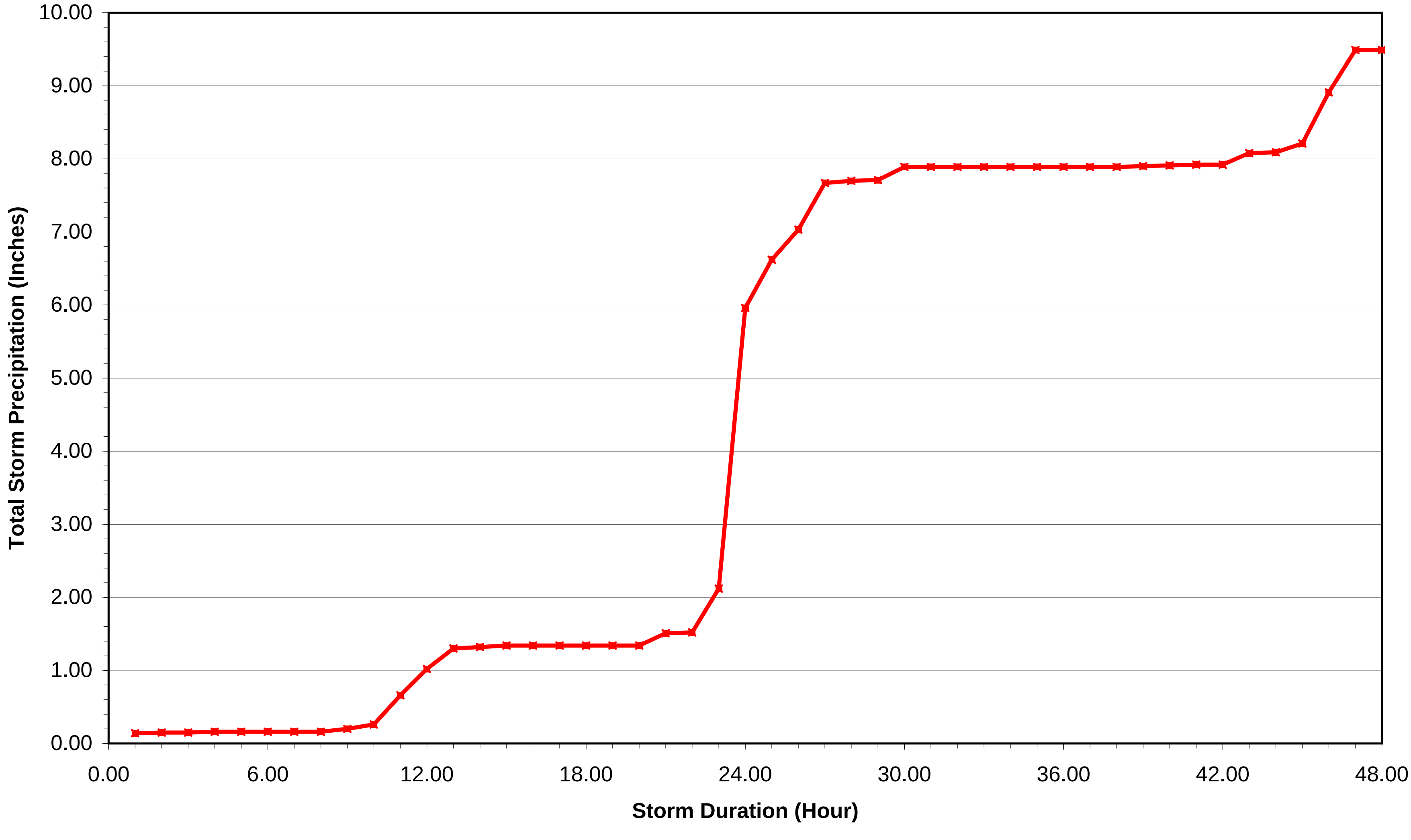
SISLERS RAIN GAGE (I1083) 48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06		
Hour	**Rainfall Measured**	**Cumulative**
1.00	0.03	0.03
2.00	0.00	0.03
3.00	0.00	0.03
4.00	0.00	0.03
5.00	0.00	0.03
6.00	0.00	0.03
7.00	0.00	0.03
8.00	0.00	0.03
9.00	0.03	0.06
10.00	0.09	0.15
11.00	0.12	0.27
12.00	0.53	0.80
13.00	0.32	1.12
14.00	0.25	1.37
15.00	0.02	1.39
16.00	0.00	1.39
17.00	0.04	1.43
18.00	0.00	1.43
19.00	0.00	1.43
20.00	0.00	1.43
21.00	0.00	1.43
22.00	0.00	1.43
23.00	0.00	1.43
24.00	0.00	1.43
25.00	0.00	1.43
26.00	1.39	2.82
27.00	0.78	3.60
28.00	0.29	3.89
29.00	0.02	3.91
30.00	0.05	3.96
31.00	0.03	3.99
32.00	0.00	3.99
33.00	0.20	4.19
34.00	0.00	4.19
35.00	0.00	4.19
36.00	0.00	4.19
37.00	0.00	4.19
38.00	0.00	4.19
39.00	0.00	4.19
40.00	0.00	4.19
41.00	0.01	4.20
42.00	0.08	4.28
43.00	0.03	4.31
44.00	0.16	4.47
45.00	0.09	4.56
46.00	0.93	5.49
47.00	1.18	6.67
48.00	0.12	6.79

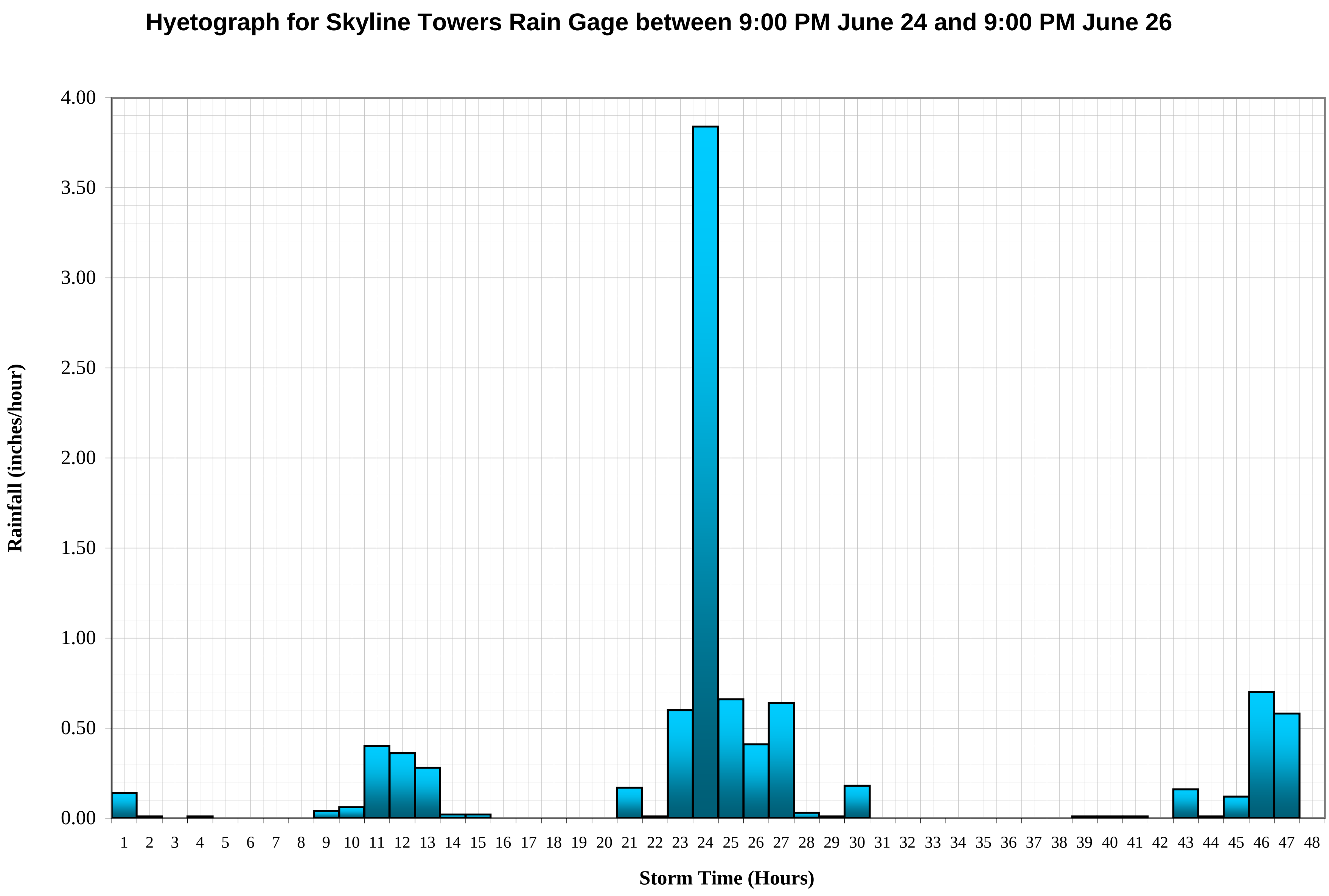

Precipitation vs. Time at Sisler's Gage. 48-Hour Storm Starting at 9:00 pm on 24 June 06 and Ending at 9:00 PM 26 June 06
Total Storm Precipitation (inches)
Storm Duration (Hour)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00


Hyetograph for Sisler's Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

SKYLINE TOWERS RAIN GAGE (H2022) 48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06		
Hour	**Rainfall Measured**	**Cumulative**
1.00	0.14	0.14
2.00	0.01	0.15
3.00	0.00	0.15
4.00	0.01	0.16
5.00	0.00	0.16
6.00	0.00	0.16
7.00	0.00	0.16
8.00	0.00	0.16
9.00	0.04	0.20
10.00	0.06	0.26
11.00	0.40	0.66
12.00	0.36	1.02
13.00	0.28	1.30
14.00	0.02	1.32
15.00	0.02	1.34
16.00	0.00	1.34
17.00	0.00	1.34
18.00	0.00	1.34
19.00	0.00	1.34
20.00	0.00	1.34
21.00	0.17	1.51
22.00	0.01	1.52
23.00	0.60	2.12
24.00	3.84	5.96
25.00	0.66	6.62
26.00	0.41	7.03
27.00	0.64	7.67
28.00	0.03	7.70
29.00	0.01	7.71
30.00	0.18	7.89
31.00	0.00	7.89
32.00	0.00	7.89
33.00	0.00	7.89
34.00	0.00	7.89
35.00	0.00	7.89
36.00	0.00	7.89
37.00	0.00	7.89
38.00	0.00	7.89
39.00	0.01	7.90
40.00	0.01	7.91
41.00	0.01	7.92
42.00	0.00	7.92
43.00	0.16	8.08
44.00	0.01	8.09
45.00	0.12	8.21
46.00	0.70	8.91
47.00	0.58	9.49
48.00	0.00	9.49

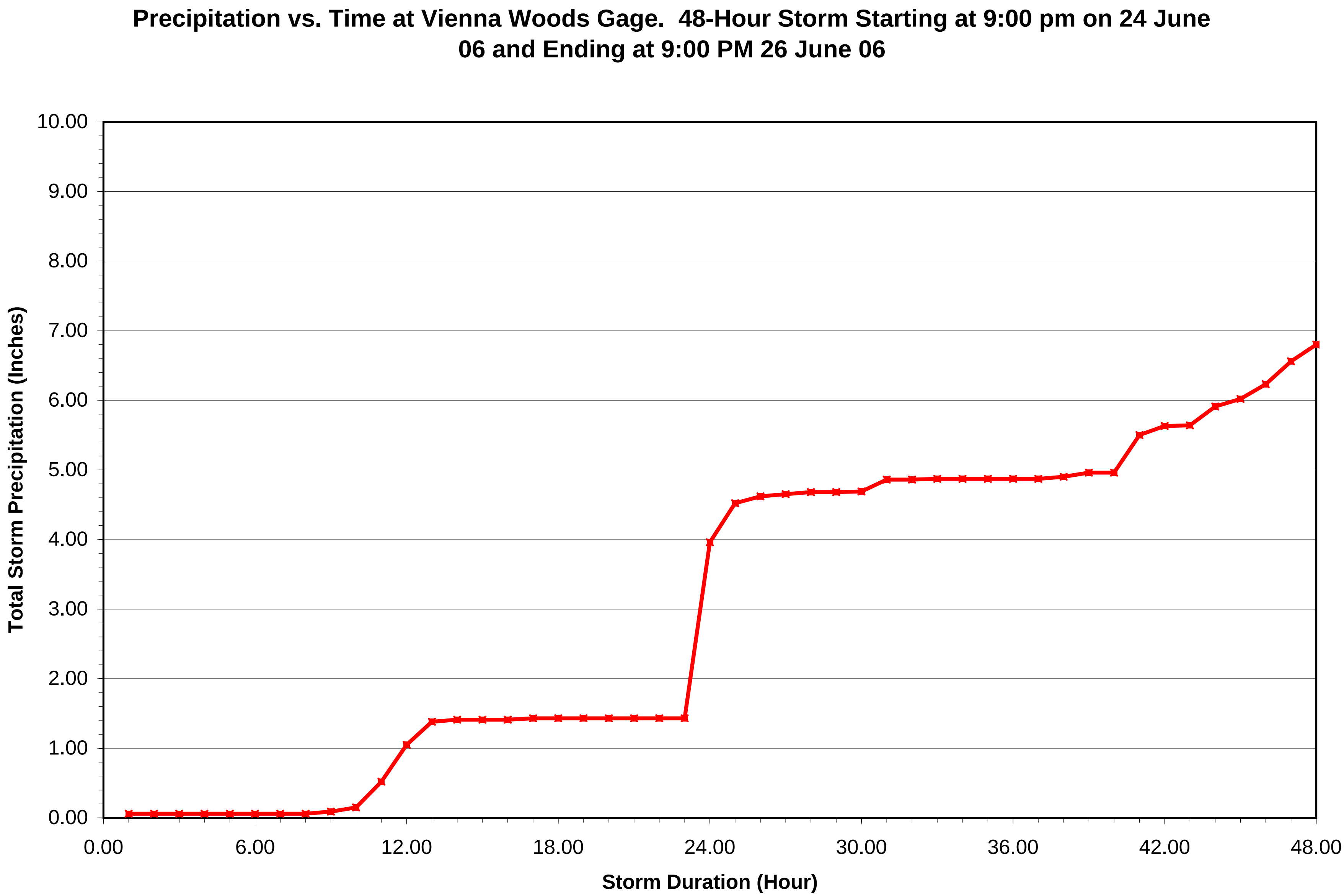
Precipitation vs. Time at Skyline Towers Gage. 48-Hour Storm Starting at 9:00 pm on 24 June 06 and Ending at 9:00 PM 26 June 06

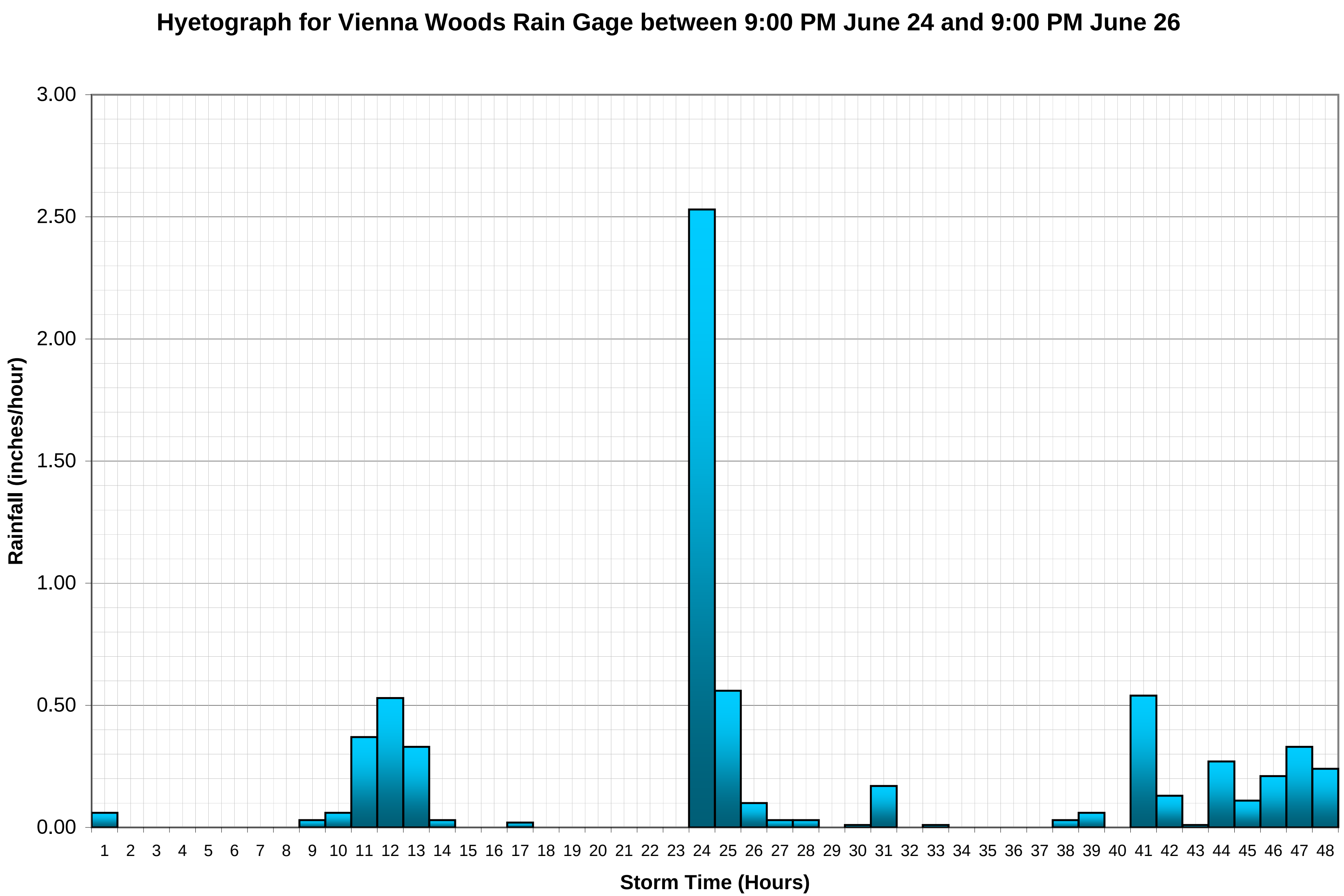




Hyetograph for Skyline Towers Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

VIENNA WOODS RAIN GAGE (M2028) 48 Hour Storm. Beginning 9:00 PM on 24 June 06, ending 9:00 pm 26 June 06		
Hour	**Rainfall Measured**	**Cumulative**
1.00	0.06	0.06
2.00	0.00	0.06
3.00	0.00	0.06
4.00	0.00	0.06
5.00	0.00	0.06
6.00	0.00	0.06
7.00	0.00	0.06
8.00	0.00	0.06
9.00	0.03	0.09
10.00	0.06	0.15
11.00	0.37	0.52
12.00	0.53	1.05
13.00	0.33	1.38
14.00	0.03	1.41
15.00	0.00	1.41
16.00	0.00	1.41
17.00	0.02	1.43
18.00	0.00	1.43
19.00	0.00	1.43
20.00	0.00	1.43
21.00	0.00	1.43
22.00	0.00	1.43
23.00	0.00	1.43
24.00	2.53	3.96
25.00	0.56	4.52
26.00	0.10	4.62
27.00	0.03	4.65
28.00	0.03	4.68
29.00	0.00	4.68
30.00	0.01	4.69
31.00	0.17	4.86
32.00	0.00	4.86
33.00	0.01	4.87
34.00	0.00	4.87
35.00	0.00	4.87
36.00	0.00	4.87
37.00	0.00	4.87
38.00	0.03	4.90
39.00	0.06	4.96
40.00	0.00	4.96
41.00	0.54	5.50
42.00	0.13	5.63
43.00	0.01	5.64
44.00	0.27	5.91
45.00	0.11	6.02
46.00	0.21	6.23
47.00	0.33	6.56
48.00	0.24	6.80


Precipitation vs. Time at Vienna Woods Gage. 48-Hour Storm Starting at 9:00 pm on 24 June 06 and Ending at 9:00 PM 26 June 06
Total Storm Precipitation (Inches)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
Storm Duration (Hour)


Hyetograph for Vienna Woods Rain Gage between 9:00 PM June 24 and 9:00 PM June 26
Rainfall (inches/hour)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Storm Time (Hours)

APPENDIX C

USGS 01653000 FLOW DATA FOR JUNE 2006 FLOOD EVENT

USGS 01653000 Flow Data for June 2006 Flood Event

Date/Time of Measurement	Gage Height	Discharge (cfs)
6/24/2006 21:00	0.89	6.8
6/24/2006 21:15	0.89	6.8
6/24/2006 21:30	0.9	7.6
6/24/2006 21:45	0.99	16
6/24/2006 22:00	1.08	27
6/24/2006 22:15	1.19	44
6/24/2006 22:30	1.35	76
6/24/2006 22:45	1.4	87
6/24/2006 23:00	1.41	90
6/24/2006 23:15	1.41	90
6/24/2006 23:30	1.45	102
6/24/2006 23:45	1.59	137
6/25/2006 0:00	1.66	158
6/25/2006 0:15	1.75	185
6/25/2006 0:30	1.85	218
6/25/2006 0:45	1.86	222
6/25/2006 1:00	1.86	222
6/25/2006 1:15	1.86	222
6/25/2006 1:30	1.86	222
6/25/2006 1:45	1.83	212
6/25/2006 2:00	1.77	191
6/25/2006 2:15	1.69	168
6/25/2006 2:30	1.59	137
6/25/2006 2:45	1.51	118
6/25/2006 3:00	1.46	104
6/25/2006 3:15	1.41	90
6/25/2006 3:30	1.37	81
6/25/2006 3:45	1.33	72
6/25/2006 4:00	1.31	66
6/25/2006 4:15	1.29	62
6/25/2006 4:30	1.27	59
6/25/2006 4:45	1.26	57
6/25/2006 5:00	1.24	53
6/25/2006 5:15	1.24	53
6/25/2006 5:30	1.23	50
6/25/2006 5:45	1.22	48
6/25/2006 6:00	1.22	48
6/25/2006 6:15	1.22	48
6/25/2006 6:30	1.26	57
6/25/2006 6:45	1.36	78
6/25/2006 7:00	1.45	102
6/25/2006 7:15	1.5	114
6/25/2006 7:30	1.5	114
6/25/2006 7:45	1.48	109
6/25/2006 8:00	2.53	513
6/25/2006 8:15	3.58	1,110
6/25/2006 8:30	3.48	1,040
6/25/2006 8:45	3.78	1,230
6/25/2006 9:00	4.81	1,970
6/25/2006 9:15	5.1	2,200
6/25/2006 9:30	4.78	1,940

USGS 01653000 Flow Data for June 2006 Flood Event

Date/Time of Measurement	Gage Height	Discharge (cfs)
6/25/2006 9:45	4.51	1,740
6/25/2006 10:00	4.13	1,460
6/25/2006 10:15	4.2	1,510
6/25/2006 10:30	4.21	1,520
6/25/2006 10:45	4.04	1,400
6/25/2006 11:00	3.74	1,200
6/25/2006 11:15	3.55	1,090
6/25/2006 11:30	3.42	1,010
6/25/2006 11:45	3.18	870
6/25/2006 12:00	3.01	775
6/25/2006 12:15	2.94	732
6/25/2006 12:30	2.89	706
6/25/2006 12:45	2.85	680
6/25/2006 13:00	2.84	675
6/25/2006 13:15	2.85	680
6/25/2006 13:30	2.85	680
6/25/2006 13:45	2.76	630
6/25/2006 14:00	2.58	535
6/25/2006 14:15	2.51	504
6/25/2006 14:30	2.66	577
6/25/2006 14:45	2.68	587
6/25/2006 15:00	2.59	540
6/25/2006 15:15	2.4	448
6/25/2006 15:30	2.27	391
6/25/2006 15:45	2.23	370
6/25/2006 16:00	2.2	358
6/25/2006 16:15	2.19	354
6/25/2006 16:30	2.18	350
6/25/2006 16:45	2.16	342
6/25/2006 17:00	2.15	338
6/25/2006 17:15	2.14	330
6/25/2006 17:30	2.12	323
6/25/2006 17:45	2.11	319
6/25/2006 18:00	2.09	311
6/25/2006 18:15	2.08	308
6/25/2006 18:30	2.06	300
6/25/2006 18:45	2.03	286
6/25/2006 19:00	1.95	254
6/25/2006 19:15	1.89	234
6/25/2006 19:30	1.91	241
6/25/2006 19:45	1.93	247
6/25/2006 20:00	1.86	222
6/25/2006 20:15	1.82	209
6/25/2006 20:30	1.82	209
6/25/2006 20:45	2.1	315
6/25/2006 21:00	2.21	362
6/25/2006 21:15	3.76	1,220
6/25/2006 21:30	8.13	5,170
6/25/2006 21:45	12.23	10,800
6/25/2006 22:00	14.05	13,800
6/25/2006 22:15	15.52	16,500

USGS 01653000 Flow Data for June 2006 Flood Event

Date/Time of Measurement	Gage Height	Discharge (cfs)
6/25/2006 22:30	15.36	16,200
6/25/2006 22:45	15.29	16,100
6/25/2006 23:00	14.69	14,900
6/25/2006 23:15	13.6	13,000
6/25/2006 23:30	11.92	10,300
6/25/2006 23:45	10.36	7,990
6/26/2006 0:00	8.88	6,060
6/26/2006 0:15	8.4	5,480
6/26/2006 0:30	8.16	5,200
6/26/2006 0:45	7.53	4,500
6/26/2006 1:00	7.27	4,220
6/26/2006 1:15	6.55	3,490
6/26/2006 1:30	6.04	3,010
6/26/2006 1:45	5.62	2,630
6/26/2006 2:00	5.4	2,440
6/26/2006 2:15	5.24	2,310
6/26/2006 2:30	5.02	2,130
6/26/2006 2:45	4.8	1,960
6/26/2006 3:00	4.6	1,810
6/26/2006 3:15	4.46	1,700
6/26/2006 3:30	4.24	1,540
6/26/2006 3:45	4.07	1,420
6/26/2006 4:00	4.02	1,390
6/26/2006 4:15	4.45	1,690
6/26/2006 4:30	4.26	1,550
6/26/2006 4:45	4.23	1,530
6/26/2006 5:00	4.22	1,530
6/26/2006 5:15	4.17	1,490
6/26/2006 5:30	3.93	1,330
6/26/2006 5:45	3.98	1,360
6/26/2006 6:00	3.89	1,300
6/26/2006 6:15	3.66	1,150
6/26/2006 6:30	3.55	1,090
6/26/2006 6:45	3.47	1,040
6/26/2006 7:00	3.52	1,070
6/26/2006 7:15	3.54	1,080
6/26/2006 7:30	3.38	986
6/26/2006 7:45	3.31	946
6/26/2006 8:00	3.29	934
6/26/2006 8:15	3.18	870
6/26/2006 8:30	3.05	797
6/26/2006 8:45	2.99	764
6/26/2006 9:00	2.96	748
6/26/2006 9:15	3.12	836
6/26/2006 9:30	3.06	802
6/26/2006 9:45	2.93	727
6/26/2006 10:00	2.83	670
6/26/2006 10:15	2.81	660
6/26/2006 10:30	2.81	660
6/26/2006 10:45	2.79	650
6/26/2006 11:00	2.75	625

USGS 01653000 Flow Data for June 2006 Flood Event

Date/Time of Measurement	Gage Height	Discharge (cfs)
6/26/2006 11:15	2.74	620
6/26/2006 11:30	2.72	611
6/26/2006 11:45	2.69	596
6/26/2006 12:00	2.62	558
6/26/2006 12:15	2.59	540
6/26/2006 12:30	2.61	554
6/26/2006 12:45	2.74	620
6/26/2006 13:00	3	770
6/26/2006 13:15	2.94	732
6/26/2006 13:30	2.81	660
6/26/2006 13:45	2.76	630
6/26/2006 14:00	2.71	606
6/26/2006 14:15	2.64	568
6/26/2006 14:30	2.64	568
6/26/2006 14:45	2.82	665
6/26/2006 15:00	2.93	727
6/26/2006 15:15	2.94	732
6/26/2006 15:30	2.96	748
6/26/2006 15:45	2.96	748
6/26/2006 16:00	2.97	753
6/26/2006 16:15	2.92	722
6/26/2006 16:30	3.13	841
6/26/2006 16:45	3.47	1,040
6/26/2006 17:00	3.48	1,040
6/26/2006 17:15	3.61	1,120
6/26/2006 17:30	3.41	1,000
6/26/2006 17:45	4.17	1,490
6/26/2006 18:00	6.11	3,070
6/26/2006 18:15	7.1	4,040
6/26/2006 18:30	7.57	4,540
6/26/2006 18:45	7.4	4,360
6/26/2006 19:00	6.55	3,490
6/26/2006 19:15	5.67	2,680
6/26/2006 19:30	5.19	2,270
6/26/2006 19:45	4.92	2,050
6/26/2006 20:00	4.78	1,940
6/26/2006 20:15	5.67	2,680
6/26/2006 20:30	6.67	3,610
6/26/2006 20:45	7.21	4,160
6/26/2006 21:00	7.66	4,640

APPENDIX D

LAKE BARCROFT REPORT

Report on the Response of Lake Barcroft Dam to Heavy Rains during the Period June 23 through June 29, 2006

Prepared by:

LBWID trustees:
Charles W. de Seve, Chairman
Peter A. Silvia
L. Anthony Bracken

LBWID Director of Operations:
Davis Grant

Lake Barcroft Watershed Improvement District

July 23, 2006

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I. Overview

During the period from Friday, June 23 to Thursday, June 29, 2006, a stationary weather system sent a series of rainstorms up the East Coast in what has variously been reported as a “major” or even “300-year” storm. Total rainfall for our general area in the period was reported to be 12.10 inches. The Washington Post reported a 24-hour total of more than seven inches of rain on the 26th with more arriving overnight on the 27th.

As a result of this rain, flooding was experienced in Holmes Run downstream of Lake Barcroft and in the Huntington area of Fairfax, just south of the City of Alexandria, also downstream. Fairfax County engineers are exploring the dynamics of the heavy flow and trying to understand the functioning of the Lake Barcroft dam as one piece of the puzzle.

This report first describes the Lake Barcroft dam and the operation of its large hydraulic gate, designed to maintain a nearly constant lake level. Second, it uses data from the computer control system that operates the gate to show exactly how the gate functioned over the storm period.

The recorded minute-by-minute data on rainfall, lake level, gate position and flow over the dam demonstrate that the Lake Barcroft dam did not contribute to downstream flooding, performing flawlessly throughout the storm to maintain a nearly constant water level in the lake. Water flowing downstream from the dam consisted entirely of water flowing into the lake from its feeder inlets (primarily Holmes Run and Tripps Run) and a much smaller amount of direct rainfall into the lake. The unfortunate flooding downstream would have been comparable if the lake and dam did not exist.

II. Lake Barcroft Dam Background

THE DAM

Lake Barcroft was created by constructing a masonry dam with earthen embankments at the sides in the early 1900’s just below the confluence of Tripp’s Run and Holmes Run. The dam was originally built as a reservoir for the City of Alexandria. By the 1940’s the city’s population had outgrown the watershed’s capacity to supply water. Of little use after the construction of a large county reservoir and water system, the lake was sold and its adjoining land subdivided for residential development breaking ground in the 1950’s.

The original dam continued in service until 1972 when rains from Hurricane Agnes caused exceptionally high water to erode the earthen embankment at the western end of the masonry portion of the dam. The erosion scoured out the embankment and drained the lake.

The dam was rebuilt with protection against rising lake levels in the form of a 151 ft wide by 12 ft high bascule gate set into the top of the masonry. Four huge hydraulic rams (like arms) open and close the gate in response to a computer-operated monitoring and control system. The combination is designed to maintain the lake level and essentially remove the risk of the dam failing in the manner it did during Hurricane Agnes. The picture, below, is the dam and its hydraulic rams seen from downstream.

LAKE BARCROFT DAM AND GATE

DAM OPERATOR

The dam is operated and managed by the Lake Barcroft Watershed Improvement District (LBWID), a government entity with taxing authority to raise capital and operating funds.[1] LBWID is governed by the state via the Northern Virginia Soil and Water Conservation District, and its annual budget is reviewed and approved at state level by the Virginia Soil and Water Conservation Board. The Lake Barcroft dam, as all dams in the state, is regulated and monitored and inspected by the Virginia Dam Safety Board.

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[1] The Lake Barcroft Watershed Improvement District is organized under Virginia Law § 10.1-614, which authorizes the creation of watershed improvement districts. To raise funds, LBWID is empowered to levy property taxes and to issue municipal debt. It also may exercise eminent domain within its boundaries. It is managed by three pro-bono trustees appointed by the State and has a permanent full-time staff of four plus seasonal workers.

The dam structure is licensed under Virginia Department of Conservation and Recreation's Dam Safety Division, which issues a Class 1 Operations and Maintenance Certificate. The authorization for reconstructing the Lake Barcroft Dam and the Lake Barcroft impoundment (post Hurricane Agnes) was granted by the Circuit Court in Fairfax, Virginia, on January 12, 1973. The court ordered that the dam be operated in accordance with recommendations of Whitman, Requardt and Associates, the engineering firm that managed the reconstruction. One specific requirement of that ruling is that the dam cannot be used as a flood control device.

LAKE BARCROFT'S WATERSHED

A 14.5 square miles watershed drains into Lake Barcroft. It includes parts of Fairfax County and most of the City of Falls Church, bounded roughly by Route 7 on the east and north, Gallows Road on the west and Columbia Pike on the south. A short stretch of Route 66 forms a northwest piece of the boundary.

The area of Lake Barcroft itself is about 135 acres, about 1.5% of its watershed. This is an important ratio because it indicates that in watershed rain events, the water added to Lake Barcroft, and subsequently flowing downstream, is overwhelmingly drainage from the watershed, not rainfall directly into the lake. This effect is intensified when additional rain falls upon an already saturated watershed.

Downstream of Lake Barcroft, water flows into lower Holmes Run, which crosses into Alexandria and joins Cameron Run alongside the Beltway between Van Dorn Street and Telegraph Road. Cameron Run becomes Hunting Creek south of Alexandria, where it empties into the Potomac just below the Wilson Bridge.

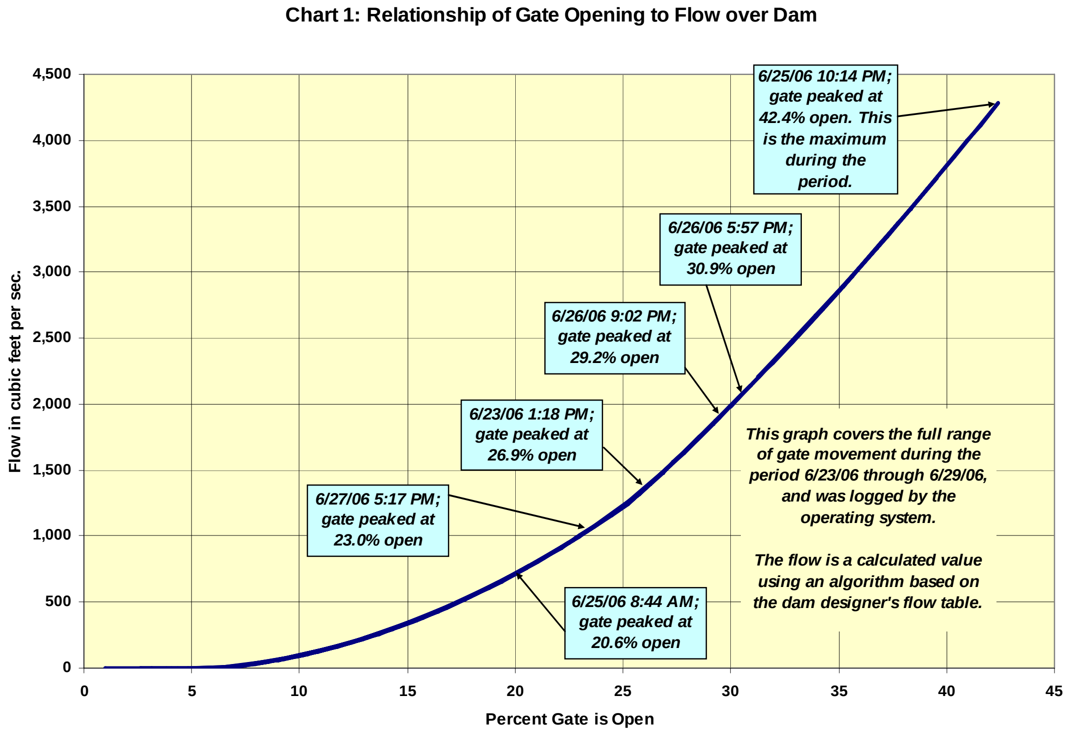
DAM GATE OPERATION

The Virginia state operating license for the dam requires the water level in the lake to be maintained at an elevation above sea level between 208.5 feet and 209.0 feet. The maximum depth of the lake is approximately 45 feet.

The control system for the gate includes sensors that measure the water level accurately to the nearest 0.01 ft. The control system updates its readings every second, so literally, the second that inflowing rain water begins to raise the water level above 208.50 feet, the control computer begins the process of sending instructions to a powerful electro-hydraulic system to open the gate a specific amount and allow the incoming water to flow downstream. The computer carefully matches the gate position to the water level, opening the gate to the degree needed as the water level rises, and closing it as the water level recedes.

Even when the gate is 100% closed, small amounts of water pass through the end seals of the gate and over a secondary fixed spillway at the 208.5 baseline water level. This nearly constant flow prevents the downstream channel from drying out in periods of low rainfall and allows the normal small inflows to the lake to pass without lowering the gate.

Moved by four huge hydraulic rams, the gate opens by tilting around hinges along its lower edge. For the first third of its travel, the top lip moves in a fairly flat arc and changes height slowly. That motion, plus the normal position of the lip six inches above water level when the gate is fully closed, creates a small delay in releasing water as the lake's water level begins to rise. Thus, as water enters the lake, the dam stores two or three inches (20 or 30 acre-feet) of it before significant flow is released downstream. This is a moderation of flow downstream, which becomes less significant as the gate opens. In the final two-thirds of its travel, the lip of the gate descends more quickly, and the rate of flow over the gate increases more rapidly.



Notice in Chart 1, which relates the percent of gate opening (bottom scale) to the flow over the dam (right scale), how the first 10% passes only a minor amount of water. As the gate opens wider, flow increases less than proportionately with only about 20% of flow capacity passing over the dam at 40% of gate opening. Only above 40% does the flow increase become roughly linear.

The maximum flow over the dam in Hurricane Agnes, with the primitive old gate in service, was estimated to be 14,500 cubic feet per minute. The new gate has the capacity to pass 21,500 cubic feet per second. In an extreme rainfall event, the dam could pass up to 29,000 cubic feet per second without endangering the earthen embankments.

Chart 1 also dates the significant peak openings of the gate during the June storm event. The greatest opening, at 42.4% was well below the full capacity of the gate to discharge water flowing into Lake Barcroft. The greatest flow over the dam at the peak discharge occurring at 10:14 PM on 6/25 was approximately 4,300 cubic feet per second, compared to a maximum possible 21,500 at a 100% gate opening. The latter would only occur during an almost unimaginable storm, even more severe than Hurricane Agnes. (Subsequent charts and discussion will examine rainfall, lake level, gate operation and flow during the storm).

III. Gate Performance During the June 2006 Rain Event

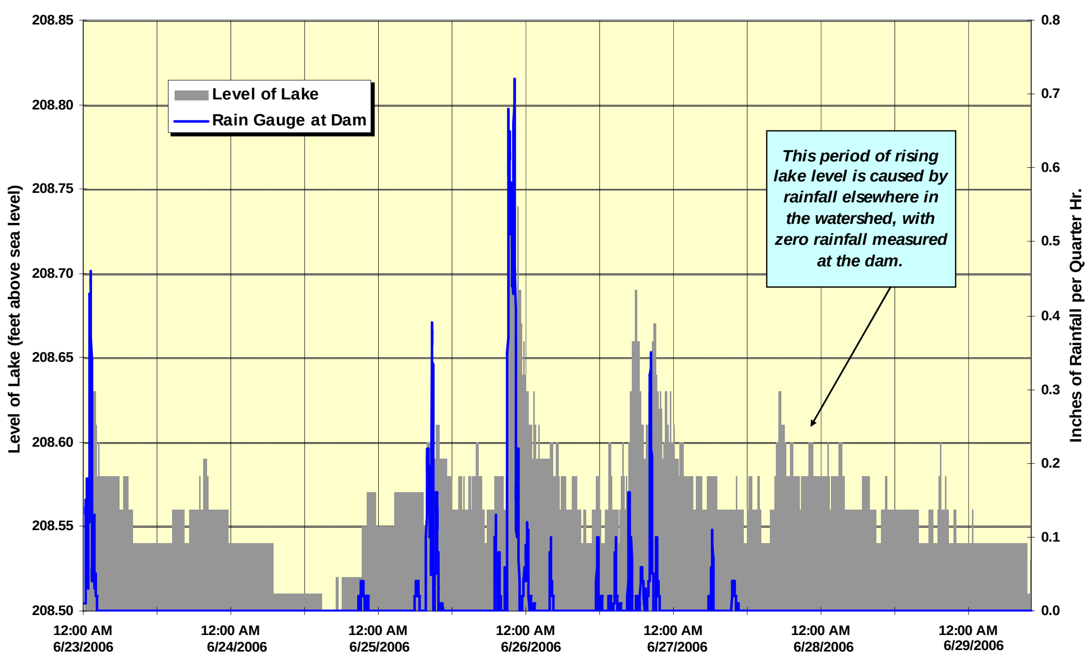
The gate control system, which has been completely renewed and upgraded during the past three years, automatically logs lake level and limited weather data, along with the performance of the dam gate. Extracted minute-by-minute data covering the time period 6/23/2006 through 6/29/2006 is displayed in a series of charts, below.

The charts unequivocally demonstrate that the gate performed as designed when torrents of storm water swept down Tripps Run and Holmes Run into the lake. The small change in lake level during the entire period is evidence that what flowed in, flowed out, nothing more, nothing less, except for a small moderation in flow each time the gate first opened (as discussed earlier).

LAKE LEVEL AND RAINFALL COMPARED

The control process is driven by sensors that measure the water level of the lake, with changes caused by rainfall (or lack thereof) throughout the lake's watershed. Chart 2, comparing rainfall and lake level, shows how quickly water flushes down the watershed into the lake. The left scale, corresponding to lake level and represented by the solid grey areas of the chart, is contrasted with rainfall at the dam, shown on the right scale and represented by the thin (blue, if color) line.

Chart 2: Rainfall Measured at Dam versus Lake Level



Note:Depending on location of rain in watershed, the time for watershed flow to reach the dam varies.

Rainfall is measured in small increments, reported by the minute, and aggregated into blocks of time. The data presented here are rainfall in rolling 15-minute aggregations. That interval most clearly shows the extreme variation in the rate of rainfall over the period. Rainfall aggregated into longer one-hour or several-hour blocks averages out and hides the surprising short-term intensity of individual storm cells.

The peaks in both rainfall and lake level that occurred around midnight on the 23rd, both late morning and again at midnight on the 25th, and a double peak on the 26th show very little time lag between the rainfall peak and the lake level peak. The storm cells that passed over our watershed had quite sharply defined, intense and often violent leading edges.

It is important to note that the rainfall data shown was gathered from a gauge located at the dam. This is at the southeastern edge of the lake watershed. Because storm cells can be relatively small in area, it frequently happens that rain may fall heavily in one part of the watershed and lightly or not at all in other parts. So there is only imperfect correlation between rainfall at the dam and the indication, by rising water level in the lake, of heavy rain elsewhere in the watershed.

The Lake Barcroft watershed is extremely responsive in moving storm water down the network of streams. Two factors contribute to this:

- Large areas of impervious surfaces in Fairfax and Falls Church, consequent to development of buildings, parking lots, and roads; and

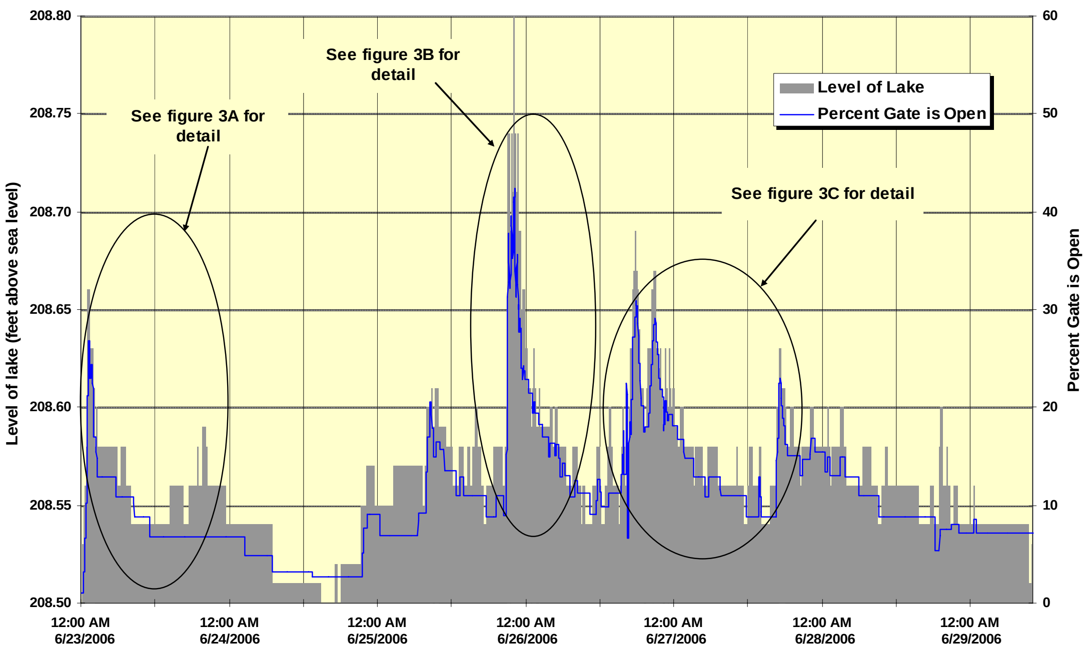
- The high-velocity concrete-lined drainage channel for Tripps Run in the City of Falls Church.

