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

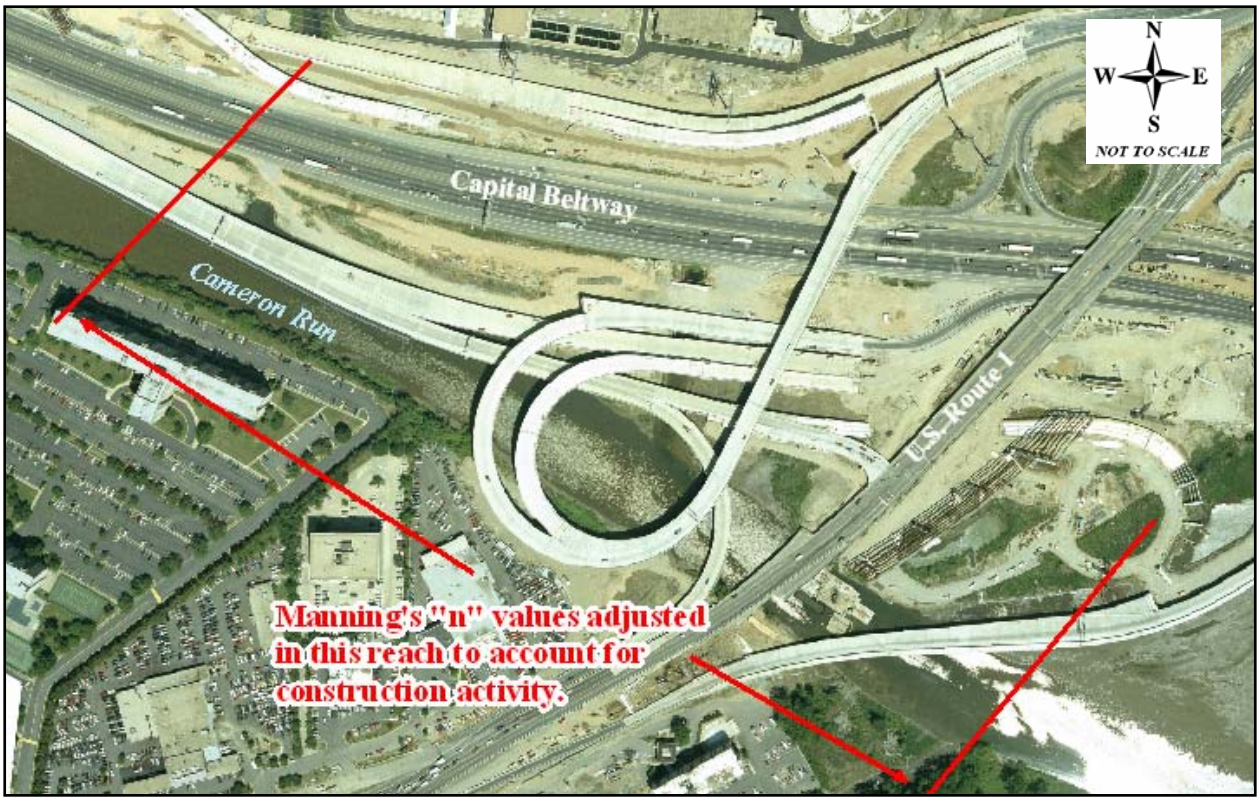
Plan	Geometric File	Flow File	Explanation
JUNE 2006 FLOOD EVENT PLAN	*JUNE 2006 CONDITIONS*	*JUNE 2006 FLOOD EVENT (TIDE)*	Discussed in Section 6.2. The June 2006 flood event
JUNE 2006 (WITHOUT BRIDGE ACTIVITY)	MODIFIED VDOT EXISTING	*JUNE 2006 FLOOD EVENT (TIDE)*	If the June 2006 flood event occurred 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

