Documentation and Analysis of Flash Flood Prone Streams and Subwatershed Basins in Pulaski County, Virginia

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Abstract

Flash flooding is the number one weather-related killer in the United States[1]. With so many deaths related to this type of severe weather, additional detailed information about local streams and creeks could help forecasters issue more accurate and precise warnings, which could help save lives.

Streams within twenty-five feet of a roadway in Pulaski County, Virginia were selected to be surveyed and mapped using GIS software. In total, 319 points along these streams were physically measured to determine how high stream levels would need to rise in order to flood nearby roadway(s). Multiple digital pictures document the environment upstream and downstream from the survey point. This information was color-coded, mapped, and overlaid in Google Earth for quick reference on computers at the National Weather Service Office in Blacksburg, Virginia. It has also been compiled into an operational handbook and DVD for use at the NWS.

Introduction & Research Purpose

Intense rainfall over a certain area in a short period of time can cause local streams and creeks to rise quickly and cause flash flooding. If there are nearby roadways this flooding can cause road closures or delays. To better understand which roads and areas are more likely to be impacted by flash flooding, research and field work must be conducted to determine how high water from a stream would have to rise in order for it to flood the roadway and cause a closure. The objectives of this project include:

•Identify, measure, and fully document areas in Pulaski County, Virginia that are prone to flash flooding using both GIS and field measurements.

•Compile finalized data in digital form on DVD as well as in paper form in an operational handbook.

•Create an overlay in Google Earth with all available data that can be accessible from workstations at the National Weather Service.

•<u>Overall purpose</u>: Provide the NWS with detailed information about Pulaski County's streams and their flood stages so that forecasters can make flash flood warnings more precise and accurate.

Methodology

ArcGIS software from ESRI was used to identify and map stream networks in Pulaski County that are within 25' of a roadway. GIS (Geographic Information Systems) is a very sophisticated and accurate geographical mapping tool and has been used before by the NWS to delineate local subwatershed basins for use in FFMP. Once USGS stream and road data was imported into ArcGIS, calculations were made to identify points where a stream was located within 25' of a named road.

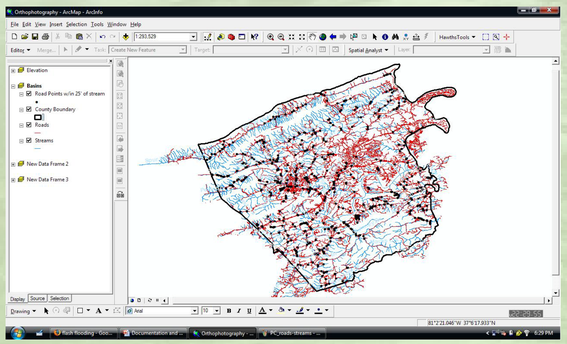

Figure 1. Pulaski County with roads (red), streams (blue) and identified points (black dots) overlaid.

ArcGIS initially identified 651 road locations that were within 25' of a stream. These points then became the survey locations where a number of field measurements were made. Eight items of information were collected at these points:

•Road name
•Road type
•Stream name
•Stream flow (slow, normal, fast, none)
•Distance from road to stream
•Angle of depression
•Upstream picture
•Downstream picture

Object_ID	Road	Stream	Stream_Flow	Road_Type	d	θ	Type	Upstream_ID	Downstream_ID	Radians	Flood_Stage
111	Cherry Branch Road	Cherry Branch	normal	paved	16	35	AS	IMG-0070	IMG-0071	0.61087	3.18
112	Cherry Branch Road	Cherry Branch	none	paved	10	90	C	none	none	1.5708	4.00
113	Cherry Branch Road	Cherry Branch	none	paved	10.5	90	C	IMG-0068	IMG-0069	1.5708	4.50
114	Cherry Branch Road	unlisted	none	paved	9.5	90	C	IMG-0066	IMG-0067	1.5708	3.50
116	Cherry Branch Road	unlisted	slow	dirt	13.5	38	C	IMG-0064	IMG-0065	0.66323	2.31
117	Cherry Branch Road	Burks Run	slow	dirt	13	90	B	IMG-0062	IMG-0063	1.5708	7.00
118	Lead Mine Road	Burks Run	slow	paved	15.5	90	C	IMG-0060	IMG-0061	1.5708	9.50
119	Lead Mine Road	unlisted	normal	paved	12.5	90	B	IMG-0058	IMG-0059	1.5708	6.50
120	Lead Mine Road	unlisted	normal	paved	13	90	C	IMG-0056	IMG-0057	1.5708	7.00
124	Greenhouse Road	Burks Run	slow	paved	13	90	C	IMG-0010	IMG-0011	1.5708	7.00
125	Greenhouse Road	unlisted	slow	paved	14.5	52	C	IMG-0012	IMG-0013	0.90757	5.43
127	Simpkinstown Road	unlisted	normal	dirt	9	90	AS	none	none	1.5708	3.00
128	Gum Log Road	unlisted	normal	paved	12.5	90	B	IMG-0046	IMG-0047	1.5708	6.50
129	Gum Log Road	unlisted	normal	paved	11	51	AS	IMG-0048	IMG-0049	0.89012	2.55
130	Gum Log Road	unlisted	none	paved	8.5	90	C	IMG-0050	IMG-0051	1.5708	2.50
133	Gum Log Road	unlisted	none	paved	15	44	C	IMG-0052	IMG-0053	0.76794	4.42
134	Gum Log Road	unlisted	none	paved	10	51	C	IMG-0054	IMG-0055	0.89012	1.77
135	Greenhouse Road	unlisted	none	paved	11	52	C	IMG-0014	IMG-0015	0.90757	2.67
137	Simpkinstown Road	unlisted	none	dirt	11.5	90	C	IMG-0044	IMG-0045	1.5708	5.50
140	Simpkinstown Road	unlisted	none	paved	12.5	50	C	IMG-0016	IMG-0017	0.87266	3.58
141	Simpkinstown Road	unlisted	none	paved	23.5	30	C	IMG-0018	IMG-0019	0.5236	5.75