In June, the situation was worsened by ground saturation from earlier rain that encouraged new rainfall to run immediately into the streams. It takes varying amounts of time for the watershed to drain into its streams and then into the lake. Depending on the rain's location, the permeability and saturation of the ground upon which it falls, the grey area of the chart may extend in diminishing steps for many hours after the rain ceases. Rain elsewhere in the watershed may cause the lake to rise even with a zero measurement of rain at the dam.

LAKE LEVEL AND DAM GATE OPENING COMPARED

As rain falls and storm water runoff arrives in Lake Barcroft, the water level begins to rise. In response, the gate control system begins to open the gate, the computer control responding to the change in lake level sensors to determine the degree of gate opening.

Chart 3: Percent of Gate Opening versus Level of Lake



Lake level is compared to the percent of gate opening in Chart 3 to illustrate how closely the gate opening is linked to changes in water level. The left scale, corresponding to lake level and represented by the solid grey areas of the chart, is contrasted with the percent of gate opening, shown on the right scale and represented by the thin (blue, if color) line.

By design and in accordance with the license under which the dam operates, water coming into the lake is passed downstream almost immediately. Notice in the chart how an increase in lake level is matched by a greater gate opening. Notice also, particularly with large gate openings, how lake level reduces as the open gate spills more water downstream, decreasing the lake towards its target of 208.5 feet above sea level.

In order to see the detail of operations during the particularly high peaks of water inflow to the lake, segments of Chart 3 are enlarged for three intense storm periods (Chart 3A 12:00 AM 6/23 to 12:00 AM 6/24, Chart 3B 4:43 PM 6/25 to 10:43 AM 6/26, and Chart 3C 12:00 PM 6/26 to 6:00 PM 6/27).

Chart 3A: Percent of Gate Opening versus Level of Lake

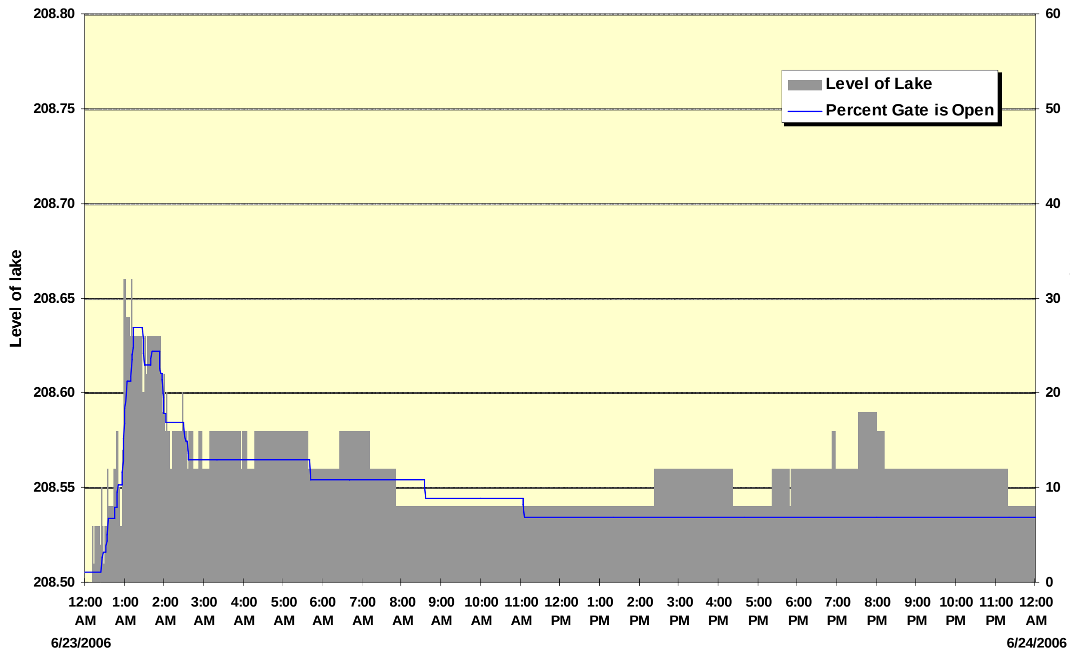


Chart 3B: Percent of Gate Opening versus Level of Lake

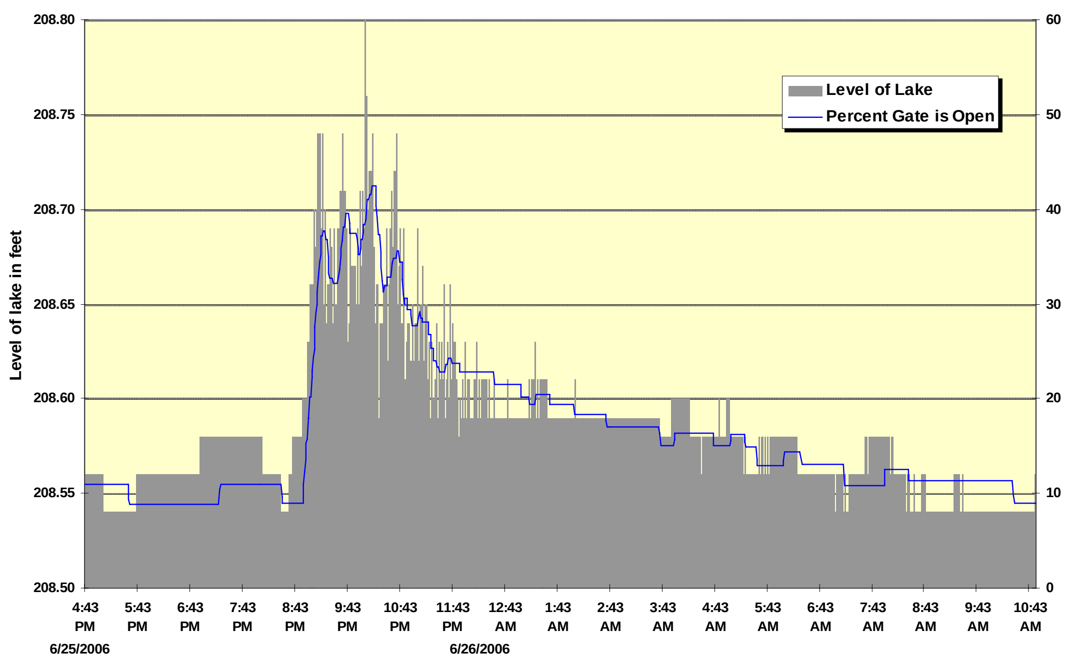
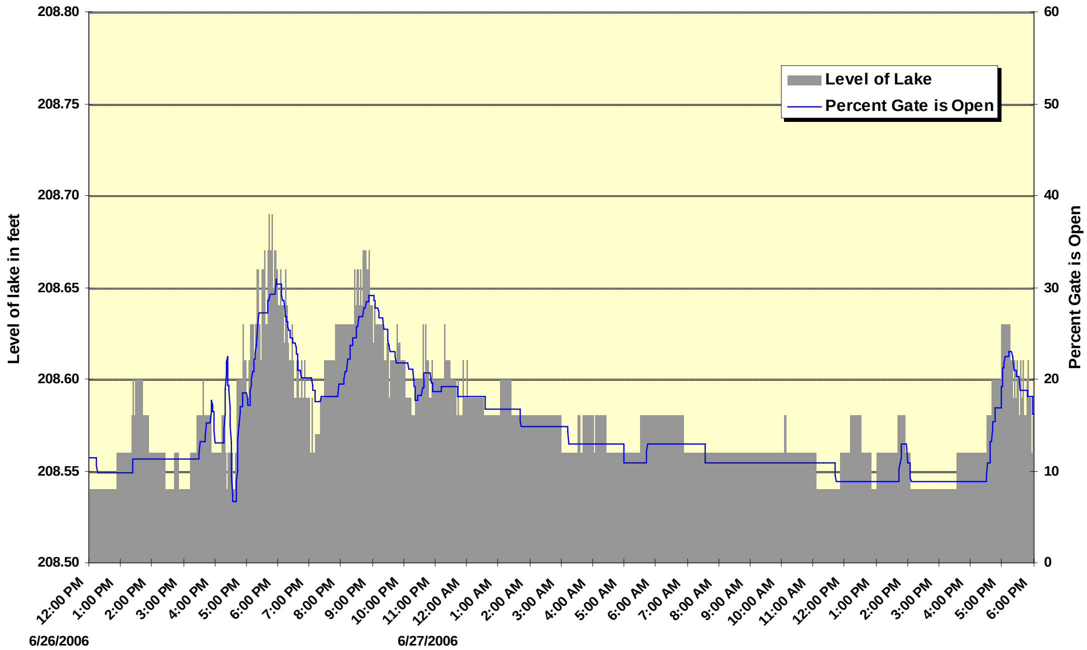


Chart 3C: Percent of Gate Opening versus Level of Lake



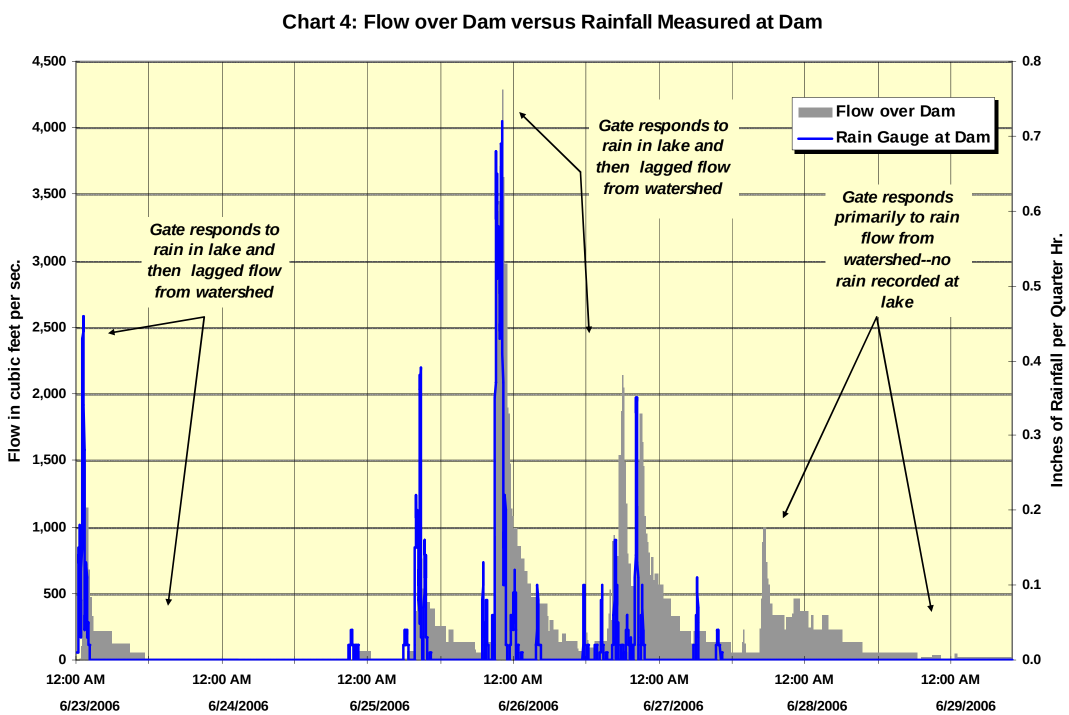
Each of the Charts, 3A, 3B, and 3C, shows an interesting phenomenon that occurs during periods of peak water level. It is best seen in Chart 3B, which documents the peak that occurred just after 10:00 PM on 6/25. At this time, the peak water level very briefly touched 208.8 feet, the maximum for the entire storm period.

At this water level, the operating rule calls for the gate to open as much as 60%. However, the peak gate opening was only about 43%. The time lags built into the computer software controlling gate openings allows a brief water level peak to pass before opening the gate to the rule value. This moderating influence prevented a surge over the dam and downstream. Similar lags and gradual peak reductions are also shown on Charts 3A and 3C.

FLOW OVER DAM AND RAINFALL COMPARED

The relationship between gate opening and flow over the dam (from Chart 1) is used to convert gate openings to flow in Chart 4. The left scale, corresponding to flow over the dam and represented by the solid grey areas of the chart, is contrasted with the amount of rainfall, shown on the right scale and represented by the thin (blue, if color) line.

Despite the moderation in flow that may be inferred from Chart 3, the passage of storm cells over the watershed did create sharp spikes in flow down the streams feeding into the lake, and consequently, over the dam and downstream into Holmes Run. Similar spikes very likely were experienced throughout all the branches of Cameron Run. It is simply water flowing into the lake from the watershed and then flowing over the dam into the lower reaches of Holmes Run.



Note:Depending on location of rain in watershed, the time for watershed flow to reach the dam varies.

These spikes in flow probably were the cause of the surges and abrupt high water experienced at the foot of Chambliss Street, about a mile below the Lake Barcroft Dam on lower Holmes Run. The spikes may have exacerbated the flooding in Huntington. It is clear they were not caused by the Lake Barcroft Dam, but rather were the consequence of water quickly draining through a saturated and largely impervious watershed into the lake and subsequently discharged according to the dam's design and its operating license.

IV. Closing Observations

FUTURE HEAVY STORMS MAY INEVITABLY LEAD TO FLOODING

As damaging as they were, the June, 2006 rain events were characterized by distinct storm cells of intense rain in transit through the watershed. They often impacted relatively small areas at a given time and quickly passed elsewhere. Future high intensity storms of longer duration may cause greater flooding downstream from Lake Barcroft. This is one consequence of swift drainage throughout a highly impervious watershed into the lake. Speeding water away from upstream roads and streets into sewers, culverts and other devices that empty into Holmes Run and Tripps Run may have solved some problems, but inevitably causes others.

It is troublesome that in recent years weather seems to be more unpredictable and severe. Our area may well experience even worse rain and flooding than the June storm. The response of the watershed to the June, 2006, rain events should be looked at as part of a broader set of possibilities.

Hurricanes in particular carry with them the inherent threat of greater potential for flooding and destruction in Northern Virginia's watersheds. Unlike storm cells that produce spikes of rainfall and runoff that peak and quickly dissipate, hurricanes can produce long-duration downpours that result in flows of very destructive high-energy water.

In a hurricane, erosion and flooding may build up to extreme levels and persist for many hours. Trees and debris carried downstream by the raging flow will jam up at choke points to create dams that exacerbate local flooding. The Lake Barcroft community and its dam do what can be done within their physical and operational limitations to moderate flow and trap debris to keep it from adding to problems downstream.

However, even in a hurricane flow, the lake and dam cannot do more than pass the storm water into the downstream watercourses as soon as it flows through the lake. It is a simple equation: what flows into the lake flows out.

LIMITATIONS IN THE ABILITY OF THE WATERSHED TO HANDLE LARGE RAINFALLS

The June, 2006, rain events exposed limitations in the ability of the Holmes Run and Cameron Run channels to handle high runoff. This is a warning that worse may be in store unless changes are made to the channels, the flood plains, and the choke points such as culverts.

The impact of Lake Barcroft and its dam on the downstream water is the same as if the dam and lake did not exist. The design and operating rules of the gate control system do not add to the natural flow over the dam gate. If anything, they introduce a small time lag in passing storm water over the gate that marginally moderates flow in the downstream channels.

Large volumes of water flowing through the lake from Tripps Run and upper Holmes Run are likely to contribute to flooding in some areas of lower Holmes Run and Cameron Run. However, Lake Barcroft does not have the capacity to store storm water. The dam was designed to create a reservoir, not to impound storm water. There is only a 6-inch working freeboard and an additional 2-1/2 feet of emergency freeboard beyond that before we risk Agnes-like erosion of the earthen embankments on either side of the dam. Weather predictions are too unreliable to risk either delayed or premature gate opening, and it is not possible to lower the lake significantly because hydrostatic pressure would collapse seawalls and cause immense damage.

Lake Barcroft occupies 1.5% of its watershed. If one half-inch of rain falls in the entire watershed, and if the lake could somehow retain all that water (which it cannot), its water level would rise nearly six feet. The experience of Lake Needwood near Rockville, MD, during the June, 2006, rain events shows what a storm water impoundment dam does in response to high rainfall. Their water level rose 25 feet and nearly caused the dam to fail!

Lake Barcroft performs a valuable service for downstream areas by traping all the trash, debris and heavy sediments carried with the storm water from 14.5 square miles of Fairfax County and Falls Church. The result is cleaner water downstream to the Potomac River and, ultimately, the Chesapeake Bay.

It is unfortunate that some properties downstream were flooded by the June storm. However, the flow of water down Holmes Run and into Cameron Run and the watershed was a direct result of the amount of rain and the speed of watershed drainage. The Lake Barcroft dam did nothing to increase the flow, and had no capacity to decrease it. What flowed into the lake flowed out.

APPENDIX E

VDOT NARRATIVE OF CONSTRUCTION ACTIVITY DURING JUNE 2006 FLOOD EVENT

Narrative Summary of the Woodrow Wilson Bridge Project Status near Cameron Run on June 25, 2006

On the evening of June 25, 2006, a significant amount of precipitation fell within the Cameron Run watershed in a relatively short period of time resulting in significant flooding within the Woodrow Wilson Bridge Project Area and beyond. In June of 2006, the Woodrow Wilson Bridge (WWB) Project had two construction contracts working within the Cameron Run floodplain: VB-5 and VA-6/7.

Contract VB-5

As depicted on the submitted WWB Project "Rainbow Charts," Contract VB-5 is the first contract for the Telegraph Road interchange with I-95/495 (Capital Beltway) and is focused on utility relocation including tunneling and boring operations alongside and under Cameron Run, tributary Pikes Branch, and tributary Taylor Run. The various VB-5 work areas within the Telegraph Road interchange can be seen on the submitted WWB Project aerial photograph.

Contract VA-6/7

Also depicted on the "Rainbow Charts," Contract VA 6/7 is the last in a series of VDOT construction contracts completing the reconstruction of the US Route 1 interchange with I-95/495 (Capital Beltway). VA-6/7 activities can be seen on the submitted WWB aerial photograph including US Route 1 construction in and adjacent to Cameron Run. Reconstruction of this interchange was approximately 61% complete in late June. Accordingly, as of June of 2006 some new structure was in place, some pre-existing structure was in place, and some pre-existing structure had been removed, as depicted on Project aerial photographs. The following elements were identified in the July 6, 2006, agency coordination meeting as specific elements in and immediately adjacent to Cameron Run in late June within the US 1 interchange and the following dimensions were requested:

-40'x40' Material barge drawing 1 foot of water;
-30'x40' Material barge drawing 1 foot of water;
-60'x80' Crane Barge + 10'x40' ballast barge with 100-ton crane drawing 2' of water;
-17'x68' steel cofferdam for new US Route 1 bridge foundation in Cameron Run. Tops of steel sheets were approximately 10' above the Cameron Run stream bottom.
-30'Lx80'Wx15'H (approximate dimensions) dirt stockpile located on north bank of Cameron Run just west of existing US 1. The base of the stockpile was 3'-4' above the mean high water level. It should be noted that the silt fence around this stockpile was only slightly damaged and the stockpile appeared intact after the storm.

Others notes:

-In accordance with regulatory permits, temporary stone causeways were in place in June and are visible on the Project aerials in the southwest quadrant of the US 1 interchange. They are temporary and will be fully removed once construction is complete.

-As can also be seen on the Project aerial photographs, two other soil stockpiles are located along Cameron Run: one south of Cameron Run and west of Telegraph Road near Burgundy Road and one north of Cameron Run, south of the beltway, and west of the WMATA rail bridge. Both are on relatively high banks above Cameron Run and are surrounded by super silt fence. While the perimeter controls were damaged there was no evidence observed indicating that flows removed stockpiled material.
-Temporary fills in the 100-year floodplain, temporary causeways, and temporary trestles were permitted by Project permits and required for access to build the VA-5 "Advanced Bridge" Contract (depicted on the "Rainbow Chart"). All of these elements were removed and restored prior to June 2006 in a concerted effort to maintain the floodplain cross-sections in the Project models.

June 25 Storm Event
While cross-section and high water survey points were submitted by the Project under separate cover, the following are visual observations and situations experienced by Project personnel:

At approximately 10:30pm on June 25, an Environmental Inspector for the Project made observations of severe flooding in the Project area associated with Cameron Run and the tributary Pikes Branch. Also, at approximately 11:00pm on June 25, Cameron Run overtopped Interstate 95/495 just west of the Telegraph Road interchange, closing the highway until 7:00am the following morning. Debris in the glare shields in the median of I-95 indicated flows approximately five feet deep over the beltway. Debris, including large trees and upwards of 5 feet of mud covered the beltway, requiring hours of emergency operations to reopen I-95/495. The outside bank of the sharp meander in Cameron Run just upstream of the beltway bridge was overtopped, flooding the lower levels of the building adjacent to Cameron Run. Water marks and significant debris piles indicate the flow continued due east and north of the beltway and ramps to a topographical low point under the Eisenhower Avenue Bridge adjacent to Telegraph Road. Multiple floating cars were deposited at this point.

Visual evidence indicates that the flow did not overtop the Telegraph Road bridge over Cameron Run but did flow around the bridge, flooding the intersection with Huntington Avenue. Telegraph Road between Cameron Run and the Eisenhower Avenue bridge exhibited signs of inundation. The flooding south of Cameron Run near Telegraph Road was exaggerated by Pike's Branch flooding just to the west which overtopped Burgundy Road. The flows significantly scoured a 55'x30' steel cofferdam located on the south bank of Cameron Run just east of Telegraph Road. This cofferdam was basically idle at the time of the flood but was intended to function as a receiving/launching pit for an ongoing microtunneling operation to the north, as part of the VB-5 contract.

At the US 1 interchange, visual observations at approximately 10:30pm on June 25 indicate both high water levels and high velocities in the main Cameron Run channel under the US 1 bridge. Flooding extended back to the Fort Hunt Road intersection to the south and generally to the beltway toe of slope to the north. The crane barge noted above was spudded down with 40' steel spuds (steel girders positioned vertically into the stream bed to anchor the barge in place). In spite of the anchoring, the crane barge was pushed downstream by the flood flow and against the ramp bridge from US 1 northbound to I-95/495 outer loop (northbound) causing some damage to the first 24”x24” pre-cast concrete pile in that particular bent (row) of piles. At some point during the storm the 40’x40’ material barge (also noted above) broke loose from the crane barge and floated downstream. At 6am on June 26, a Project manager observed the material barge located at the South Washington Street (George Washington Memorial Parkway) stone arch bridge over Cameron Run/Hunting Creek. This bridge is basically located at the mouth of Cameron Run/Hunting Creek at the confluence with the Potomac River. Divers, cranes, and crews worked to raise the partially sunken barge and float it back to the work area by Thursday, June 29, in spite of continued heavy rains and elevated flows. No damage to the bridge was observed by VDOT and FHWA bridge experts. This bridge has three arches, with the center arch being the largest and located in the deepest water. The barge was partially blocking a portion of the smaller southern arch. It was estimated that the barge may have blocked approximately 15% of the total capacity of the arch bridge flow capacity. There was no visual evidence of blockages of any sort within or around the other two arches.

Other notes:
-An overturned vehicle is visually evident on the downstream side of the arch bridge, which apparently floated downstream and through the arch bridge during the flood.
-During the days of subsequent rains and storms beyond June 25, flows remained elevated within Cameron Run but the Project did not observe subsequent overtopping of Cameron Run stream banks within the Project area.
-The Potomac River crested on or about June 28 but the actual Wilson Bridge construction contracts in Jones Point Park were not affected. They were heavily damaged by storm surge and high tides associated with Tropical Storm Isabel.

APPENDIX F

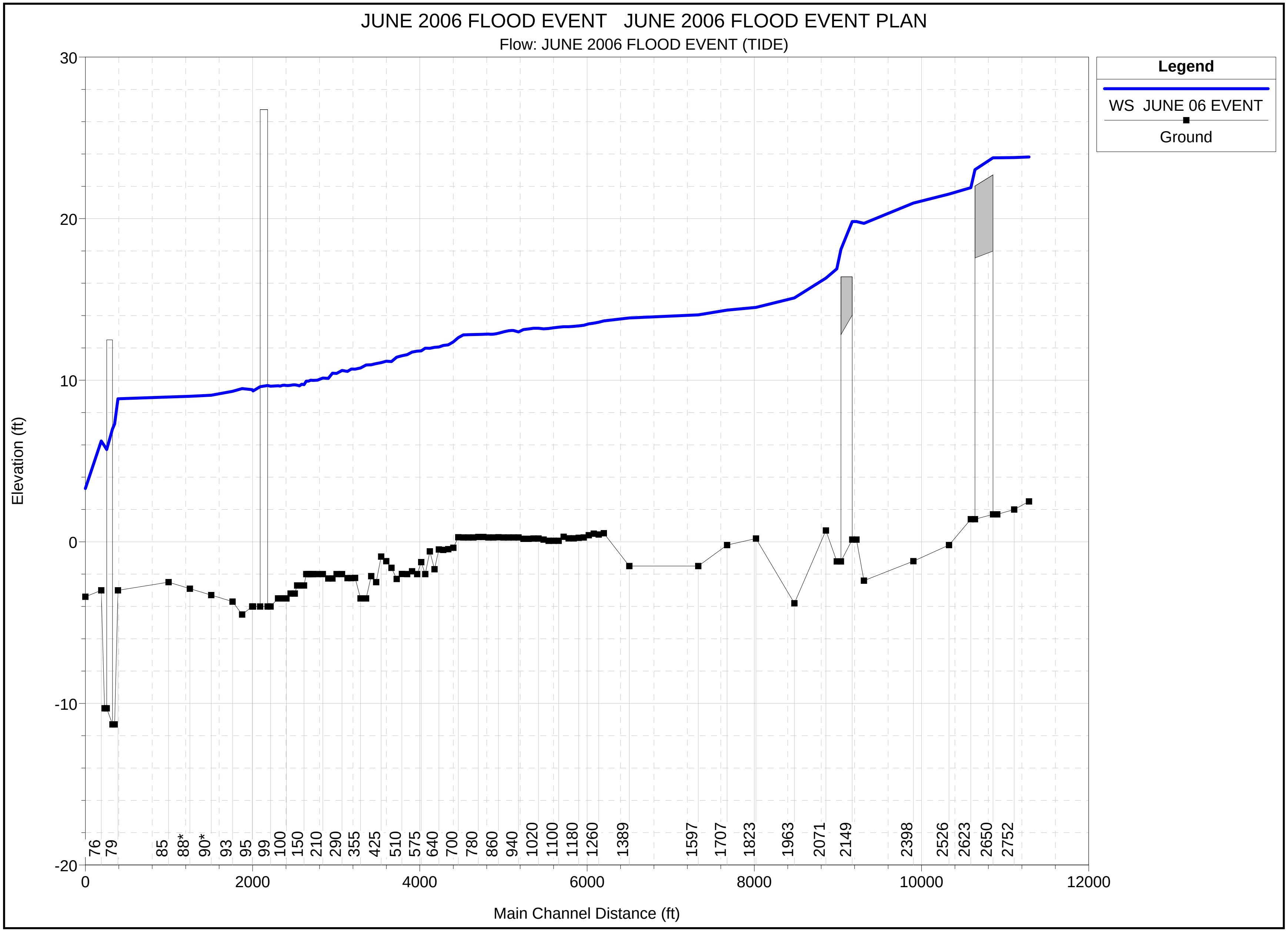
JUNE 2006 FLOOD EVENT HEC-RAS MODELING RESULTS

HEC-RAS Plan: 2006 River: Cameron Run Reach: One

Reach	River Sta	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)	
One	2806	17857.00	2.50	23.82	9.44	23.99	0.000184	3.43	6047.78	404.80	0.14
One	2752	17857.00	2.00	23.78	9.76	23.96	0.000188	3.49	5958.28	557.07	0.14
One	2677	17857.00	1.70	23.76	9.23	23.90	0.000151	3.08	7692.28	1320.84	0.13
One	2650	Bridge									
One	2623	17857.00	1.40	21.92	8.97	22.13	0.000259	3.69	5561.03	703.74	0.16
One	2526	17857.00	-0.20	21.52		21.97	0.000554	6.41	5917.68	630.74	0.25
One	2398	17857.00	-1.20	20.96		21.68	0.000879	7.79	4679.85	630.48	0.31
One	2211	19076.00	-2.40	19.71		20.97	0.001387	9.65	3376.42	451.01	0.38
One	2169	19076.00	0.14	19.82	10.91	20.55	0.001155	8.13	3829.25	601.40	0.33
One	2149	Bridge									
One	2129	19076.00	-1.21	16.89	9.94	17.86	0.001286	8.54	3106.75	381.98	0.37
One	2071	19076.00	0.70	16.32		17.57	0.001828	9.51	2821.79	255.41	0.43
One	1963	19076.00	-3.80	15.09		16.71	0.002744	11.13	2699.47	329.30	0.51
One	1823	19076.00	0.20	14.51		15.57	0.001704	8.71	3227.46	449.88	0.41
One	1707	19678.00	-0.20	14.34		15.05	0.000891	6.89	3472.23	541.23	0.38
One	1597	19678.00	-1.50	14.05		14.68	0.001122	7.55	5210.97	590.75	0.36
One	1389	19678.00	-1.50	13.85		14.12	0.000319	4.94	8828.11	1018.53	0.24
One	1280	19678.00	0.53	13.67		14.01	0.000397	5.35	6810.02	890.56	0.26
One	1260	19678.00	0.45	13.59		13.98	0.000439	5.66	6499.46	889.95	0.28
One	1240	19678.00	0.50	13.53		13.95	0.000474	5.83	6307.71	891.20	0.29
One	1220	19678.00	0.41	13.49		13.92	0.000486	5.93	6237.57	879.28	0.29
One	1200	19678.00	0.27	13.40		13.88	0.000553	6.25	5978.65	875.12	0.31
One	1180	19678.00	0.25	13.36		13.85	0.000545	6.27	6003.49	882.96	0.31
One	1160	19678.00	0.22	13.33		13.81	0.000613	6.19	5832.06	881.52	0.31
One	1140	19678.00	0.22	13.31		13.77	0.000594	6.09	6083.89	930.44	0.30
One	1120	19678.00	0.31	13.31		13.72	0.000546	5.84	6628.61	981.20	0.29
One	1100	19678.00	0.06	13.28		13.69	0.000539	5.78	6697.76	1033.39	0.28
One	1080	19678.00	0.06	13.24		13.66	0.000510	5.85	6722.68	1032.28	0.29
One	1060	19678.00	0.06	13.20		13.63	0.000506	5.94	6962.07	1090.24	0.30
One	1040	19678.00	0.14	13.18		13.59	0.000493	5.96	7167.87	1089.35	0.29
One	1020	19678.00	0.20	13.22		13.54	0.000410	5.42	8260.13	1098.69	0.27
One	1000	19678.00	0.20	13.22		13.50	0.000378	5.23	8579.85	1089.90	0.26
One	980	19678.00	0.19	13.17		13.48	0.000396	5.34	8231.93	1082.08	0.26
One	960	19678.00	0.19	13.13		13.45	0.000401	5.33	7906.84	1080.99	0.27
One	940	19678.00	0.27	12.99		13.42	0.000490	5.84	6403.58	948.06	0.29
One	920	19678.00	0.27	13.08		13.34	0.000425	4.86	8190.13	1065.61	0.24
One	900	19678.00	0.27	13.06		13.31	0.000390	4.72	8407.80	1082.65	0.23
One	880	19678.00	0.27	12.98		13.28	0.000374	5.17	8182.97	1093.64	0.26
One	860	19678.00	0.28	12.92		13.26	0.000401	5.31	7655.98	1091.45	0.27
One	840	19678.00	0.27	12.84		13.23	0.000435	5.44	6580.64	1067.18	0.28
One	820	19678.00	0.27	12.86		13.18	0.000391	5.15	7402.67	1075.66	0.26
One	800	19678.00	0.30	12.85		13.15	0.000374	5.07	7977.88	1070.27	0.26
One	780	19678.00	0.30	12.83		13.13	0.000372	5.06	7999.01	1089.06	0.25
One	760	19678.00	0.27	12.82		13.10	0.000349	4.86	8167.16	1088.36	0.25
One	740	19678.00	0.27	12.82		13.07	0.000321	4.68	8668.84	1138.28	0.24
One	720	19678.00	0.27	12.80		13.06	0.000319	4.67	8630.47	1136.67	0.24
One	700	19678.00	0.28	12.64		13.02	0.000442	5.45	6957.08	1223.69	0.28
One	680	19678.00	-0.37	12.37		12.97	0.000608	6.33	3402.31	334.00	0.32
One	660	19678.00	-0.46	12.19		12.91	0.000761	7.00	3120.83	319.81	0.36
One	659	19678.00	-0.50	12.15		12.87	0.000755	6.93	3369.85	657.86	0.36
One	640	19678.00	-0.47	12.06		12.82	0.000781	7.12	3078.49	369.25	0.36
One	625	19678.00	-1.70	12.03		12.77	0.000790	7.06	3130.35	388.85	0.35
One	610	19678.00	-0.59	11.98		12.73	0.000866	7.09	3094.03	344.83	0.36
One	595	19678.00	-2.00	11.98		12.66	0.000765	6.78	3200.04	312.14	0.34
One	575	19678.00	-1.26	11.81		12.61	0.001048	7.30	2960.41	323.60	0.37
One	555	19678.00	-2.00	11.80		12.54	0.001072	7.05	3022.53	303.77	0.36
One	540	19678.00	-1.82	11.74		12.47	0.001192	7.04	3024.02	302.68	0.35
One	530	19678.00	-2.00	11.58		12.37	0.001493	7.37	2844.64	277.64	0.37
One	510	19678.00	-1.99	11.51		12.27	0.001488	7.20	2887.88	283.82	0.37
One	485	19678.00	-2.30	11.43		12.17	0.001595	7.01	2858.88	272.68	0.37
One	465	19678.00	-1.61	11.16		12.06	0.001434	7.78	2650.44	257.59	0.41
One	445	19678.00	-1.20	11.18		11.93	0.001194	7.11	2850.69	271.15	0.37
One	425	19678.00	-0.91	11.09		11.86	0.001231	7.17	2811.20	264.25	0.38
One	395	19678.00	-2.50	11.03		11.78	0.001287	7.06	2845.18	257.35	0.36
One	385	19678.00	-2.12	10.96		11.70	0.001200	7.05	2879.75	281.15	0.37
One	375	19678.00	-3.50	10.94		11.61	0.001074	6.75	3020.68	268.63	0.34
One	355	19678.00	-3.50	10.76		11.52	0.001256	7.26	2870.23	257.44	0.37
One	337	19678.00	-2.23	10.69		11.43	0.001235	7.15	2907.32	300.14	0.37
One	325	19678.00	-2.25	10.69		11.36	0.001048	6.80	3100.32	312.64	0.35

HEC-RAS Plan: 2006 River: Cameron Run Reach: One (Continued)

Reach	River Sta	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)	
One	310	19678.00	-2.25	10.55		11.30	0.001354	7.24	2934.34	299.82	0.37
One	290	19678.00	-2.00	10.60		11.15	0.001393	6.41	3536.27	434.56	0.33
One	270	19678.00	-2.00	10.42		11.04	0.001540	6.86	3368.39	410.11	0.36
One	255	19678.00	-2.27	10.43		10.95	0.001042	6.14	3812.26	452.67	0.32
One	240	19678.00	-2.27	10.12		10.86	0.001767	7.29	3446.04	414.48	0.39
One	210	19678.00	-2.00	10.13		10.74	0.000846	6.77	4378.01	506.17	0.35
One	180	19678.00	-2.00	10.00		10.67	0.001168	7.14	4050.55	462.36	0.37
One	170	19678.00	-2.00	9.99		10.60	0.000911	6.78	4235.86	487.28	0.35
One	165	19678.00	-2.00	10.00		10.56	0.000671	6.55	4455.81	512.73	0.34
One	160	19678.00	-2.00	9.94		10.54	0.000962	6.74	4307.85	499.10	0.35
One	155	19678.00	-2.00	9.94		10.51	0.000682	6.58	4427.94	511.06	0.34
One	150	19678.00	-2.70	9.73		10.47	0.000879	7.37	3940.25	525.74	0.39
One	145	19678.00	-2.70	9.75		10.42	0.000812	7.09	4150.82	568.01	0.37
One	135	19678.00	-2.70	9.65		10.39	0.000894	7.42	4131.94	527.80	0.39
One	130	19678.00	-2.70	9.69		10.34	0.000812	7.09	4334.75	557.06	0.37
One	120	19678.00	-3.20	9.71		10.30	0.000720	6.86	4704.39	634.98	0.35
One	110	19678.00	-3.20	9.68		10.26	0.000717	6.83	4779.58	657.40	0.35
One	100	19678.00	-3.50	9.68		10.21	0.000743	6.61	5052.98	677.19	0.34
One	99.8	19678.00	-3.50	9.70		10.18	0.000587	6.30	5361.06	715.69	0.32
One	99.7	19678.00	-3.50	9.68		10.16	0.000952	6.43	5147.31	685.41	0.33
One	99.6	19678.00	-3.50	9.63		10.14	0.000610	6.40	5374.83	709.27	0.33
One	99.5	19678.00	-3.50	9.66		10.10	0.000772	6.17	5602.44	753.77	0.31
One	99	21237.00	-4.00	9.63	5.84	10.02	0.000725	5.56	6121.06	1165.97	0.34
One	96	Bridge									
One	95.5	21237.00	-4.00	9.34		9.77	0.000831	5.82	5796.23	1067.22	0.36
One	95	21237.00	-4.00	9.42		9.73	0.000564	5.55	8720.57	1300.63	0.30
One	94*	21237.00	-4.50	9.49		9.63	0.000316	3.93	11585.43	1586.71	0.21
One	93	21237.00	-3.70	9.31		9.57	0.000551	5.42	9152.44	1416.62	0.28
One	90*	21237.00	-3.30	9.07		9.40	0.000807	5.26	6542.23	1061.06	0.28
One	88*	21237.00	-2.90	9.00		9.24	0.000370	4.06	6415.96	920.37	0.23
One	85	21237.00	-2.50	8.96		9.14	0.000262	3.45	6634.22	827.44	0.20
One	79	21237.00	-3.00	8.85		8.96	0.000267	3.83	16013.40	4506.96	0.21
One	78	21237.00	-11.30	7.29	0.93	8.59	0.001140	9.24	3317.68	2322.00	0.43
One	77.5	Bridge									
One	77	21237.00	-10.30	5.93	1.87	7.61	0.001930	10.40	2042.64	184.22	0.55
One	76	21237.00	-3.00	6.24	6.24	7.09	0.003475	8.00	4962.16	4203.55	0.66
One	75	21237.00	-3.40	3.30	3.30	4.56	0.005723	9.22	2885.92	1825.76	0.83



JUNE 2006 FLOOD EVENT   JUNE 2006 FLOOD EVENT PLAN
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
76
79
85
88*
90*
93
95
99
100
150
210
290
355
425
510
575
640
700
780
860
940
1020
1100
1180
1260
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

APPENDIX G

SENSITIVITY ANALYSIS HEC-RAS MODELING RESULTS

HEC-RAS River: Cameron Run Reach: One

Reach	River Sta	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)	
One	2806	NO US1 CONST	17857.00	2.50	23.67	9.44	23.85	0.000189	3.46	5987.95	401.93	0.14
One	2806	2006	17857.00	2.50	23.82	9.44	23.99	0.000184	3.43	6047.78	404.80	0.14
One	2752	NO US1 CONST	17857.00	2.00	23.63	9.76	23.81	0.000194	3.52	5875.14	551.26	0.15
One	2752	2006	17857.00	2.00	23.78	9.76	23.96	0.000188	3.49	5958.28	557.07	0.14
One	2677	NO US1 CONST	17857.00	1.70	23.61	9.23	23.76	0.000156	3.12	7495.74	1280.99	0.13
One	2677	2006	17857.00	1.70	23.76	9.23	23.90	0.000151	3.08	7692.28	1320.84	0.13
One	2650		Bridge									
One	2623	NO US1 CONST	17857.00	1.40	21.73	8.97	21.94	0.000269	3.74	5431.39	674.30	0.16
One	2623	2006	17857.00	1.40	21.92	8.97	22.13	0.000259	3.69	5561.03	703.74	0.16
One	2526	NO US1 CONST	17857.00	-0.20	21.31		21.77	0.000583	6.53	5785.45	624.29	0.25
One	2526	2006	17857.00	-0.20	21.52		21.97	0.000554	6.41	5917.68	630.74	0.25
One	2398	NO US1 CONST	17857.00	-1.20	20.73		21.47	0.000922	7.92	4536.09	608.32	0.31
One	2398	2006	17857.00	-1.20	20.96		21.68	0.000879	7.79	4679.85	630.48	0.31
One	2211	NO US1 CONST	19076.00	-2.40	19.61		20.77	0.001327	9.41	3340.47	340.88	0.37
One	2211	2006	19076.00	-2.40	19.71		20.97	0.001387	9.65	3376.42	451.01	0.38
One	2169	NO US1 CONST	19076.00	0.14	19.72	10.91	20.46	0.001186	8.20	3765.46	600.65	0.34
One	2169	2006	19076.00	0.14	19.82	10.91	20.55	0.001155	8.13	3829.25	601.40	0.33
One	2149		Bridge									
One	2129	NO US1 CONST	19076.00	-1.21	16.74	9.94	17.74	0.001336	8.65	3048.75	379.44	0.37
One	2129	2006	19076.00	-1.21	16.89	9.94	17.86	0.001286	8.54	3106.75	381.98	0.37
One	2071	NO US1 CONST	19076.00	0.70	16.15		17.44	0.001904	9.63	2779.14	254.96	0.44
One	2071	2006	19076.00	0.70	16.32		17.57	0.001828	9.51	2821.79	255.41	0.43
One	1963	NO US1 CONST	19076.00	-3.80	14.84		16.53	0.002922	11.35	2617.11	327.26	0.52
One	1963	2006	19076.00	-3.80	15.09		16.71	0.002744	11.13	2699.47	329.30	0.51
One	1823	NO US1 CONST	19076.00	0.20	14.17		15.31	0.001873	8.99	3076.82	447.10	0.43
One	1823	2006	19076.00	0.20	14.51		15.57	0.001704	8.71	3227.46	449.88	0.41
One	1707	NO US1 CONST	19678.00	-0.20	13.95		14.74	0.001021	7.19	3266.84	534.39	0.40
One	1707	2006	19678.00	-0.20	14.34		15.05	0.000891	6.89	3472.23	541.23	0.38
One	1597	NO US1 CONST	19678.00	-1.50	13.62		14.31	0.001258	7.88	4960.47	584.92	0.38
One	1597	2006	19678.00	-1.50	14.05		14.68	0.001122	7.55	5210.97	590.75	0.36
One	1389	NO US1 CONST	19678.00	-1.50	13.39		13.69	0.000367	5.18	8356.49	1006.76	0.26
One	1389	2006	19678.00	-1.50	13.85		14.12	0.000319	4.94	8828.11	1018.53	0.24
One	1280	NO US1 CONST	19678.00	0.53	13.09		13.54	0.000536	6.02	6481.40	891.95	0.31
One	1280	2006	19678.00	0.53	13.67		14.01	0.000397	5.35	6810.02	890.56	0.26
One	1260	NO US1 CONST	19678.00	0.45	13.01		13.50	0.000575	6.29	6171.84	889.41	0.32
One	1260	2006	19678.00	0.45	13.59		13.98	0.000439	5.66	6499.46	889.95	0.28
One	1240	NO US1 CONST	19678.00	0.50	12.94		13.46	0.000612	6.42	5980.91	893.59	0.33
One	1240	2006	19678.00	0.50	13.53		13.95	0.000474	5.83	6307.71	891.20	0.29
One	1220	NO US1 CONST	19678.00	0.41	12.89		13.43	0.000621	6.50	5908.99	880.85	0.33
One	1220	2006	19678.00	0.41	13.49		13.92	0.000486	5.93	6237.57	879.28	0.29
One	1200	NO US1 CONST	19678.00	0.27	12.78		13.38	0.000716	6.88	5613.92	873.38	0.35
One	1200	2006	19678.00	0.27	13.40		13.88	0.000553	6.25	5978.65	875.12	0.31
One	1180	NO US1 CONST	19678.00	0.25	12.74		13.33	0.000686	6.80	5636.28	881.39	0.34
One	1180	2006	19678.00	0.25	13.36		13.85	0.000545	6.27	6003.49	882.96	0.31
One	1160	NO US1 CONST	19678.00	0.22	12.69		13.29	0.000692	6.81	5450.28	878.86	0.35
One	1160	2006	19678.00	0.22	13.33		13.81	0.000613	6.19	5832.06	881.52	0.31
One	1140	NO US1 CONST	19678.00	0.22	12.66		13.24	0.000663	6.68	5667.48	927.84	0.34
One	1140	2006	19678.00	0.22	13.31		13.77	0.000594	6.09	6083.89	930.44	0.30
One	1120	NO US1 CONST	19678.00	0.31	12.67		13.19	0.000616	6.44	6173.85	998.06	0.33
One	1120	2006	19678.00	0.31	13.31		13.72	0.000546	5.84	6628.61	981.20	0.29
One	1100	NO US1 CONST	19678.00	0.06	12.63		13.15	0.000601	6.38	6194.39	1042.98	0.32
One	1100	2006	19678.00	0.06	13.28		13.69	0.000539	5.78	6697.76	1033.39	0.28