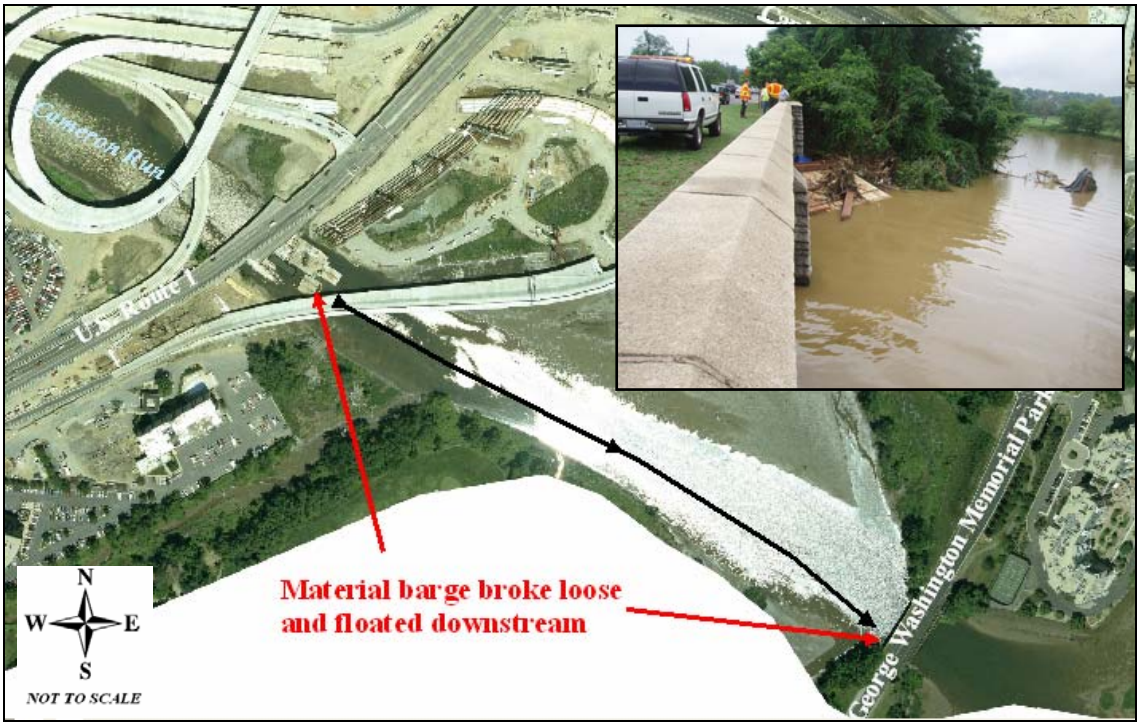
SECTION	*JUNE 2006 FLOOD EVENT PLAN*	*JUNE 2006 (WITHOUT BRIDGE ACTIVITY)*	*INCREASE AS A RESULT OF U.S. ROUTE 1 INTERCHANGE ACTIVITY*
2752	23.8	23.6	0.2
2398	21.0	20.7	0.2
2071	16.3	16.2	0.2
1389	13.9	13.4	0.5
1180	13.4	12.7	0.7
1000	13.2	12.6	0.6
820	12.8	12.1	0.7
660	12.2	11.3	0.9
445	11.2	10.3	0.8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

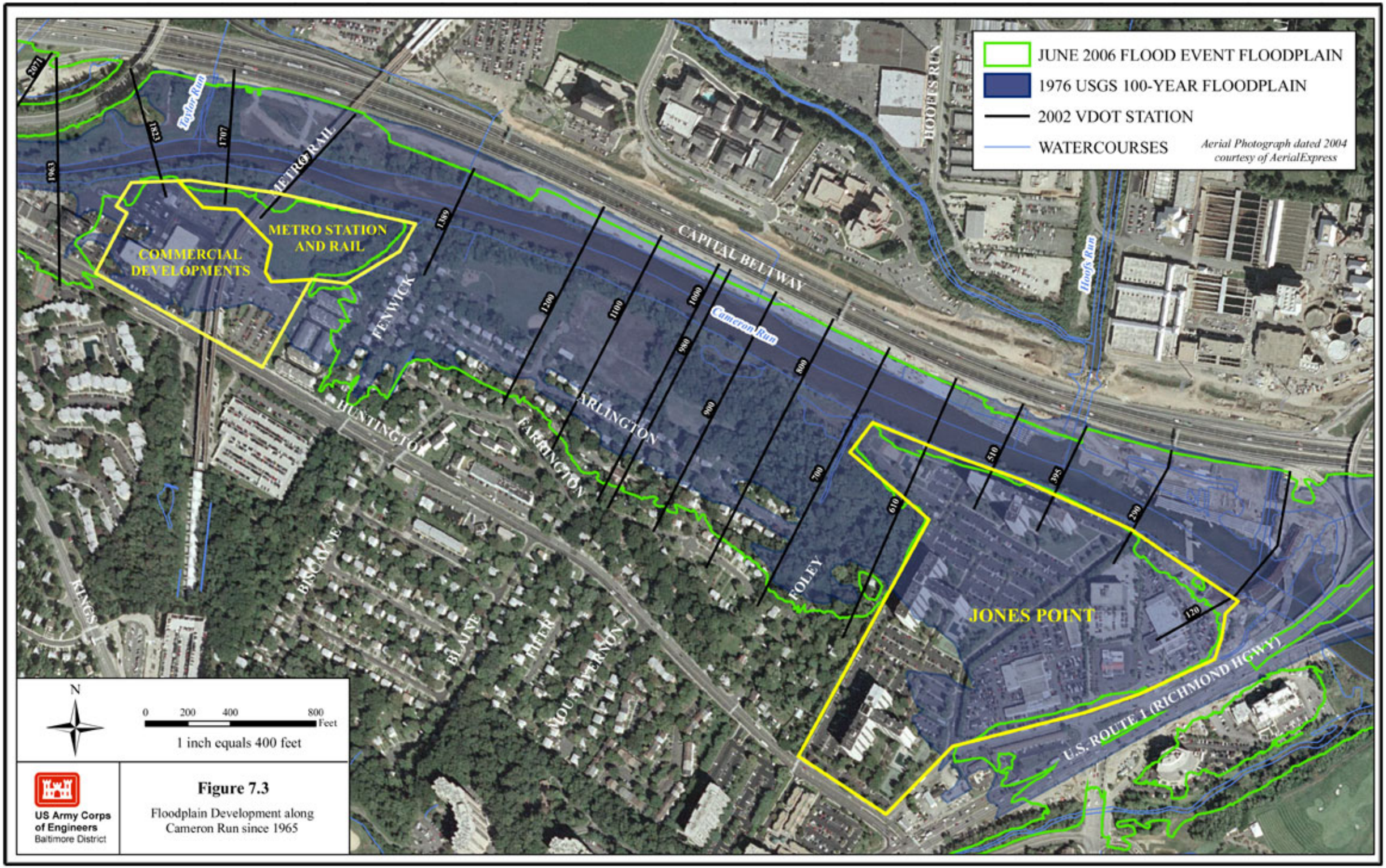


Figure 7.3

Floodplain Development along Cameron Run since 1965

Figure 7.4. Depth of Fill for Jones Point

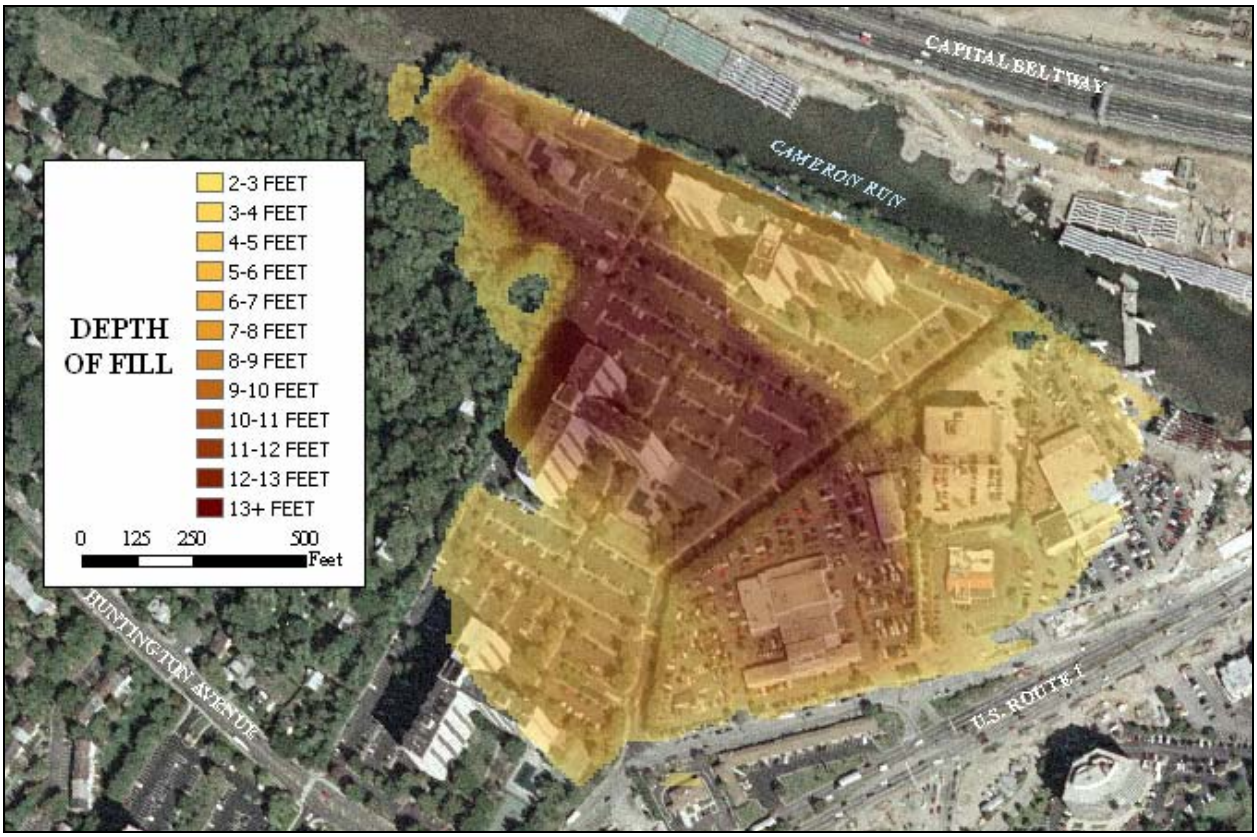