HEC-RAS River: Cameron Run Reach: One (Continued)

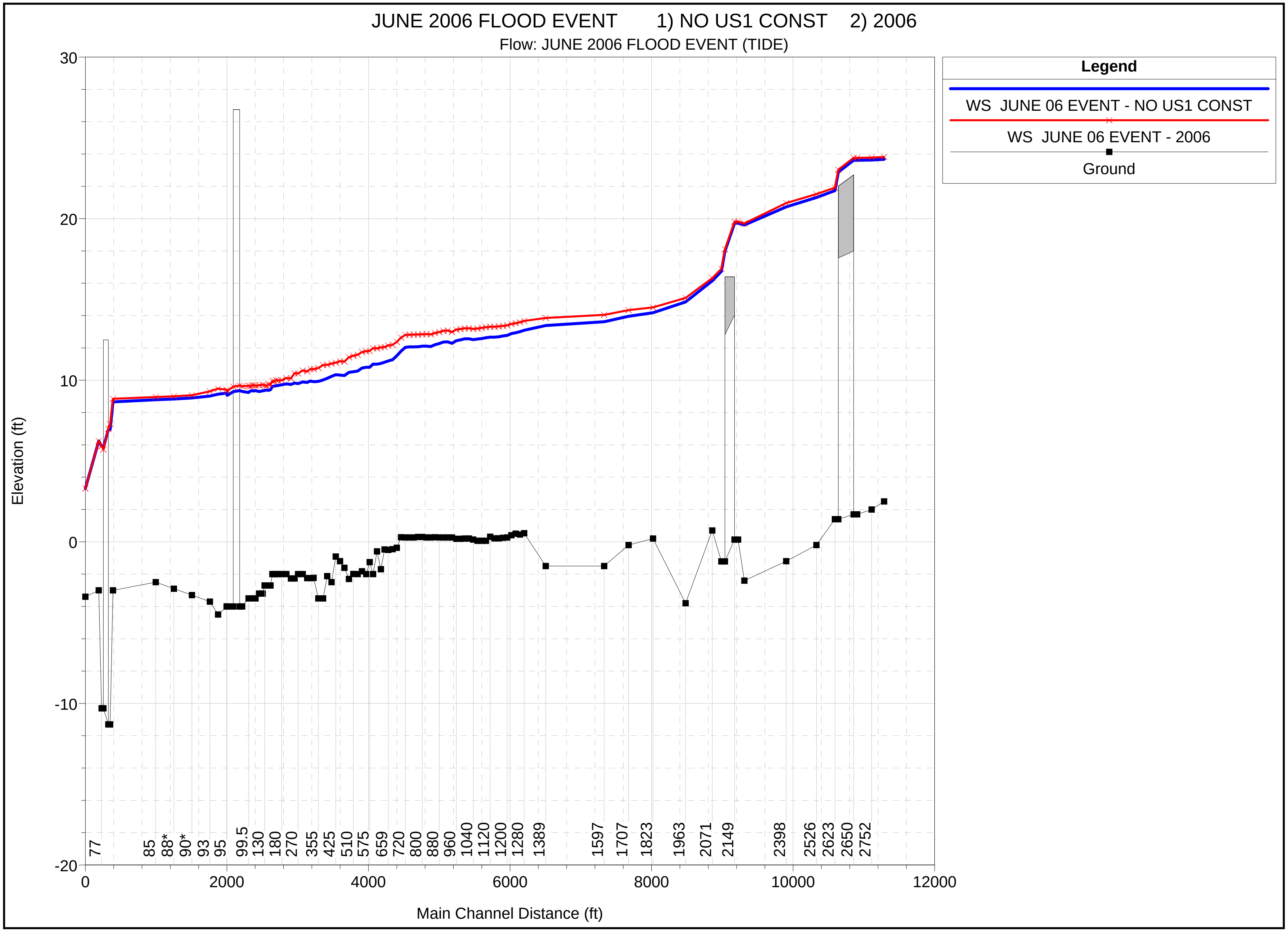
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	1080	NO US1 CONST	19678.00	0.06	12.58		13.11	0.000640	6.50	6201.29	1041.30	0.33
One	1080	2006	19678.00	0.06	13.24		13.66	0.000510	5.85	6722.68	1032.28	0.29
One	1060	NO US1 CONST	19678.00	0.06	12.55		13.07	0.000652	6.50	6402.71	1094.81	0.33
One	1060	2006	19678.00	0.06	13.20		13.63	0.000506	5.94	6962.07	1090.24	0.30
One	1040	NO US1 CONST	19678.00	0.14	12.51		13.03	0.000638	6.54	6605.51	1094.04	0.33
One	1040	2006	19678.00	0.14	13.18		13.59	0.000493	5.96	7167.87	1089.35	0.29
One	1020	NO US1 CONST	19678.00	0.20	12.56		12.96	0.000534	5.97	7547.82	1094.83	0.30
One	1020	2006	19678.00	0.20	13.22		13.54	0.000410	5.42	8260.13	1098.69	0.27
One	1000	NO US1 CONST	19678.00	0.20	12.56		12.92	0.000484	5.71	8012.68	1096.04	0.29
One	1000	2006	19678.00	0.20	13.22		13.50	0.000378	5.23	8579.85	1089.90	0.26
One	980	NO US1 CONST	19678.00	0.19	12.50		12.88	0.000513	5.87	7650.38	1089.01	0.30
One	980	2006	19678.00	0.19	13.17		13.48	0.000396	5.34	8231.93	1082.08	0.26
One	960	NO US1 CONST	19678.00	0.19	12.44		12.85	0.000529	5.90	7310.44	1087.87	0.30
One	960	2006	19678.00	0.19	13.13		13.45	0.000401	5.33	7906.84	1080.99	0.27
One	940	NO US1 CONST	19678.00	0.27	12.28		12.80	0.000630	6.37	5892.41	919.55	0.33
One	940	2006	19678.00	0.27	12.99		13.42	0.000490	5.84	6403.58	948.06	0.29
One	920	NO US1 CONST	19678.00	0.27	12.37		12.72	0.000444	5.45	7624.90	1079.23	0.28
One	920	2006	19678.00	0.27	13.08		13.34	0.000425	4.86	8190.13	1065.61	0.24
One	900	NO US1 CONST	19678.00	0.27	12.37		12.69	0.000410	5.20	7928.55	1107.17	0.27
One	900	2006	19678.00	0.27	13.06		13.31	0.000390	4.72	8407.80	1082.65	0.23
One	880	NO US1 CONST	19678.00	0.27	12.27		12.65	0.000493	5.71	7513.28	1106.40	0.29
One	880	2006	19678.00	0.27	12.98		13.28	0.000374	5.17	8182.97	1093.64	0.26
One	860	NO US1 CONST	19678.00	0.28	12.20		12.62	0.000530	5.86	6960.05	1104.85	0.30
One	860	2006	19678.00	0.28	12.92		13.26	0.000401	5.31	7655.98	1091.45	0.27
One	840	NO US1 CONST	19678.00	0.27	12.09		12.58	0.000582	6.03	5877.36	1072.00	0.32
One	840	2006	19678.00	0.27	12.84		13.23	0.000435	5.44	6580.64	1067.18	0.28
One	820	NO US1 CONST	19678.00	0.27	12.11		12.52	0.000518	5.68	6703.02	1082.54	0.30
One	820	2006	19678.00	0.27	12.86		13.18	0.000391	5.15	7402.67	1075.66	0.26
One	800	NO US1 CONST	19678.00	0.30	12.11		12.48	0.000490	5.57	7288.57	1073.92	0.29
One	800	2006	19678.00	0.30	12.85		13.15	0.000374	5.07	7977.88	1070.27	0.26
One	780	NO US1 CONST	19678.00	0.30	12.07		12.45	0.000491	5.58	7258.05	1088.21	0.29
One	780	2006	19678.00	0.30	12.83		13.13	0.000372	5.06	7999.01	1089.06	0.25
One	760	NO US1 CONST	19678.00	0.27	12.07		12.41	0.000460	5.35	7459.03	1094.78	0.28
One	760	2006	19678.00	0.27	12.82		13.10	0.000349	4.86	8167.16	1088.36	0.25
One	740	NO US1 CONST	19678.00	0.27	12.06		12.38	0.000423	5.15	7923.99	1144.67	0.27
One	740	2006	19678.00	0.27	12.82		13.07	0.000321	4.68	8668.84	1138.28	0.24
One	720	NO US1 CONST	19678.00	0.27	12.04		12.35	0.000421	5.13	7883.49	1143.16	0.27
One	720	2006	19678.00	0.27	12.80		13.06	0.000319	4.67	8630.47	1136.67	0.24
One	700	NO US1 CONST	19678.00	0.28	11.80		12.30	0.000609	6.09	6095.12	1233.73	0.32
One	700	2006	19678.00	0.28	12.64		13.02	0.000442	5.45	6957.08	1223.69	0.28
One	680	NO US1 CONST	19678.00	-0.37	11.51		12.24	0.000804	6.92	3286.06	359.39	0.37
One	680	2006	19678.00	-0.37	12.37		12.97	0.000608	6.33	3402.31	334.00	0.32
One	660	NO US1 CONST	19678.00	-0.46	11.26		12.16	0.001037	7.75	2984.30	337.01	0.41
One	660	2006	19678.00	-0.46	12.19		12.91	0.000761	7.00	3120.83	319.81	0.36
One	659	NO US1 CONST	19678.00	-0.50	11.20		12.10	0.001049	7.72	2921.11	447.65	0.41
One	659	2006	19678.00	-0.50	12.15		12.87	0.000755	6.93	3369.85	657.86	0.36
One	640	NO US1 CONST	19678.00	-0.47	11.10		12.04	0.001064	7.86	2806.43	336.55	0.42
One	640	2006	19678.00	-0.47	12.06		12.82	0.000781	7.12	3078.49	369.25	0.36
One	625	NO US1 CONST	19678.00	-1.70	11.05		11.99	0.001019	7.86	2894.32	340.08	0.41
One	625	2006	19678.00	-1.70	12.03		12.77	0.000790	7.06	3130.35	388.85	0.35
One	610	NO US1 CONST	19678.00	-0.59	10.99		11.93	0.001034	7.84	2854.79	337.50	0.41
One	610	2006	19678.00	-0.59	11.98		12.73	0.000866	7.09	3094.03	344.83	0.36

Reach	River Sta	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)	
One	595	NO US1 CONST	19678.00	-2.00	11.00		11.85	0.000919	7.50	3020.06	317.67	0.39
One	595	2006	19678.00	-2.00	11.98		12.66	0.000765	6.78	3200.04	312.14	0.34
One	575	NO US1 CONST	19678.00	-1.26	10.80		11.79	0.001110	8.04	2753.55	310.77	0.42
One	575	2006	19678.00	-1.26	11.81		12.61	0.001048	7.30	2960.41	323.60	0.37
One	555	NO US1 CONST	19678.00	-2.00	10.80		11.71	0.001010	7.75	2843.12	305.40	0.41
One	555	2006	19678.00	-2.00	11.80		12.54	0.001072	7.05	3022.53	303.77	0.36
One	540	NO US1 CONST	19678.00	-1.82	10.75		11.65	0.000993	7.72	2940.32	323.83	0.40
One	540	2006	19678.00	-1.82	11.74		12.47	0.001192	7.04	3024.02	302.68	0.35
One	530	NO US1 CONST	19678.00	-2.00	10.57		11.58	0.001155	8.19	2807.97	294.54	0.43
One	530	2006	19678.00	-2.00	11.58		12.37	0.001493	7.37	2844.64	277.64	0.37
One	510	NO US1 CONST	19678.00	-1.99	10.52		11.49	0.001137	8.03	2859.61	316.24	0.43
One	510	2006	19678.00	-1.99	11.51		12.27	0.001488	7.20	2887.88	283.82	0.37
One	485	NO US1 CONST	19678.00	-2.30	10.49		11.41	0.001093	7.79	2821.70	312.10	0.42
One	485	2006	19678.00	-2.30	11.43		12.17	0.001595	7.01	2858.88	272.68	0.37
One	465	NO US1 CONST	19678.00	-1.61	10.29		11.32	0.001252	8.27	2729.03	315.52	0.45
One	465	2006	19678.00	-1.61	11.16		12.06	0.001434	7.78	2650.44	257.59	0.41
One	445	NO US1 CONST	19678.00	-1.20	10.32		11.21	0.001063	7.69	2931.98	325.83	0.42
One	445	2006	19678.00	-1.20	11.18		11.93	0.001194	7.11	2850.69	271.15	0.37
One	425	NO US1 CONST	19678.00	-0.91	10.34		11.11	0.000989	7.36	3448.48	340.71	0.40
One	425	2006	19678.00	-0.91	11.09		11.86	0.001231	7.17	2811.20	264.25	0.38
One	395	NO US1 CONST	19678.00	-2.50	10.23		11.05	0.000924	7.38	3100.73	325.85	0.39
One	395	2006	19678.00	-2.50	11.03		11.78	0.001287	7.06	2845.18	257.35	0.36
One	385	NO US1 CONST	19678.00	-2.12	10.13		10.99	0.001051	7.54	3000.40	339.70	0.41
One	385	2006	19678.00	-2.12	10.96		11.70	0.001200	7.05	2879.75	281.15	0.37
One	375	NO US1 CONST	19678.00	-3.50	10.02		10.92	0.001014	7.82	3140.83	331.73	0.41
One	375	2006	19678.00	-3.50	10.94		11.61	0.001074	6.75	3020.68	268.63	0.34
One	355	NO US1 CONST	19678.00	-3.50	9.93		10.85	0.001045	7.90	3099.06	332.28	0.41
One	355	2006	19678.00	-3.50	10.76		11.52	0.001256	7.26	2870.23	257.44	0.37
One	337	NO US1 CONST	19678.00	-2.23	9.91		10.76	0.001018	7.63	3101.02	373.19	0.41
One	337	2006	19678.00	-2.23	10.69		11.43	0.001235	7.15	2907.32	300.14	0.37
One	325	NO US1 CONST	19678.00	-2.25	9.95		10.68	0.000863	7.19	3398.99	399.94	0.38
One	325	2006	19678.00	-2.25	10.69		11.36	0.001048	6.80	3100.32	312.64	0.35
One	310	NO US1 CONST	19678.00	-2.25	9.87		10.64	0.000913	7.39	3328.01	395.72	0.39
One	310	2006	19678.00	-2.25	10.55		11.30	0.001354	7.24	2934.34	299.82	0.37
One	290	NO US1 CONST	19678.00	-2.00	9.89		10.55	0.000844	7.07	3866.13	495.67	0.38
One	290	2006	19678.00	-2.00	10.60		11.15	0.001393	6.41	3536.27	434.56	0.33
One	270	NO US1 CONST	19678.00	-2.00	9.79		10.48	0.000907	7.25	3722.84	484.39	0.39
One	270	2006	19678.00	-2.00	10.42		11.04	0.001540	6.86	3368.39	410.11	0.36
One	255	NO US1 CONST	19678.00	-2.27	9.82		10.41	0.000746	6.59	4106.33	533.49	0.35
One	255	2006	19678.00	-2.27	10.43		10.95	0.001042	6.14	3812.26	452.67	0.32
One	240	NO US1 CONST	19678.00	-2.27	9.74		10.37	0.000792	6.76	4065.24	529.08	0.36
One	240	2006	19678.00	-2.27	10.12		10.86	0.001767	7.29	3446.04	414.48	0.39
One	210	NO US1 CONST	19678.00	-2.00	9.77		10.29	0.000662	6.42	4891.30	613.46	0.34
One	210	2006	19678.00	-2.00	10.13		10.74	0.000846	6.77	4378.01	506.17	0.35
One	180	NO US1 CONST	19678.00	-2.00	9.72		10.25	0.000678	6.48	4838.30	611.09	0.34
One	180	2006	19678.00	-2.00	10.00		10.67	0.001168	7.14	4050.55	462.36	0.37
One	170	NO US1 CONST	19678.00	-2.00	9.68		10.21	0.000687	6.51	4813.21	609.79	0.34
One	170	2006	19678.00	-2.00	9.99		10.60	0.000911	6.78	4235.86	487.28	0.35
One	165	NO US1 CONST	19678.00	-2.00	9.66		10.19	0.000692	6.52	4801.19	609.17	0.34
One	165	2006	19678.00	-2.00	10.00		10.56	0.000671	6.55	4455.81	512.73	0.34
One	160	NO US1 CONST	19678.00	-2.00	9.64		10.17	0.000696	6.53	4789.10	608.54	0.34
One	160	2006	19678.00	-2.00	9.94		10.54	0.000962	6.74	4307.85	499.10	0.35

Reach	River Sta	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)	
One	155	NO US1 CONST	19678.00	-2.00	9.62		10.16	0.000701	6.55	4776.92	607.91	0.35
One	155	2006	19678.00	-2.00	9.94		10.51	0.000682	6.58	4427.94	511.06	0.34
One	150	NO US1 CONST	19678.00	-2.70	9.41		10.12	0.000904	7.33	4260.76	660.55	0.39
One	150	2006	19678.00	-2.70	9.73		10.47	0.000879	7.37	3940.25	525.74	0.39
One	145	NO US1 CONST	19678.00	-2.70	9.38		10.09	0.000914	7.36	4239.44	658.72	0.39
One	145	2006	19678.00	-2.70	9.75		10.42	0.000812	7.09	4150.82	568.01	0.37
One	135	NO US1 CONST	19678.00	-2.70	9.39		10.05	0.000861	7.17	4514.00	659.35	0.38
One	135	2006	19678.00	-2.70	9.65		10.39	0.000894	7.42	4131.94	527.80	0.39
One	130	NO US1 CONST	19678.00	-2.70	9.36		10.02	0.000870	7.19	4494.27	657.30	0.38
One	130	2006	19678.00	-2.70	9.69		10.34	0.000812	7.09	4334.75	557.06	0.37
One	120	NO US1 CONST	19678.00	-3.20	9.35		10.00	0.000826	7.19	4734.93	720.22	0.38
One	120	2006	19678.00	-3.20	9.71		10.30	0.000720	6.86	4704.39	634.98	0.35
One	110	NO US1 CONST	19678.00	-3.20	9.30		9.95	0.000840	7.23	4698.63	716.69	0.38
One	110	2006	19678.00	-3.20	9.68		10.26	0.000717	6.83	4779.58	657.40	0.35
One	100	NO US1 CONST	19678.00	-3.50	9.36		9.87	0.000653	6.52	5362.61	782.52	0.34
One	100	2006	19678.00	-3.50	9.68		10.21	0.000743	6.61	5052.98	677.19	0.34
One	99.8	NO US1 CONST	19678.00	-3.50	9.34		9.86	0.000657	6.53	5348.10	781.24	0.34
One	99.8	2006	19678.00	-3.50	9.70		10.18	0.000587	6.30	5361.06	715.69	0.32
One	99.7	NO US1 CONST	19678.00	-3.50	9.35		9.83	0.000614	6.33	5607.05	791.93	0.33
One	99.7	2006	19678.00	-3.50	9.68		10.16	0.000952	6.43	5147.31	685.41	0.33
One	99.6	NO US1 CONST	19678.00	-3.50	9.33		9.81	0.000618	6.34	5593.25	790.99	0.33
One	99.6	2006	19678.00	-3.50	9.63		10.14	0.000610	6.40	5374.83	709.27	0.33
One	99.5	NO US1 CONST	19678.00	-3.50	9.24		9.79	0.000690	6.66	5463.29	799.37	0.34
One	99.5	2006	19678.00	-3.50	9.66		10.10	0.000772	6.17	5602.44	753.77	0.31
One	99	NO US1 CONST	21237.00	-4.00	9.31	5.88	9.67	0.000740	5.48	6828.70	1402.89	0.34
One	99	2006	21237.00	-4.00	9.63	5.84	10.02	0.000725	5.56	6121.06	1165.97	0.34
One	96		Bridge									
One	95.5	NO US1 CONST	21237.00	-4.00	9.06		9.45	0.000824	5.67	6493.17	1364.18	0.35
One	95.5	2006	21237.00	-4.00	9.34		9.77	0.000831	5.82	5796.23	1067.22	0.36
One	95	NO US1 CONST	21237.00	-4.00	9.20		9.38	0.000556	4.65	9745.46	1426.48	0.26
One	95	2006	21237.00	-4.00	9.42		9.73	0.000564	5.55	8720.57	1300.63	0.30
One	94*	NO US1 CONST	21237.00	-4.50	9.14		9.33	0.000329	4.41	10778.34	1532.11	0.24
One	94*	2006	21237.00	-4.50	9.49		9.63	0.000316	3.93	11585.43	1586.71	0.21
One	93	NO US1 CONST	21237.00	-3.70	9.02		9.28	0.000495	5.48	10092.11	1591.61	0.29
One	93	2006	21237.00	-3.70	9.31		9.57	0.000551	5.42	9152.44	1416.62	0.28
One	90*	NO US1 CONST	21237.00	-3.30	8.90		9.17	0.000390	4.67	7687.33	1318.98	0.25
One	90*	2006	21237.00	-3.30	9.07		9.40	0.000807	5.26	6542.23	1061.06	0.28
One	88*	NO US1 CONST	21237.00	-2.90	8.83		9.07	0.000326	4.04	6445.66	934.16	0.23
One	88*	2006	21237.00	-2.90	9.00		9.24	0.000370	4.06	6415.96	920.37	0.23
One	85	NO US1 CONST	21237.00	-2.50	8.79		8.98	0.000280	3.52	6493.02	825.18	0.21
One	85	2006	21237.00	-2.50	8.96		9.14	0.000262	3.45	6634.22	827.44	0.20
One	79	NO US1 CONST	21237.00	-3.00	8.66		8.78	0.000307	4.06	15138.83	4482.11	0.22
One	79	2006	21237.00	-3.00	8.85		8.96	0.000267	3.83	16013.40	4506.96	0.21
One	78	NO US1 CONST	21237.00	-11.30	6.95	0.93	8.37	0.001269	9.63	2670.79	1391.17	0.46
One	78	2006	21237.00	-11.30	7.29	0.93	8.59	0.001140	9.24	3317.68	2322.00	0.43
One	77.5		Bridge									
One	77	NO US1 CONST	21237.00	-10.30	5.93	1.87	7.61	0.001930	10.40	2042.64	184.22	0.55
One	77	2006	21237.00	-10.30	5.93	1.87	7.61	0.001930	10.40	2042.64	184.22	0.55
One	76	NO US1 CONST	21237.00	-3.00	6.24	6.24	7.09	0.003475	8.00	4962.16	4203.55	0.66
One	76	2006	21237.00	-3.00	6.24	6.24	7.09	0.003475	8.00	4962.16	4203.55	0.66
One	75	NO US1 CONST	21237.00	-3.40	3.30	3.30	4.56	0.005723	9.22	2885.92	1825.76	0.83

HEC-RAS River: Cameron Run Reach: One (Continued)

Reach	River Sta	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)	
One	75	2006	21237.00	-3.40	3.30	3.30	4.56	0.005723	9.22	2885.92	1825.76	0.83



JUNE 2006 FLOOD EVENT 1) NO US1 CONST 2) 2006
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT - NO US1 CONST
WS JUNE 06 EVENT - 2006
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
77
85
88*
90*
93
95
99.5
130
180
270
355
425
510
575
659
720
800
880
960
1040
1120
1200
1280
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

HEC-RAS River: Cameron Run Reach: One

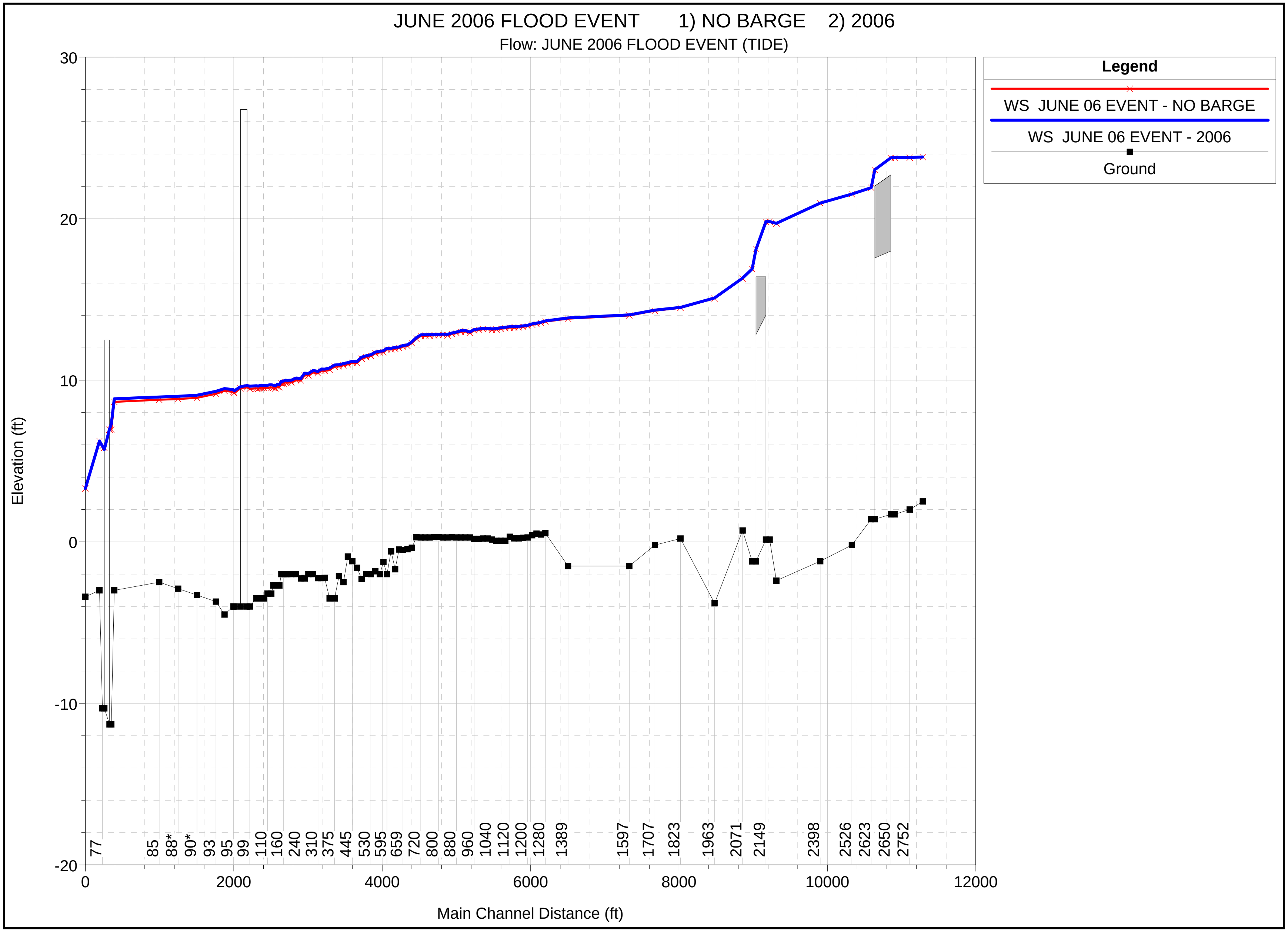
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	2806	NO BARGE	17857	2.5	23.8	9.4	24.0	0.0002	3.4	6046.2	404.7	0.1
One	2806	2006	17857	2.5	23.8	9.4	24.0	0.0002	3.4	6047.8	404.8	0.1
One	2752	NO BARGE	17857	2.0	23.8	9.8	24.0	0.0002	3.5	5956.0	556.9	0.1
One	2752	2006	17857	2.0	23.8	9.8	24.0	0.0002	3.5	5958.3	557.1	0.1
One	2677	NO BARGE	17857	1.7	23.8	9.2	23.9	0.0002	3.1	7687.0	1319.8	0.1
One	2677	2006	17857	1.7	23.8	9.2	23.9	0.0002	3.1	7692.3	1320.8	0.1
One	2650		Bridge									
One	2623	NO BARGE	17857	1.4	21.9	9.0	22.1	0.0003	3.7	5557.2	702.9	0.2
One	2623	2006	17857	1.4	21.9	9.0	22.1	0.0003	3.7	5561.0	703.7	0.2
One	2526	NO BARGE	17857	-0.2	21.5		22.0	0.0006	6.4	5913.9	630.6	0.2
One	2526	2006	17857	-0.2	21.5		22.0	0.0006	6.4	5917.7	630.7	0.2
One	2398	NO BARGE	17857	-1.2	21.0		21.7	0.0009	7.8	4675.7	629.8	0.3
One	2398	2006	17857	-1.2	21.0		21.7	0.0009	7.8	4679.9	630.5	0.3
One	2211	NO BARGE	19076	-2.4	19.7		21.0	0.0014	9.7	3372.0	451.0	0.4
One	2211	2006	19076	-2.4	19.7		21.0	0.0014	9.7	3376.4	451.0	0.4
One	2169	NO BARGE	19076	0.1	19.8	10.9	20.5	0.0012	8.1	3822.8	601.3	0.3
One	2169	2006	19076	0.1	19.8	10.9	20.5	0.0012	8.1	3829.2	601.4	0.3
One	2149		Bridge									
One	2129	NO BARGE	19076	-1.2	16.9	9.9	17.8	0.0013	8.6	3100.8	381.7	0.4
One	2129	2006	19076	-1.2	16.9	9.9	17.9	0.0013	8.5	3106.8	382.0	0.4
One	2071	NO BARGE	19076	0.7	16.3		17.6	0.0018	9.5	2817.4	255.4	0.4
One	2071	2006	19076	0.7	16.3		17.6	0.0018	9.5	2821.8	255.4	0.4
One	1963	NO BARGE	19076	-3.8	15.1		16.7	0.0028	11.1	2691.1	329.1	0.5
One	1963	2006	19076	-3.8	15.1		16.7	0.0027	11.1	2699.5	329.3	0.5
One	1823	NO BARGE	19076	0.2	14.5		15.5	0.0017	8.7	3212.5	449.6	0.4
One	1823	2006	19076	0.2	14.5		15.6	0.0017	8.7	3227.5	449.9	0.4
One	1707	NO BARGE	19678	-0.2	14.3		15.0	0.0009	6.9	3452.0	540.6	0.4
One	1707	2006	19678	-0.2	14.3		15.1	0.0009	6.9	3472.2	541.2	0.4
One	1597	NO BARGE	19678	-1.5	14.0		14.6	0.0011	7.6	5186.7	590.1	0.4
One	1597	2006	19678	-1.5	14.0		14.7	0.0011	7.6	5211.0	590.7	0.4
One	1389	NO BARGE	19678	-1.5	13.8		14.1	0.0003	5.0	8782.7	1017.4	0.2
One	1389	2006	19678	-1.5	13.9		14.1	0.0003	4.9	8828.1	1018.5	0.2
One	1280	NO BARGE	19678	0.5	13.6		14.0	0.0004	5.4	6768.3	888.2	0.3
One	1280	2006	19678	0.5	13.7		14.0	0.0004	5.3	6810.0	890.6	0.3
One	1260	NO BARGE	19678	0.4	13.5		13.9	0.0004	5.7	6456.9	887.4	0.3
One	1260	2006	19678	0.4	13.6		14.0	0.0004	5.7	6499.5	889.9	0.3
One	1240	NO BARGE	19678	0.5	13.5		13.9	0.0005	5.9	6264.2	888.8	0.3
One	1240	2006	19678	0.5	13.5		13.9	0.0005	5.8	6307.7	891.2	0.3
One	1220	NO BARGE	19678	0.4	13.4		13.9	0.0005	6.0	6194.0	876.8	0.3
One	1220	2006	19678	0.4	13.5		13.9	0.0005	5.9	6237.6	879.3	0.3
One	1200	NO BARGE	19678	0.3	13.4		13.8	0.0006	6.3	5934.1	872.6	0.3
One	1200	2006	19678	0.3	13.4		13.9	0.0006	6.3	5978.6	875.1	0.3
One	1180	NO BARGE	19678	0.3	13.3		13.8	0.0006	6.3	5957.8	880.4	0.3
One	1180	2006	19678	0.3	13.4		13.9	0.0005	6.3	6003.5	883.0	0.3
One	1160	NO BARGE	19678	0.2	13.3		13.8	0.0006	6.2	5785.9	878.9	0.3
One	1160	2006	19678	0.2	13.3		13.8	0.0006	6.2	5832.1	881.5	0.3
One	1140	NO BARGE	19678	0.2	13.3		13.7	0.0006	6.1	6034.7	927.8	0.3
One	1140	2006	19678	0.2	13.3		13.8	0.0006	6.1	6083.9	930.4	0.3
One	1120	NO BARGE	19678	0.3	13.3		13.7	0.0006	5.9	6576.3	980.1	0.3
One	1120	2006	19678	0.3	13.3		13.7	0.0005	5.8	6628.6	981.2	0.3
One	1100	NO BARGE	19678	0.1	13.2		13.6	0.0005	5.8	6642.0	1031.8	0.3

Reach	River Sta	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)	
One	1100	2006	19678	0.1	13.3		13.7	0.0005	5.8	6697.8	1033.4	0.3
One	1080	NO BARGE	19678	0.1	13.2		13.6	0.0005	5.9	6666.4	1030.6	0.3
One	1080	2006	19678	0.1	13.2		13.7	0.0005	5.9	6722.7	1032.3	0.3
One	1060	NO BARGE	19678	0.1	13.1		13.6	0.0005	6.0	6901.5	1088.2	0.3
One	1060	2006	19678	0.1	13.2		13.6	0.0005	5.9	6962.1	1090.2	0.3
One	1040	NO BARGE	19678	0.1	13.1		13.5	0.0005	6.0	7106.8	1087.3	0.3
One	1040	2006	19678	0.1	13.2		13.6	0.0005	6.0	7167.9	1089.3	0.3
One	1020	NO BARGE	19678	0.2	13.2		13.5	0.0004	5.4	8199.3	1097.3	0.3
One	1020	2006	19678	0.2	13.2		13.5	0.0004	5.4	8260.1	1098.7	0.3
One	1000	NO BARGE	19678	0.2	13.2		13.5	0.0004	5.3	8519.6	1088.1	0.3
One	1000	2006	19678	0.2	13.2		13.5	0.0004	5.2	8579.9	1089.9	0.3
One	980	NO BARGE	19678	0.2	13.1		13.4	0.0004	5.4	8171.1	1080.4	0.3
One	980	2006	19678	0.2	13.2		13.5	0.0004	5.3	8231.9	1082.1	0.3
One	960	NO BARGE	19678	0.2	13.1		13.4	0.0004	5.4	7845.2	1079.3	0.3
One	960	2006	19678	0.2	13.1		13.5	0.0004	5.3	7906.8	1081.0	0.3
One	940	NO BARGE	19678	0.3	12.9		13.4	0.0005	5.9	6348.0	943.4	0.3
One	940	2006	19678	0.3	13.0		13.4	0.0005	5.8	6403.6	948.1	0.3
One	920	NO BARGE	19678	0.3	13.0		13.3	0.0004	4.9	8128.3	1064.4	0.2
One	920	2006	19678	0.3	13.1		13.3	0.0004	4.9	8190.1	1065.6	0.2
One	900	NO BARGE	19678	0.3	13.0		13.3	0.0004	4.7	8344.7	1081.1	0.2
One	900	2006	19678	0.3	13.1		13.3	0.0004	4.7	8407.8	1082.6	0.2
One	880	NO BARGE	19678	0.3	12.9		13.2	0.0004	5.2	8117.7	1092.4	0.3
One	880	2006	19678	0.3	13.0		13.3	0.0004	5.2	8183.0	1093.6	0.3
One	860	NO BARGE	19678	0.3	12.9		13.2	0.0004	5.3	7589.3	1090.2	0.3
One	860	2006	19678	0.3	12.9		13.3	0.0004	5.3	7656.0	1091.5	0.3
One	840	NO BARGE	19678	0.3	12.8		13.2	0.0004	5.5	6513.7	1065.3	0.3
One	840	2006	19678	0.3	12.8		13.2	0.0004	5.4	6580.6	1067.2	0.3
One	820	NO BARGE	19678	0.3	12.8		13.1	0.0004	5.2	7335.5	1073.8	0.3
One	820	2006	19678	0.3	12.9		13.2	0.0004	5.2	7402.7	1075.7	0.3
One	800	NO BARGE	19678	0.3	12.8		13.1	0.0004	5.1	7911.0	1068.3	0.3
One	800	2006	19678	0.3	12.9		13.2	0.0004	5.1	7977.9	1070.3	0.3
One	780	NO BARGE	19678	0.3	12.8		13.1	0.0004	5.1	7930.4	1087.0	0.3
One	780	2006	19678	0.3	12.8		13.1	0.0004	5.1	7999.0	1089.1	0.3
One	760	NO BARGE	19678	0.3	12.8		13.0	0.0004	4.9	8098.5	1086.3	0.2
One	760	2006	19678	0.3	12.8		13.1	0.0003	4.9	8167.2	1088.4	0.2
One	740	NO BARGE	19678	0.3	12.8		13.0	0.0003	4.7	8596.8	1136.3	0.2
One	740	2006	19678	0.3	12.8		13.1	0.0003	4.7	8668.8	1138.3	0.2
One	720	NO BARGE	19678	0.3	12.7		13.0	0.0003	4.7	8558.1	1134.6	0.2
One	720	2006	19678	0.3	12.8		13.1	0.0003	4.7	8630.5	1136.7	0.2
One	700	NO BARGE	19678	0.3	12.6		13.0	0.0005	5.5	6873.7	1221.4	0.3
One	700	2006	19678	0.3	12.6		13.0	0.0004	5.4	6957.1	1223.7	0.3
One	680	NO BARGE	19678	-0.4	12.3		12.9	0.0006	6.4	3379.5	331.7	0.3
One	680	2006	19678	-0.4	12.4		13.0	0.0006	6.3	3402.3	334.0	0.3
One	660	NO BARGE	19678	-0.5	12.1		12.9	0.0008	7.0	3098.1	316.7	0.4
One	660	2006	19678	-0.5	12.2		12.9	0.0008	7.0	3120.8	319.8	0.4
One	659	NO BARGE	19678	-0.5	12.1		12.8	0.0008	7.0	3322.1	640.5	0.4
One	659	2006	19678	-0.5	12.2		12.9	0.0008	6.9	3369.8	657.9	0.4
One	640	NO BARGE	19678	-0.5	12.0		12.8	0.0008	7.2	3051.4	365.2	0.4
One	640	2006	19678	-0.5	12.1		12.8	0.0008	7.1	3078.5	369.3	0.4
One	625	NO BARGE	19678	-1.7	12.0		12.7	0.0008	7.1	3102.5	364.9	0.4
One	625	2006	19678	-1.7	12.0		12.8	0.0008	7.1	3130.4	388.8	0.4

Reach	River Sta	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)	
One	610	NO BARGE	19678	-0.6	11.9		12.7	0.0009	7.1	3067.9	342.6	0.4
One	610	2006	19678	-0.6	12.0		12.7	0.0009	7.1	3094.0	344.8	0.4
One	595	NO BARGE	19678	-2.0	11.9		12.6	0.0008	6.8	3176.4	310.6	0.3
One	595	2006	19678	-2.0	12.0		12.7	0.0008	6.8	3200.0	312.1	0.3
One	575	NO BARGE	19678	-1.3	11.7		12.5	0.0011	7.4	2934.7	320.9	0.4
One	575	2006	19678	-1.3	11.8		12.6	0.0010	7.3	2960.4	323.6	0.4
One	555	NO BARGE	19678	-2.0	11.7		12.5	0.0011	7.1	2998.2	302.2	0.4
One	555	2006	19678	-2.0	11.8		12.5	0.0011	7.1	3022.5	303.8	0.4
One	540	NO BARGE	19678	-1.8	11.7		12.4	0.0012	7.1	2999.3	300.9	0.4
One	540	2006	19678	-1.8	11.7		12.5	0.0012	7.0	3024.0	302.7	0.4
One	530	NO BARGE	19678	-2.0	11.5		12.3	0.0015	7.4	2821.1	276.0	0.4
One	530	2006	19678	-2.0	11.6		12.4	0.0015	7.4	2844.6	277.6	0.4
One	510	NO BARGE	19678	-2.0	11.4		12.2	0.0015	7.3	2863.3	280.6	0.4
One	510	2006	19678	-2.0	11.5		12.3	0.0015	7.2	2887.9	283.8	0.4
One	485	NO BARGE	19678	-2.3	11.3		12.1	0.0016	7.1	2834.4	272.3	0.4
One	485	2006	19678	-2.3	11.4		12.2	0.0016	7.0	2858.9	272.7	0.4
One	465	NO BARGE	19678	-1.6	11.1		12.0	0.0015	7.8	2626.0	252.6	0.4
One	465	2006	19678	-1.6	11.2		12.1	0.0014	7.8	2650.4	257.6	0.4
One	445	NO BARGE	19678	-1.2	11.1		11.9	0.0012	7.2	2824.6	270.7	0.4
One	445	2006	19678	-1.2	11.2		11.9	0.0012	7.1	2850.7	271.1	0.4
One	425	NO BARGE	19678	-0.9	11.0		11.8	0.0013	7.2	2785.1	264.0	0.4
One	425	2006	19678	-0.9	11.1		11.9	0.0012	7.2	2811.2	264.3	0.4
One	395	NO BARGE	19678	-2.5	10.9		11.7	0.0013	7.1	2819.4	257.0	0.4
One	395	2006	19678	-2.5	11.0		11.8	0.0013	7.1	2845.2	257.4	0.4
One	385	NO BARGE	19678	-2.1	10.9		11.6	0.0012	7.1	2850.6	280.8	0.4
One	385	2006	19678	-2.1	11.0		11.7	0.0012	7.0	2879.8	281.2	0.4
One	375	NO BARGE	19678	-3.5	10.8		11.5	0.0011	6.8	2992.9	268.4	0.3
One	375	2006	19678	-3.5	10.9		11.6	0.0011	6.7	3020.7	268.6	0.3
One	355	NO BARGE	19678	-3.5	10.6		11.4	0.0013	7.3	2842.3	257.2	0.4
One	355	2006	19678	-3.5	10.8		11.5	0.0013	7.3	2870.2	257.4	0.4
One	337	NO BARGE	19678	-2.2	10.6		11.3	0.0013	7.2	2873.6	299.0	0.4
One	337	2006	19678	-2.2	10.7		11.4	0.0012	7.2	2907.3	300.1	0.4
One	325	NO BARGE	19678	-2.3	10.6		11.3	0.0011	6.9	3065.0	312.0	0.4
One	325	2006	19678	-2.3	10.7		11.4	0.0010	6.8	3100.3	312.6	0.4
One	310	NO BARGE	19678	-2.3	10.4		11.2	0.0014	7.3	2899.0	299.2	0.4
One	310	2006	19678	-2.3	10.5		11.3	0.0014	7.2	2934.3	299.8	0.4
One	290	NO BARGE	19678	-2.0	10.5		11.0	0.0014	6.5	3485.5	427.0	0.3
One	290	2006	19678	-2.0	10.6		11.1	0.0014	6.4	3536.3	434.6	0.3
One	270	NO BARGE	19678	-2.0	10.3		10.9	0.0016	6.9	3318.4	402.2	0.4
One	270	2006	19678	-2.0	10.4		11.0	0.0015	6.9	3368.4	410.1	0.4
One	255	NO BARGE	19678	-2.3	10.3		10.8	0.0011	6.2	3756.6	447.5	0.3
One	255	2006	19678	-2.3	10.4		10.9	0.0010	6.1	3812.3	452.7	0.3
One	240	NO BARGE	19678	-2.3	10.0		10.7	0.0018	7.4	3391.0	408.7	0.4
One	240	2006	19678	-2.3	10.1		10.9	0.0018	7.3	3446.0	414.5	0.4
One	210	NO BARGE	19678	-2.0	10.0		10.6	0.0009	6.9	4311.2	499.3	0.4
One	210	2006	19678	-2.0	10.1		10.7	0.0008	6.8	4378.0	506.2	0.3
One	180	NO BARGE	19678	-2.0	9.9		10.5	0.0012	7.2	3985.8	458.0	0.4
One	180	2006	19678	-2.0	10.0		10.7	0.0012	7.1	4050.6	462.4	0.4
One	170	NO BARGE	19678	-2.0	9.8		10.5	0.0009	6.9	4167.4	482.9	0.4
One	170	2006	19678	-2.0	10.0		10.6	0.0009	6.8	4235.9	487.3	0.4
One	165	NO BARGE	19678	-2.0	9.9		10.4	0.0007	6.6	4383.9	508.3	0.3
One	165	2006	19678	-2.0	10.0		10.6	0.0007	6.6	4455.8	512.7	0.3