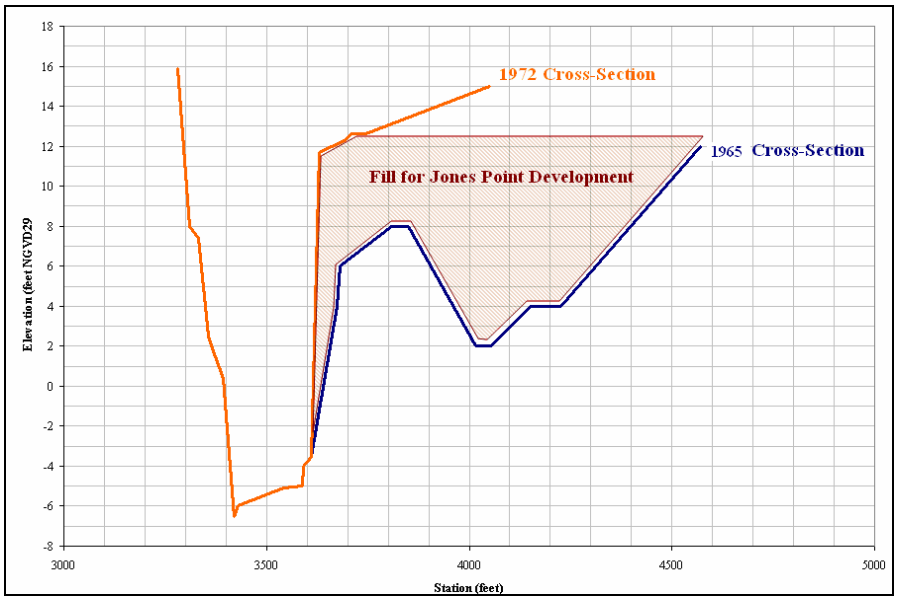


Figure 7.5. Comparison of Typical Cross-Section for Jones Point



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.

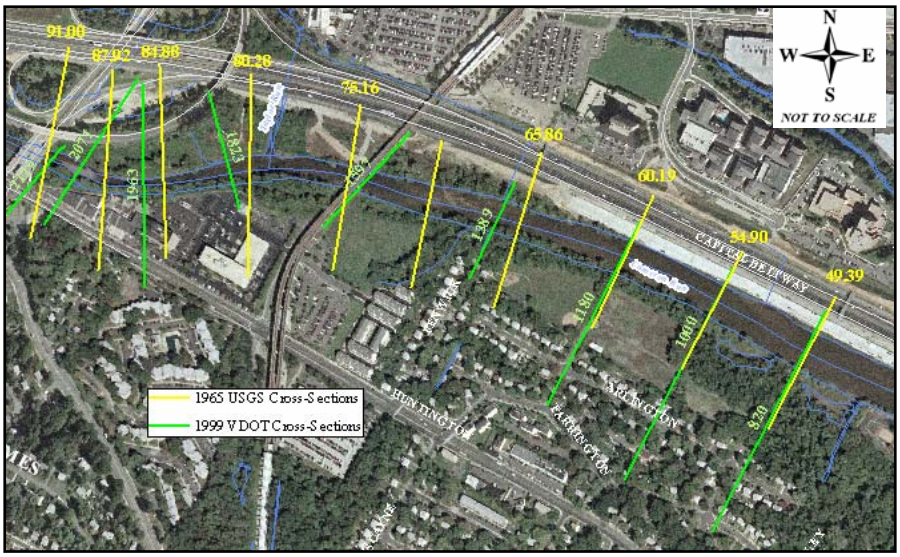
7.4 CHANNEL SEDIMENTATION

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

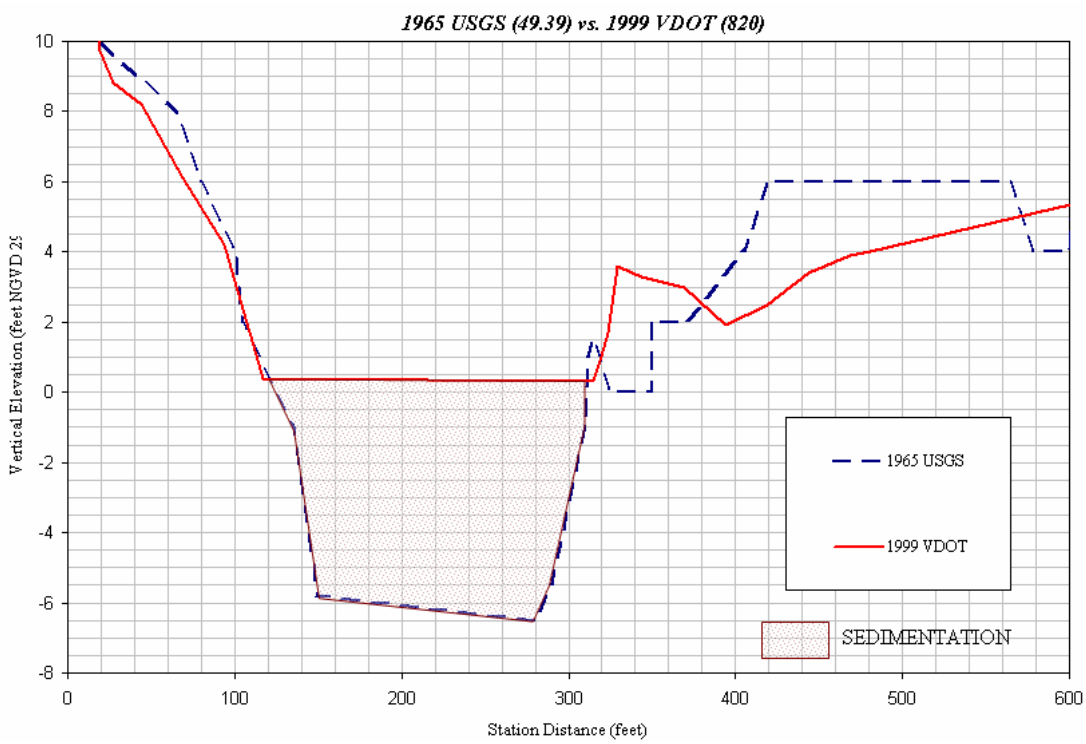
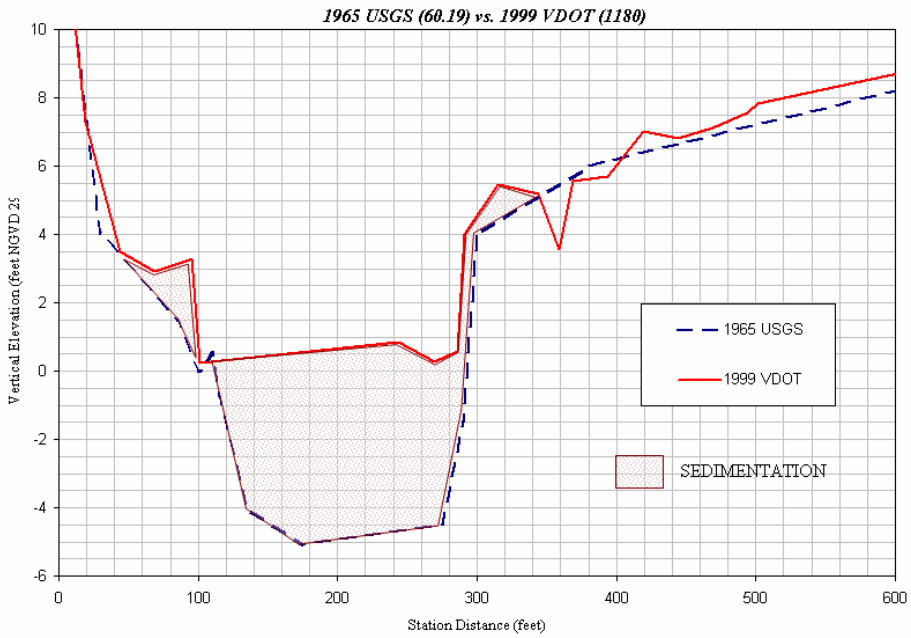