Reach	River Sta	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)	
One	160	NO BARGE	19678	-2.0	9.8		10.4	0.0010	6.8	4236.4	494.7	0.4
One	160	2006	19678	-2.0	9.9		10.5	0.0010	6.7	4307.8	499.1	0.4
One	155	NO BARGE	19678	-2.0	9.8		10.4	0.0007	6.7	4354.8	506.6	0.3
One	155	2006	19678	-2.0	9.9		10.5	0.0007	6.6	4427.9	511.1	0.3
One	150	NO BARGE	19678	-2.7	9.6		10.3	0.0009	7.5	3859.1	518.5	0.4
One	150	2006	19678	-2.7	9.7		10.5	0.0009	7.4	3940.3	525.7	0.4
One	145	NO BARGE	19678	-2.7	9.6		10.3	0.0009	7.2	4063.0	560.8	0.4
One	145	2006	19678	-2.7	9.8		10.4	0.0008	7.1	4150.8	568.0	0.4
One	135	NO BARGE	19678	-2.7	9.5		10.3	0.0009	7.5	4050.0	520.6	0.4
One	135	2006	19678	-2.7	9.7		10.4	0.0009	7.4	4131.9	527.8	0.4
One	130	NO BARGE	19678	-2.7	9.5		10.2	0.0009	7.2	4248.3	549.8	0.4
One	130	2006	19678	-2.7	9.7		10.3	0.0008	7.1	4334.8	557.1	0.4
One	120	NO BARGE	19678	-3.2	9.6		10.2	0.0008	7.0	4605.4	626.8	0.4
One	120	2006	19678	-3.2	9.7		10.3	0.0007	6.9	4704.4	635.0	0.4
One	110	NO BARGE	19678	-3.2	9.5		10.1	0.0008	6.9	4675.8	649.1	0.4
One	110	2006	19678	-3.2	9.7		10.3	0.0007	6.8	4779.6	657.4	0.4
One	100	NO BARGE	19678	-3.5	9.5		10.1	0.0008	6.7	4945.6	669.4	0.3
One	100	2006	19678	-3.5	9.7		10.2	0.0007	6.6	5053.0	677.2	0.3
One	99.8	NO BARGE	19678	-3.5	9.5		10.0	0.0006	6.4	5247.9	707.9	0.3
One	99.8	2006	19678	-3.5	9.7		10.2	0.0006	6.3	5361.1	715.7	0.3
One	99.7	NO BARGE	19678	-3.5	9.5		10.0	0.0010	6.5	5037.5	677.2	0.3
One	99.7	2006	19678	-3.5	9.7		10.2	0.0010	6.4	5147.3	685.4	0.3
One	99.6	NO BARGE	19678	-3.5	9.5		10.0	0.0006	6.5	5261.5	701.1	0.3
One	99.6	2006	19678	-3.5	9.6		10.1	0.0006	6.4	5374.8	709.3	0.3
One	99.5	NO BARGE	19678	-3.5	9.5		10.0	0.0008	6.3	5481.4	745.8	0.3
One	99.5	2006	19678	-3.5	9.7		10.1	0.0008	6.2	5602.4	753.8	0.3
One	99	NO BARGE	21237	-4.0	9.5	5.8	9.9	0.0008	5.7	5937.1	1111.1	0.3
One	99	2006	21237	-4.0	9.6	5.8	10.0	0.0007	5.6	6121.1	1166.0	0.3
One	96		Bridge									
One	95.5	NO BARGE	21237	-4.0	9.2		9.6	0.0009	5.9	5649.5	1021.2	0.4
One	95.5	2006	21237	-4.0	9.3		9.8	0.0008	5.8	5796.2	1067.2	0.4
One	95	NO BARGE	21237	-4.0	9.3		9.6	0.0006	5.6	8542.0	1253.2	0.3
One	95	2006	21237	-4.0	9.4		9.7	0.0006	5.5	8720.6	1300.6	0.3
One	94*	NO BARGE	21237	-4.5	9.3		9.5	0.0003	4.0	11359.9	1583.9	0.2
One	94*	2006	21237	-4.5	9.5		9.6	0.0003	3.9	11585.4	1586.7	0.2
One	93	NO BARGE	21237	-3.7	9.2		9.4	0.0006	5.5	8941.6	1386.2	0.3
One	93	2006	21237	-3.7	9.3		9.6	0.0006	5.4	9152.4	1416.6	0.3
One	90*	NO BARGE	21237	-3.3	8.9		9.2	0.0009	5.4	6372.1	1033.4	0.3
One	90*	2006	21237	-3.3	9.1		9.4	0.0008	5.3	6542.2	1061.1	0.3
One	88*	NO BARGE	21237	-2.9	8.8		9.1	0.0004	4.1	6262.7	910.2	0.2
One	88*	2006	21237	-2.9	9.0		9.2	0.0004	4.1	6416.0	920.4	0.2
One	85	NO BARGE	21237	-2.5	8.8		9.0	0.0003	3.5	6493.0	825.2	0.2
One	85	2006	21237	-2.5	9.0		9.1	0.0003	3.5	6634.2	827.4	0.2
One	79	NO BARGE	21237	-3.0	8.7		8.8	0.0003	4.1	15138.8	4482.1	0.2
One	79	2006	21237	-3.0	8.9		9.0	0.0003	3.8	16013.4	4507.0	0.2
One	78	NO BARGE	21237	-11.3	6.9	0.9	8.4	0.0013	9.6	2670.8	1391.2	0.5
One	78	2006	21237	-11.3	7.3	0.9	8.6	0.0011	9.2	3317.7	2322.0	0.4
One	77.5		Bridge									
One	77	NO BARGE	21237	-10.3	5.9	1.9	7.6	0.0019	10.4	2042.6	184.2	0.6
One	77	2006	21237	-10.3	5.9	1.9	7.6	0.0019	10.4	2042.6	184.2	0.6

Reach	River Sta	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)	
One	76	NO BARGE	21237	-3.0	6.2	6.2	7.1	0.0035	8.0	4962.2	4203.6	0.7
One	76	2006	21237	-3.0	6.2	6.2	7.1	0.0035	8.0	4962.2	4203.6	0.7
One	75	NO BARGE	21237	-3.4	3.3	3.3	4.6	0.0057	9.2	2885.9	1825.8	0.8
One	75	2006	21237	-3.4	3.3	3.3	4.6	0.0057	9.2	2885.9	1825.8	0.8



JUNE 2006 FLOOD EVENT 1) NO BARGE 2) 2006
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT - NO BARGE
WS JUNE 06 EVENT - 2006
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
77
85
88*
90*
93
95
99
110
160
240
310
375
445
530
595
659
720
800
880
960
1040
1120
1200
1280
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

HEC-RAS River: Cameron Run Reach: One

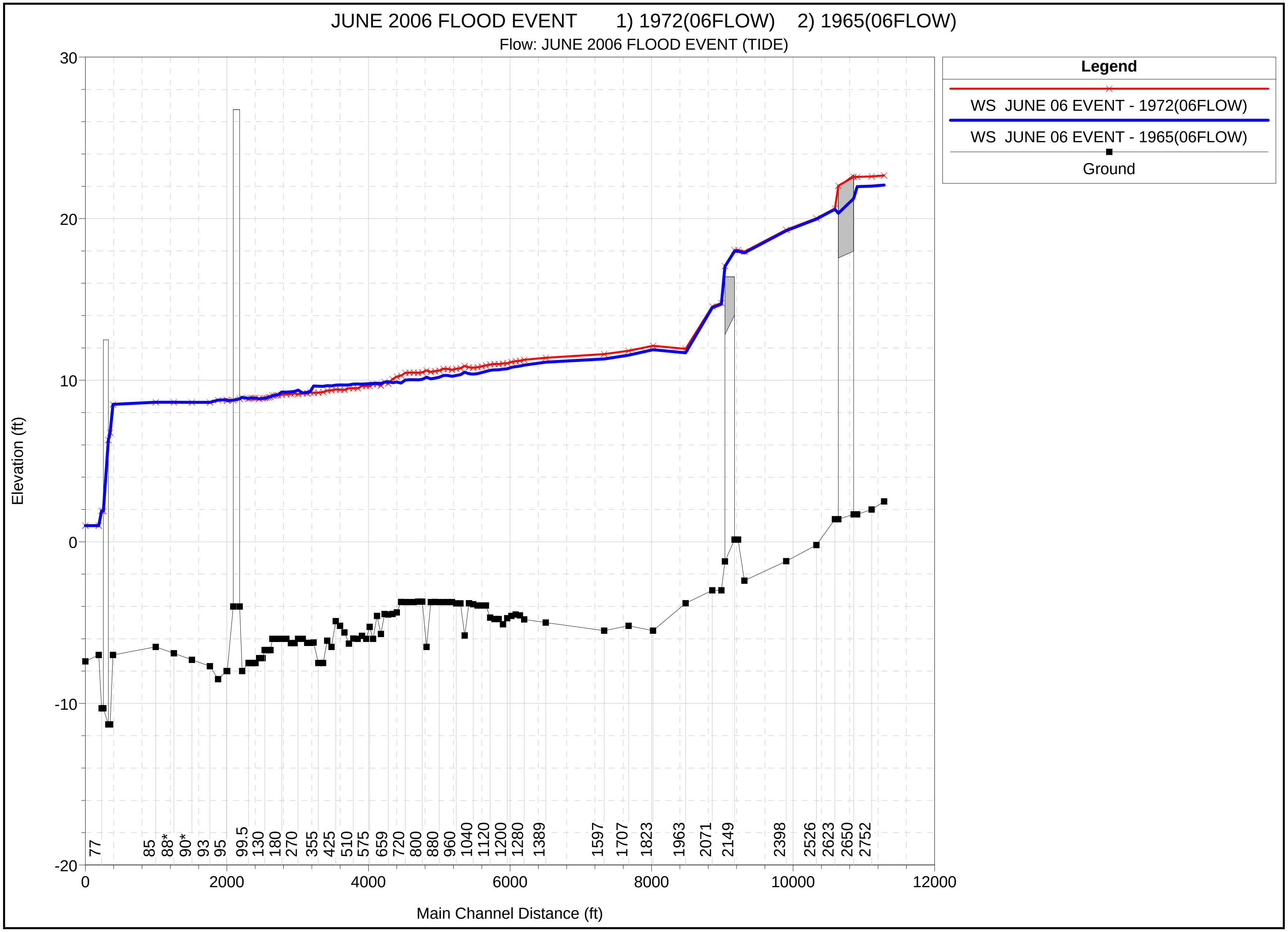
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	2806	1972(06FLOW)	17857	2.5	22.7	9.4	22.9	0.0002	3.7	5595.1	388.9	0.2
One	2806	1965(06FLOW)	17857	2.5	22.1	9.4	22.3	0.0003	3.8	5364.2	388.8	0.2
One	2752	1972(06FLOW)	17857	2.0	22.6	9.8	22.8	0.0002	3.8	5335.5	523.2	0.2
One	2752	1965(06FLOW)	17857	2.0	22.0	9.8	22.2	0.0003	3.9	5058.8	437.5	0.2
One	2677	1972(06FLOW)	17857	1.7	22.6	9.2	22.8	0.0002	3.4	5299.2	971.7	0.1
One	2677	1965(06FLOW)	17857	1.7	22.0	9.2	22.2	0.0002	3.6	5087.6	844.7	0.2
One	2650		Bridge									
One	2623	1972(06FLOW)	17857	1.4	20.6	9.0	20.9	0.0003	4.0	4771.6	527.4	0.2
One	2623	1965(06FLOW)	17857	1.4	20.6	9.0	20.8	0.0003	4.0	4749.8	522.5	0.2
One	2526	1972(06FLOW)	17857	-0.2	20.0		20.6	0.0008	7.3	4997.0	601.7	0.3
One	2526	1965(06FLOW)	17857	-0.2	20.0		20.6	0.0008	7.4	4966.9	600.8	0.3
One	2398	1972(06FLOW)	17857	-1.2	19.3		20.2	0.0012	8.7	3768.6	487.4	0.4
One	2398	1965(06FLOW)	17857	-1.2	19.3		20.2	0.0012	8.8	3740.7	484.0	0.4
One	2211	1972(06FLOW)	19076	-2.4	18.0		19.3	0.0018	10.2	2852.9	253.4	0.4
One	2211	1965(06FLOW)	19076	-2.4	17.9		19.3	0.0018	10.2	2835.2	251.3	0.4
One	2169	1972(06FLOW)	19076	0.1	18.1	10.9	18.9	0.0016	8.9	3260.5	277.5	0.4
One	2169	1965(06FLOW)	19076	0.1	18.0	10.9	18.9	0.0016	9.0	3240.9	276.5	0.4
One	2149		Bridge									
One	2129	1972(06FLOW)	19076	-3.0	14.8	9.3	16.1	0.0019	9.7	2567.1	259.7	0.4
One	2129	1965(06FLOW)	19076	-3.0	14.7	9.3	16.0	0.0019	9.8	2549.3	258.9	0.4
One	2071	1972(06FLOW)	19076	-3.0	14.6		15.8	0.0017	9.4	2676.6	229.2	0.4
One	2071	1965(06FLOW)	19076	-3.0	14.5		15.8	0.0018	9.4	2660.3	228.6	0.4
One	1963	1972(06FLOW)	19076	-3.8	11.9		14.6	0.0057	14.1	1952.3	205.3	0.7
One	1963	1965(06FLOW)	19076	-3.8	11.7		14.5	0.0061	14.4	1902.5	204.1	0.7
One	1823	1972(06FLOW)	19076	-5.5	12.1		13.1	0.0012	7.9	3268.5	546.7	0.3
One	1823	1965(06FLOW)	19076	-5.5	11.9		12.9	0.0013	8.1	3138.2	527.5	0.4
One	1707	1972(06FLOW)	19678	-5.2	11.8		12.7	0.0010	8.0	3747.4	558.4	0.4
One	1707	1965(06FLOW)	19678	-5.2	11.5		12.4	0.0011	8.2	3595.3	532.4	0.4
One	1597	1972(06FLOW)	19678	-5.5	11.6		12.4	0.0007	7.6	4973.1	649.3	0.3
One	1597	1965(06FLOW)	19678	-5.5	11.3		12.1	0.0007	7.8	4780.1	643.0	0.4
One	1389	1972(06FLOW)	19678	-5.0	11.4		11.8	0.0005	5.8	6820.3	956.2	0.3
One	1389	1965(06FLOW)	19678	-5.0	11.1		11.5	0.0005	5.8	6561.1	949.3	0.3
One	1280	1972(06FLOW)	19678	-4.8	11.3		11.7	0.0004	5.5	5931.2	795.4	0.3
One	1280	1965(06FLOW)	19678	-4.8	10.9		11.4	0.0004	5.7	5672.7	778.0	0.3
One	1260	1972(06FLOW)	19678	-4.6	11.2		11.7	0.0004	5.7	5654.9	787.5	0.3
One	1260	1965(06FLOW)	19678	-4.6	10.9		11.4	0.0004	5.9	5395.9	768.6	0.3
One	1240	1972(06FLOW)	19678	-4.5	11.2		11.6	0.0004	5.7	5511.6	800.7	0.3
One	1240	1965(06FLOW)	19678	-4.5	10.8		11.3	0.0004	5.9	5245.2	783.0	0.3
One	1220	1972(06FLOW)	19678	-4.6	11.1		11.6	0.0004	5.8	5423.4	788.4	0.3
One	1220	1965(06FLOW)	19678	-4.6	10.8		11.3	0.0004	6.0	5158.1	770.5	0.3
One	1200	1972(06FLOW)	19678	-4.7	11.1		11.6	0.0004	6.1	5144.5	782.6	0.3
One	1200	1965(06FLOW)	19678	-4.7	10.7		11.3	0.0005	6.3	4875.1	764.3	0.3
One	1180	1972(06FLOW)	19678	-5.1	11.0		11.6	0.0004	6.1	5199.7	791.6	0.3
One	1180	1965(06FLOW)	19678	-5.1	10.7		11.2	0.0004	6.2	4925.8	773.2	0.3
One	1160	1972(06FLOW)	19678	-4.8	11.0		11.5	0.0004	6.1	4987.6	790.4	0.3
One	1160	1965(06FLOW)	19678	-4.8	10.6		11.2	0.0005	6.3	4711.3	771.8	0.3
One	1140	1972(06FLOW)	19678	-4.8	11.0		11.5	0.0004	5.9	5181.5	840.2	0.3
One	1140	1965(06FLOW)	19678	-4.8	10.6		11.2	0.0004	6.1	4886.4	821.5	0.3
One	1120	1972(06FLOW)	19678	-4.7	11.0		11.5	0.0004	5.9	5490.1	959.9	0.3
One	1120	1965(06FLOW)	19678	-4.7	10.6		11.2	0.0004	6.1	5145.9	951.7	0.3
One	1100	1972(06FLOW)	19678	-3.9	10.9		11.4	0.0005	6.1	5255.3	986.3	0.3
One	1100	1965(06FLOW)	19678	-3.9	10.5		11.1	0.0005	6.3	4890.5	974.0	0.3
One	1080	1972(06FLOW)	19678	-3.9	10.9		11.4	0.0005	6.3	5233.0	984.6	0.3
One	1080	1965(06FLOW)	19678	-3.9	10.5		11.1	0.0006	6.5	4859.5	972.0	0.3

Reach	River Sta	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)	
One	1060	1972(06FLOW)	19678	-3.9	10.8		11.4	0.0005	6.4	5316.7	1026.6	0.3
One	1060	1965(06FLOW)	19678	-3.9	10.4		11.1	0.0006	6.7	4917.8	1011.3	0.3
One	1040	1972(06FLOW)	19678	-3.9	10.8		11.4	0.0005	6.5	5494.2	1026.1	0.3
One	1040	1965(06FLOW)	19678	-3.9	10.4		11.0	0.0006	6.7	5089.6	1010.6	0.3
One	1020	1972(06FLOW)	19678	-3.8	10.8		11.3	0.0005	6.1	6417.5	1033.3	0.3
One	1020	1965(06FLOW)	19678	-3.8	10.4		10.9	0.0005	6.3	6012.9	1019.4	0.3
One	1000	1972(06FLOW)	19678	-5.8	10.9		11.2	0.0003	5.1	7417.2	1037.2	0.2
One	1000	1965(06FLOW)	19678	-5.8	10.5		10.9	0.0003	5.3	7023.1	1023.8	0.2
One	980	1972(06FLOW)	19678	-3.8	10.7		11.2	0.0004	5.9	6561.5	1031.5	0.3
One	980	1965(06FLOW)	19678	-3.8	10.3		10.8	0.0005	6.2	6145.8	1018.2	0.3
One	960	1972(06FLOW)	19678	-3.8	10.7		11.2	0.0004	5.9	6254.2	1030.9	0.3
One	960	1965(06FLOW)	19678	-3.8	10.3		10.8	0.0005	6.2	5833.3	1017.4	0.3
One	940	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0004	5.9	5338.4	786.1	0.3
One	940	1965(06FLOW)	19678	-3.7	10.2		10.8	0.0005	6.1	5027.2	753.0	0.3
One	920	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0004	5.3	6712.6	1040.1	0.3
One	920	1965(06FLOW)	19678	-3.7	10.3		10.7	0.0004	5.6	6292.2	1030.5	0.3
One	900	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0003	5.1	7012.9	1066.7	0.2
One	900	1965(06FLOW)	19678	-3.7	10.3		10.7	0.0004	5.3	6581.4	1056.8	0.3
One	880	1972(06FLOW)	19678	-3.7	10.6		11.0	0.0004	5.6	6557.8	1066.7	0.3
One	880	1965(06FLOW)	19678	-3.7	10.2		10.7	0.0004	5.8	6111.0	1056.7	0.3
One	860	1972(06FLOW)	19678	-3.7	10.6		11.0	0.0004	5.6	6053.7	1066.0	0.3
One	860	1965(06FLOW)	19678	-3.7	10.1		10.6	0.0005	5.9	5600.1	1055.8	0.3
One	840	1972(06FLOW)	19678	-3.7	10.5		11.0	0.0004	5.6	5133.4	1019.0	0.3
One	840	1965(06FLOW)	19678	-3.7	10.1		10.6	0.0005	5.9	4699.5	1004.6	0.3
One	820	1972(06FLOW)	19678	-6.5	10.6		10.9	0.0002	4.6	6710.2	1032.2	0.2
One	820	1965(06FLOW)	19678	-6.5	10.2		10.5	0.0002	4.8	6283.7	1018.3	0.2
One	800	1972(06FLOW)	19678	-3.7	10.5		10.9	0.0004	5.4	6483.1	1017.7	0.3
One	800	1965(06FLOW)	19678	-3.7	10.1		10.5	0.0004	5.6	6041.9	1002.6	0.3
One	780	1972(06FLOW)	19678	-3.7	10.5		10.9	0.0004	5.4	6450.4	1025.7	0.3
One	780	1965(06FLOW)	19678	-3.7	10.0		10.5	0.0004	5.6	6002.2	1010.9	0.3
One	760	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	5.2	6681.3	1038.7	0.2
One	760	1965(06FLOW)	19678	-3.7	10.0		10.4	0.0004	5.4	6227.1	1023.3	0.3
One	740	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	5.0	7126.4	1088.4	0.2
One	740	1965(06FLOW)	19678	-3.7	10.0		10.4	0.0004	5.2	6649.8	1072.8	0.3
One	720	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	4.9	7109.6	1087.9	0.2
One	720	1965(06FLOW)	19678	-3.7	10.0		10.4	0.0004	5.1	6630.6	1072.4	0.2
One	700	1972(06FLOW)	19678	-3.7	10.3		10.8	0.0004	5.6	5223.3	1180.7	0.3
One	700	1965(06FLOW)	19678	-3.7	9.8		10.3	0.0005	5.8	4693.5	1049.6	0.3
One	680	1972(06FLOW)	19678	-4.4	10.2		10.7	0.0004	5.7	3802.3	345.9	0.3
One	680	1965(06FLOW)	19678	-4.4	9.9		10.3	0.0004	5.3	6432.6	1182.6	0.3
One	660	1972(06FLOW)	19678	-4.5	10.1		10.7	0.0005	6.3	3466.5	313.0	0.3
One	660	1965(06FLOW)	19678	-4.5	9.8		10.3	0.0004	5.6	6465.7	1157.0	0.3
One	659	1972(06FLOW)	19678	-4.5	9.8		10.6	0.0009	7.4	2913.0	303.4	0.4
One	659	1965(06FLOW)	19678	-4.5	9.9		10.2	0.0004	5.1	7947.9	1184.4	0.3
One	640	1972(06FLOW)	19678	-4.5	9.9		10.5	0.0005	6.4	3288.8	302.0	0.3
One	640	1965(06FLOW)	19678	-4.5	9.9		10.2	0.0003	4.9	7246.9	896.3	0.2
One	625	1972(06FLOW)	19678	-5.7	9.7		10.5	0.0008	7.3	2981.7	291.7	0.4
One	625	1965(06FLOW)	19678	-5.7	9.8		10.2	0.0004	5.5	6670.0	879.9	0.3
One	610	1972(06FLOW)	19678	-4.6	9.8		10.4	0.0005	6.4	3313.0	308.3	0.3
One	610	1965(06FLOW)	19678	-4.6	9.8		10.1	0.0003	5.0	7129.7	879.2	0.2
One	595	1972(06FLOW)	19678	-6.0	9.7		10.3	0.0005	6.3	3468.0	298.2	0.3
One	595	1965(06FLOW)	19678	-6.0	9.8		10.1	0.0003	4.9	7199.3	909.8	0.2
One	575	1972(06FLOW)	19678	-5.3	9.6		10.3	0.0006	6.6	3223.1	279.2	0.3
One	575	1965(06FLOW)	19678	-5.3	9.8		10.1	0.0003	4.9	7668.3	985.4	0.2

HEC-RAS River: Cameron Run Reach: One (Continued)

Reach	River Sta	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)	
One	555	1972(06FLOW)	19678	-6.0	9.6		10.3	0.0005	6.4	3323.3	288.0	0.3
One	555	1965(06FLOW)	19678	-6.0	9.8		10.1	0.0003	4.8	7426.9	915.2	0.2
One	540	1972(06FLOW)	19678	-5.8	9.6		10.2	0.0005	6.3	3455.8	303.1	0.3
One	540	1965(06FLOW)	19678	-5.8	9.8		10.0	0.0003	4.9	7563.3	1016.6	0.2
One	530	1972(06FLOW)	19678	-6.0	9.5		10.2	0.0006	6.7	3267.2	288.2	0.3
One	530	1965(06FLOW)	19678	-6.0	9.8		10.0	0.0003	4.7	7166.9	1017.0	0.2
One	510	1972(06FLOW)	19678	-6.0	9.5		10.1	0.0005	6.4	3396.2	313.2	0.3
One	510	1965(06FLOW)	19678	-6.0	9.8		10.0	0.0003	4.5	7451.9	1098.1	0.2
One	485	1972(06FLOW)	19678	-6.3	9.5		10.1	0.0005	6.2	3416.8	306.2	0.3
One	485	1965(06FLOW)	19678	-6.3	9.7		10.0	0.0003	4.7	6992.6	1080.5	0.2
One	465	1972(06FLOW)	19678	-5.6	9.4		10.1	0.0006	6.5	3316.3	312.9	0.3
One	465	1965(06FLOW)	19678	-5.6	9.7		10.0	0.0003	4.6	7251.5	1087.5	0.2
One	445	1972(06FLOW)	19678	-5.2	9.4		10.0	0.0005	6.2	3490.4	322.1	0.3
One	445	1965(06FLOW)	19678	-5.2	9.7		9.9	0.0002	4.4	7492.3	1028.8	0.2
One	425	1972(06FLOW)	19678	-4.9	9.4		10.0	0.0005	6.0	4046.5	340.4	0.3
One	425	1965(06FLOW)	19678	-4.9	9.7		9.9	0.0002	4.4	7949.9	1148.0	0.2
One	395	1972(06FLOW)	19678	-6.5	9.4		9.9	0.0005	6.0	3680.4	322.2	0.3
One	395	1965(06FLOW)	19678	-6.5	9.6		9.9	0.0002	4.6	7491.7	1163.5	0.2
One	385	1972(06FLOW)	19678	-6.1	9.4		9.9	0.0005	5.9	3655.4	336.3	0.3
One	385	1965(06FLOW)	19678	-6.1	9.7		9.9	0.0002	4.1	7674.4	1223.7	0.2
One	375	1972(06FLOW)	19678	-7.5	9.3		9.9	0.0005	6.3	3711.7	328.3	0.3
One	375	1965(06FLOW)	19678	-7.5	9.6		9.9	0.0002	4.5	8006.1	1254.9	0.2
One	355	1972(06FLOW)	19678	-7.5	9.2		9.8	0.0005	6.3	3686.6	329.1	0.3
One	355	1965(06FLOW)	19678	-7.5	9.6		9.8	0.0002	4.3	8512.6	1262.0	0.2
One	337	1972(06FLOW)	19678	-6.2	9.2		9.8	0.0005	6.1	3701.0	364.0	0.3
One	337	1965(06FLOW)	19678	-6.2	9.6		9.8	0.0002	3.9	8483.0	1373.6	0.2
One	325	1972(06FLOW)	19678	-6.3	9.2		9.8	0.0004	5.9	3956.4	393.5	0.3
One	325	1965(06FLOW)	19678	-6.3	9.3		9.8	0.0004	5.6	4505.6	564.7	0.3
One	310	1972(06FLOW)	19678	-6.3	9.2		9.7	0.0005	6.1	3865.1	392.2	0.3
One	310	1965(06FLOW)	19678	-6.3	9.2		9.7	0.0004	5.9	4121.3	430.6	0.3
One	290	1972(06FLOW)	19678	-6.0	9.2		9.7	0.0004	6.0	4329.1	469.5	0.3
One	290	1965(06FLOW)	19678	-6.0	9.2		9.7	0.0004	6.0	4281.2	455.8	0.3
One	270	1972(06FLOW)	19678	-6.0	9.1		9.7	0.0005	6.0	4217.1	460.9	0.3
One	270	1965(06FLOW)	19678	-6.0	9.4		9.6	0.0002	4.5	7809.7	1447.7	0.2
One	255	1972(06FLOW)	19678	-6.3	9.2		9.6	0.0004	5.4	4691.3	515.1	0.3
One	255	1965(06FLOW)	19678	-6.3	9.3		9.6	0.0003	4.8	7784.0	1465.5	0.2
One	240	1972(06FLOW)	19678	-6.3	9.1		9.6	0.0004	5.5	4664.0	514.6	0.3
One	240	1965(06FLOW)	19678	-6.3	9.3		9.6	0.0003	4.8	7825.8	1500.1	0.2
One	210	1972(06FLOW)	19678	-6.0	9.1		9.6	0.0004	5.6	5256.8	589.5	0.3
One	210	1965(06FLOW)	19678	-6.0	9.3		9.6	0.0003	4.9	8259.3	1554.3	0.2
One	180	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5218.1	591.7	0.3
One	180	1965(06FLOW)	19678	-6.0	9.3		9.5	0.0003	4.7	9027.4	1649.5	0.2
One	170	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5205.5	591.0	0.3
One	170	1965(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.5	5923.0	892.1	0.3
One	165	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5199.2	590.7	0.3
One	165	1965(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.5	5914.5	891.2	0.3
One	160	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5192.8	590.3	0.3
One	160	1965(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5643.5	877.8	0.3
One	155	1972(06FLOW)	19678	-6.0	9.0		9.5	0.0004	5.7	5186.4	590.0	0.3
One	155	1965(06FLOW)	19678	-6.0	9.0		9.5	0.0004	5.6	5634.7	877.4	0.3
One	150	1972(06FLOW)	19678	-6.7	9.0		9.5	0.0004	6.0	4787.1	635.3	0.3
One	150	1965(06FLOW)	19678	-6.7	9.0		9.5	0.0004	5.9	5025.9	720.9	0.3
One	145	1972(06FLOW)	19678	-6.7	8.9		9.5	0.0004	6.0	4778.9	634.6	0.3
One	145	1965(06FLOW)	19678	-6.7	9.0		9.4	0.0004	5.9	5017.0	720.4	0.3

Reach	River Sta	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)	
One	135	1972(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4852.2	626.5	0.3
One	135	1965(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4825.2	625.2	0.3
One	130	1972(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4842.8	625.5	0.3
One	130	1965(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4815.8	624.4	0.3
One	120	1972(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.3	5021.3	687.4	0.3
One	120	1965(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.2	5071.4	669.0	0.3
One	110	1972(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.3	5003.5	685.6	0.3
One	110	1965(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.2	5054.3	668.0	0.3
One	100	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.6	5732.1	751.7	0.3
One	100	1965(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5649.5	776.2	0.3
One	99.8	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5725.1	751.1	0.3
One	99.8	1965(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5642.2	776.0	0.3
One	99.7	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	5973.0	768.0	0.3
One	99.7	1965(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	6104.7	809.4	0.3
One	99.6	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	5966.2	767.5	0.3
One	99.6	1965(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	6097.6	809.3	0.3
One	99.5	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5866.8	776.3	0.3
One	99.5	1965(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.6	6369.2	896.5	0.3
One	99	1972(06FLOW)	21237	-8.0	8.9	1.7	9.2	0.0003	4.6	7480.6	1362.4	0.2
One	99	1965(06FLOW)	21237	-8.0	8.9	1.7	9.2	0.0003	4.5	8265.6	1817.1	0.2
One	96		Bridge									
One	95.5	1972(06FLOW)	21237	-8.0	8.7		9.0	0.0004	4.7	7210.1	1359.7	0.2
One	95.5	1965(06FLOW)	21237	-8.0	8.7		9.0	0.0004	4.7	7210.1	1359.7	0.2
One	95	1972(06FLOW)	21237	-8.0	8.8		9.0	0.0004	4.5	9942.2	1421.6	0.2
One	95	1965(06FLOW)	21237	-8.0	8.8		9.0	0.0004	4.5	9942.2	1421.6	0.2
One	94*	1972(06FLOW)	21237	-8.5	8.8		9.0	0.0002	4.0	11202.4	1524.7	0.2
One	94*	1965(06FLOW)	21237	-8.5	8.8		9.0	0.0002	4.0	11202.4	1524.7	0.2
One	93	1972(06FLOW)	21237	-7.7	8.6		8.9	0.0004	5.4	9987.2	1523.7	0.3
One	93	1965(06FLOW)	21237	-7.7	8.6		8.9	0.0004	5.4	9987.2	1523.7	0.3
One	90*	1972(06FLOW)	21237	-7.3	8.6		8.8	0.0002	3.8	8687.7	1308.8	0.2
One	90*	1965(06FLOW)	21237	-7.3	8.6		8.8	0.0002	3.8	8687.7	1308.8	0.2
One	88*	1972(06FLOW)	21237	-6.9	8.6		8.8	0.0001	3.0	8235.4	923.9	0.1
One	88*	1965(06FLOW)	21237	-6.9	8.6		8.8	0.0001	3.0	8235.4	923.9	0.1
One	85	1972(06FLOW)	21237	-6.5	8.6		8.7	0.0001	2.5	8959.9	823.2	0.1
One	85	1965(06FLOW)	21237	-6.5	8.6		8.7	0.0001	2.5	8959.9	823.2	0.1
One	79	1972(06FLOW)	21237	-7.0	8.5		8.7	0.0002	3.9	15347.9	4462.7	0.2
One	79	1965(06FLOW)	21237	-7.0	8.5		8.7	0.0002	3.9	15347.9	4462.7	0.2
One	78	1972(06FLOW)	21237	-11.3	6.8	0.9	8.2	0.0013	9.8	2451.6	953.8	0.5
One	78	1965(06FLOW)	21237	-11.3	6.8	0.9	8.2	0.0013	9.8	2451.6	953.8	0.5
One	77.5		Bridge									
One	77	1972(06FLOW)	21237	-10.3	1.9	1.9	5.9	0.0070	16.0	1331.2	168.6	1.0
One	77	1965(06FLOW)	21237	-10.3	1.9	1.9	5.9	0.0070	16.0	1331.2	168.6	1.0
One	76	1972(06FLOW)	21237	-7.0	1.0	1.0	3.6	0.0077	12.8	1655.9	324.3	1.0
One	76	1965(06FLOW)	21237	-7.0	1.0	1.0	3.6	0.0077	12.8	1655.9	324.3	1.0
One	75	1972(06FLOW)	21237	-7.4	1.0	-0.9	1.9	0.0025	7.5	2840.6	532.3	0.6
One	75	1965(06FLOW)	21237	-7.4	1.0	-0.9	1.9	0.0025	7.5	2840.6	532.3	0.6



JUNE 2006 FLOOD EVENT 1) 1972(06FLOW) 2) 1965(06FLOW)
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT - 1972(06FLOW)
WS JUNE 06 EVENT - 1965(06FLOW)
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
77
85
88*
90*
93
95
99.5
130
180
270
355
425
510
575
659
720
800
880
960
1040
1120
1200
1280
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

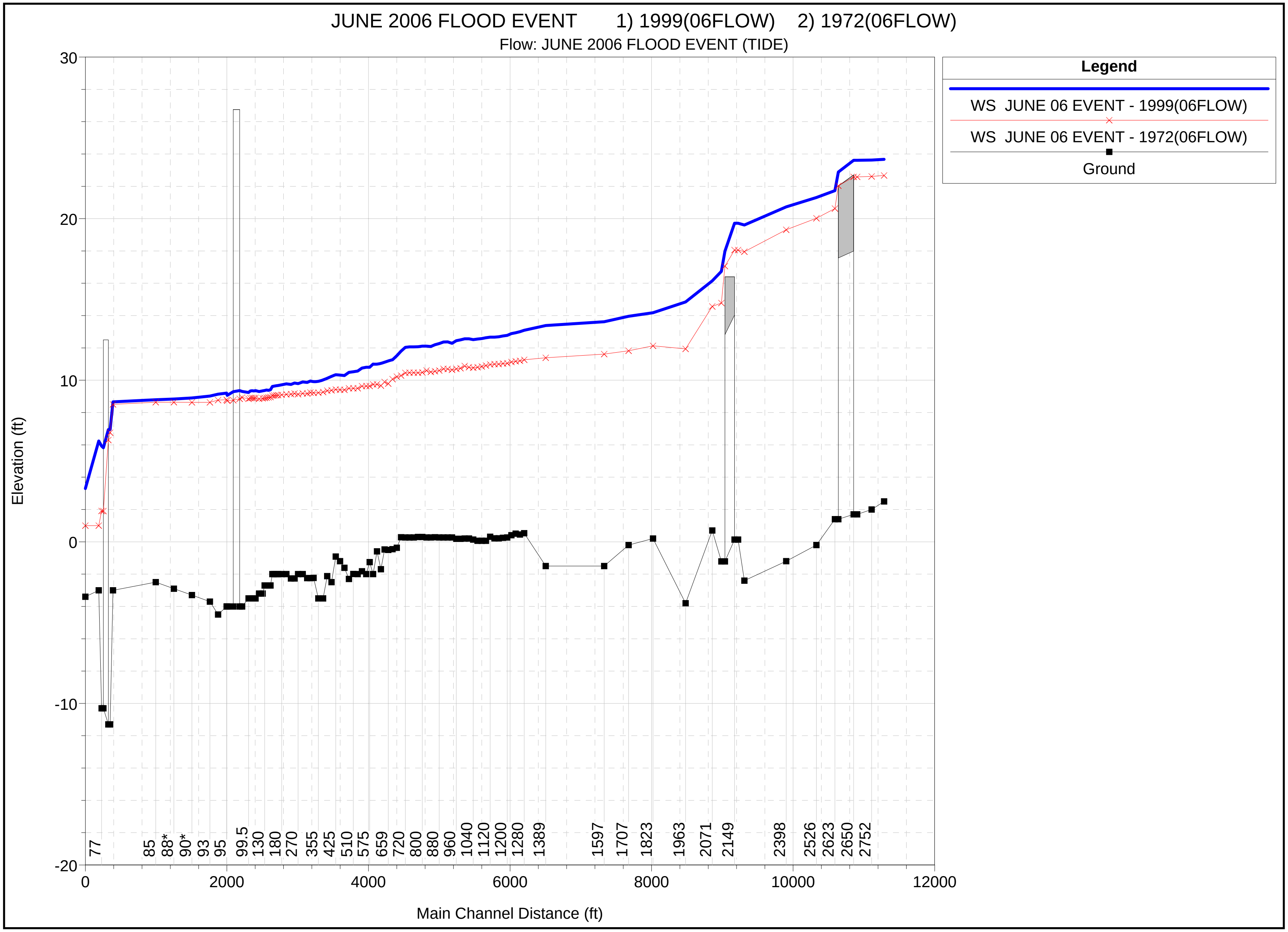
HEC-RAS River: Cameron Run Reach: One

Reach	River Sta	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)	
One	2806	1999(06FLOW)	17857	2.5	23.7	9.4	23.8	0.0002	3.5	5987.9	401.9	0.1
One	2806	1972(06FLOW)	17857	2.5	22.7	9.4	22.9	0.0002	3.7	5595.1	388.9	0.2
One	2752	1999(06FLOW)	17857	2.0	23.6	9.8	23.8	0.0002	3.5	5875.1	551.3	0.1
One	2752	1972(06FLOW)	17857	2.0	22.6	9.8	22.8	0.0002	3.8	5335.5	523.2	0.2
One	2677	1999(06FLOW)	17857	1.7	23.6	9.2	23.8	0.0002	3.1	7495.7	1281.0	0.1
One	2677	1972(06FLOW)	17857	1.7	22.6	9.2	22.8	0.0002	3.4	5299.2	971.7	0.1
One	2650		Bridge									
One	2623	1999(06FLOW)	17857	1.4	21.7	9.0	21.9	0.0003	3.7	5431.4	674.3	0.2
One	2623	1972(06FLOW)	17857	1.4	20.6	9.0	20.9	0.0003	4.0	4771.6	527.4	0.2
One	2526	1999(06FLOW)	17857	-0.2	21.3		21.8	0.0006	6.5	5785.5	624.3	0.3
One	2526	1972(06FLOW)	17857	-0.2	20.0		20.6	0.0008	7.3	4997.0	601.7	0.3
One	2398	1999(06FLOW)	17857	-1.2	20.7		21.5	0.0009	7.9	4536.1	608.3	0.3
One	2398	1972(06FLOW)	17857	-1.2	19.3		20.2	0.0012	8.7	3768.6	487.4	0.4
One	2211	1999(06FLOW)	19076	-2.4	19.6		20.8	0.0013	9.4	3340.5	340.9	0.4
One	2211	1972(06FLOW)	19076	-2.4	18.0		19.3	0.0018	10.2	2852.9	253.4	0.4
One	2169	1999(06FLOW)	19076	0.1	19.7	10.9	20.5	0.0012	8.2	3765.5	600.6	0.3
One	2169	1972(06FLOW)	19076	0.1	18.1	10.9	18.9	0.0016	8.9	3260.5	277.5	0.4
One	2149		Bridge									
One	2129	1999(06FLOW)	19076	-1.2	16.7	9.9	17.7	0.0013	8.7	3048.7	379.4	0.4
One	2129	1972(06FLOW)	19076	-3.0	14.8	9.3	16.1	0.0019	9.7	2567.1	259.7	0.4
One	2071	1999(06FLOW)	19076	0.7	16.1		17.4	0.0019	9.6	2779.1	255.0	0.4
One	2071	1972(06FLOW)	19076	-3.0	14.6		15.8	0.0017	9.4	2676.6	229.2	0.4
One	1963	1999(06FLOW)	19076	-3.8	14.8		16.5	0.0029	11.4	2617.1	327.3	0.5
One	1963	1972(06FLOW)	19076	-3.8	11.9		14.6	0.0057	14.1	1952.3	205.3	0.7
One	1823	1999(06FLOW)	19076	0.2	14.2		15.3	0.0019	9.0	3076.8	447.1	0.4
One	1823	1972(06FLOW)	19076	-5.5	12.1		13.1	0.0012	7.9	3268.5	546.7	0.3
One	1707	1999(06FLOW)	19678	-0.2	14.0		14.7	0.0010	7.2	3266.8	534.4	0.4
One	1707	1972(06FLOW)	19678	-5.2	11.8		12.7	0.0010	8.0	3747.4	558.4	0.4
One	1597	1999(06FLOW)	19678	-1.5	13.6		14.3	0.0013	7.9	4960.5	584.9	0.4
One	1597	1972(06FLOW)	19678	-5.5	11.6		12.4	0.0007	7.6	4973.1	649.3	0.3
One	1389	1999(06FLOW)	19678	-1.5	13.4		13.7	0.0004	5.2	8356.5	1006.8	0.3
One	1389	1972(06FLOW)	19678	-5.0	11.4		11.8	0.0005	5.8	6820.3	956.2	0.3
One	1280	1999(06FLOW)	19678	0.5	13.1		13.5	0.0005	6.0	6481.4	891.9	0.3
One	1280	1972(06FLOW)	19678	-4.8	11.3		11.7	0.0004	5.5	5931.2	795.4	0.3
One	1260	1999(06FLOW)	19678	0.4	13.0		13.5	0.0006	6.3	6171.8	889.4	0.3
One	1260	1972(06FLOW)	19678	-4.6	11.2		11.7	0.0004	5.7	5654.9	787.5	0.3
One	1240	1999(06FLOW)	19678	0.5	12.9		13.5	0.0006	6.4	5980.9	893.6	0.3
One	1240	1972(06FLOW)	19678	-4.5	11.2		11.6	0.0004	5.7	5511.6	800.7	0.3
One	1220	1999(06FLOW)	19678	0.4	12.9		13.4	0.0006	6.5	5909.0	880.9	0.3
One	1220	1972(06FLOW)	19678	-4.6	11.1		11.6	0.0004	5.8	5423.4	788.4	0.3
One	1200	1999(06FLOW)	19678	0.3	12.8		13.4	0.0007	6.9	5613.9	873.4	0.3
One	1200	1972(06FLOW)	19678	-4.7	11.1		11.6	0.0004	6.1	5144.5	782.6	0.3
One	1180	1999(06FLOW)	19678	0.3	12.7		13.3	0.0007	6.8	5636.3	881.4	0.3
One	1180	1972(06FLOW)	19678	-5.1	11.0		11.6	0.0004	6.1	5199.7	791.6	0.3
One	1160	1999(06FLOW)	19678	0.2	12.7		13.3	0.0007	6.8	5450.3	878.9	0.3
One	1160	1972(06FLOW)	19678	-4.8	11.0		11.5	0.0004	6.1	4987.6	790.4	0.3
One	1140	1999(06FLOW)	19678	0.2	12.7		13.2	0.0007	6.7	5667.5	927.8	0.3
One	1140	1972(06FLOW)	19678	-4.8	11.0		11.5	0.0004	5.9	5181.5	840.2	0.3
One	1120	1999(06FLOW)	19678	0.3	12.7		13.2	0.0006	6.4	6173.8	998.1	0.3
One	1120	1972(06FLOW)	19678	-4.7	11.0		11.5	0.0004	5.9	5490.1	959.9	0.3
One	1100	1999(06FLOW)	19678	0.1	12.6		13.2	0.0006	6.4	6194.4	1043.0	0.3
One	1100	1972(06FLOW)	19678	-3.9	10.9		11.4	0.0005	6.1	5255.3	986.3	0.3
One	1080	1999(06FLOW)	19678	0.1	12.6		13.1	0.0006	6.5	6201.3	1041.3	0.3
One	1080	1972(06FLOW)	19678	-3.9	10.9		11.4	0.0005	6.3	5233.0	984.6	0.3