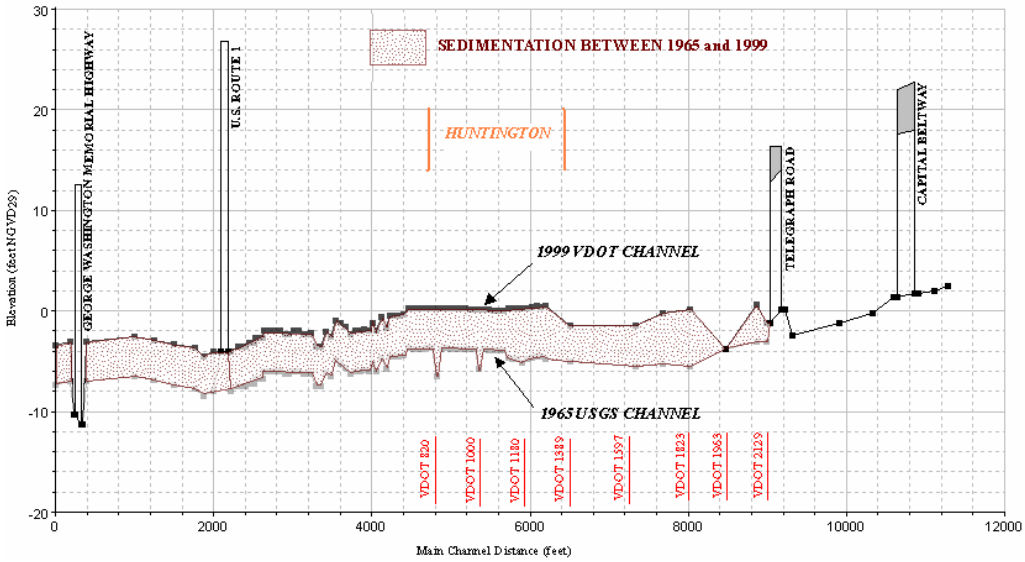


Figure 7.7. Comparison of 1965 USGS Cross-Sections with 1999 VDOT Cross-Sections (Continued)



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.