Reach	River Sta	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)	
One	1060	1999(06FLOW)	19678	0.1	12.5		13.1	0.0007	6.5	6402.7	1094.8	0.3
One	1060	1972(06FLOW)	19678	-3.9	10.8		11.4	0.0005	6.4	5316.7	1026.6	0.3
One	1040	1999(06FLOW)	19678	0.1	12.5		13.0	0.0006	6.5	6605.5	1094.0	0.3
One	1040	1972(06FLOW)	19678	-3.9	10.8		11.4	0.0005	6.5	5494.2	1026.1	0.3
One	1020	1999(06FLOW)	19678	0.2	12.6		13.0	0.0005	6.0	7547.8	1094.8	0.3
One	1020	1972(06FLOW)	19678	-3.8	10.8		11.3	0.0005	6.1	6417.5	1033.3	0.3
One	1000	1999(06FLOW)	19678	0.2	12.6		12.9	0.0005	5.7	8012.7	1096.0	0.3
One	1000	1972(06FLOW)	19678	-5.8	10.9		11.2	0.0003	5.1	7417.2	1037.2	0.2
One	980	1999(06FLOW)	19678	0.2	12.5		12.9	0.0005	5.9	7650.4	1089.0	0.3
One	980	1972(06FLOW)	19678	-3.8	10.7		11.2	0.0004	5.9	6561.5	1031.5	0.3
One	960	1999(06FLOW)	19678	0.2	12.4		12.9	0.0005	5.9	7310.4	1087.9	0.3
One	960	1972(06FLOW)	19678	-3.8	10.7		11.2	0.0004	5.9	6254.2	1030.9	0.3
One	940	1999(06FLOW)	19678	0.3	12.3		12.8	0.0006	6.4	5892.4	919.5	0.3
One	940	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0004	5.9	5338.4	786.1	0.3
One	920	1999(06FLOW)	19678	0.3	12.4		12.7	0.0004	5.5	7624.9	1079.2	0.3
One	920	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0004	5.3	6712.6	1040.1	0.3
One	900	1999(06FLOW)	19678	0.3	12.4		12.7	0.0004	5.2	7928.6	1107.2	0.3
One	900	1972(06FLOW)	19678	-3.7	10.7		11.1	0.0003	5.1	7012.9	1066.7	0.2
One	880	1999(06FLOW)	19678	0.3	12.3		12.7	0.0005	5.7	7513.3	1106.4	0.3
One	880	1972(06FLOW)	19678	-3.7	10.6		11.0	0.0004	5.6	6557.8	1066.7	0.3
One	860	1999(06FLOW)	19678	0.3	12.2		12.6	0.0005	5.9	6960.0	1104.9	0.3
One	860	1972(06FLOW)	19678	-3.7	10.6		11.0	0.0004	5.6	6053.7	1066.0	0.3
One	840	1999(06FLOW)	19678	0.3	12.1		12.6	0.0006	6.0	5877.4	1072.0	0.3
One	840	1972(06FLOW)	19678	-3.7	10.5		11.0	0.0004	5.6	5133.4	1019.0	0.3
One	820	1999(06FLOW)	19678	0.3	12.1		12.5	0.0005	5.7	6703.0	1082.5	0.3
One	820	1972(06FLOW)	19678	-6.5	10.6		10.9	0.0002	4.6	6710.2	1032.2	0.2
One	800	1999(06FLOW)	19678	0.3	12.1		12.5	0.0005	5.6	7288.6	1073.9	0.3
One	800	1972(06FLOW)	19678	-3.7	10.5		10.9	0.0004	5.4	6483.1	1017.7	0.3
One	780	1999(06FLOW)	19678	0.3	12.1		12.4	0.0005	5.6	7258.1	1088.2	0.3
One	780	1972(06FLOW)	19678	-3.7	10.5		10.9	0.0004	5.4	6450.4	1025.7	0.3
One	760	1999(06FLOW)	19678	0.3	12.1		12.4	0.0005	5.3	7459.0	1094.8	0.3
One	760	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	5.2	6681.3	1038.7	0.2
One	740	1999(06FLOW)	19678	0.3	12.1		12.4	0.0004	5.1	7924.0	1144.7	0.3
One	740	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	5.0	7126.4	1088.4	0.2
One	720	1999(06FLOW)	19678	0.3	12.0		12.4	0.0004	5.1	7883.5	1143.2	0.3
One	720	1972(06FLOW)	19678	-3.7	10.5		10.8	0.0003	4.9	7109.6	1087.9	0.2
One	700	1999(06FLOW)	19678	0.3	11.8		12.3	0.0006	6.1	6095.1	1233.7	0.3
One	700	1972(06FLOW)	19678	-3.7	10.3		10.8	0.0004	5.6	5223.3	1180.7	0.3
One	680	1999(06FLOW)	19678	-0.4	11.5		12.2	0.0008	6.9	3286.1	359.4	0.4
One	680	1972(06FLOW)	19678	-4.4	10.2		10.7	0.0004	5.7	3802.3	345.9	0.3
One	660	1999(06FLOW)	19678	-0.5	11.3		12.2	0.0010	7.8	2984.3	337.0	0.4
One	660	1972(06FLOW)	19678	-4.5	10.1		10.7	0.0005	6.3	3466.5	313.0	0.3
One	659	1999(06FLOW)	19678	-0.5	11.2		12.1	0.0010	7.7	2921.1	447.6	0.4
One	659	1972(06FLOW)	19678	-4.5	9.8		10.6	0.0009	7.4	2913.0	303.4	0.4
One	640	1999(06FLOW)	19678	-0.5	11.1		12.0	0.0011	7.9	2806.4	336.5	0.4
One	640	1972(06FLOW)	19678	-4.5	9.9		10.5	0.0005	6.4	3288.8	302.0	0.3
One	625	1999(06FLOW)	19678	-1.7	11.1		12.0	0.0010	7.9	2894.3	340.1	0.4
One	625	1972(06FLOW)	19678	-5.7	9.7		10.5	0.0008	7.3	2981.7	291.7	0.4
One	610	1999(06FLOW)	19678	-0.6	11.0		11.9	0.0010	7.8	2854.8	337.5	0.4
One	610	1972(06FLOW)	19678	-4.6	9.8		10.4	0.0005	6.4	3313.0	308.3	0.3
One	595	1999(06FLOW)	19678	-2.0	11.0		11.8	0.0009	7.5	3020.1	317.7	0.4
One	595	1972(06FLOW)	19678	-6.0	9.7		10.3	0.0005	6.3	3468.0	298.2	0.3
One	575	1999(06FLOW)	19678	-1.3	10.8		11.8	0.0011	8.0	2753.6	310.8	0.4
One	575	1972(06FLOW)	19678	-5.3	9.6		10.3	0.0006	6.6	3223.1	279.2	0.3

Reach	River Sta	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)	
One	555	1999(06FLOW)	19678	-2.0	10.8		11.7	0.0010	7.7	2843.1	305.4	0.4
One	555	1972(06FLOW)	19678	-6.0	9.6		10.3	0.0005	6.4	3323.3	288.0	0.3
One	540	1999(06FLOW)	19678	-1.8	10.7		11.7	0.0010	7.7	2940.3	323.8	0.4
One	540	1972(06FLOW)	19678	-5.8	9.6		10.2	0.0005	6.3	3455.8	303.1	0.3
One	530	1999(06FLOW)	19678	-2.0	10.6		11.6	0.0012	8.2	2808.0	294.5	0.4
One	530	1972(06FLOW)	19678	-6.0	9.5		10.2	0.0006	6.7	3267.2	288.2	0.3
One	510	1999(06FLOW)	19678	-2.0	10.5		11.5	0.0011	8.0	2859.6	316.2	0.4
One	510	1972(06FLOW)	19678	-6.0	9.5		10.1	0.0005	6.4	3396.2	313.2	0.3
One	485	1999(06FLOW)	19678	-2.3	10.5		11.4	0.0011	7.8	2821.7	312.1	0.4
One	485	1972(06FLOW)	19678	-6.3	9.5		10.1	0.0005	6.2	3416.8	306.2	0.3
One	465	1999(06FLOW)	19678	-1.6	10.3		11.3	0.0013	8.3	2729.0	315.5	0.4
One	465	1972(06FLOW)	19678	-5.6	9.4		10.1	0.0006	6.5	3316.3	312.9	0.3
One	445	1999(06FLOW)	19678	-1.2	10.3		11.2	0.0011	7.7	2932.0	325.8	0.4
One	445	1972(06FLOW)	19678	-5.2	9.4		10.0	0.0005	6.2	3490.4	322.1	0.3
One	425	1999(06FLOW)	19678	-0.9	10.3		11.1	0.0010	7.4	3448.5	340.7	0.4
One	425	1972(06FLOW)	19678	-4.9	9.4		10.0	0.0005	6.0	4046.5	340.4	0.3
One	395	1999(06FLOW)	19678	-2.5	10.2		11.0	0.0009	7.4	3100.7	325.8	0.4
One	395	1972(06FLOW)	19678	-6.5	9.4		9.9	0.0005	6.0	3680.4	322.2	0.3
One	385	1999(06FLOW)	19678	-2.1	10.1		11.0	0.0011	7.5	3000.4	339.7	0.4
One	385	1972(06FLOW)	19678	-6.1	9.4		9.9	0.0005	5.9	3655.4	336.3	0.3
One	375	1999(06FLOW)	19678	-3.5	10.0		10.9	0.0010	7.8	3140.8	331.7	0.4
One	375	1972(06FLOW)	19678	-7.5	9.3		9.9	0.0005	6.3	3711.7	328.3	0.3
One	355	1999(06FLOW)	19678	-3.5	9.9		10.9	0.0010	7.9	3099.1	332.3	0.4
One	355	1972(06FLOW)	19678	-7.5	9.2		9.8	0.0005	6.3	3686.6	329.1	0.3
One	337	1999(06FLOW)	19678	-2.2	9.9		10.8	0.0010	7.6	3101.0	373.2	0.4
One	337	1972(06FLOW)	19678	-6.2	9.2		9.8	0.0005	6.1	3701.0	364.0	0.3
One	325	1999(06FLOW)	19678	-2.3	9.9		10.7	0.0009	7.2	3399.0	399.9	0.4
One	325	1972(06FLOW)	19678	-6.3	9.2		9.8	0.0004	5.9	3956.4	393.5	0.3
One	310	1999(06FLOW)	19678	-2.3	9.9		10.6	0.0009	7.4	3328.0	395.7	0.4
One	310	1972(06FLOW)	19678	-6.3	9.2		9.7	0.0005	6.1	3865.1	392.2	0.3
One	290	1999(06FLOW)	19678	-2.0	9.9		10.5	0.0008	7.1	3866.1	495.7	0.4
One	290	1972(06FLOW)	19678	-6.0	9.2		9.7	0.0004	6.0	4329.1	469.5	0.3
One	270	1999(06FLOW)	19678	-2.0	9.8		10.5	0.0009	7.3	3722.8	484.4	0.4
One	270	1972(06FLOW)	19678	-6.0	9.1		9.7	0.0005	6.0	4217.1	460.9	0.3
One	255	1999(06FLOW)	19678	-2.3	9.8		10.4	0.0007	6.6	4106.3	533.5	0.4
One	255	1972(06FLOW)	19678	-6.3	9.2		9.6	0.0004	5.4	4691.3	515.1	0.3
One	240	1999(06FLOW)	19678	-2.3	9.7		10.4	0.0008	6.8	4065.2	529.1	0.4
One	240	1972(06FLOW)	19678	-6.3	9.1		9.6	0.0004	5.5	4664.0	514.6	0.3
One	210	1999(06FLOW)	19678	-2.0	9.8		10.3	0.0007	6.4	4891.3	613.5	0.3
One	210	1972(06FLOW)	19678	-6.0	9.1		9.6	0.0004	5.6	5256.8	589.5	0.3
One	180	1999(06FLOW)	19678	-2.0	9.7		10.2	0.0007	6.5	4838.3	611.1	0.3
One	180	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5218.1	591.7	0.3
One	170	1999(06FLOW)	19678	-2.0	9.7		10.2	0.0007	6.5	4813.2	609.8	0.3
One	170	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5205.5	591.0	0.3
One	165	1999(06FLOW)	19678	-2.0	9.7		10.2	0.0007	6.5	4801.2	609.2	0.3
One	165	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5199.2	590.7	0.3
One	160	1999(06FLOW)	19678	-2.0	9.6		10.2	0.0007	6.5	4789.1	608.5	0.3
One	160	1972(06FLOW)	19678	-6.0	9.1		9.5	0.0004	5.6	5192.8	590.3	0.3
One	155	1999(06FLOW)	19678	-2.0	9.6		10.2	0.0007	6.5	4776.9	607.9	0.3
One	155	1972(06FLOW)	19678	-6.0	9.0		9.5	0.0004	5.7	5186.4	590.0	0.3
One	150	1999(06FLOW)	19678	-2.7	9.4		10.1	0.0009	7.3	4260.8	660.5	0.4
One	150	1972(06FLOW)	19678	-6.7	9.0		9.5	0.0004	6.0	4787.1	635.3	0.3
One	145	1999(06FLOW)	19678	-2.7	9.4		10.1	0.0009	7.4	4239.4	658.7	0.4
One	145	1972(06FLOW)	19678	-6.7	8.9		9.5	0.0004	6.0	4778.9	634.6	0.3

Reach	River Sta	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)	
One	135	1999(06FLOW)	19678	-2.7	9.4		10.0	0.0009	7.2	4514.0	659.4	0.4
One	135	1972(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4852.2	626.5	0.3
One	130	1999(06FLOW)	19678	-2.7	9.4		10.0	0.0009	7.2	4494.3	657.3	0.4
One	130	1972(06FLOW)	19678	-6.7	8.9		9.4	0.0005	6.2	4842.8	625.5	0.3
One	120	1999(06FLOW)	19678	-3.2	9.3		10.0	0.0008	7.2	4734.9	720.2	0.4
One	120	1972(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.3	5021.3	687.4	0.3
One	110	1999(06FLOW)	19678	-3.2	9.3		10.0	0.0008	7.2	4698.6	716.7	0.4
One	110	1972(06FLOW)	19678	-7.2	8.9		9.4	0.0005	6.3	5003.5	685.6	0.3
One	100	1999(06FLOW)	19678	-3.5	9.4		9.9	0.0007	6.5	5362.6	782.5	0.3
One	100	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.6	5732.1	751.7	0.3
One	99.8	1999(06FLOW)	19678	-3.5	9.3		9.9	0.0007	6.5	5348.1	781.2	0.3
One	99.8	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5725.1	751.1	0.3
One	99.7	1999(06FLOW)	19678	-3.5	9.4		9.8	0.0006	6.3	5607.1	791.9	0.3
One	99.7	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	5973.0	768.0	0.3
One	99.6	1999(06FLOW)	19678	-3.5	9.3		9.8	0.0006	6.3	5593.2	791.0	0.3
One	99.6	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0003	5.5	5966.2	767.5	0.3
One	99.5	1999(06FLOW)	19678	-3.5	9.2		9.8	0.0007	6.7	5463.3	799.4	0.3
One	99.5	1972(06FLOW)	19678	-7.5	8.9		9.3	0.0004	5.7	5866.8	776.3	0.3
One	99	1999(06FLOW)	21237	-4.0	9.3	5.9	9.7	0.0007	5.5	6828.7	1402.9	0.3
One	99	1972(06FLOW)	21237	-8.0	8.9	1.7	9.2	0.0003	4.6	7480.6	1362.4	0.2
One	96		Bridge									
One	95.5	1999(06FLOW)	21237	-4.0	9.1		9.5	0.0008	5.7	6493.2	1364.2	0.4
One	95.5	1972(06FLOW)	21237	-8.0	8.7		9.0	0.0004	4.7	7210.1	1359.7	0.2
One	95	1999(06FLOW)	21237	-4.0	9.2		9.4	0.0006	4.6	9745.5	1426.5	0.3
One	95	1972(06FLOW)	21237	-8.0	8.8		9.0	0.0004	4.5	9942.2	1421.6	0.2
One	94*	1999(06FLOW)	21237	-4.5	9.1		9.3	0.0003	4.4	10778.3	1532.1	0.2
One	94*	1972(06FLOW)	21237	-8.5	8.8		9.0	0.0002	4.0	11202.4	1524.7	0.2
One	93	1999(06FLOW)	21237	-3.7	9.0		9.3	0.0005	5.5	10092.1	1591.6	0.3
One	93	1972(06FLOW)	21237	-7.7	8.6		8.9	0.0004	5.4	9987.2	1523.7	0.3
One	90*	1999(06FLOW)	21237	-3.3	8.9		9.2	0.0004	4.7	7687.3	1319.0	0.3
One	90*	1972(06FLOW)	21237	-7.3	8.6		8.8	0.0002	3.8	8687.7	1308.8	0.2
One	88*	1999(06FLOW)	21237	-2.9	8.8		9.1	0.0003	4.0	6445.7	934.2	0.2
One	88*	1972(06FLOW)	21237	-6.9	8.6		8.8	0.0001	3.0	8235.4	923.9	0.1
One	85	1999(06FLOW)	21237	-2.5	8.8		9.0	0.0003	3.5	6493.0	825.2	0.2
One	85	1972(06FLOW)	21237	-6.5	8.6		8.7	0.0001	2.5	8959.9	823.2	0.1
One	79	1999(06FLOW)	21237	-3.0	8.7		8.8	0.0003	4.1	15138.8	4482.1	0.2
One	79	1972(06FLOW)	21237	-7.0	8.5		8.7	0.0002	3.9	15347.9	4462.7	0.2
One	78	1999(06FLOW)	21237	-11.3	6.9	0.9	8.4	0.0013	9.6	2670.8	1391.2	0.5
One	78	1972(06FLOW)	21237	-11.3	6.8	0.9	8.2	0.0013	9.8	2451.6	953.8	0.5
One	77.5		Bridge									
One	77	1999(06FLOW)	21237	-10.3	5.9	1.9	7.6	0.0019	10.4	2042.6	184.2	0.6
One	77	1972(06FLOW)	21237	-10.3	1.9	1.9	5.9	0.0070	16.0	1331.2	168.6	1.0
One	76	1999(06FLOW)	21237	-3.0	6.2	6.2	7.1	0.0035	8.0	4962.2	4203.6	0.7
One	76	1972(06FLOW)	21237	-7.0	1.0	1.0	3.6	0.0077	12.8	1655.9	324.3	1.0
One	75	1999(06FLOW)	21237	-3.4	3.3	3.3	4.6	0.0057	9.2	2885.9	1825.8	0.8
One	75	1972(06FLOW)	21237	-7.4	1.0	-0.9	1.9	0.0025	7.5	2840.6	532.3	0.6


JUNE 2006 FLOOD EVENT 1) 1999(06FLOW) 2) 1972(06FLOW)
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT - 1999(06FLOW)
WS JUNE 06 EVENT - 1972(06FLOW)
Ground
Elevation (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
77
85
88*
90*
93
95
99.5
130
180
270
355
425
510
575
659
720
800
880
960
1040
1120
1200
1280
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

HEC-RAS River: Cameron Run Reach: One

Reach	River Sta	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)	
One	2806	JUNE 2006	17857	2.5	23.8	9.4	24.0	0.0002	3.4	6047.8	404.8	0.1
One	2806	POT 5.0	17857	2.5	23.8	9.4	24.0	0.0002	3.4	6047.5	404.8	0.1
One	2806	POT 11.0	17857	2.5	23.9	9.4	24.0	0.0002	3.4	6068.7	405.8	0.1
One	2752	JUNE 2006	17857	2.0	23.8	9.8	24.0	0.0002	3.5	5958.3	557.1	0.1
One	2752	POT 5.0	17857	2.0	23.8	9.8	24.0	0.0002	3.5	5957.9	557.0	0.1
One	2752	POT 11.0	17857	2.0	23.8	9.8	24.0	0.0002	3.5	5987.3	559.1	0.1
One	2677	JUNE 2006	17857	1.7	23.8	9.2	23.9	0.0002	3.1	7692.3	1320.8	0.1
One	2677	POT 5.0	17857	1.7	23.8	9.2	23.9	0.0002	3.1	7691.3	1320.7	0.1
One	2677	POT 11.0	17857	1.7	23.8	9.2	24.0	0.0001	3.1	7761.9	1334.7	0.1
One	2650		Bridge									
One	2623	JUNE 2006	17857	1.4	21.9	9.0	22.1	0.0003	3.7	5561.0	703.7	0.2
One	2623	POT 5.0	17857	1.4	21.9	9.0	22.1	0.0003	3.7	5560.4	703.6	0.2
One	2623	POT 11.0	17857	1.4	22.0	9.0	22.2	0.0003	3.7	5608.0	714.1	0.2
One	2526	JUNE 2006	17857	-0.2	21.5		22.0	0.0006	6.4	5917.7	630.7	0.2
One	2526	POT 5.0	17857	-0.2	21.5		22.0	0.0006	6.4	5917.0	630.7	0.2
One	2526	POT 11.0	17857	-0.2	21.6		22.0	0.0005	6.4	5964.3	633.0	0.2
One	2398	JUNE 2006	17857	-1.2	21.0		21.7	0.0009	7.8	4679.9	630.5	0.3
One	2398	POT 5.0	17857	-1.2	21.0		21.7	0.0009	7.8	4679.1	630.4	0.3
One	2398	POT 11.0	17857	-1.2	21.0		21.7	0.0009	7.7	4731.5	638.3	0.3
One	2211	JUNE 2006	19076	-2.4	19.7		21.0	0.0014	9.7	3376.4	451.0	0.4
One	2211	POT 5.0	19076	-2.4	19.7		21.0	0.0014	9.7	3375.6	451.0	0.4
One	2211	POT 11.0	19076	-2.4	19.8		21.1	0.0013	9.6	3430.1	451.2	0.4
One	2169	JUNE 2006	19076	0.1	19.8	10.9	20.5	0.0012	8.1	3829.2	601.4	0.3
One	2169	POT 5.0	19076	0.1	19.8	10.9	20.5	0.0012	8.1	3828.1	601.4	0.3
One	2169	POT 11.0	19076	0.1	20.0	10.9	20.7	0.0011	8.0	3932.3	602.6	0.3
One	2149		Bridge									
One	2129	JUNE 2006	19076	-1.2	16.9	9.9	17.9	0.0013	8.5	3106.8	382.0	0.4
One	2129	POT 5.0	19076	-1.2	16.9	9.9	17.9	0.0013	8.5	3105.7	381.9	0.4
One	2129	POT 11.0	19076	-1.2	17.1	9.9	18.1	0.0012	8.4	3203.9	386.8	0.4
One	2071	JUNE 2006	19076	0.7	16.3		17.6	0.0018	9.5	2821.8	255.4	0.4
One	2071	POT 5.0	19076	0.7	16.3		17.6	0.0018	9.5	2821.1	255.4	0.4
One	2071	POT 11.0	19076	0.7	16.6		17.8	0.0017	9.3	2891.3	256.2	0.4
One	1963	JUNE 2006	19076	-3.8	15.1		16.7	0.0027	11.1	2699.5	329.3	0.5
One	1963	POT 5.0	19076	-3.8	15.1		16.7	0.0027	11.1	2698.0	329.3	0.5
One	1963	POT 11.0	19076	-3.8	15.5		17.0	0.0025	10.8	2830.1	331.9	0.5
One	1823	JUNE 2006	19076	0.2	14.5		15.6	0.0017	8.7	3227.5	449.9	0.4
One	1823	POT 5.0	19076	0.2	14.5		15.6	0.0017	8.7	3224.9	449.8	0.4
One	1823	POT 11.0	19076	0.2	15.0		16.0	0.0015	8.3	3453.7	454.0	0.4
One	1707	JUNE 2006	19678	-0.2	14.3		15.1	0.0009	6.9	3472.2	541.2	0.4
One	1707	POT 5.0	19678	-0.2	14.3		15.0	0.0009	6.9	3468.8	541.1	0.4
One	1707	POT 11.0	19678	-0.2	14.9		15.5	0.0007	6.5	3773.8	551.1	0.3
One	1597	JUNE 2006	19678	-1.5	14.0		14.7	0.0011	7.6	5211.0	590.7	0.4
One	1597	POT 5.0	19678	-1.5	14.0		14.7	0.0011	7.6	5206.9	590.6	0.4
One	1597	POT 11.0	19678	-1.5	14.6		15.2	0.0010	7.1	5570.2	603.4	0.3
One	1389	JUNE 2006	19678	-1.5	13.9		14.1	0.0003	4.9	8828.1	1018.5	0.2
One	1389	POT 5.0	19678	-1.5	13.8		14.1	0.0003	4.9	8820.4	1018.3	0.2
One	1389	POT 11.0	19678	-1.5	14.5		14.7	0.0003	4.6	9492.1	1040.7	0.2
One	1280	JUNE 2006	19678	0.5	13.7		14.0	0.0004	5.3	6810.0	890.6	0.3
One	1280	POT 5.0	19678	0.5	13.7		14.0	0.0004	5.4	6803.0	890.2	0.3
One	1280	POT 11.0	19678	0.5	14.3		14.6	0.0003	5.0	7421.6	924.3	0.2
One	1260	JUNE 2006	19678	0.4	13.6		14.0	0.0004	5.7	6499.5	889.9	0.3
One	1260	POT 5.0	19678	0.4	13.6		14.0	0.0004	5.7	6492.3	889.5	0.3
One	1260	POT 11.0	19678	0.4	14.3		14.6	0.0004	5.3	7124.1	927.1	0.3
One	1240	JUNE 2006	19678	0.5	13.5		13.9	0.0005	5.8	6307.7	891.2	0.3
One	1240	POT 5.0	19678	0.5	13.5		13.9	0.0005	5.8	6300.4	890.8	0.3
One	1240	POT 11.0	19678	0.5	14.2		14.6	0.0004	5.4	6943.6	926.2	0.3
One	1220	JUNE 2006	19678	0.4	13.5		13.9	0.0005	5.9	6237.6	879.3	0.3
One	1220	POT 5.0	19678	0.4	13.5		13.9	0.0005	5.9	6230.2	878.9	0.3
One	1220	POT 11.0	19678	0.4	14.2		14.6	0.0004	5.5	6872.7	914.7	0.3
One	1200	JUNE 2006	19678	0.3	13.4		13.9	0.0006	6.3	5978.6	875.1	0.3

Reach	River Sta	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)	
One	1200	POT 5.0	19678	0.3	13.4		13.9	0.0006	6.3	5971.1	874.7	0.3
One	1200	POT 11.0	19678	0.3	14.1		14.5	0.0004	5.8	6626.7	911.4	0.3
One	1180	JUNE 2006	19678	0.3	13.4		13.9	0.0005	6.3	6003.5	883.0	0.3
One	1180	POT 5.0	19678	0.3	13.4		13.8	0.0005	6.3	5995.8	882.5	0.3
One	1180	POT 11.0	19678	0.3	14.1		14.5	0.0004	5.8	6665.6	919.7	0.3
One	1160	JUNE 2006	19678	0.2	13.3		13.8	0.0006	6.2	5832.1	881.5	0.3
One	1160	POT 5.0	19678	0.2	13.3		13.8	0.0006	6.2	5824.3	881.1	0.3
One	1160	POT 11.0	19678	0.2	14.1		14.5	0.0005	5.7	6500.5	918.7	0.3
One	1140	JUNE 2006	19678	0.2	13.3		13.8	0.0006	6.1	6083.9	930.4	0.3
One	1140	POT 5.0	19678	0.2	13.3		13.8	0.0006	6.1	6075.6	930.0	0.3
One	1140	POT 11.0	19678	0.2	14.1		14.4	0.0005	5.6	6794.9	967.9	0.3
One	1120	JUNE 2006	19678	0.3	13.3		13.7	0.0005	5.8	6628.6	981.2	0.3
One	1120	POT 5.0	19678	0.3	13.3		13.7	0.0005	5.8	6619.8	981.0	0.3
One	1120	POT 11.0	19678	0.3	14.1		14.4	0.0004	5.4	7373.1	996.3	0.3
One	1100	JUNE 2006	19678	0.1	13.3		13.7	0.0005	5.8	6697.8	1033.4	0.3
One	1100	POT 5.0	19678	0.1	13.3		13.7	0.0005	5.8	6688.4	1033.1	0.3
One	1100	POT 11.0	19678	0.1	14.0		14.4	0.0004	5.3	7492.4	1056.2	0.3
One	1080	JUNE 2006	19678	0.1	13.2		13.7	0.0005	5.9	6722.7	1032.3	0.3
One	1080	POT 5.0	19678	0.1	13.2		13.6	0.0005	5.9	6713.2	1032.0	0.3
One	1080	POT 11.0	19678	0.1	14.0		14.4	0.0004	5.4	7524.6	1055.3	0.3
One	1060	JUNE 2006	19678	0.1	13.2		13.6	0.0005	5.9	6962.1	1090.2	0.3
One	1060	POT 5.0	19678	0.1	13.2		13.6	0.0005	5.9	6951.9	1089.9	0.3
One	1060	POT 11.0	19678	0.1	14.0		14.3	0.0004	5.4	7824.2	1118.4	0.3
One	1040	JUNE 2006	19678	0.1	13.2		13.6	0.0005	6.0	7167.9	1089.3	0.3
One	1040	POT 5.0	19678	0.1	13.2		13.6	0.0005	6.0	7157.6	1089.0	0.3
One	1040	POT 11.0	19678	0.1	14.0		14.3	0.0004	5.5	8035.5	1117.7	0.3
One	1020	JUNE 2006	19678	0.2	13.2		13.5	0.0004	5.4	8260.1	1098.7	0.3
One	1020	POT 5.0	19678	0.2	13.2		13.5	0.0004	5.4	8249.9	1098.5	0.3
One	1020	POT 11.0	19678	0.2	14.0		14.3	0.0003	5.0	9122.3	1118.9	0.2
One	1000	JUNE 2006	19678	0.2	13.2		13.5	0.0004	5.2	8579.9	1089.9	0.3
One	1000	POT 5.0	19678	0.2	13.2		13.5	0.0004	5.2	8569.7	1089.6	0.3
One	1000	POT 11.0	19678	0.2	14.0		14.2	0.0003	4.8	9436.9	1114.8	0.2
One	980	JUNE 2006	19678	0.2	13.2		13.5	0.0004	5.3	8231.9	1082.1	0.3
One	980	POT 5.0	19678	0.2	13.2		13.5	0.0004	5.3	8221.7	1081.8	0.3
One	980	POT 11.0	19678	0.2	14.0		14.2	0.0003	4.9	9094.8	1105.7	0.2
One	960	JUNE 2006	19678	0.2	13.1		13.5	0.0004	5.3	7906.8	1081.0	0.3
One	960	POT 5.0	19678	0.2	13.1		13.4	0.0004	5.3	7896.5	1080.7	0.3
One	960	POT 11.0	19678	0.2	13.9		14.2	0.0003	4.9	8779.1	1104.9	0.2
One	940	JUNE 2006	19678	0.3	13.0		13.4	0.0005	5.8	6403.6	948.1	0.3
One	940	POT 5.0	19678	0.3	13.0		13.4	0.0005	5.8	6394.2	947.3	0.3
One	940	POT 11.0	19678	0.3	13.8		14.2	0.0004	5.4	7208.2	1012.9	0.3
One	920	JUNE 2006	19678	0.3	13.1		13.3	0.0004	4.9	8190.1	1065.6	0.2
One	920	POT 5.0	19678	0.3	13.1		13.3	0.0004	4.9	8179.7	1065.4	0.2
One	920	POT 11.0	19678	0.3	13.9		14.1	0.0003	4.4	9060.5	1082.6	0.2
One	900	JUNE 2006	19678	0.3	13.1		13.3	0.0004	4.7	8407.8	1082.6	0.2
One	900	POT 5.0	19678	0.3	13.1		13.3	0.0004	4.7	8397.2	1082.4	0.2
One	900	POT 11.0	19678	0.3	13.9		14.1	0.0003	4.3	9297.6	1104.6	0.2
One	880	JUNE 2006	19678	0.3	13.0		13.3	0.0004	5.2	8183.0	1093.6	0.3
One	880	POT 5.0	19678	0.3	13.0		13.3	0.0004	5.2	8172.0	1093.4	0.3
One	880	POT 11.0	19678	0.3	13.8		14.1	0.0003	4.7	9097.1	1110.2	0.2
One	860	JUNE 2006	19678	0.3	12.9		13.3	0.0004	5.3	7656.0	1091.5	0.3
One	860	POT 5.0	19678	0.3	12.9		13.2	0.0004	5.3	7644.8	1091.2	0.3
One	860	POT 11.0	19678	0.3	13.8		14.0	0.0003	4.8	8585.4	1108.4	0.2
One	840	JUNE 2006	19678	0.3	12.8		13.2	0.0004	5.4	6580.6	1067.2	0.3
One	840	POT 5.0	19678	0.3	12.8		13.2	0.0004	5.4	6569.4	1066.9	0.3
One	840	POT 11.0	19678	0.3	13.7		14.0	0.0003	4.9	7514.0	1093.1	0.2
One	820	JUNE 2006	19678	0.3	12.9		13.2	0.0004	5.2	7402.7	1075.7	0.3
One	820	POT 5.0	19678	0.3	12.8		13.2	0.0004	5.2	7391.4	1075.3	0.3
One	820	POT 11.0	19678	0.3	13.7		14.0	0.0003	4.7	8339.8	1101.5	0.2
One	800	JUNE 2006	19678	0.3	12.9		13.2	0.0004	5.1	7977.9	1070.3	0.3
One	800	POT 5.0	19678	0.3	12.8		13.1	0.0004	5.1	7966.6	1069.9	0.3

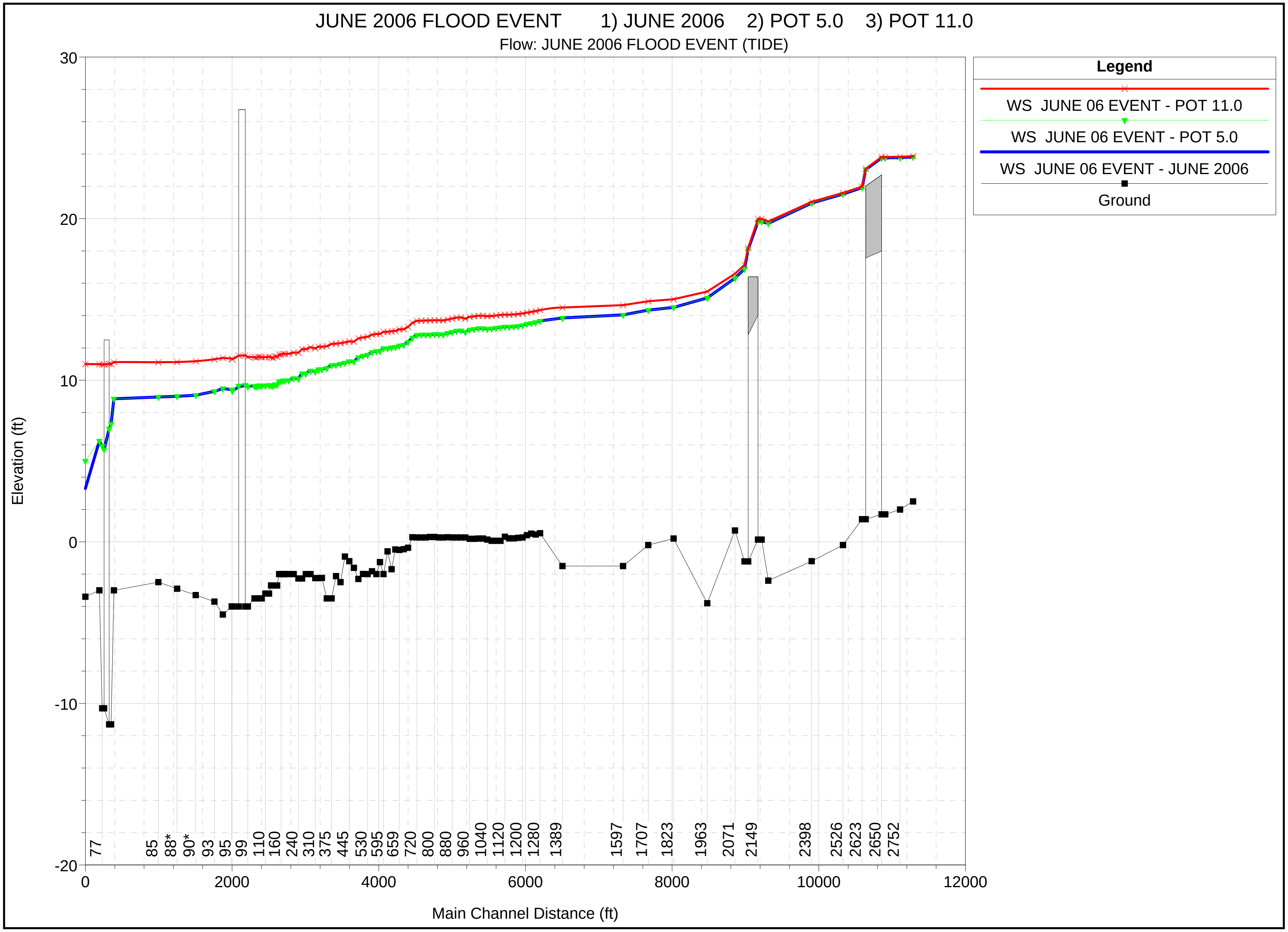
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	800	POT 11.0	19678	0.3	13.7		14.0	0.0003	4.6	8911.5	1097.8	0.2
One	780	JUNE 2006	19678	0.3	12.8		13.1	0.0004	5.1	7999.0	1089.1	0.3
One	780	POT 5.0	19678	0.3	12.8		13.1	0.0004	5.1	7987.5	1088.7	0.3
One	780	POT 11.0	19678	0.3	13.7		13.9	0.0003	4.6	8955.4	1116.8	0.2
One	760	JUNE 2006	19678	0.3	12.8		13.1	0.0003	4.9	8167.2	1088.4	0.2
One	760	POT 5.0	19678	0.3	12.8		13.1	0.0004	4.9	8155.6	1088.0	0.2
One	760	POT 11.0	19678	0.3	13.7		13.9	0.0003	4.4	9124.9	1116.2	0.2
One	740	JUNE 2006	19678	0.3	12.8		13.1	0.0003	4.7	8668.8	1138.3	0.2
One	740	POT 5.0	19678	0.3	12.8		13.1	0.0003	4.7	8656.7	1137.9	0.2
One	740	POT 11.0	19678	0.3	13.7		13.9	0.0002	4.3	9671.7	1166.1	0.2
One	720	JUNE 2006	19678	0.3	12.8		13.1	0.0003	4.7	8630.5	1136.7	0.2
One	720	POT 5.0	19678	0.3	12.8		13.0	0.0003	4.7	8618.3	1136.3	0.2
One	720	POT 11.0	19678	0.3	13.7		13.9	0.0002	4.3	9637.4	1164.7	0.2
One	700	JUNE 2006	19678	0.3	12.6		13.0	0.0004	5.4	6957.1	1223.7	0.3
One	700	POT 5.0	19678	0.3	12.6		13.0	0.0004	5.5	6943.1	1223.3	0.3
One	700	POT 11.0	19678	0.3	13.6		13.9	0.0003	4.9	8101.8	1255.1	0.2
One	680	JUNE 2006	19678	-0.4	12.4		13.0	0.0006	6.3	3402.3	334.0	0.3
One	680	POT 5.0	19678	-0.4	12.4		13.0	0.0006	6.3	3398.5	333.6	0.3
One	680	POT 11.0	19678	-0.4	13.3		13.8	0.0005	5.9	3732.9	378.4	0.3
One	660	JUNE 2006	19678	-0.5	12.2		12.9	0.0008	7.0	3120.8	319.8	0.4
One	660	POT 5.0	19678	-0.5	12.2		12.9	0.0008	7.0	3117.0	319.3	0.4
One	660	POT 11.0	19678	-0.5	13.2		13.8	0.0006	6.5	3451.0	365.8	0.3
One	659	JUNE 2006	19678	-0.5	12.2		12.9	0.0008	6.9	3369.8	657.9	0.4
One	659	POT 5.0	19678	-0.5	12.1		12.9	0.0008	6.9	3361.7	654.9	0.4
One	659	POT 11.0	19678	-0.5	13.1		13.7	0.0006	6.3	4143.2	893.7	0.3
One	640	JUNE 2006	19678	-0.5	12.1		12.8	0.0008	7.1	3078.5	369.3	0.4
One	640	POT 5.0	19678	-0.5	12.0		12.8	0.0008	7.1	3073.9	368.6	0.4
One	640	POT 11.0	19678	-0.5	13.1		13.7	0.0006	6.5	3470.9	420.6	0.3
One	625	JUNE 2006	19678	-1.7	12.0		12.8	0.0008	7.1	3130.4	388.8	0.4
One	625	POT 5.0	19678	-1.7	12.0		12.8	0.0008	7.1	3125.6	384.8	0.4
One	625	POT 11.0	19678	-1.7	13.0		13.7	0.0006	6.5	3683.4	714.0	0.3
One	610	JUNE 2006	19678	-0.6	12.0		12.7	0.0009	7.1	3094.0	344.8	0.4
One	610	POT 5.0	19678	-0.6	12.0		12.7	0.0009	7.1	3089.6	344.4	0.4
One	610	POT 11.0	19678	-0.6	13.0		13.6	0.0007	6.5	3461.2	389.1	0.3
One	595	JUNE 2006	19678	-2.0	12.0		12.7	0.0008	6.8	3200.0	312.1	0.3
One	595	POT 5.0	19678	-2.0	12.0		12.6	0.0008	6.8	3196.1	311.9	0.3
One	595	POT 11.0	19678	-2.0	13.0		13.6	0.0006	6.2	3543.3	369.9	0.3
One	575	JUNE 2006	19678	-1.3	11.8		12.6	0.0010	7.3	2960.4	323.6	0.4
One	575	POT 5.0	19678	-1.3	11.8		12.6	0.0011	7.3	2956.1	323.2	0.4
One	575	POT 11.0	19678	-1.3	12.9		13.5	0.0008	6.7	3319.2	352.4	0.3
One	555	JUNE 2006	19678	-2.0	11.8		12.5	0.0011	7.1	3022.5	303.8	0.4
One	555	POT 5.0	19678	-2.0	11.8		12.5	0.0011	7.1	3018.4	303.5	0.4
One	555	POT 11.0	19678	-2.0	12.9		13.5	0.0008	6.4	3368.6	356.9	0.3
One	540	JUNE 2006	19678	-1.8	11.7		12.5	0.0012	7.0	3024.0	302.7	0.4
One	540	POT 5.0	19678	-1.8	11.7		12.5	0.0012	7.0	3019.9	302.4	0.4
One	540	POT 11.0	19678	-1.8	12.8		13.4	0.0009	6.4	3373.2	363.6	0.3
One	530	JUNE 2006	19678	-2.0	11.6		12.4	0.0015	7.4	2844.6	277.6	0.4
One	530	POT 5.0	19678	-2.0	11.6		12.4	0.0015	7.4	2840.7	277.4	0.4
One	530	POT 11.0	19678	-2.0	12.7		13.3	0.0011	6.7	3166.4	299.8	0.3
One	510	JUNE 2006	19678	-2.0	11.5		12.3	0.0015	7.2	2887.9	283.8	0.4
One	510	POT 5.0	19678	-2.0	11.5		12.3	0.0015	7.2	2883.7	283.3	0.4
One	510	POT 11.0	19678	-2.0	12.7		13.3	0.0011	6.5	3238.3	345.6	0.3
One	485	JUNE 2006	19678	-2.3	11.4		12.2	0.0016	7.0	2858.9	272.7	0.4
One	485	POT 5.0	19678	-2.3	11.4		12.2	0.0016	7.0	2854.8	272.6	0.4
One	485	POT 11.0	19678	-2.3	12.6		13.2	0.0012	6.3	3204.8	345.0	0.3
One	465	JUNE 2006	19678	-1.6	11.2		12.1	0.0014	7.8	2650.4	257.6	0.4
One	465	POT 5.0	19678	-1.6	11.1		12.0	0.0014	7.8	2646.3	256.8	0.4
One	465	POT 11.0	19678	-1.6	12.4		13.1	0.0010	7.0	3011.6	354.9	0.3
One	445	JUNE 2006	19678	-1.2	11.2		11.9	0.0012	7.1	2850.7	271.1	0.4
One	445	POT 5.0	19678	-1.2	11.2		11.9	0.0012	7.1	2846.3	271.1	0.4
One	445	POT 11.0	19678	-1.2	12.4		13.0	0.0009	6.4	3200.9	325.2	0.3