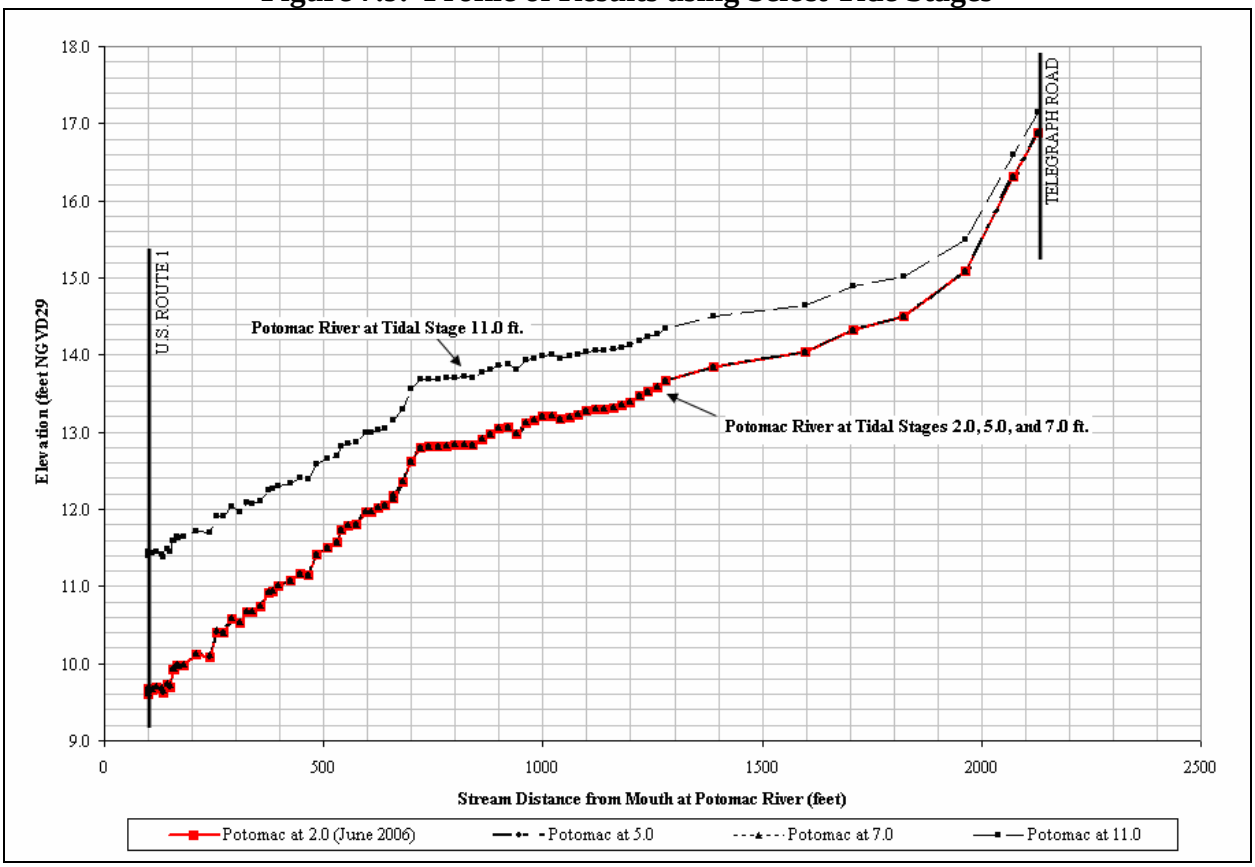
7.5 POTOMAC INFLUENCE

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.