Reach	River Sta	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)	
One	425	JUNE 2006	19678	-0.9	11.1		11.9	0.0012	7.2	2811.2	264.3	0.4
One	425	POT 5.0	19678	-0.9	11.1		11.8	0.0012	7.2	2806.8	264.2	0.4
One	425	POT 11.0	19678	-0.9	12.3		13.0	0.0009	6.4	3145.4	277.3	0.3
One	395	JUNE 2006	19678	-2.5	11.0		11.8	0.0013	7.1	2845.2	257.4	0.4
One	395	POT 5.0	19678	-2.5	11.0		11.8	0.0013	7.1	2840.9	257.3	0.4
One	395	POT 11.0	19678	-2.5	12.3		12.9	0.0009	6.3	3193.1	320.9	0.3
One	385	JUNE 2006	19678	-2.1	11.0		11.7	0.0012	7.0	2879.8	281.2	0.4
One	385	POT 5.0	19678	-2.1	10.9		11.7	0.0012	7.1	2874.9	281.1	0.4
One	385	POT 11.0	19678	-2.1	12.3		12.8	0.0008	6.2	3273.4	332.6	0.3
One	375	JUNE 2006	19678	-3.5	10.9		11.6	0.0011	6.7	3020.7	268.6	0.3
One	375	POT 5.0	19678	-3.5	10.9		11.6	0.0011	6.8	3016.0	268.6	0.3
One	375	POT 11.0	19678	-3.5	12.2		12.8	0.0008	6.0	3447.6	365.6	0.3
One	355	JUNE 2006	19678	-3.5	10.8		11.5	0.0013	7.3	2870.2	257.4	0.4
One	355	POT 5.0	19678	-3.5	10.7		11.5	0.0013	7.3	2865.6	257.4	0.4
One	355	POT 11.0	19678	-3.5	12.1		12.7	0.0009	6.5	3282.3	352.8	0.3
One	337	JUNE 2006	19678	-2.2	10.7		11.4	0.0012	7.2	2907.3	300.1	0.4
One	337	POT 5.0	19678	-2.2	10.7		11.4	0.0012	7.2	2901.7	299.9	0.4
One	337	POT 11.0	19678	-2.2	12.1		12.6	0.0008	6.3	3354.6	377.4	0.3
One	325	JUNE 2006	19678	-2.3	10.7		11.4	0.0010	6.8	3100.3	312.6	0.4
One	325	POT 5.0	19678	-2.3	10.7		11.3	0.0011	6.8	3094.4	312.5	0.4
One	325	POT 11.0	19678	-2.3	12.1		12.6	0.0007	6.0	3559.1	358.2	0.3
One	310	JUNE 2006	19678	-2.3	10.5		11.3	0.0014	7.2	2934.3	299.8	0.4
One	310	POT 5.0	19678	-2.3	10.5		11.3	0.0014	7.3	2928.4	299.7	0.4
One	310	POT 11.0	19678	-2.3	12.0		12.5	0.0009	6.4	3381.9	336.8	0.3
One	290	JUNE 2006	19678	-2.0	10.6		11.1	0.0014	6.4	3536.3	434.6	0.3
One	290	POT 5.0	19678	-2.0	10.6		11.1	0.0014	6.4	3527.7	433.3	0.3
One	290	POT 11.0	19678	-2.0	12.0		12.4	0.0009	5.5	4228.8	526.2	0.3
One	270	JUNE 2006	19678	-2.0	10.4		11.0	0.0015	6.9	3368.4	410.1	0.4
One	270	POT 5.0	19678	-2.0	10.4		11.0	0.0015	6.9	3360.0	408.8	0.4
One	270	POT 11.0	19678	-2.0	11.9		12.4	0.0010	5.9	4054.2	506.7	0.3
One	255	JUNE 2006	19678	-2.3	10.4		10.9	0.0010	6.1	3812.3	452.7	0.3
One	255	POT 5.0	19678	-2.3	10.4		10.9	0.0010	6.1	3803.0	451.8	0.3
One	255	POT 11.0	19678	-2.3	11.9		12.3	0.0007	5.3	4533.0	515.2	0.3
One	240	JUNE 2006	19678	-2.3	10.1		10.9	0.0018	7.3	3446.0	414.5	0.4
One	240	POT 5.0	19678	-2.3	10.1		10.8	0.0018	7.3	3436.8	413.5	0.4
One	240	POT 11.0	19678	-2.3	11.7		12.2	0.0012	6.3	4156.6	481.1	0.3
One	210	JUNE 2006	19678	-2.0	10.1		10.7	0.0008	6.8	4378.0	506.2	0.3
One	210	POT 5.0	19678	-2.0	10.1		10.7	0.0009	6.8	4366.8	505.0	0.3
One	210	POT 11.0	19678	-2.0	11.7		12.2	0.0006	5.9	5242.1	588.3	0.3
One	180	JUNE 2006	19678	-2.0	10.0		10.7	0.0012	7.1	4050.6	462.4	0.4
One	180	POT 5.0	19678	-2.0	10.0		10.6	0.0012	7.2	4039.8	461.6	0.4
One	180	POT 11.0	19678	-2.0	11.6		12.1	0.0008	6.1	4877.2	547.4	0.3
One	170	JUNE 2006	19678	-2.0	10.0		10.6	0.0009	6.8	4235.9	487.3	0.4
One	170	POT 5.0	19678	-2.0	10.0		10.6	0.0009	6.8	4224.5	486.6	0.4
One	170	POT 11.0	19678	-2.0	11.6		12.1	0.0006	5.8	5104.3	572.3	0.3
One	165	JUNE 2006	19678	-2.0	10.0		10.6	0.0007	6.6	4455.8	512.7	0.3
One	165	POT 5.0	19678	-2.0	10.0		10.5	0.0007	6.6	4443.8	512.0	0.3
One	165	POT 11.0	19678	-2.0	11.6		12.1	0.0004	5.7	5363.5	597.7	0.3
One	160	JUNE 2006	19678	-2.0	9.9		10.5	0.0010	6.7	4307.8	499.1	0.4
One	160	POT 5.0	19678	-2.0	9.9		10.5	0.0010	6.8	4295.9	498.4	0.4
One	160	POT 11.0	19678	-2.0	11.6		12.0	0.0006	5.9	5198.9	595.5	0.3
One	155	JUNE 2006	19678	-2.0	9.9		10.5	0.0007	6.6	4427.9	511.1	0.3
One	155	POT 5.0	19678	-2.0	9.9		10.5	0.0007	6.6	4415.7	510.3	0.3
One	155	POT 11.0	19678	-2.0	11.6		12.0	0.0004	5.7	5341.9	595.8	0.3
One	150	JUNE 2006	19678	-2.7	9.7		10.5	0.0009	7.4	3940.3	525.7	0.4
One	150	POT 5.0	19678	-2.7	9.7		10.4	0.0009	7.4	3926.7	524.5	0.4
One	150	POT 11.0	19678	-2.7	11.5		12.0	0.0005	6.3	4919.7	631.1	0.3
One	145	JUNE 2006	19678	-2.7	9.8		10.4	0.0008	7.1	4150.8	568.0	0.4
One	145	POT 5.0	19678	-2.7	9.7		10.4	0.0008	7.1	4136.2	566.8	0.4
One	145	POT 11.0	19678	-2.7	11.5		12.0	0.0005	6.0	5222.6	668.0	0.3

HEC-RAS River: Cameron Run Reach: One (Continued)

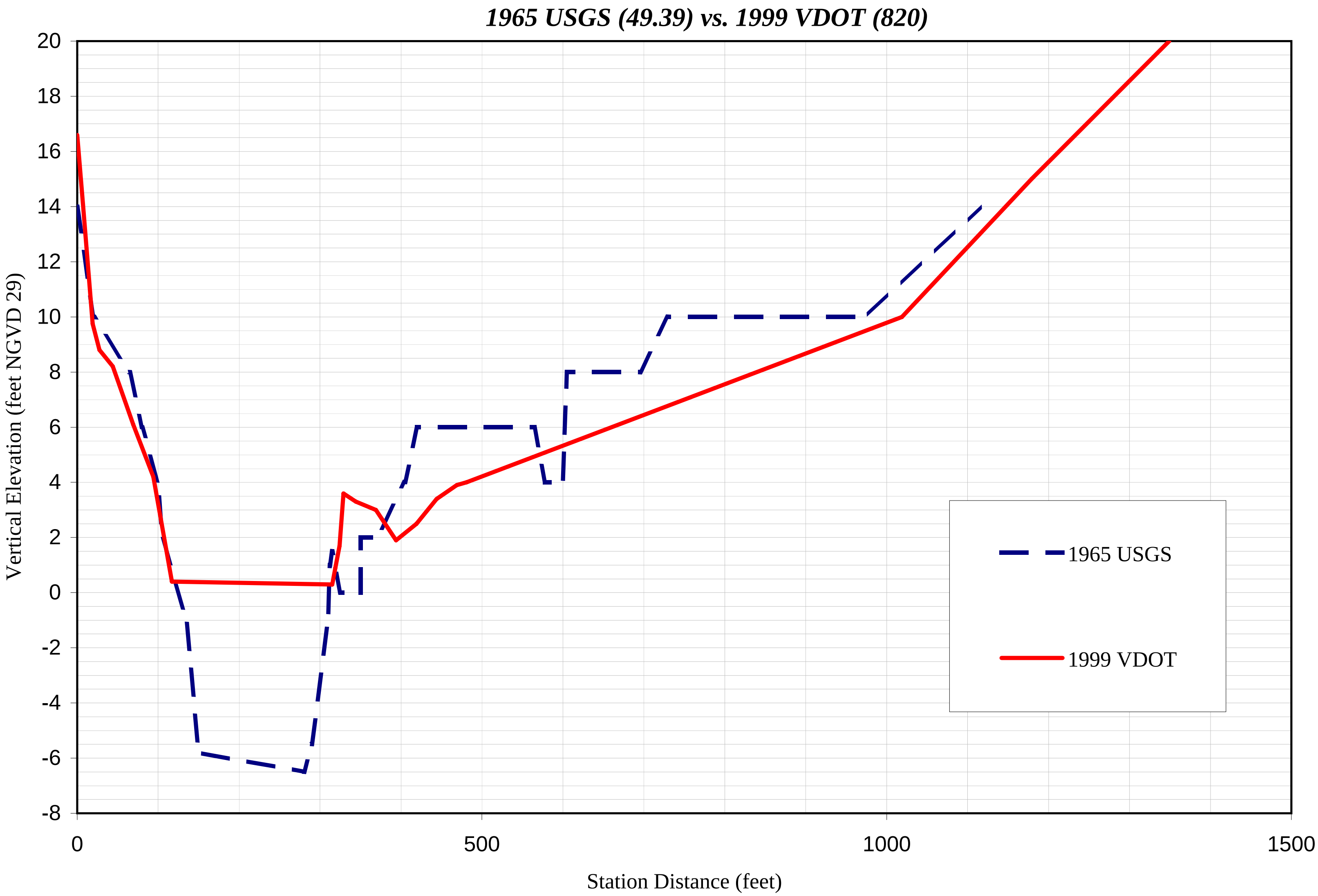
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	135	JUNE 2006	19678	-2.7	9.7		10.4	0.0009	7.4	4131.9	527.8	0.4
One	135	POT 5.0	19678	-2.7	9.6		10.4	0.0009	7.4	4118.3	526.6	0.4
One	135	POT 11.0	19678	-2.7	11.4		11.9	0.0005	6.4	5130.6	642.0	0.3
One	130	JUNE 2006	19678	-2.7	9.7		10.3	0.0008	7.1	4334.8	557.1	0.4
One	130	POT 5.0	19678	-2.7	9.7		10.3	0.0008	7.1	4320.4	555.9	0.4
One	130	POT 11.0	19678	-2.7	11.4		11.9	0.0005	6.1	5380.8	663.5	0.3
One	120	JUNE 2006	19678	-3.2	9.7		10.3	0.0007	6.9	4704.4	635.0	0.4
One	120	POT 5.0	19678	-3.2	9.7		10.3	0.0007	6.9	4687.9	633.6	0.4
One	120	POT 11.0	19678	-3.2	11.4		11.9	0.0004	5.8	5898.6	747.1	0.3
One	110	JUNE 2006	19678	-3.2	9.7		10.3	0.0007	6.8	4779.6	657.4	0.4
One	110	POT 5.0	19678	-3.2	9.7		10.2	0.0007	6.8	4762.3	656.0	0.4
One	110	POT 11.0	19678	-3.2	11.4		11.8	0.0004	5.8	6015.6	761.3	0.3
One	100	JUNE 2006	19678	-3.5	9.7		10.2	0.0007	6.6	5053.0	677.2	0.3
One	100	POT 5.0	19678	-3.5	9.6		10.2	0.0007	6.6	5035.1	675.9	0.3
One	100	POT 11.0	19678	-3.5	11.4		11.8	0.0004	5.6	6332.0	779.7	0.3
One	99.8	JUNE 2006	19678	-3.5	9.7		10.2	0.0006	6.3	5361.1	715.7	0.3
One	99.8	POT 5.0	19678	-3.5	9.7		10.2	0.0006	6.3	5342.2	714.4	0.3
One	99.8	POT 11.0	19678	-3.5	11.5		11.8	0.0003	5.3	6704.2	818.2	0.3
One	99.7	JUNE 2006	19678	-3.5	9.7		10.2	0.0010	6.4	5147.3	685.4	0.3
One	99.7	POT 5.0	19678	-3.5	9.7		10.1	0.0010	6.4	5129.0	684.0	0.3
One	99.7	POT 11.0	19678	-3.5	11.5		11.8	0.0006	5.3	6457.5	798.7	0.3
One	99.6	JUNE 2006	19678	-3.5	9.6		10.1	0.0006	6.4	5374.8	709.3	0.3
One	99.6	POT 5.0	19678	-3.5	9.6		10.1	0.0006	6.4	5356.0	707.9	0.3
One	99.6	POT 11.0	19678	-3.5	11.4		11.7	0.0004	5.4	6717.0	812.7	0.3
One	99.5	JUNE 2006	19678	-3.5	9.7		10.1	0.0008	6.2	5602.4	753.8	0.3
One	99.5	POT 5.0	19678	-3.5	9.6		10.1	0.0008	6.2	5582.3	752.5	0.3
One	99.5	POT 11.0	19678	-3.5	11.4		11.7	0.0005	5.2	7023.5	863.5	0.2
One	99	JUNE 2006	21237	-4.0	9.6	5.8	10.0	0.0007	5.6	6121.1	1166.0	0.3
One	99	POT 5.0	21237	-4.0	9.6	5.8	10.0	0.0007	5.6	6089.9	1156.9	0.3
One	99	POT 11.0	21237	-4.0	11.4	5.8	11.7	0.0003	4.4	8574.8	1482.4	0.2
One	96		Bridge									
One	95.5	JUNE 2006	21237	-4.0	9.3		9.8	0.0008	5.8	5796.2	1067.2	0.4
One	95.5	POT 5.0	21237	-4.0	9.3		9.8	0.0008	5.8	5796.2	1067.2	0.4
One	95.5	POT 11.0	21237	-4.0	11.3		11.5	0.0004	4.6	8359.4	1463.1	0.3
One	95	JUNE 2006	21237	-4.0	9.4		9.7	0.0006	5.5	8720.6	1300.6	0.3
One	95	POT 5.0	21237	-4.0	9.4		9.7	0.0006	5.5	8720.6	1300.6	0.3
One	95	POT 11.0	21237	-4.0	11.3		11.5	0.0003	4.5	11651.9	1674.2	0.2
One	94*	JUNE 2006	21237	-4.5	9.5		9.6	0.0003	3.9	11585.4	1586.7	0.2
One	94*	POT 5.0	21237	-4.5	9.5		9.6	0.0003	3.9	11585.4	1586.7	0.2
One	94*	POT 11.0	21237	-4.5	11.4		11.5	0.0002	3.1	14676.5	1690.0	0.2
One	93	JUNE 2006	21237	-3.7	9.3		9.6	0.0006	5.4	9152.4	1416.6	0.3
One	93	POT 5.0	21237	-3.7	9.3		9.6	0.0006	5.4	9152.4	1416.6	0.3
One	93	POT 11.0	21237	-3.7	11.3		11.4	0.0003	4.2	12371.9	1842.6	0.2
One	90*	JUNE 2006	21237	-3.3	9.1		9.4	0.0008	5.3	6542.2	1061.1	0.3
One	90*	POT 5.0	21237	-3.3	9.1		9.4	0.0008	5.3	6542.2	1061.1	0.3
One	90*	POT 11.0	21237	-3.3	11.2		11.4	0.0004	4.0	9161.7	1444.4	0.2
One	88*	JUNE 2006	21237	-2.9	9.0		9.2	0.0004	4.1	6416.0	920.4	0.2
One	88*	POT 5.0	21237	-2.9	9.0		9.2	0.0004	4.1	6416.0	920.4	0.2
One	88*	POT 11.0	21237	-2.9	11.1		11.3	0.0002	3.2	8857.3	1365.6	0.2
One	85	JUNE 2006	21237	-2.5	9.0		9.1	0.0003	3.5	6634.2	827.4	0.2
One	85	POT 5.0	21237	-2.5	9.0		9.1	0.0003	3.5	6634.2	827.4	0.2
One	85	POT 11.0	21237	-2.5	11.1		11.2	0.0001	2.8	8540.2	1031.9	0.1
One	79	JUNE 2006	21237	-3.0	8.9		9.0	0.0003	3.8	16013.4	4507.0	0.2
One	79	POT 5.0	21237	-3.0	8.9		9.0	0.0003	3.8	16013.4	4507.0	0.2
One	79	POT 11.0	21237	-3.0	11.1		11.1	0.0001	2.2	26488.4	4682.4	0.1
One	78	JUNE 2006	21237	-11.3	7.3	0.9	8.6	0.0011	9.2	3317.7	2322.0	0.4
One	78	POT 5.0	21237	-11.3	7.3	0.9	8.6	0.0011	9.2	3317.7	2322.0	0.4
One	78	POT 11.0	21237	-11.3	11.0	0.9	11.1	0.0001	3.7	17986.9	4375.9	0.2
One	77.5		Bridge									
One	77	JUNE 2006	21237	-10.3	5.9	1.9	7.6	0.0019	10.4	2042.6	184.2	0.6

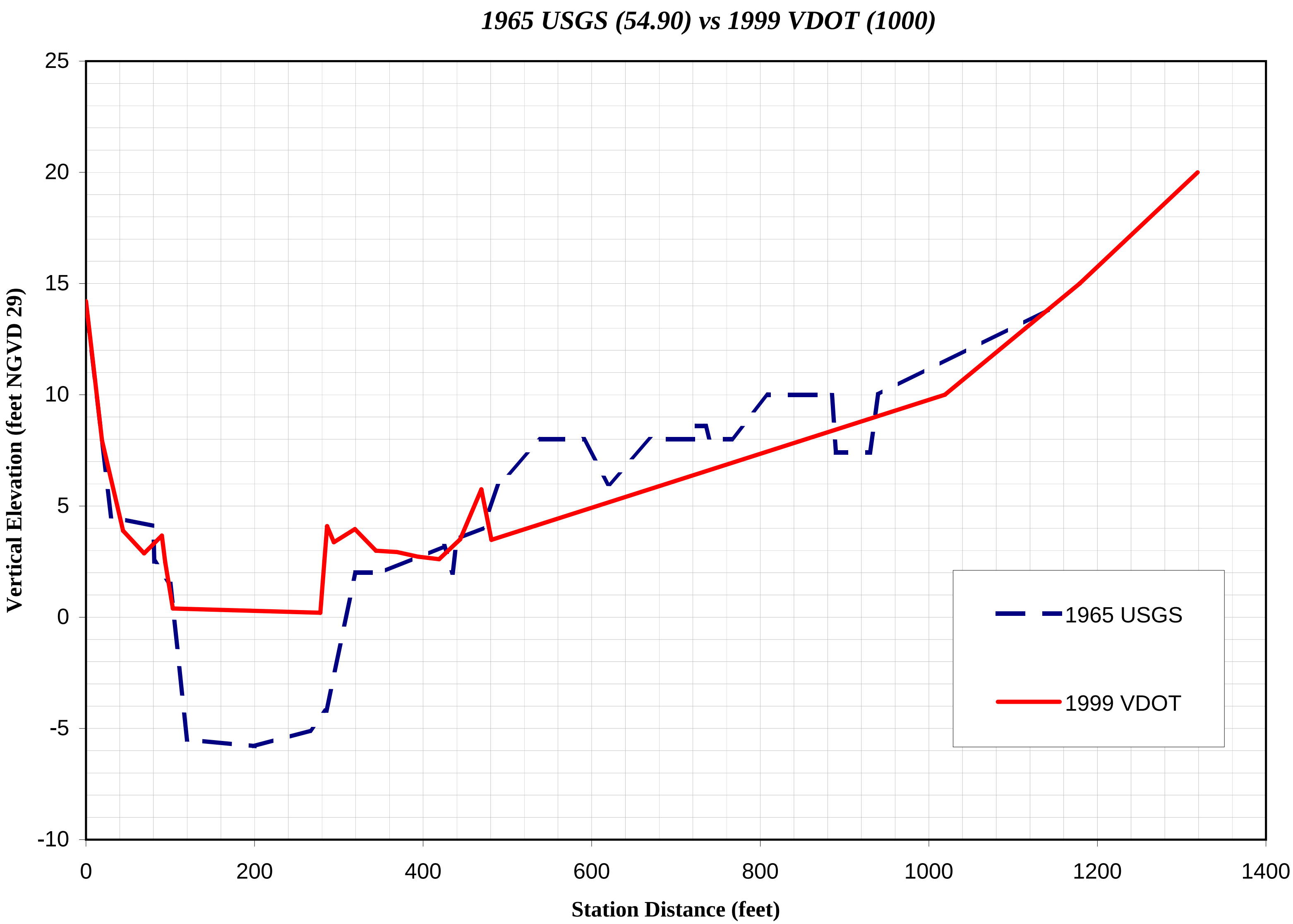
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
One	77	POT 5.0	21237	-10.3	5.9	1.9	7.6	0.0019	10.4	2042.6	184.2	0.6
One	77	POT 11.0	21237	-10.3	11.0	1.9	11.0	0.0001	3.0	27602.2	8968.5	0.1
One	76	JUNE 2006	21237	-3.0	6.2	6.2	7.1	0.0035	8.0	4962.2	4203.6	0.7
One	76	POT 5.0	21237	-3.0	6.2	6.2	7.1	0.0035	8.0	4962.2	4203.6	0.7
One	76	POT 11.0	21237	-3.0	11.0		11.0	0.0001	1.7	26411.2	4636.4	0.1
One	75	JUNE 2006	21237	-3.4	3.3	3.3	4.6	0.0057	9.2	2885.9	1825.8	0.8
One	75	POT 5.0	21237	-3.4	5.0	3.3	5.3	0.0010	5.0	7766.4	3917.7	0.4
One	75	POT 11.0	21237	-3.4	11.0	3.3	11.0	0.0000	0.9	53138.2	8445.0	0.0


JUNE 2006 FLOOD EVENT 1) JUNE 2006 2) POT 5.0 3) POT 11.0
Flow: JUNE 2006 FLOOD EVENT (TIDE)
Legend
WS JUNE 06 EVENT - POT 11.0
WS JUNE 06 EVENT - POT 5.0
WS JUNE 06 EVENT - JUNE 2006
Ground
Elevation (ft)
Main Channel Distance (ft)
30
20
10
0
-10
-20
0
2000
4000
6000
8000
10000
12000
77
85
88*
90*
93
95
99
110
160
240
310
375
445
530
595
659
720
800
880
960
1040
1120
1200
1280
1389
1597
1707
1823
1963
2071
2149
2398
2526
2623
2650
2752

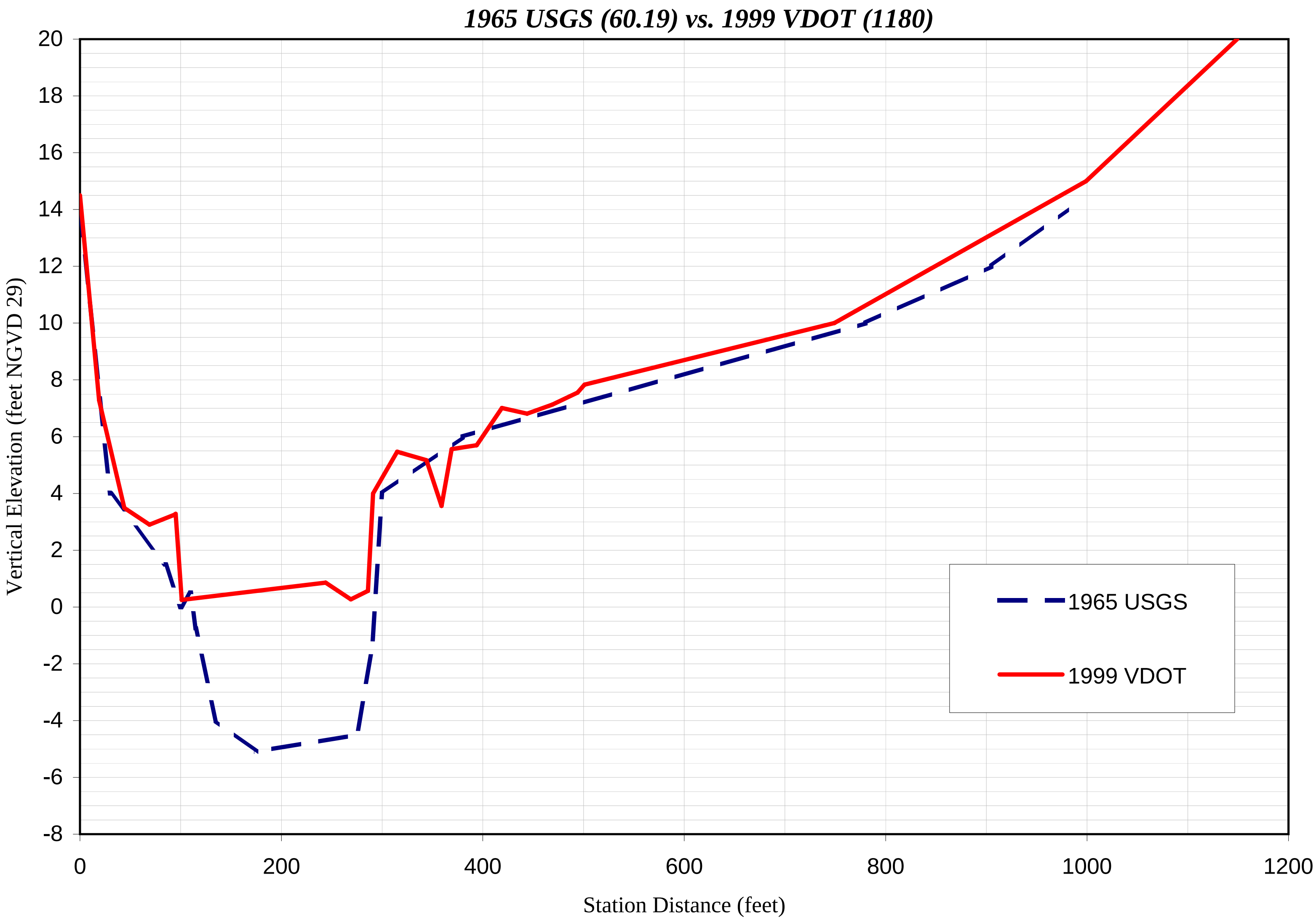
APPENDIX H

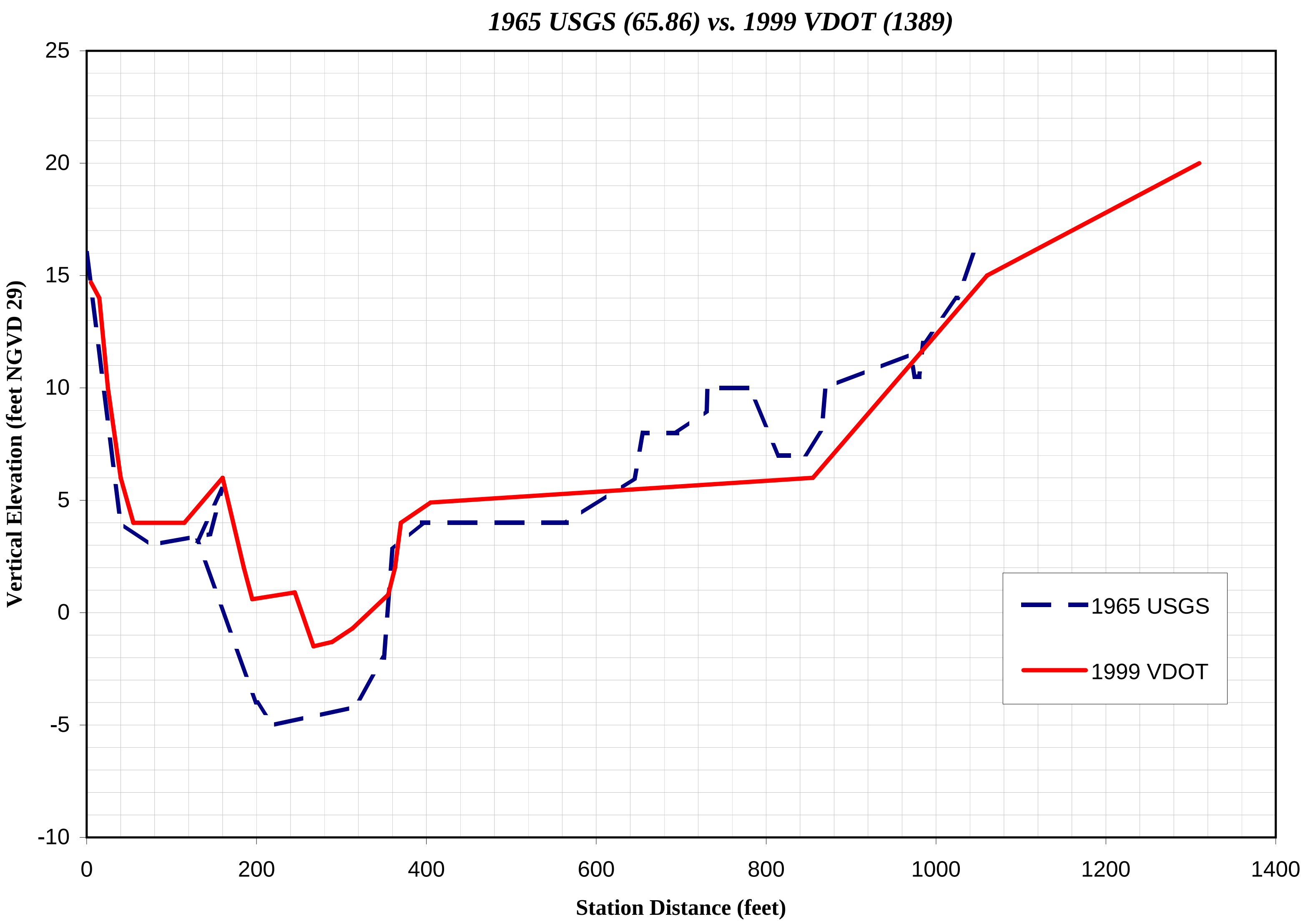
1965 CROSS-SECTIONS VS. 1999 CROSS-SECTIONS

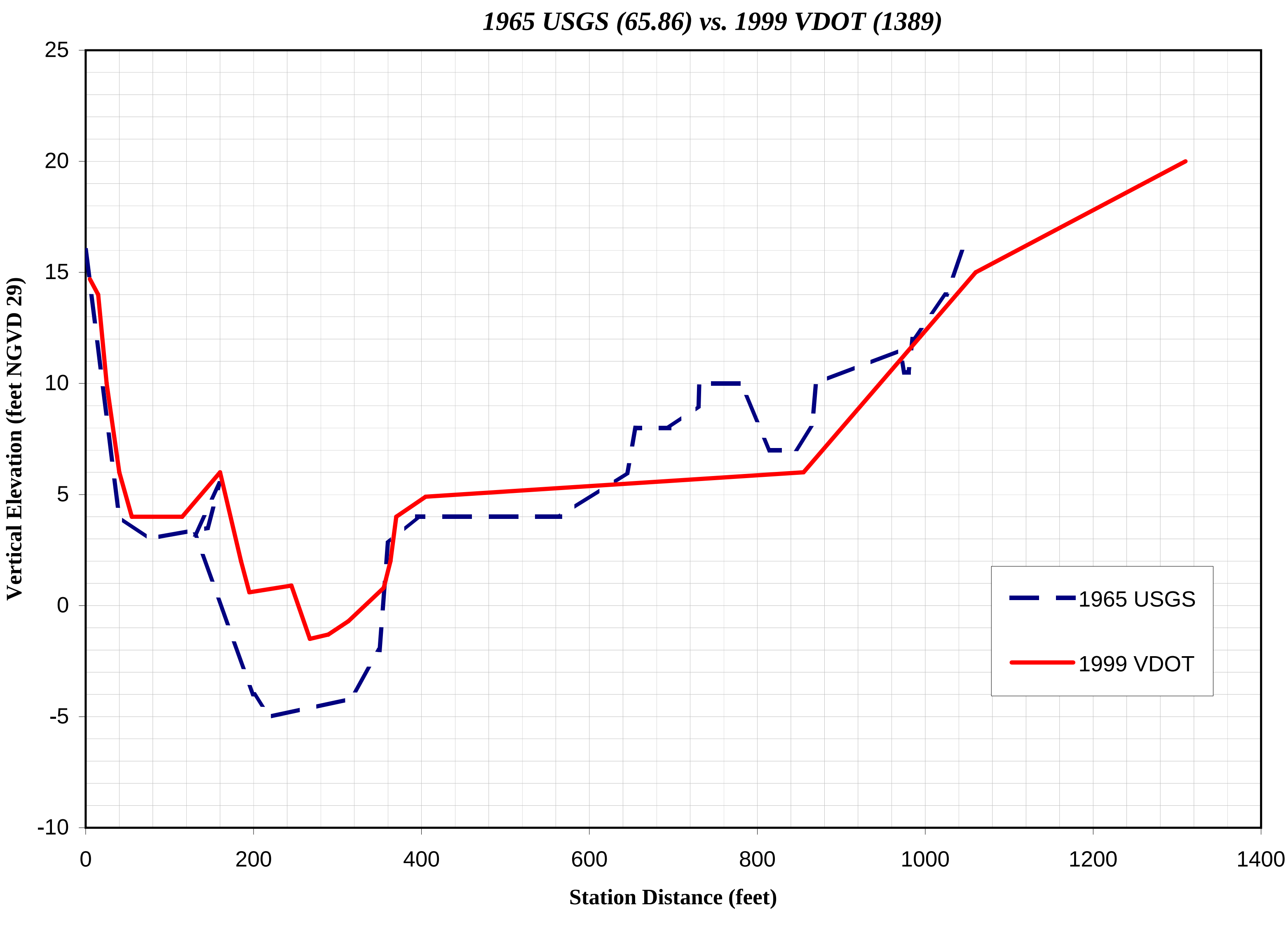

1965 USGS (49.39) vs. 1999 VDOT (820)
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
0
500
1000
1500
1965 USGS
1999 VDOT



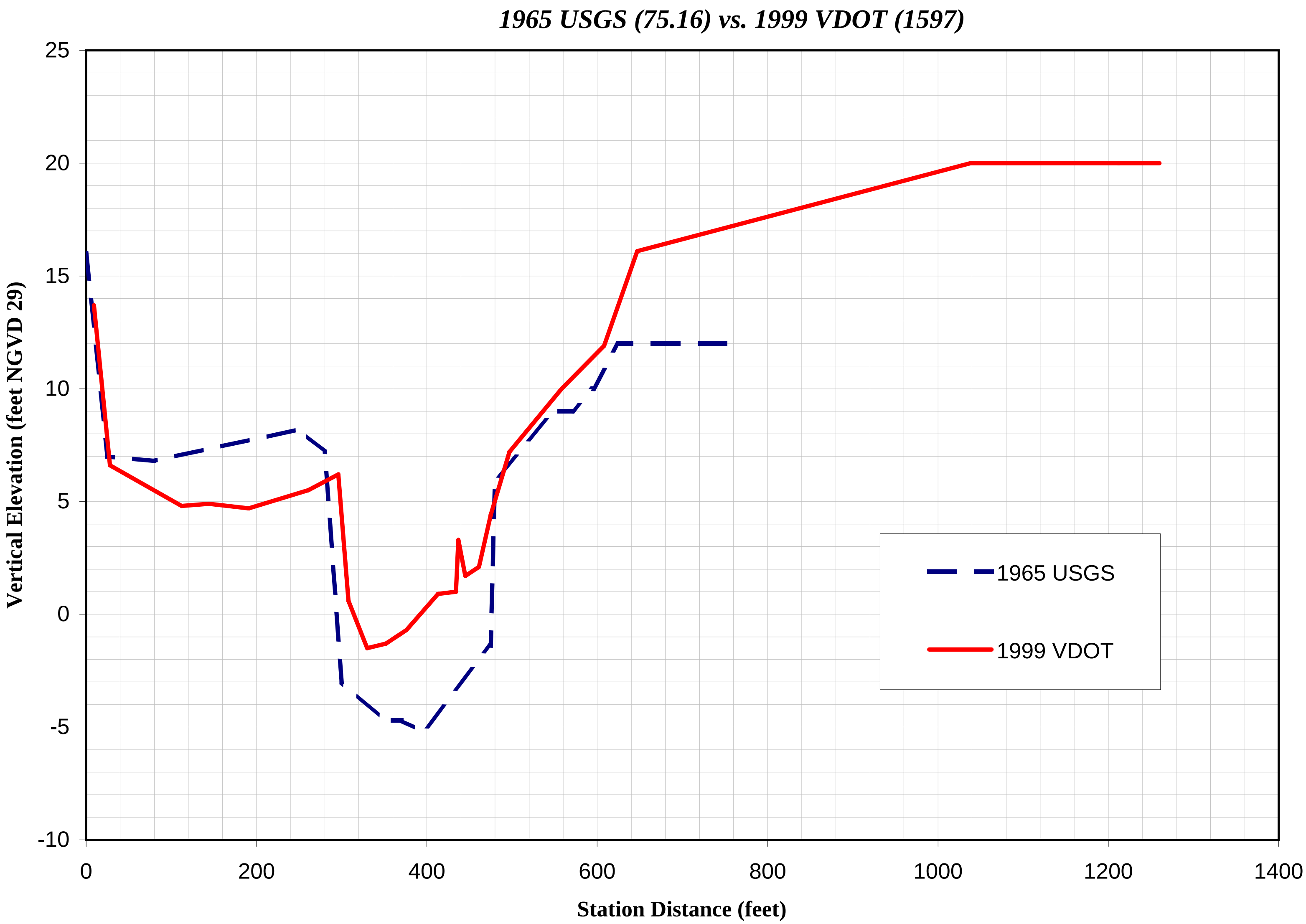
1965 USGS (54.90) vs 1999 VDOT (1000)
25
20
15
10
5
0
-5
-10
0
200
400
600
800
1000
1200
1400
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
1965 USGS
1999 VDOT

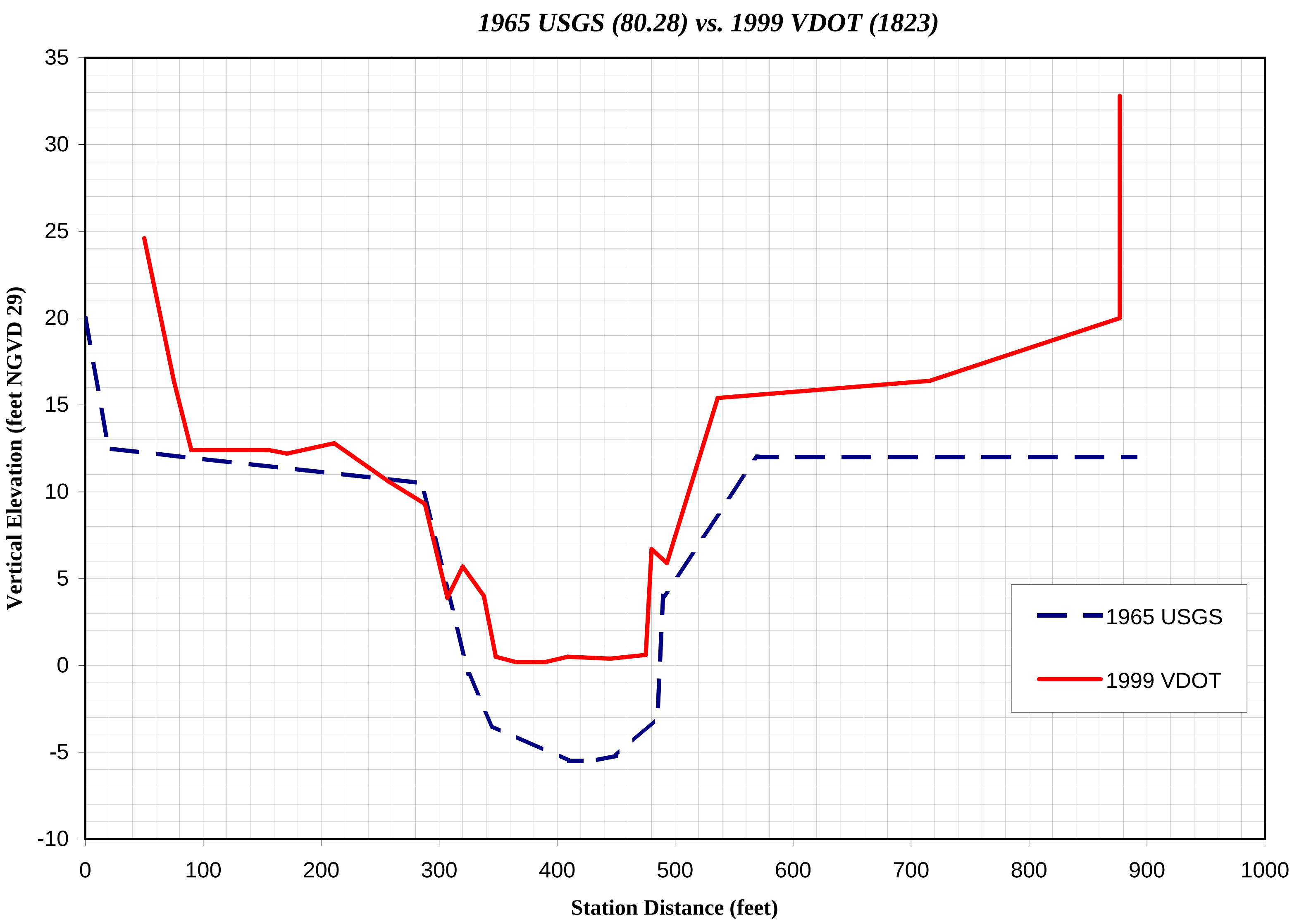

1965 USGS (60.19) vs. 1999 VDOT (1180)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
Vertical Elevation (feet NGVD 29)
0
200
400
600
800
1000
1200
Station Distance (feet)
1965 USGS
1999 VDOT


1965 USGS (65.86) vs. 1999 VDOT (1389)
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
25
20
15
10
5
0
-5
-10
0
200
400
600
800
1000
1200
1400
1965 USGS
1999 VDOT

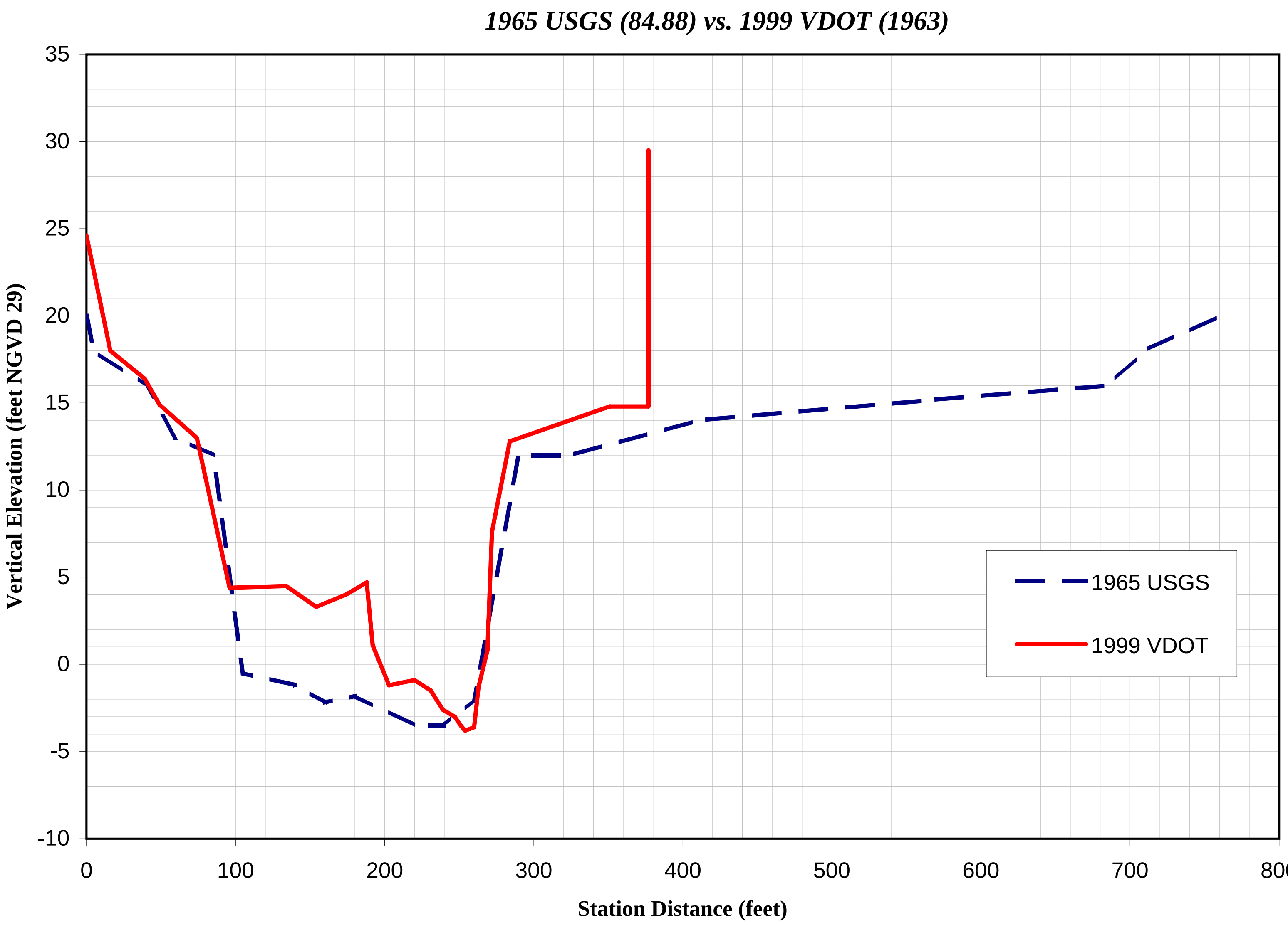


1965 USGS (65.86) vs. 1999 VDOT (1389)
25
20
15
10
5
0
-5
-10
0
200
400
600
800
1000
1200
1400
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
1965 USGS
1999 VDOT

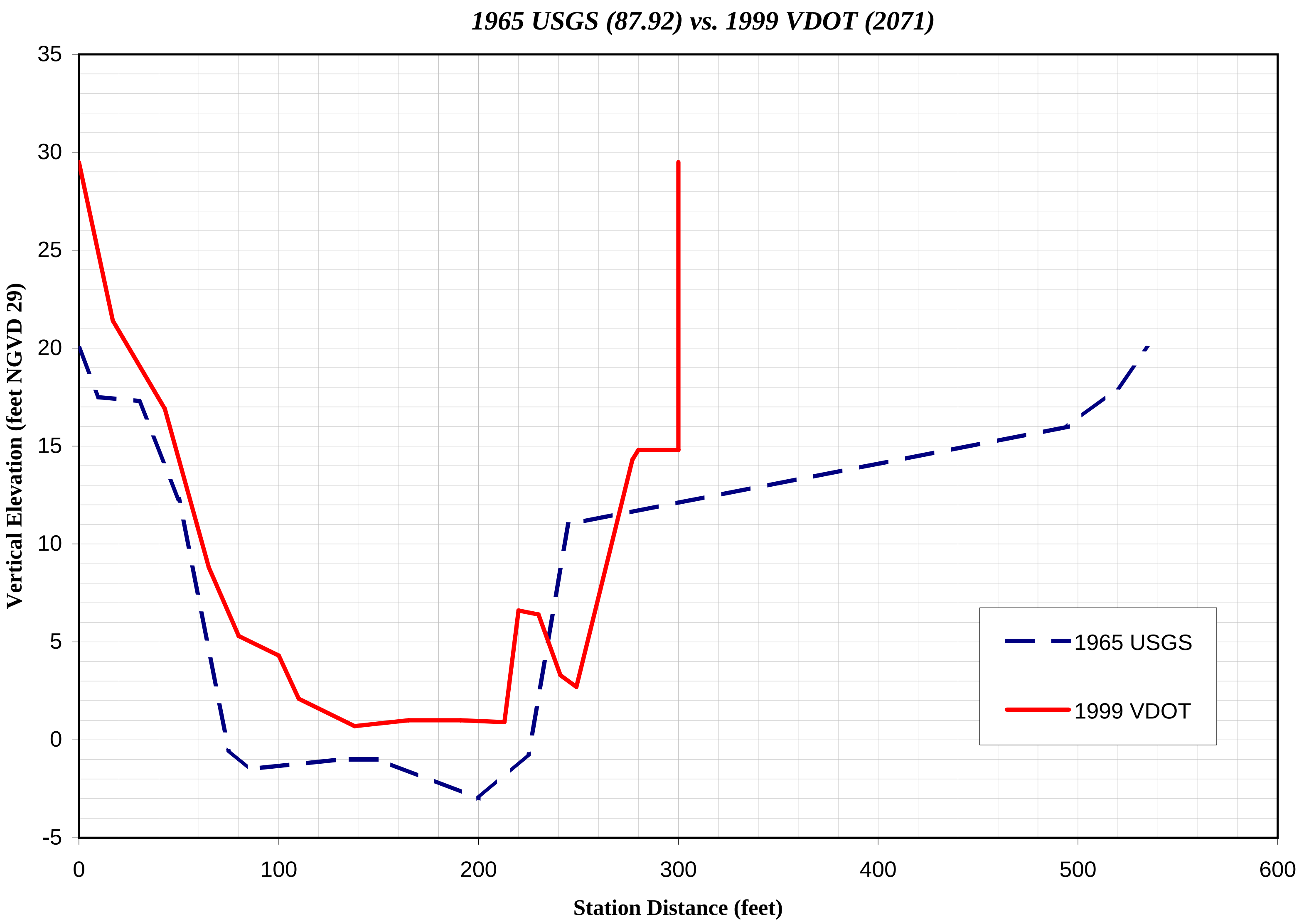

1965 USGS (75.16) vs. 1999 VDOT (1597)
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
25
20
15
10
5
0
-5
-10
0
200
400
600
800
1000
1200
1400
1965 USGS
1999 VDOT

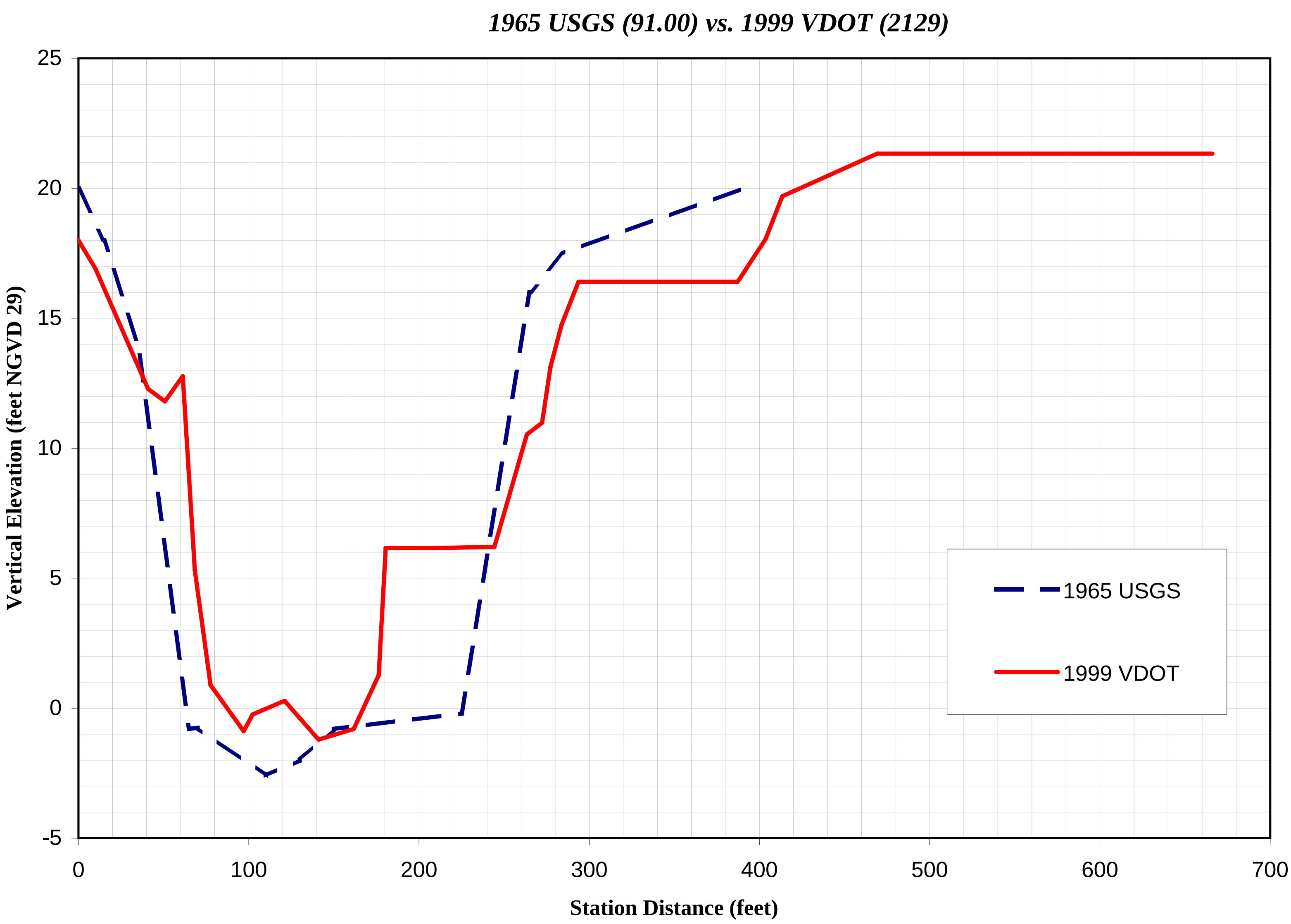


1965 USGS (80.28) vs. 1999 VDOT (1823)
35
30
25
20
15
10
5
0
-5
-10
0
100
200
300
400
500
600
700
800
900
1000
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
1965 USGS
1999 VDOT



1965 USGS (84.88) vs. 1999 VDOT (1963)
35
30
25
20
15
10
5
0
-5
-10
0
100
200
300
400
500
600
700
800
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
1965 USGS
1999 VDOT


1965 USGS (87.92) vs. 1999 VDOT (2071)
35
30
25
20
15
10
5
0
-5
Vertical Elevation (feet NGVD 29)
0
100
200
300
400
500
600
Station Distance (feet)
1965 USGS
1999 VDOT



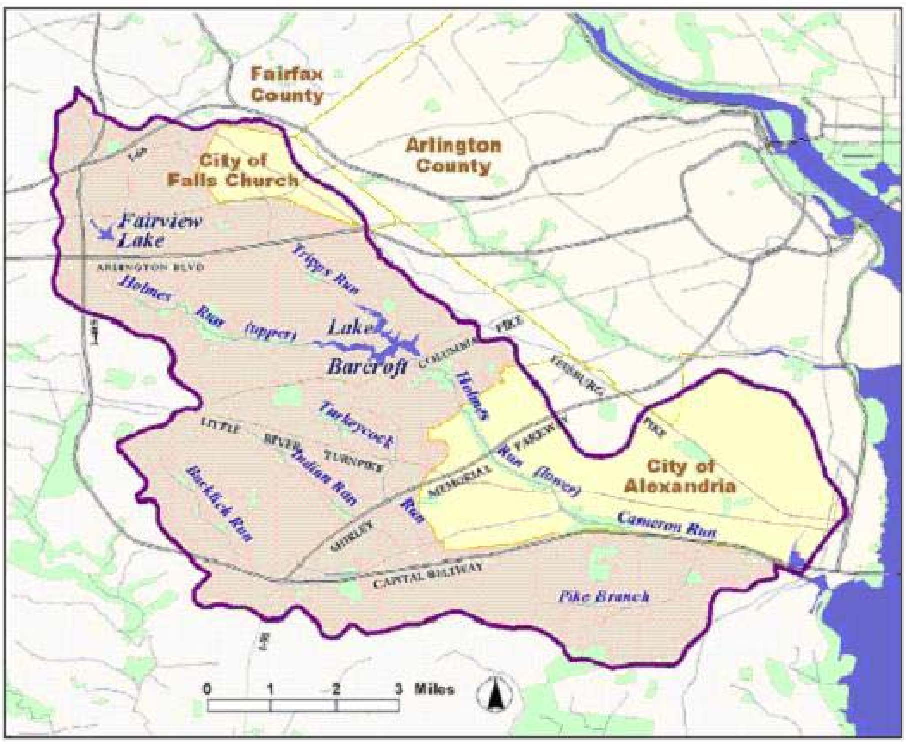
1965 USGS (91.00) vs. 1999 VDOT (2129)
Vertical Elevation (feet NGVD 29)
Station Distance (feet)
25
20
15
10
5
0
-5
0
100
200
300
400
500
600
700
1965 USGS
1999 VDOT

APPENDIX I

FLOOD FREQUENCY ANALYSIS REPORT

Flood Frequency Analysis

For Cameron Run at
USGS Gaging Station 01653000
At Alexandria, Virginia



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December 6, 2006

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The Northern Virginia Regional Commission (NVRC) is an independent public agency chartered in 1969 to plan for the physical, social and economic development of the region. The Commission serves in an advisory capacity to local, state, and federal governments and as an advocate for Northern Virginia and its 1.9 millions residents. The Commission's policies and programs are established by a twenty-five member Board of Commissioners comprised of elected officials appointed by the governing bodies of Arlington, Fairfax, Loudoun and Prince William; the Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park, and the Towns of Dumfries, Herndon, Leesburg, Purcellville and Vienna.

Funding for this work was generously provided to the Northern Virginia Regional Commission from the US Army Corps of Engineers to assist with their ongoing feasibility study with Fairfax County and the City of Alexandria. Any assessments and conclusions contained in this report represent the results of the staff's technical investigations and do not represent policy positions of the Northern Virginia Regional Commission unless so stated in any adopted Resolutions of said Commission.

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Executive Summary

The purpose of this study is twofold. The primary purpose of this study is to perform a current flood flow frequency analysis for Cameron Run with existing stream gage data. This analysis follows the federally recommended guidelines described in Bulletin 17B, "*Guidelines for Determining Flood Flow Frequency*" by the Interagency Advisory Committee on Water Data. A secondary purpose of this study is to identify and consolidate earlier analyses of the Cameron Run stream gage data.

To meet the first objective, annual peak flow data collected at the US Geological Survey (USGS) gaging station (Station 01653000) on Cameron Run in Alexandria, Virginia were compiled for water years 1953 through 2006. Using the methodologies prescribed by Bulletin 17B, generally conforming to a Log Pearson Type III distribution, a frequency curve was developed with the data.

In finalizing this frequency curve, staff from the Northern Virginia Regional Commission (NVRC) met with the Cameron Run Hydrology and Hydraulics (H&H) Workgroup to discuss various concerns regarding the data set. Key issues included: intended use of the frequency data; validation of the June 25, 2006 flood event; gage placement; minor gaps in the data set; management of the Lake Barcroft dam; and urbanization of the watershed during the period of record.

Although the ultimate use of the published frequency curve can not be dictated by this document, the project's H&H workgroup agreed that understanding the existing and potential flood protection on Cameron Run should be the primary focus of this analysis. Therefore, the efforts to develop this analysis align with current Federal Emergency Management Agency (FEMA) requirements for such analyses and special attention was given to the magnitude of 100-year recurrence interval. The 100-year event, or the event with a one percent (1%) chance of occurring during any given year, is often used as a target when designing flood protection projects.

The final flow frequency relationship presented in Table 1 was generated using industry standard techniques including the statistical modeling package PeakFQ developed by the USGS and adhering to the guidelines of Bulletin 17B. The input and output files are included as an appendix to this document.

(1) Recurrence Interval [years]	(2) Probability	(4) 2006 Analysis 1956 – 2006 (cfs)
2	0.5	4,157
5	0.2	6,993
10	0.1	9,266
25	0.04	12,600
50	0.02	15,430
100	0.01	18,570
500	0.002	27,210

Table 1 2006 Flood Frequency Analysis Based on 1956 thru 2006 data set.

Also included in this report are results of earlier frequency analyses developed for various studies associated with Cameron Run during the last 35 years. Since 1971 the US Army Corps of Engineers (USACE), FEMA, and USGS have published frequency data for Cameron Run at various times. These studies predicted magnitudes of the 100-year event ranging from 12,000 to 30,000 cubic feet per second. The variability of these predictions stems from the various methodologies employed to determine the values and the length of records in the data set available at the time of analysis.

Background

Cameron Run is a direct tributary of the Potomac River (Hydrologic Unit Code (HUC) 02070010). Its 42 square mile watershed drains portions of Fairfax County and the cities of Falls Church and Alexandria as well as a very small portion of Arlington County. The Potomac River Basin cradles the Cameron Run watershed and ultimately carries its waters to the Chesapeake Bay.

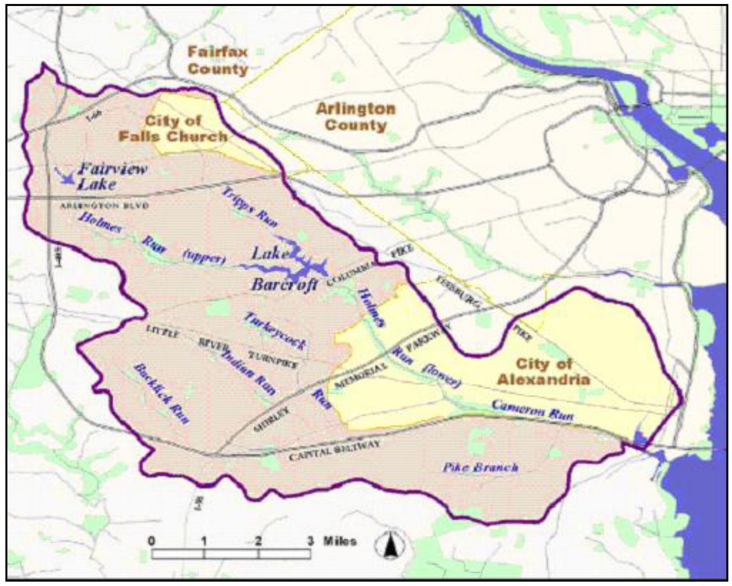

Figure 1. Cameron Run Watershed with Jurisdictional Boundaries

Cameron Run drains tributaries in Fairfax County, Falls Church and Alexandria including: Holmes Run, Tripps Run, Turkeycock Run, Indian Run, Backlick Run and Pike Branch. Water from the Cameron Run watershed generally flows in an eastward direction to the Potomac River. Cameron Run changes names to Great Hunting Creek just upstream of its confluence with the Potomac River.

The western portion of the watershed (west of the "Fall Line") is characterized by the Piedmont physiographic province; east of this division is described by the Coastal Plain physiographic province. Prior to European immigration to the area the watershed was primarily a forested landscape. During the 1600s and early 1700s farmers converted the forested landscape to agricultural uses that included tobacco, wheat, and corn crops. Since the 1700s, and primarily during the 20th century, the watershed has transformed into an "ultra-urban" state with no agricultural uses beyond that of a backyard or community garden.

The major tributaries of Cameron Run rise in Fairfax County and collect in the mainstems of Backlick Run and Tripps/Holmes Run. These streams flow through portions of Fairfax County and Falls Church before reaching Alexandria where they combine to form Cameron Run. Cameron Run's flood control channel carries water out of Alexandria and back into Fairfax County where it picks up the discharge from Pikes Branch and becomes Great Hunting Creek before discharging into the Potomac River. The lower portion of Cameron Run and the entire reach of Great Hunting Creek are tidally influenced.

USGS Gaging Station 0165300

Eight hundred feet downstream of the confluence of Backlick and Holmes Run, within the free flowing or alluvial section of Cameron Run, the USGS maintains a gaging station. The gage is located on the downstream side of the railroad bridge depicted in Figure 2. The gaging station captures stage (and flow) data from the 33.7 square mile sub-watershed draining to the gage location. This sub-basin represents approximately 80% of the entire watershed area that ultimately drains to the Potomac River.

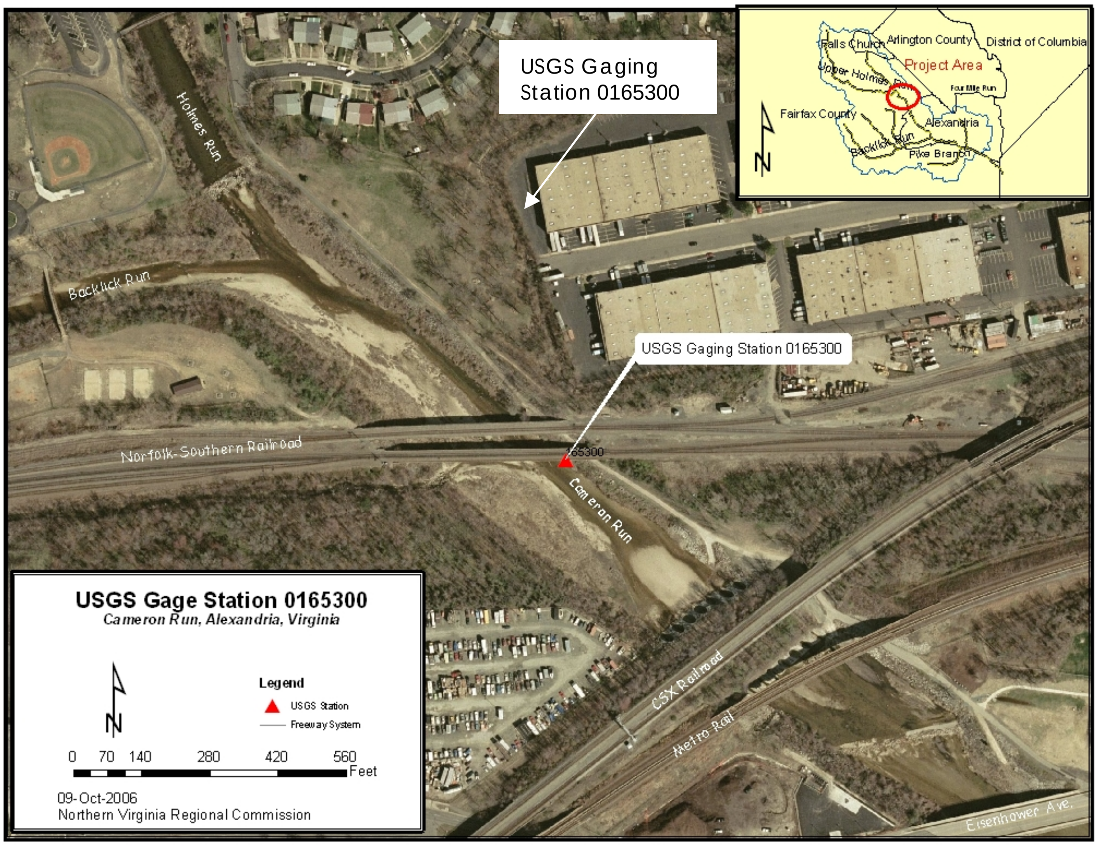

Figure 2. Photographic Map of USGS Gaging Station 0165300

The USGS gaging station on Cameron Run has collected flow data from 1956[1] through the present. The gage is sponsored by the City of Alexandria with maintenance and calibration services provided by the USGS. The gage records a stage measurement every 15 minutes. Each recorded value is digitally transferred to USGS and a corresponding discharge value is calculated from a site specific stage-discharge curve. These values are then uploaded to the station's website and provided to the public at: http://nwis.waterdata.usgs.gov/dc/nwis/uv?site_no=01653000 . All measurements and

[1] The USGS Annual Peak Data Set includes a historical stage measurement from 1953. The stage value represents a specific high event where stage data could be indirectly measured and was not used in this flow-based analysis.

related calculations preceding USGS publication of this data must conform to the applicable USGS standard protocol.

For each year the single highest peak flow measurement recorded at the station is incorporated into a list of annual peak values. Those records constitute the primary data set used to develop this flood frequency analysis. The annual peaks for the Cameron Run station recorded are included in Table 2. The values presented were extracted from data downloaded from the USGS website for the Cameron Run station in September 2006. Original USGS data for the 0165300 station was provided electronically in the standard USGS WATSTORE electronic data format.

Water Year	Date	Flow (cfs)	Gage Height
1953	05-May-1953		*11.9
1956	20-Jul-1956	3,950	8.62
1957	05-Apr-1957	865	5.5
1958	08-Jul-1958	2,600	7.93
1959	12-Jun-1959	2,900	7.93
1960	05-Apr-960	1,300	5.68
1961	26-Aug-1961	3,820	7.35
1962	12-Mar-1962	1,230	4.84
1963	20-Aug-1963	6,480	10.48
1964	13-May-64	2,550	5.78
1965	05-Mar-1965	3,330	6.92
1966	14-Sep-1966	9,300	14.14
1967	25-Aug-1967	6,950	12.72
1968	10-Sep-1968	4,780	10.65
1969	08-Sep-1969	4,030	9.66
1970	09-Jul-1970	6,910	13.11
1971	27-Aug-1971	4,320	9.32
1972	22-Jun-1972	19,900	18.14
1973	10-Jul-1973	4,730	9.94
1974	30-Aug-1974	3,860	8.39
1975	26-Sep-1975	14,900	16.73
1976	31-Dec-1975	3,700	8.1
1977	12-Jul-1977	5,040	8.2
1978	26-Jan-1978	6,200	8.93
1979	25-Feb-1979	4,300	7.3
1980	13-Mar-1980	1,900	4.74

ater ear	Date	Flow (cfs)	Gage Height
1981	04-Jul-1981	6,920	8.45
1982	30-May-82	3,720	5.95
1983	21-Jun-1983	5,710	9.03
1984	29-Mar-1984	4,460	6.95
1985	05-Nov-1984	3,950	6.4
1986	02-Aug-1986	3,630	6.04
1987	24-Dec-1986	3,890	6.84
1988	18-May-1988	2,980	5.33
1989	06-May-1989	6,960	9.5
1990	05-Jul-1990	3,510	5.67
1991	23-Oct-1990	4,800	7.34
1992	24-Jul-1992	3,570	6.15
1993	23-Nov-1992	2,650	4.94
1994	28-Nov-1993	5,900	8.5
1995	20-Jan-1995	2,130	5.02
1996	19-Jan-1996	5,870	8.73
1997	08-Nov-1996	3,760	6.82
1998	17-Feb-1998	3,230	6.28
1999	16-Sep-1999	2,820	5.83
2000	28-Jul-2000	7,020	9.64
2001	17-Dec-2000	5,410	8.34
2002	19-Jun-2002	1,420	4.07
2003	23-Sep-2003	9,330	11.29
2004	19-Nov-2003	4,220	7.27
2005	28-Mar-2005	4,770	7.78
2006	25-Jun-2006	16,500	17

* Historic Peak

Table 2. USGS Stream Gage Information for Station 1653000 Cameron Run, Virginia

There are fifty (50) records[2] available through the WATSTORE file, including an historical peak stage value for record-year 1953. (An historic record reflects a record that would

[2] The value for WY2006 (16,500 cfs) is a USGS-provided value recorded at the gage on June 25, 2006. This value was validated by the USGS in an e-mail to Bill Hicks dated November 30, 2006 and incorporated into the data set for inclusion in the statistical modeling contained herein.

have otherwise not been observed except for evidence indicating its unusual magnitude.) The series corresponds to “Water Years” where a water year is defined as the period between October 1st of one year and September 30th of the next. Flow data are presented in units of cubic feet per second (cfs) and stage data in feet above the station datum.

Examination of the Data Set

Table 3 annotates the same Cameron Run Peak Flow records to clarify the gaps or discrepancies in the data set.

The data for 1953 is based on a historic stage record. No flow values were recorded at the gaging station until 1956. The frequency analysis is based only on peak **flow** data; so consequently, the 1953 record is not used in frequency analysis. The flow values included in the data set begin at water year 1956.

The “Event of Record,” or the highest recorded peak flow in the period of record, was recorded in 1972. Its recording coincided with Tropical Storm Agnes’s presence in the area on July 22, 1972 and resulted in a recorded peak flow of 19,900 cfs.

During a period of bridge construction between 1977 and 1979 the gage was temporarily moved downstream of its present location (1,200 feet and 2,500 feet). Although the USGS was unable to confirm the exact positions the relocations the descriptions correspond to the Eisenhower Avenue Bridge and a grade control structure in the run, respectively. Neither location resulted in a location downstream of a major tributary to Cameron Run where the data recorded at these relocations would be substantially affected by increased flows. Furthermore, during this period the flow values recorded were of a relatively minor magnitude thereby having little effect on the large magnitude event predictions of concern. For this analysis no break in the record is acknowledged for this temporary relocation of the gage. The reasoning to overlook this minor relocation is based on three factors.

First, a similar USGS gaging station, 0165200, on Four Mile Run (another Potomac River tributary in Alexandria, Virginia immediately to the North) recorded consistent low magnitude events for Four Mile Run during the same timeframe. The consistent records for a neighboring stream support the assumption that no extraordinary event occurred during this period.

Second, no major tributaries enter Cameron Run between the permanent and temporary gage locations that could drastically alter the flows passing the gage.

The third factor follows the intended purpose of the analysis, flood protection – especially regarding the 100-year event. Any temporary relocation of the gage to a downstream location inherently builds a conservative bias (predicting larger magnitude events for a given frequency) into the data set because the drainage area for the downstream, temporary location is larger than the permanent one. This means that the recorded discharge magnitudes for any given storm during the three years the gage was located downstream were larger than would have been recorded at the permanent upstream location due to the increased drainage area.

A six month gap exists in the data set from April 1979 until September 1979. This gap in data will be considered a random disturbance in the data unrelated to any flood events, e.g., the gaging instruments were destroyed during an unusually large flood event, etc. No evidence exists from the neighboring Four Mile Run watershed/gage that a significant event was missed during this timeframe. Further suggesting a hydrologically unrelated cause is that the gap occurs during the end of the aforementioned relocation period possibly caused by the logistics of relocating the gage.

On June 25, 2006 a significant flood event (16,500 cfs) occurred along Cameron Run in Alexandria and Fairfax County. The H&H workgroup pursued the confirmation of this data point and its inclusion in this analysis. The USGS develop an indirect measurement from high water marks observed near the gage from this event to confirm this value for final publication in the annual USGS Water Resources Data Book. This USGS confirmed this value in an e-mail to Bill Hicks on November 30, 2006.

Some general concern exists that during large flow events the location of the gage allows for gage readings to be influenced from backwater conditions from the CSX railroad bridge just downstream of the gage location. Evaluation of the reality of this backwater condition is beyond the scope of this study. However, during a subsequent study to this analysis the USACE will be developing a computer model (HEC-RAS) for Cameron Run that should provide some insight into this issue.

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1953	05-May-1953	11.9	
1956	20-Jul-1956	8.62	3,950
1957	05-Apr-1957	5.5	865
1958	08-Jul-1958	7.93	2,600
1959	12-Jun-1959	7.93	2,900
1960	05-Apr-960	5.68	1,300
1961	26-Aug-1961	7.35	3,820
1962	12-Mar-1962	4.84	1,230
1963	20-Aug-1963	10.48	6,480
1964	13-May-64	5.78	2,550
1965	05-Mar-1965	6.92	3,330
1966	14-Sep-1966	14.14	9,300
1967	25-Aug-1967	12.72	6,950
1968	10-Sep-1968	10.65	4,780
1969	08-Sep-1969	9.66	4,030
1970	09-Jul-1970	13.11	6,910
1971	27-Aug-1971	9.32	4,320
1972	22-Jun-1972	18.14	19,900
1973	10-Jul-1973	9.94	4,730
1974	30-Aug-1974	8.39	3,860
1975	26-Sep-1975	16.73	14,900
1976	31-Dec-1975	8.1	3,700
1977	12-Jul-1977	8.2	5,040
1978	26-Jan-1978	8.93	6,200
1979	25-Feb-1979	7.3	4,300
Gap from April 1979 until Sept 1979			
1980	13-Mar-1980	4.74	1,900
1981	04-Jul-1981	8.45	6,920
1982	30-May-82	5.95	3,720
1983	21-Jun-1983	9.03	5,710
1984	29-Mar-1984	6.95	4,460
1985	05-Nov-1984	6.4	3,950
1986	02-Aug-1986	6.04	3,630
1987	24-Dec-1986	6.84	3,890
1988	18-May-1988	5.33	2,980
1989	06-May-1989	9.5	6,960
1990	05-Jul-1990	5.67	3,510
1991	23-Oct-1990	7.34	4,800
1992	24-Jul-1992	6.15	3,570
1993	23-Nov-1992	4.94	2,650
1994	28-Nov-1993	8.5	5,900
1995	20-Jan-1995	5.02	2,130
1996	19-Jan-1996	8.73	5,870
1997	08-Nov-1996	6.82	3,760
1998	17-Feb-1998	6.28	3,230
1999	16-Sep-1999	5.83	2,820
2000	28-Jul-2000	9.64	7,020
2001	17-Dec-2000	8.34	5,410
2002	19-Jun-2002	4.07	1,420
2003	23-Sep-2003	11.29	9,330
2004	19-Nov-2003	7.27	4,220
2005	28-Mar-2005	7.78	4,770
2006	25-Jun-2006	17	16,500

Incomplete Data
Validated Data
Present Location
Downstream Location
Missing Data

Table 3. USGS Stream Gage Information for Station 1653000 Cameron Run, Virginia

Plots of the Data Record

The following plots are included to better visualize the magnitude of individual data points (annual peaks) in relation to one another and to spot trends in the data. The chart in Figure 3 presents the annual peak events recorded at the USGS gage on Cameron Run. The 1972 event of 19,900 cfs marks the event of record.

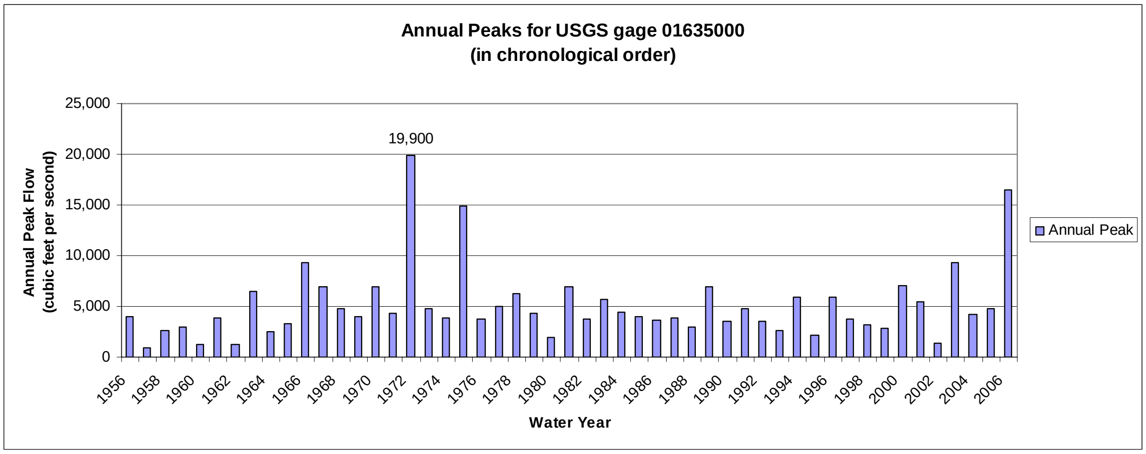

Figure 3. Annual Peak Flows in Chronological Order

The chart in Figure 4 presents the same event data in order of decreasing peak magnitude. This graphic shows that more than half of the annual peaks were of a magnitude of less than 5,000 cfs and only three events were greater than 10,000 cfs.

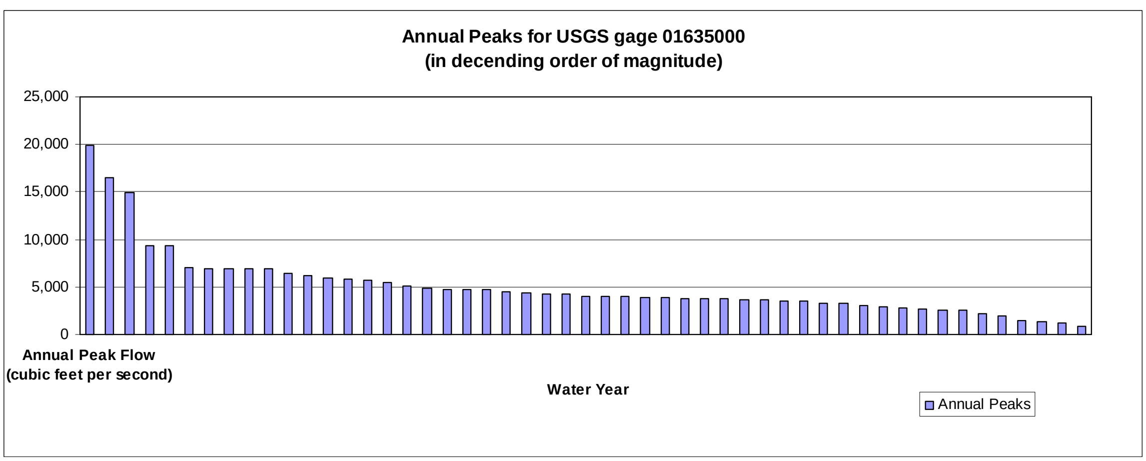

Figure 4. Annual Peaks in Descending Order

The following three scatter plots (Figures 5, 6, & 7) represent each annual peak flow with single a data point.

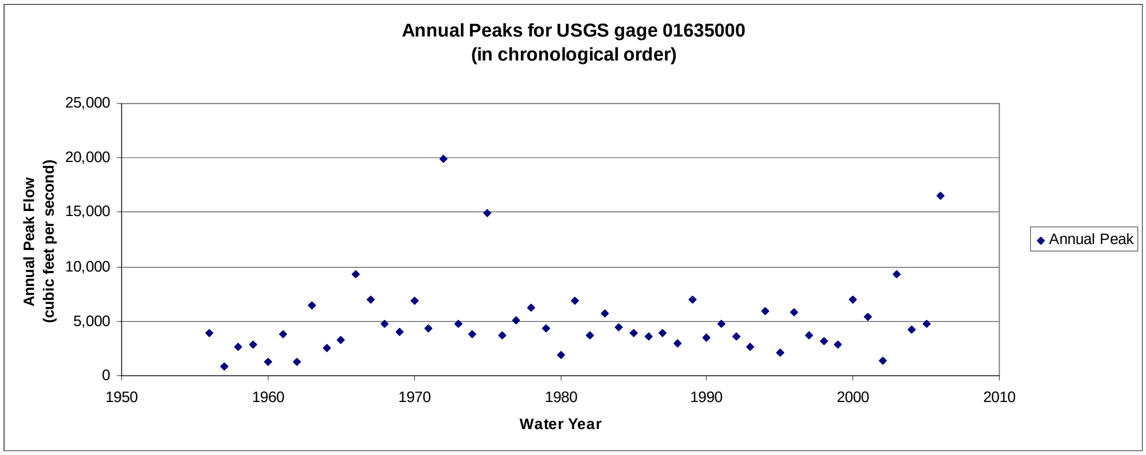

Figure 5 **Annual Peak Events – Water Years 1956 thru 2006**

The graph in Figure 6 includes a trend line developed from linear regression. A slight trend upward can be noticed on this graphic. This slope of this line is about 0.3% upward.

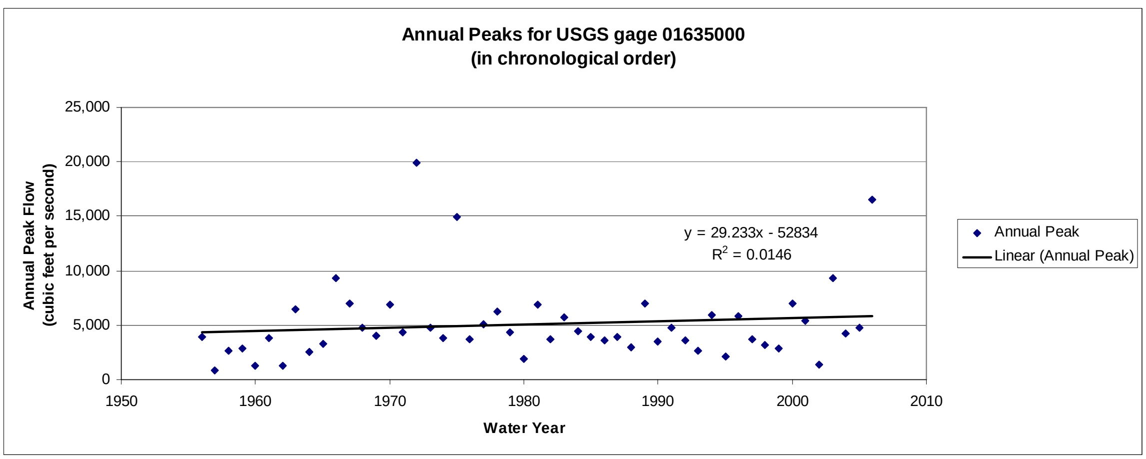

Figure 6 **Annual Peak Events – Water Years 1953 thru 2006 overlain with a trend line**

The scatter plot in Figure 7 includes the same data overlain with a line depicting the mean, or average, magnitude of annual peaks over the period of record. This value, at approximately 5,000 cfs, only provides a comparison for actual peak events.

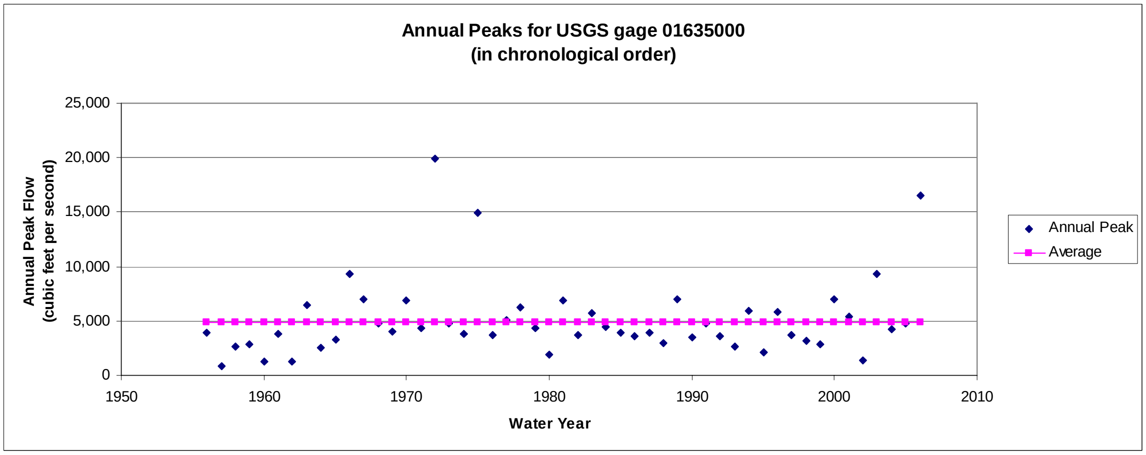

Figure 7 **Annual Peak Events – Water Years 1953 thru 2006 overlain with a mean (average) line**

Rainfall Data and Its Effects on the Data Set

This analysis compiles hourly precipitation records for the National Weather Service (NWS) station at Washington Reagan National Airport (DCA) (448906) to compare rainfall trends to annual flow peaks recorded at the Cameron Run gaging station. The weather station at DCA is located at 38° 51' N / 77°02'W, only 4.6 miles northeast of the stream gaging station as depicted in Figure 8. For this discussion it is assumed that the proximity of the DCA NWS station to the Cameron Run watershed allows recording of rainfall data similar to rainfall actually occurring in the Cameron Run watershed.

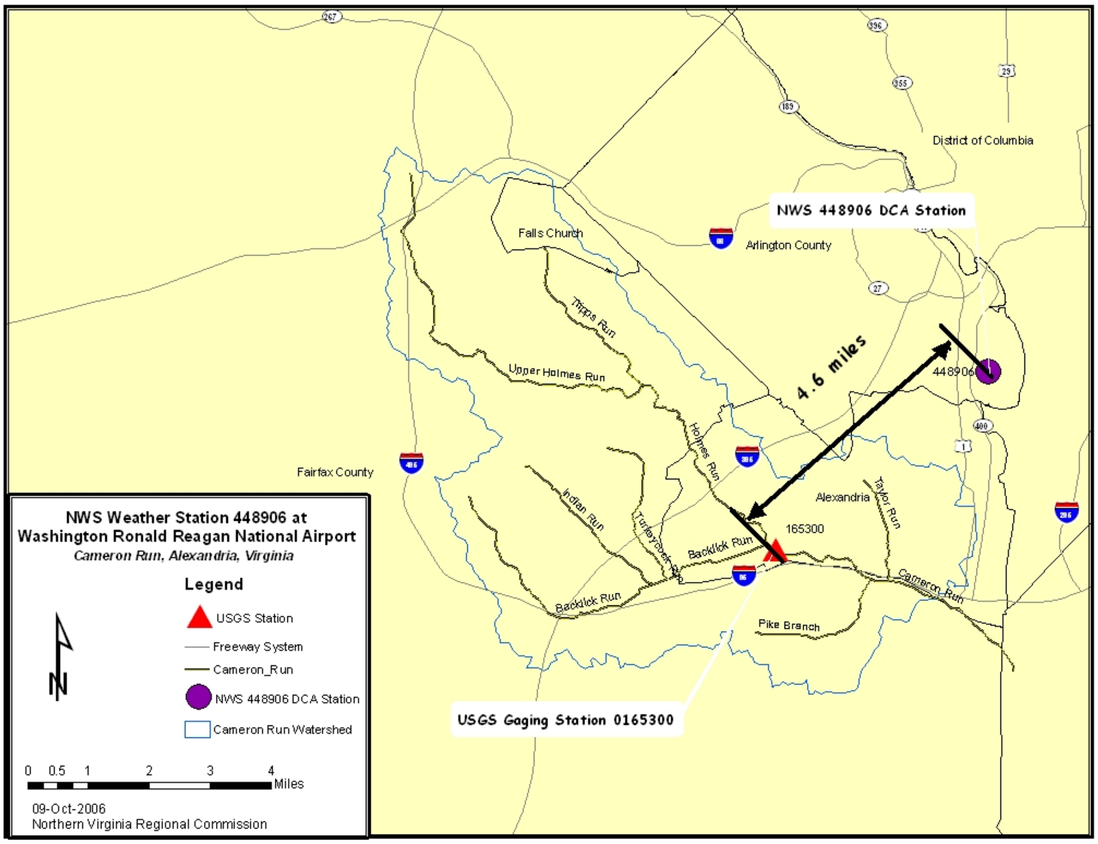

Figure 8 Location of DCA National Weather Service Station 448906

The rainfall records at the DCA station dates back to 1952. Hourly precipitation data is served on the web at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20027254. This analysis calculated annual rainfall totals for each water year and counted the number of days during each water year that experience rain. Counting days receiving rainfall was used as a simplistic proxy for counting actual storm events[3]. Figure 9 graphically depicts both annual rainfall

[3] The rainfall analysis uses a time unit (24-hours - one calendar day) to parse storm events not a true break in the storm event. Storms spanning multiple calendar days and separate storms occurring on the same calendar day are divided or lumped together, respectively.

volumes and annual days of precipitation. These scatter plots are overlain with trend lines calculated by linear regression.

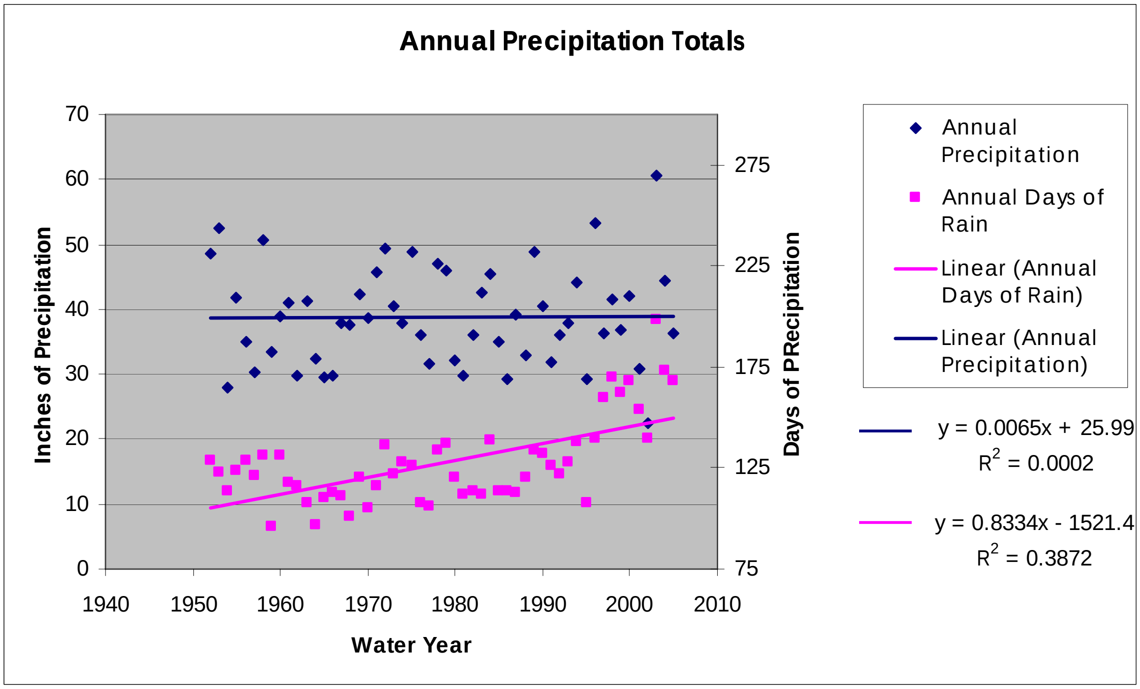

Figure 9 **Scatter Plot of Annual Rainfall Totals and Annual Days of Precipitation Recorded at the DCA Weather Station**

The trend line for annual rainfall shows that average annual rainfall recorded at the DCA station is just less than 40 inches per year. Although the totals vary from year to year the average has remained constant through the period of record. This is contrary to the number days each year that rain has been recorded which is trending upward. Because annual rainfall has stayed roughly constant and the number of rain events has increased the typical rain event has been getting smaller (by about 0.8 inches/year).

In Figure 10 the annual rainfall totals are graphed along with the annual peak flows recorded at the Cameron Run gaging station. These data are also overlain with trend lines (by linear regression). The constant annual rainfall total is contrasted by the slight upward trend of maximum flow peaks recorded on Cameron Run.

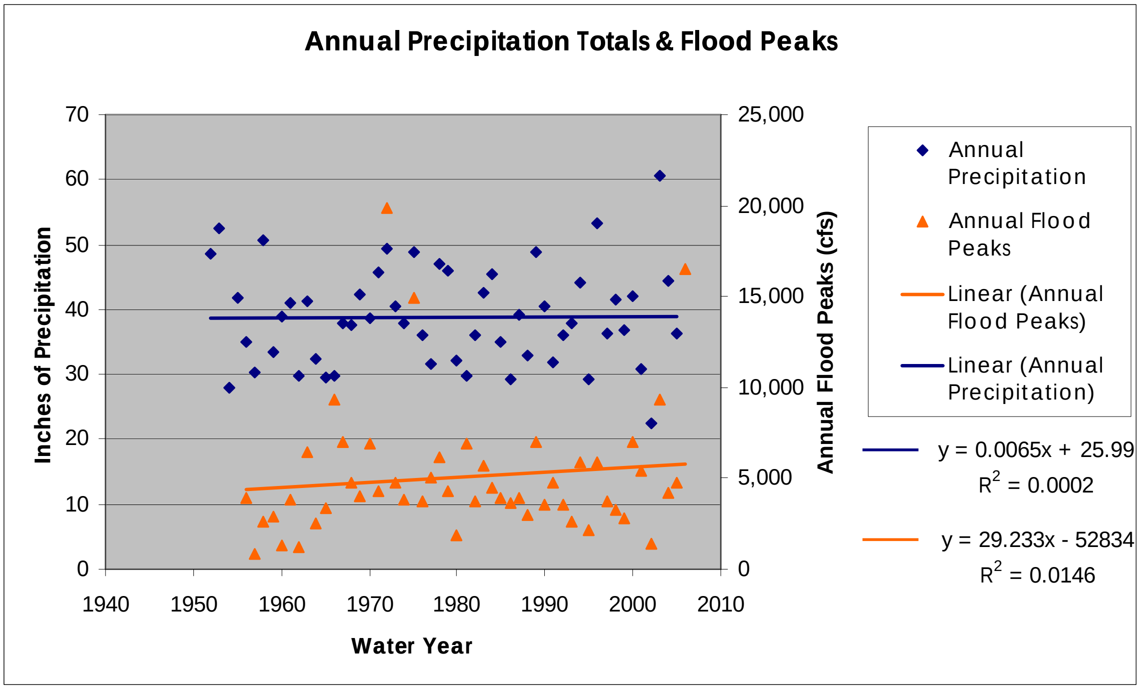

Figure 10 **Scatter Plot of Peak Flow Events Cameron Run Superimposed on Annual Precipitation Totals from the DCA Weather Station**

The annual flood peak has trended higher (29cfs/year) creating a total change in magnitude of annual peak flows across the period of record (as calculated from the trend line) of 1,450 cfs. Because the typical rain event has trended lower (Figure 9) and the typical annual peak flood event has trended higher (Figure 10) it appears that rainfall has had a negative correlation to the annual peak flow data set for Cameron Run[4].

Urbanization Effects on the Data Set

The degree of imperviousness of a watershed typically increases as the watershed becomes more developed or urbanized due to the greater percentage of area covered by impervious structures, i.e., roadways, rooftops, sidewalks, parking lots, etc. These impervious areas create higher peak flows and lower base flows in the watershed tributaries. These effects are most evident in the higher frequency, lower magnitude rain/flood events and diminish as the range of magnitudes increases because the initial abstractions (infiltration, interception, and surface storage) become less significant when measured against rainfall for a large event, e.g. a 100-year rainfall event.

Estimates of imperviousness of the Cameron Run watershed range between 23% and 41%. Although the imperviousness of the Cameron Run watershed has increased since 1956 (the period of record) this increase likely has had only a small effect on the higher

[4] This negative correlation will be discussed in the next section, **Urbanization Effects on the Data Set.**

magnitude recorded peaks. The USGS published a paper in 1970 by Daniel G. Anderson entitled "Effects of Urban Development on Floods in Northern Virginia" (Anderson, 1970). In that paper Anderson states that "impervious surface has a decreasing effect upon larger floods and has an insignificant effect upon the 100-year flood."

Historic annual aerial photography or other data providing a method to adjust the record values for the temporal development of the watershed is not readily available. However, the focus of this analysis is the 100-year flood event where Anderson states that the degree of watershed development would have a minor or negligible effect on the 100-year flood event or greater. And any increased values in the higher frequency, lower magnitude events due to increased development in the watershed only act to build a conservative bias (predicting larger magnitude events for a given frequency) into the analysis. Thus, using the data set without any adjustments for development will have a negligible affect on the 100-year event prediction and will work to create a more conservative bias in the higher frequency portion of the curve.

Lake Barcroft Effects on the Data Set

Lake Barcroft is a 135 acre manmade lake on Holmes Run in Fairfax County. Its creation in the early 1900's served the water supply needs for the City of Alexandria. No longer serving that capacity the amenity continues to exist accepting waters from the 14.5 square miles draining to it.

Typically the water level in the lake is maintained automatically at 208.5 feet elevation. Thus, the discharge from Lake Barcroft equals the inflow into the lake negating the lake's impact on the Cameron Run gage readings. However, in 1972 during the peak event for that year there was a small breach in the dam. The breach was not a catastrophic dam failure and only added a small amount of flow to Holmes and Cameron Run. The breach occurred at roughly the same time as the peak was recorded at the gaging station downstream. Given the travel time of any wave of water from the small breach at Lake Barcroft such a wave of water would only affect the recession limb of the hydrograph recorded at the gage – not the peak.

During research to develop this study, NVRC discovered a study describing uncertainty about the 1972 value (19,900 cfs) and FEMA requested that the data be excised from that analysis. To understand the effect of including or excluding the 1972 value in the analysis, NVRC ran the Log Pearson analysis both ways and developed preliminary frequency curves including and excluding the 1972 value. As expected, the removal of the 1972 event from the data set resulted in a curve significantly lower than the analysis that included the value. The magnitude of the 100-year event in the lower curve was 13,020 cfs meaning that both the actual 1972 and 1975 events would be considered well above a 100-year event magnitude under this frequency curve developed without the 1972 event.

When comparing the1972 and 1975 events on Cameron Run with similar data for Four Mile Run and its frequency curve it appears unreasonable to remove the 1972 event from the Cameron Run data set. The Four Mile Run gage, since 1951, shows no events approaching a 100-year event. So it is very unlikely that Cameron Run, only a few miles away, would have multiple events exceeding the 100-year frequency. If the value for this event has been artificially increased due to the small dam failure at the Lake Barcroft dam then it only serves to make the resulting curve more conservative (greater magnitudes for a given frequency).

Additionally some evidence indicates that some "excess" discharge from Lake Barcroft due to operator error during the 1975 event. Discussion with the H&H workgroup discounted this possibility as a random error that may or may not occur during any historic, or future, event. The USGS annual peak flow table provides no evidence of this 1975 excess. Further, any such increased values will work to make the analysis more conservative as described above.

Assumptions Regarding the Data Record

In order to develop the flood frequency analysis for this study certain assumptions were incorporated into the analysis. All of these assumptions have been discussed previously but are included here for easy reference. These assumptions relate to the intended use of the data, the completeness and cleanliness of the data provided by USGS, and to watershed characteristics affecting the data set. Those assumptions are listed below:

- The focus of this analysis is for flood protection. The predicted 100-year event is typically considered the industry standard target for protection levels.

- The six month gap in the data set during water year 1979 was the result of relocating the gage back to its original and current location or a funding shortage. As such, the gap is independent of flood levels and does not affect the record, i.e., the gage was not damaged during an elevated event and did not record, thereby skewing the data either significantly upward.

- All necessary evaluation of the raw data through WY2005 was performed by the USGS prior to posting the data in the WATSTORE format to ensure that all peak events are accurate and representative of independent events. No effort was made through this analysis to review the raw data used for creating the WATSTORE file for the period of record.

- The operation of the dam on Lake Barcroft and the minor dam breach in 1972 has not affected the annual peak values for the Cameron Run gage.

Method of Analysis

Data analysis adheres to the statistical methodology described in the 1982 edition of the Guidelines for Determining Flood Flow Frequency, Bulletin 17B, developed by the Hydrology Subcommittee for the Interagency Advisory Committee on Water Data (published under USGS cover). In summary, the methodology outlined in Bulletin 17B requires log transformation of the annual peak flow data to fit to the Pearson Type III distribution (log-Pearson Type III) for development of the annual flood series (Bulletin 17B). The method of moments is employed to develop the statistical parameters (mean, standard deviation, and skew) of the distribution from the station data (Bulletin 17B).

Bulletin 17B follows the December 1967 Bulletin 15 "A Uniform Technique for Determining Flood Flow Frequencies," issued by the Hydrology Committee of the Water Resources Council. Its general purpose was to provide a "consistent approach to flood-flow frequency determinations." Bulletin 17 (March, 1976), Bulletin 17A (June, 1977), and Bulletin 17B (issued 1981 and reissued 1982) were expansions on the 1967 publication (Bulletin 17B).

FEMA recommends specific computer software for flood frequency analyses (FEMA Website, September 2006, http://www.fema.gov/plan/prevent/fhm/en_stat.shtm). The USGS-developed PeakFQ computer program is listed by FEMA as an acceptable statistical model for determining Flood Frequency Analysis consistent with Bulletin 17B. The accepted USGS PeakFQ computer program was employed for this study.

Data was inputted into the PEAKFQ computer program through the WATSTORE ASCII text file. The output from the PEAKFQ program produces both a graphical plot of the calculated frequency curve with the observed peaks and confidence bands and an ASCII text file detailing the input data and the calculated probabilities with their associated confidence bands. Plots and text outputs for use in this study are included in the appendices.

Results

The frequency relationship developed in this study is presented below in Table 4. It was developed using the aforementioned methodology, gage records from 1956 thru 2006 and various assumptions regarding the data. The plots depicted in Figure 11 (log-log scale) and Figure 12 (normal scale) includes the best fit frequency curve and the upper and lower 95% confidence limits.

(1) Recurrence Interval [years]	(2) Probability	(4) 2006 Analysis 1956 – 2006 (cfs)
2	0.5	4,157
5	0.2	6,993
10	0.1	9,266
25	0.04	12,600
50	0.02	15,430
100	0.01	18,570
500	0.002	27,210

Table 4 Frequency vs. Flow Relationship for Cameron Run Gage Data (September 2006)

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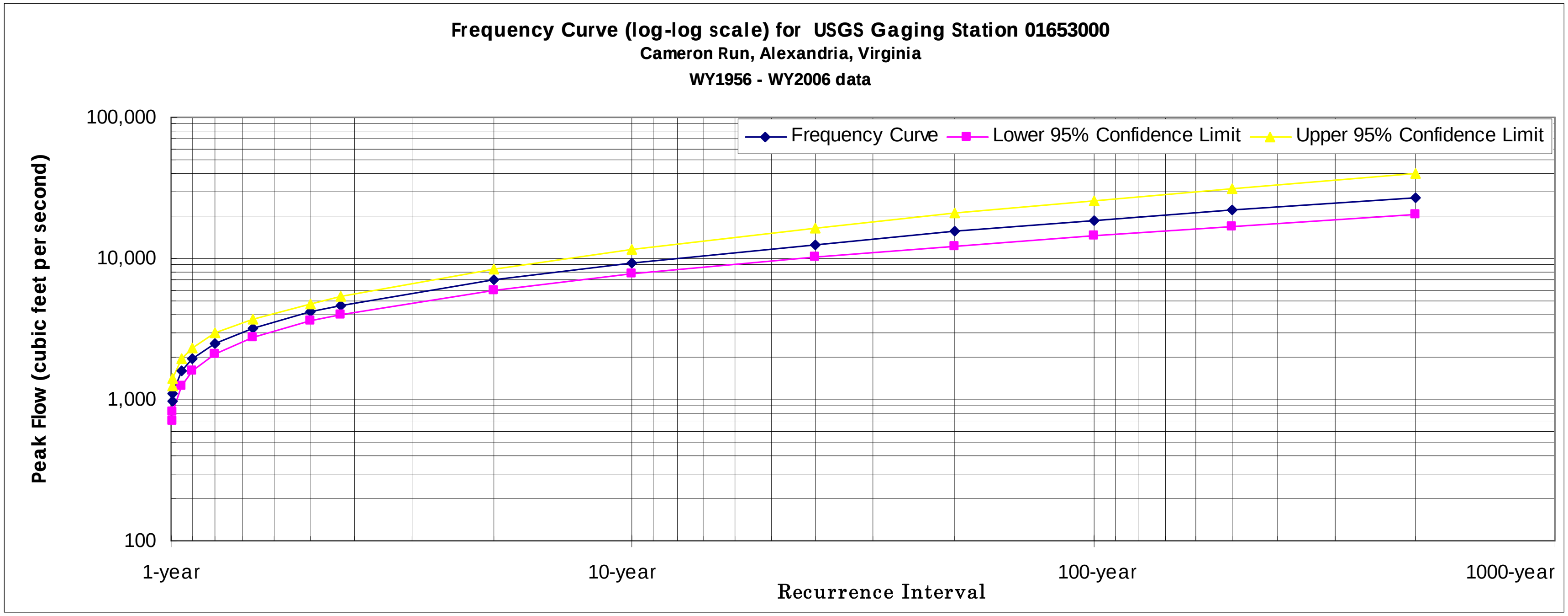

Figure 11 **Frequency Curve (log-log scale) for USGS Gaging Station 01653000**

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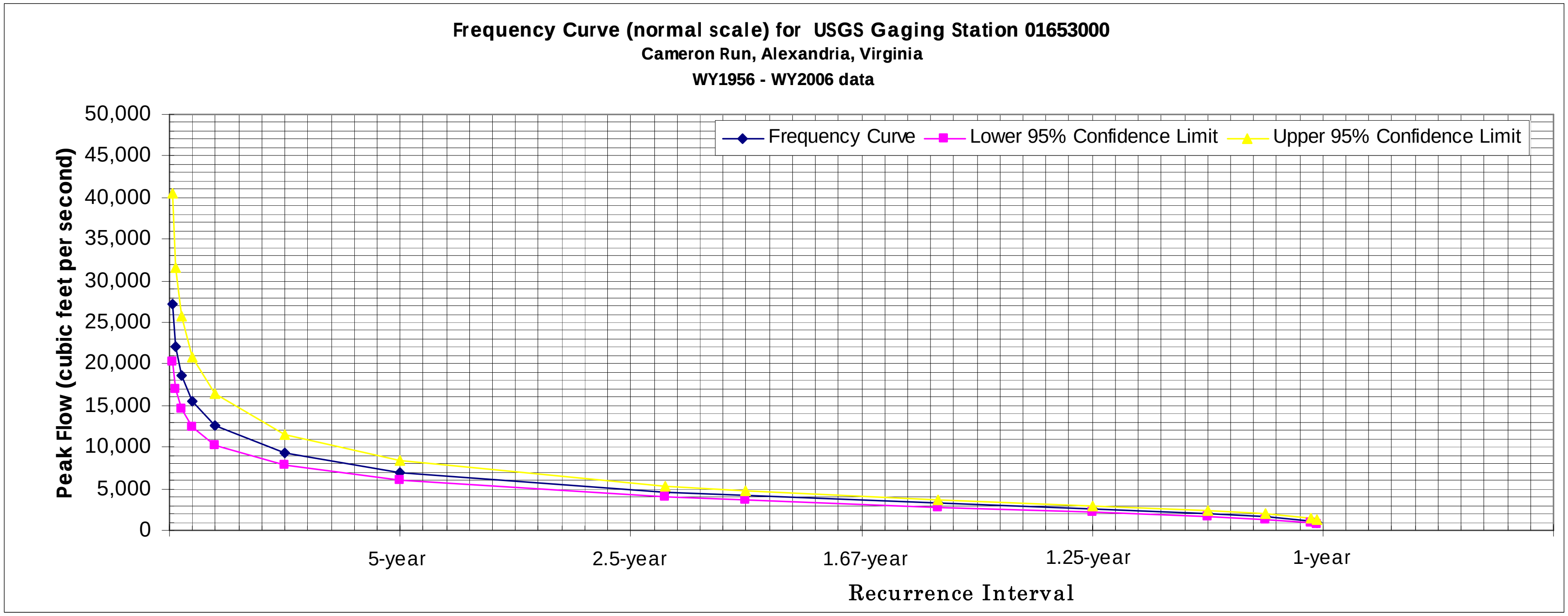

Figure 12 **Frequency Curve (normal scale) for USGS Gaging Station 01653000**

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Other Cameron Run Frequency Studies

Table 5 summarizes several previous flood frequency analyses performed to develop frequency data for Cameron Run at the gage site. The data presented ranges in completeness but all studies included show values for 100-year recurrence intervals. The 100-year predictions vary from 12,315 cfs to 30,000 cfs. The studies included differ on two key characteristics: methodology employed and the data set used.

For example, the 1971 USACE study closely aligns with the statistical methodologies employed with the current (2006) analysis but differs in the length of the period of record available for the analysis. In the 2001 FEMA/URS study URS employed three different methodologies for determining the magnitude of the 100-year event that varied from 12,000 cfs to nearly 23,000 cfs.

The Anderson method for determining frequency data has been employed for several studies for Cameron Run. When determining frequency data at the gage location, using the Anderson methodology in lieu of the industry standard, Log Pearson Type III analysis, adds uncertainly to the analysis. The Cameron Run gage data and analysis was one of the included gaging stations Anderson used to develop the Northern Virginia regression analysis.

With the variability in approaches to analyses it is difficult to draw relationships between these frequency predictions.

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Flood Probability		Recurrence Interval	1971 (1) (cfs)	1976 (2) (cfs)	1989 (3) (cfs)	1994 (4) (cfs)	1995 (5) (cfs)	1995 (6) (cfs)	2001 (7) (cfs)	2001 (8) (cfs)	2001 (9) (cfs)	2006 (10) (cfs)
0.5	50%	2-year	3,200					4,020				4,157
0.2	20%	5-year	6,400					6,720				6,993
0.1	10%	10-year	9,300					8,800		6,524	14,239	9,266
0.04	4%	25-year	11,200	13,400				1,170				12,600
0.02	2%	50-year	22,000	16,500				14,200		10,391	19,998	15,430
0.01	1%	100-year	30,000	19,500	19,400	25,600	12,927	16,800	18,000	12,315	22,931	18,570
0.002	0.2%	500-year	56,000					23,600		16,200	28,750	27,210

Table 5 Summary Table of Frequency Analyses for Cameron Run

Study
(1) 1971 USACE Flood Control Study
(2) 1976 USGS Floodplain Delineation
(3) 1989 USACE letter to FEMA
(4) 1994 Cameron Station Military Installation Flood Damage Reduction Study
(5) 1995 FEMA Flood Insurance Study (URS study)
(6) 1995 USGS Report 94-4148
(7) 2001 URS Log Pearson (avg. of 15,000 and 21,000 cfs)
(8) 2001 URS Anderson Method
(9) 2001 URS TR-20 Method
(10) 2006 NVRC Log Pearson Period of Record 1953 - 2006

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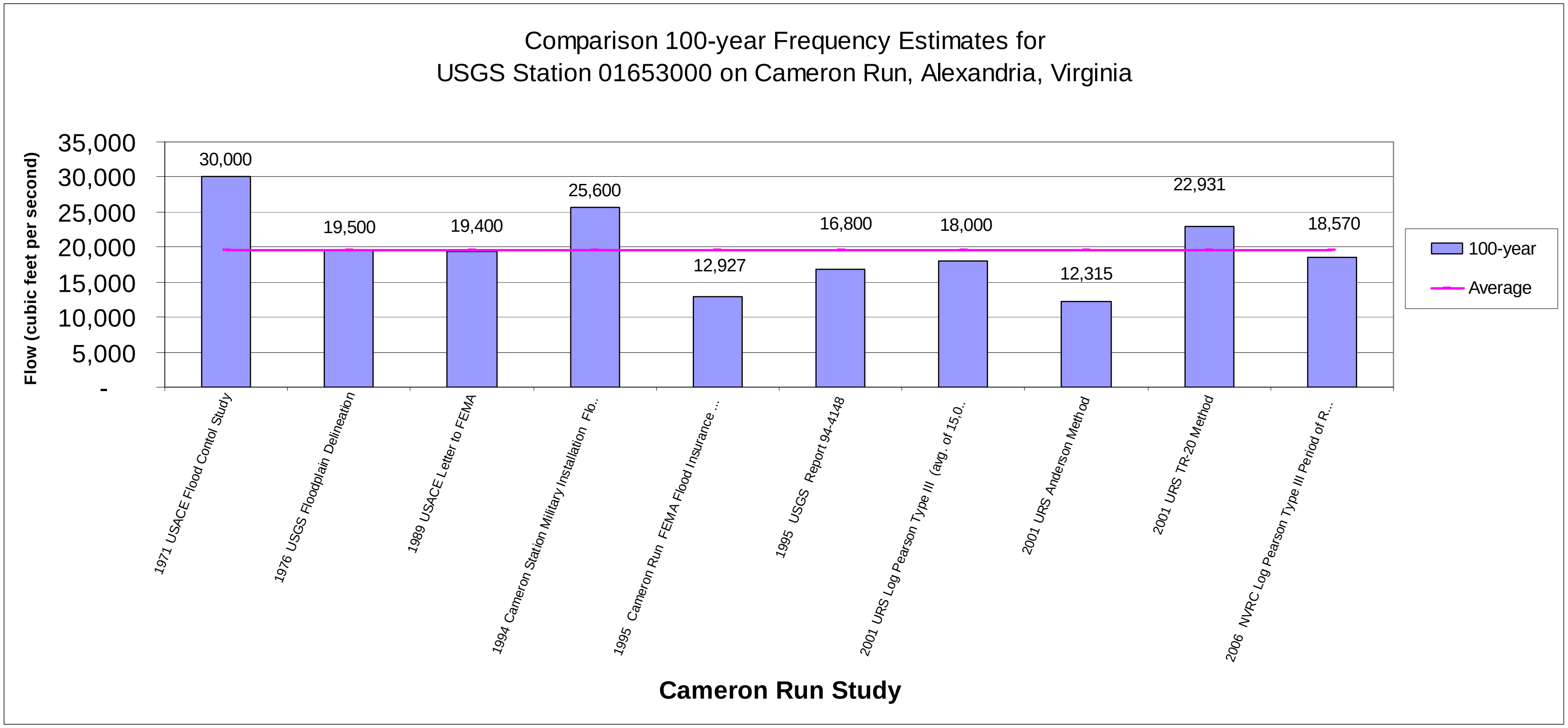

Comparison 100-year Frequency Estimates for
USGS Station 01653000 on Cameron Run, Alexandria, Virginia
Flow (cubic feet per second)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
30,000
19,500
19,400
25,600
12,927
16,800
18,000
12,315
22,931
18,570
1971 USACE Flood Contol Study
1976 USGS Floodplain Delineation
1989 USACE Letter to FEMA
1994 Cameron Station Military Installation Flo..
1995 Cameron Run FEMA Flood Insurance ...
1995 USGS Report 94-4148
2001 URS Log Pearson Type III (avg. of 15.0..
2001 URS Anderson Method
2001 URS TR-20 Method
2006 NVRC Log Pearson Type III Period of R...
100-year
Average
Cameron Run Study

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Considering High Frequency Events

The intent of this analysis was to develop a frequency curve useful in preparing for infrastructure improvements for large magnitude, low frequency flood events, e.g., the 100-year flood. However, with the current emphasis on more holistic approaches to watershed and stream management it is likely that the frequency data for the high frequency events will be used for channel improvements.

As discussed previously in this report, increased development in the watershed may have had only a minor effect on low frequency events. However, this is likely not the case for the higher frequency events, including events through the 5-year event. One factor in particular that supports this theory is the increased efficiency of neighborhood storm drain networks both above ground with the increased impervious surface coverage, and underground with expanded storm drain piping.

As development increases in a watershed the storm drain network will grow. The expanded network will usually be developed through the creation of neighborhood scale improvements not necessarily the replacement of large trunk lines or open channel sections that are typically designed for higher capacities. The drainage systems in these neighborhood areas will be designed under a dual requirement. First, these systems must adequately convey the 10-year storm event. Second, drainage pipes must meet a minimum size requirement, typically 15-inches in diameter.

Due to the smaller collection basins in a neighborhood system a 15-inch diameter storm drain will often have the capacity to carry significantly more flow from the basin area than a 10-year storm event will produce. Consequently, the higher frequency flows will have a more efficient conduit to reach the lower portions of the watershed. This efficiency of conveyance added to the combining of flows as they move to the lower portions of the watershed will work to distort the hydrograph and is likely one of the causes of higher peak flows for the lower magnitude events.

When considering why this effect cannot be extrapolated to the higher magnitude events it is important to realize that much of the storm flows associated with the higher magnitude events are not necessarily contained within the storm drain network where they can readily be carried to the downstream portions of the watershed. The stormwater in excess of the capacity of the storm drain network will contribute to localized flooding and thereby be stored, or detained, awaiting downstream capacity.

By using the Log Pearson Type III analysis the issue of stormdrain conveyance is negated. The flows analyzed represent the actual flows recorded.

In Conclusion

The data and analysis presented offer some understanding and statistical prediction derived from the actual flow data recorded at the USGS gage. Neither the data nor the analysis presented describes all of the factors acting on the watershed or the flood corridor sufficiently to allow a reader to draw definitive conclusions about flow predictions at any location beyond that of the USGS gaging station location. A thorough examination of precipitation is not presented here, nor are factors such as existing channel capacity or sediment transport included in any manner in this study. Such items, and others, are crucial to a thorough understanding of the hydrology and hydraulics of Cameron Run.

It should be noted that 20% of the land draining the Cameron Run/Great Hunting Creek confluence with the Potomac River enters the stream downstream of the USGS gage and is therefore not recorded by the gage. The magnitude of flood waves downstream must be examined through deterministic models of the watershed and hydraulic corridor.

Even so, this flood flow frequency analysis does offer the reader and decision-makers a current understanding of what flow magnitudes can be expected in Cameron Run at the gaging station. Because the methodology used in this study subscribes to industry-standard techniques (Bulletin #17B) its results can easily be used by decision-makers for meaningful discussion and application in the broader hydrology and hydraulics context.

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Appendices

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WATSTORE INPUT FILE

for

WY1956 – WY2006 Data

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```
Z01653000                       USGS
H01653000       3848230770636005151510SW0207001033.70         31.74
N01653000       CAMERON RUN AT ALEXANDRIA, VA
Y01653000
301653000       19530505                      11.90
301653000       19560720   3950                8.62
301653000       19570405    865                5.50
301653000       19580708   2600                7.93
301653000       19590612   2900                7.93
301653000       19600405   1300                5.68
301653000       19610826   3820                7.35
301653000       19620312   1230                4.84
301653000       19630820   6480               10.48
301653000       19640513   2550                5.78
301653000       19650305   3330                6.92
301653000       19660914   9300               14.14
301653000       19670825   6950               12.72
301653000       19680910   4780               10.65
301653000       19690908   4030                9.66
301653000       19700709   6910               13.11
301653000       19710827   4320                9.32
301653000       19720622  199005              18.14
301653000       19730710   4730                9.94
301653000       19740830   3860                8.39
301653000       19750926  14900               16.73
301653000       19751231   3700                8.10
301653000       19770712   5040                8.20
301653000       19780126   6200                8.93
301653000       19790225   4300                7.30
301653000       19800313   1900                4.74
301653000       19810704   6920                8.45
301653000       19820530   3720                5.95
301653000       19830621   5710                9.03
301653000       19840329   4460                6.95
301653000       19841105   3950                6.40
301653000       19860802   3630                6.04
301653000       19861224   3890                6.84
301653000       19880518   2980                5.33
301653000       19890506   6960                9.50
301653000       19900705   3510                5.67
301653000       19901023   4800                7.34
301653000       19920724   3570                6.15
301653000       19921123   2650                4.94
301653000       19931128   5900                8.50
301653000       19950120   2130                5.02
301653000       19960119   5870                8.73
301653000       19961108   3760                6.82
301653000       19980217   3230                6.28
301653000       19990916   2820                5.83
301653000       20000728   7020                9.64
301653000       20001217   5410                8.34
301653000       20020619   1420                4.07
301653000       20030923   9330               11.29
301653000       20031119   4220                7.27
301653000       20050328   4770                7.78
301653000       20060625  16500               17.00
```

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PeakFQ OUTPUT PLOT

for

WY1956 – WY2006 Data

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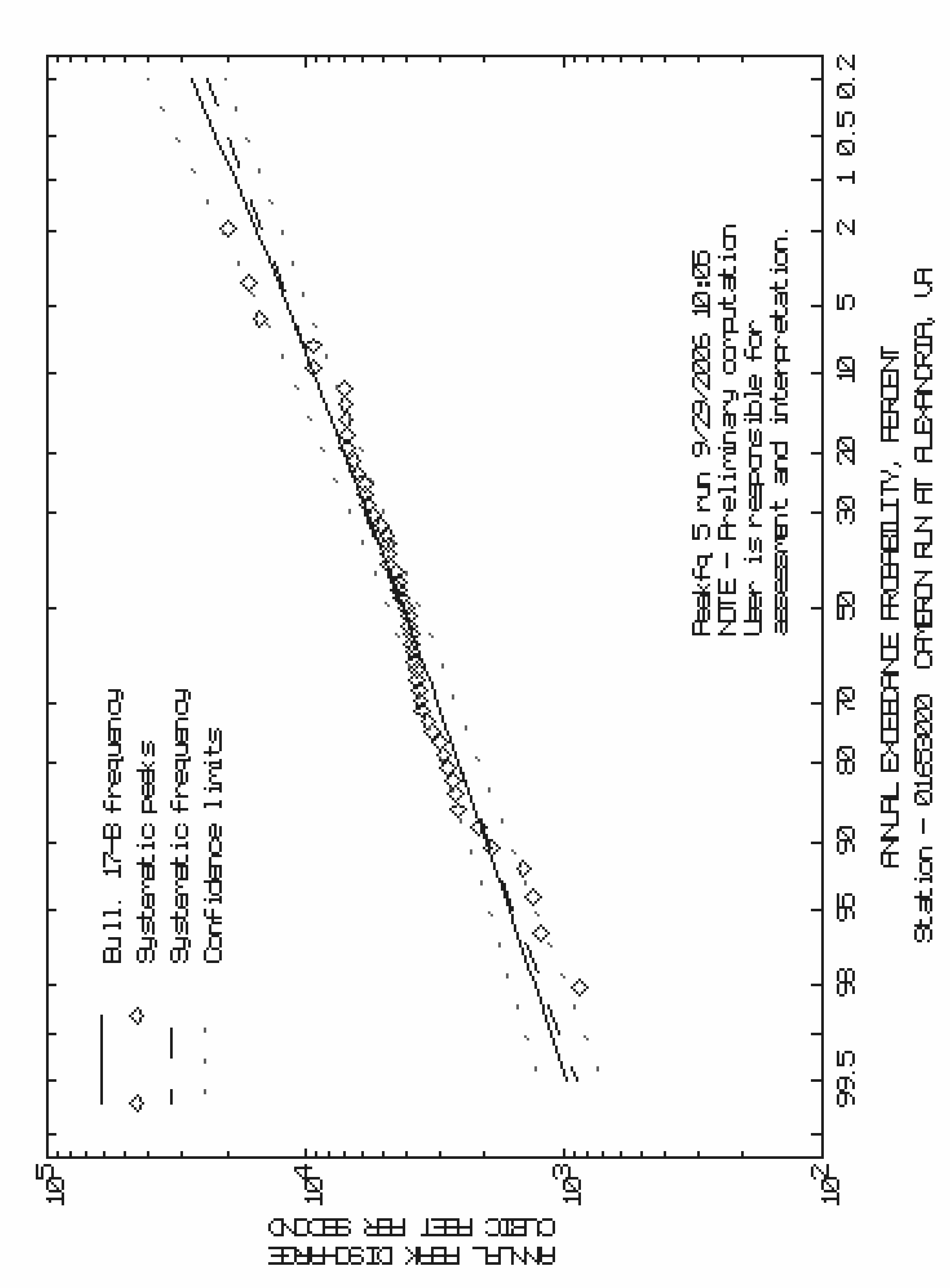
Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
Peakfq 5 run 9/29/2006 10:05
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
99.5 99 95 90 80 70 50 30 20 10 5 2 1 0.5 0.2
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA
10^2 10^3 10^4 10^5
ANNUAL PEAK DISCHARGE
CUBIC FEET PER SECOND

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PeakFQ OUTPUT FILE

for

WY1956 – WY2006 Data

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```
1
  Program PeakFq            U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
  05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = WATSTORE
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\BHICKS\MY
DOCUMENTS\CAMERON RUN\FLOOD FREQUENCY ANALYS
                         specifications - PKFQWPSF.TMP
                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\BHICKS\MY
DOCUMENTS\CAMERON RUN\FLOOD FREQUENCY ANALYS
                         bcd  - WASTORE FILE WITH WY2006.BCD

1
```

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.001
 Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
 05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

              Station - 01653000  CAMERON RUN AT ALEXANDRIA, VA


                    I N P U T   D A T A   S U M M A R Y

               Number of peaks in record            =       52
               Peaks not used in analysis           =        1
               Systematic peaks in analysis         =       51
               Historic peaks in analysis           =        0
               Years of historic record             =        0
               Generalized skew                     =    0.683
                    Standard error                  =    0.550
                    Mean Square error               =    0.303
               Skew option                          =   WEIGHTED
               Gage base discharge                  =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter          =     0.00


 *********  NOTICE  --  Preliminary machine computations.        *********
 *********  User responsible for assessment and interpretation.  *********

 **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
 **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   51
   WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                     0.0
   WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.              789.0
   WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       22638.9
   WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1
```

```
Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
 Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
 05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

              Station - 01653000  CAMERON RUN AT ALEXANDRIA, VA
```

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.6260	0.2627	-0.009
BULL.17B ESTIMATE	0.0	1.0000	3.6260	0.2627	0.165

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	977.6	885.7	914.6	705.8	1248.0
0.9900	1114.0	1031.0	1057.0	822.9	1401.0
0.9500	1609.0	1561.0	1568.0	1262.0	1944.0
0.9000	1969.0	1946.0	1937.0	1592.0	2335.0
0.8000	2530.0	2541.0	2507.0	2113.0	2944.0
0.6667	3214.0	3260.0	3202.0	2749.0	3701.0
0.5000	4157.0	4231.0	4157.0	3607.0	4785.0
0.4292	4632.0	4713.0	4639.0	4029.0	5353.0
0.2000	6993.0	7034.0	7061.0	6013.0	8363.0
0.1000	9266.0	9170.0	9448.0	7802.0	11500.0
0.0400	12600.0	12160.0	13060.0	10290.0	16390.0
0.0200	15430.0	14600.0	16240.0	12330.0	20760.0
0.0100	18570.0	17190.0	19890.0	14510.0	25790.0
0.0050	22040.0	19970.0	24100.0	16880.0	31560.0
0.0020	27210.0	23940.0	30670.0	20290.0	40470.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date / Time
05/06/2005 following Bulletin 17-B Guidelines 09/29/2006 10:05

Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1953	-8888.0		1981	6920.0	
1956	3950.0		1982	3720.0	
1957	865.0		1983	5710.0	
1958	2600.0		1984	4460.0	
1959	2900.0		1985	3950.0	
1960	1300.0		1986	3630.0	
1961	3820.0		1987	3890.0	
1962	1230.0		1988	2980.0	
1963	6480.0		1989	6960.0	
1964	2550.0		1990	3510.0	
1965	3330.0		1991	4800.0	
1966	9300.0		1992	3570.0	
1967	6950.0		1993	2650.0	
1968	4780.0		1994	5900.0	
1969	4030.0		1995	2130.0	
1970	6910.0		1996	5870.0	
1971	4320.0		1997	3760.0	
1972	19900.0		1998	3230.0	
1973	4730.0		1999	2820.0	
1974	3860.0		2000	7020.0	
1975	14900.0		2001	5410.0	
1976	3700.0		2002	1420.0	
1977	5040.0		2003	9330.0	
1978	6200.0		2004	4220.0	
1979	4300.0		2005	4770.0	
1980	1900.0		2006	16500.0	

Explanation of peak discharge qualification codes

PEAKFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq   U. S. GEOLOGICAL SURVEY   Seq.001.004
Ver. 5.0 Beta 8   Annual peak flow frequency analysis   Run Date / Time
05/06/2005   following Bulletin 17-B Guidelines   09/29/2006 10:05

Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	19900.0	0.0192	0.0192
2006	16500.0	0.0385	0.0385
1975	14900.0	0.0577	0.0577
2003	9330.0	0.0769	0.0769
1966	9300.0	0.0962	0.0962
2000	7020.0	0.1154	0.1154
1989	6960.0	0.1346	0.1346
1967	6950.0	0.1538	0.1538
1981	6920.0	0.1731	0.1731
1970	6910.0	0.1923	0.1923
1963	6480.0	0.2115	0.2115
1978	6200.0	0.2308	0.2308
1994	5900.0	0.2500	0.2500
1996	5870.0	0.2692	0.2692
1983	5710.0	0.2885	0.2885
2001	5410.0	0.3077	0.3077
1977	5040.0	0.3269	0.3269
1991	4800.0	0.3462	0.3462
1968	4780.0	0.3654	0.3654
2005	4770.0	0.3846	0.3846
1973	4730.0	0.4038	0.4038
1984	4460.0	0.4231	0.4231
1971	4320.0	0.4423	0.4423
1979	4300.0	0.4615	0.4615
2004	4220.0	0.4808	0.4808
1969	4030.0	0.5000	0.5000
1956	3950.0	0.5192	0.5192
1985	3950.0	0.5385	0.5385
1987	3890.0	0.5577	0.5577
1974	3860.0	0.5769	0.5769
1961	3820.0	0.5962	0.5962
1997	3760.0	0.6154	0.6154
1982	3720.0	0.6346	0.6346
1976	3700.0	0.6538	0.6538
1986	3630.0	0.6731	0.6731
1992	3570.0	0.6923	0.6923
1990	3510.0	0.7115	0.7115
1965	3330.0	0.7308	0.7308
1998	3230.0	0.7500	0.7500
1988	2980.0	0.7692	0.7692
1959	2900.0	0.7885	0.7885

1999	2820.0	0.8077	0.8077
1993	2650.0	0.8269	0.8269
1958	2600.0	0.8462	0.8462
1964	2550.0	0.8654	0.8654
1995	2130.0	0.8846	0.8846
1980	1900.0	0.9038	0.9038
2002	1420.0	0.9231	0.9231
1960	1300.0	0.9423	0.9423
1962	1230.0	0.9615	0.9615
1957	865.0	0.9808	0.9808
1953	-8888.0	--	--

1

```
 End PEAKFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      52
```

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01653000 USGS CAMERON RUN AT ALEXANDRIA, VA

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

USGS Data

For

Station 01653000 on Cameron Run

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Peak Streamflow for Virginia
USGS 01653000 CAMERON RUN AT ALEXANDRIA, VA

Alexandria City, Virginia
Hydrologic Unit Code 02070010
Latitude 38°48'23", Longitude 77°06'36" NAD27
Drainage area 33.70 square miles
Gage datum 31.74 feet above sea level NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1953	May 05, 1953	11.90		1980	Mar. 13, 1980	4.74	1,900
1956	Jul. 20, 1956	8.62	3,950	1981	Jul. 04, 1981	8.45	6,920
1957	Apr. 05, 1957	5.50	865	1982	May 30, 1982	5.95	3,720
1958	Jul. 08, 1958	7.93	2,600	1983	Jun. 21, 1983	9.03	5,710
1959	Jun. 12, 1959	7.93	2,900	1984	Mar. 29, 1984	6.95	4,460
1960	Apr. 05, 1960	5.68	1,300	1985	Nov. 05, 1984	6.40	3,950
1961	Aug. 26, 1961	7.35	3,820	1986	Aug. 02, 1986	6.04	3,630
1962	Mar. 12, 1962	4.84	1,230	1987	Dec. 24, 1986	6.84	3,890
1963	Aug. 20, 1963	10.48	6,480	1988	May 18, 1988	5.33	2,980
1964	May 13, 1964	5.78	2,550	1989	May 06, 1989	9.50	6,960
1965	Mar. 05, 1965	6.92	3,330	1990	Jul. 05, 1990	5.67	3,510
1966	Sep. 14, 1966	14.14	9,300	1991	Oct. 23, 1990	7.34	4,800
1967	Aug. 25, 1967	12.72	6,950	1992	Jul. 24, 1992	6.15	3,570
1968	Sep. 10, 1968	10.65	4,780	1993	Nov. 23, 1992	4.94	2,650
1969	Sep. 08, 1969	9.66	4,030	1994	Nov. 28, 1993	8.50	5,900
1970	Jul. 09, 1970	13.11	6,910	1995	Jan. 20, 1995	5.02	2,130
1971	Aug. 27, 1971	9.32	4,320	1996	Jan. 19, 1996	8.73	5,870
1972	Jun. 22, 1972	18.14	19,900[5]	1997	Nov. 08, 1996	6.82	3,760
1973	Jul. 10, 1973	9.94	4,730	1998	Feb. 17, 1998	6.28	3,230
1974	Aug. 30, 1974	8.39	3,860	1999	Sep. 16, 1999	5.83	2,820
1975	Sep. 26, 1975	16.73	14,900	2000	Jul. 28, 2000	9.64	7,020
1976	Dec. 31, 1975	8.10	3,700	2001	Dec. 17, 2000	8.34	5,410
1977	Jul. 12, 1977	8.20	5,040	2002	Jun. 19, 2002	4.07	1,420
1978	Jan. 26, 1978	8.93	6,200	2003	Sep. 23, 2003	11.29	9,330
1979	Feb. 25, 1979	7.30	4,300	2004	Nov. 19, 2003	7.27	4,220
				2005	Mar. 28, 2005	7.78	4,770

Peak Streamflow Qualification Codes.
5 -- Discharge affected to unknown degree by Regulation or Diversion

Table 6 **Peak Streamflow for Virginia USGS 01653000 CAMERON RUN AT ALEXANDRIA, VA**