Figure 2. Sample of field data collected in tabular format.

Methodology Cont.

To determine the flood stage at each survey point, both a standard 50' measuring tape and clinometer were used. First, the distance from eye-level to the stream edge (d) was measured and recorded. Next, the angle of depression (θ) from eye-level to the stream edge was calculated using the clinometer.

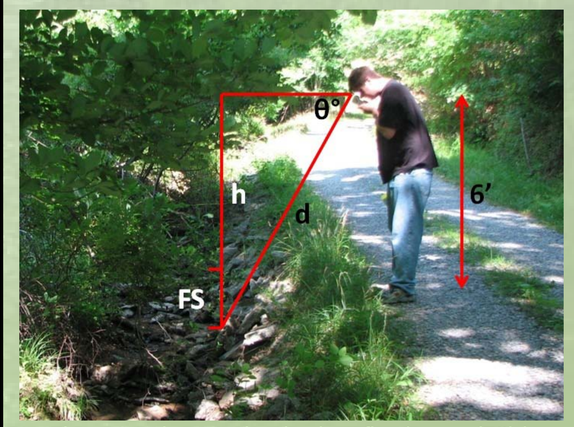

Figure 3. Diagram showing how flood stage (FS) is calculated.

Using a simple algebraic equation for right triangles, we are able to find the height of side h. This is the total height from the water edge, vertically to the author's eye-level. Knowing that the author's eye is exactly 6 feet off the ground, subtract this from the original value of h to find the flood stage (FS). The algebraic equation is as follows, where d is in feet and h equals six feet:

$$FS = [d \cdot SIN(\theta)] - h$$

Of the 651 initial survey points, only 319 were fully documented. The remaining 332 points were either private roads, non-existent, or not likely see any flooding.

Discussion & Final Results

Once all field work was complete the collected data was imported into ArcGIS. The flood stage for each survey point was color-coded and mapped with aerial photography for each NWS subbasin in the county (Figure 4). Each subbasin can be identified by a unique PFAF ID number, which can be used to reference the subbasin back to FFMP during hazardous weather events.

Discussion & Final Results Cont.

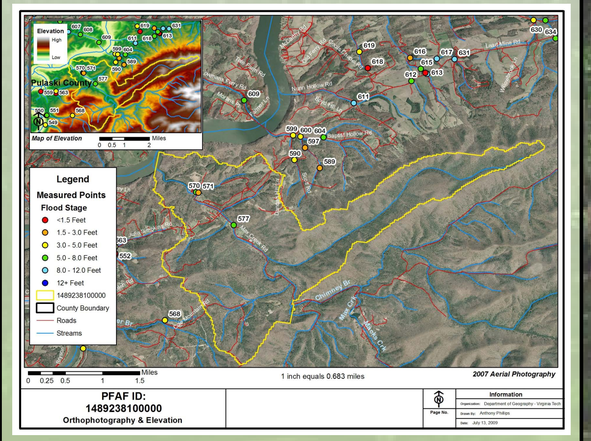

Figure 4. Orthophotography & elevation map with NWS-delineated subbasin and associated PFAF ID.

Attached to each subbasin map is an additional page with tabular data listing each survey point measured within that particular basin. Also on this page is information regarding land use, forest cover, and soil type.

Additionally, all data, including photographs and maps, have been imported into Google Earth as a .kml file and uploaded to servers at the NWS office for quick reference at any forecaster's workstation.

Since completing the research for Pulaski County, the NWS has provided funding to survey Montgomery County, home to Virginia Tech and the local WFO.

References

(1) "Flash Floods and Floods…The Awesome Power! A Preparedness Guide." NOAA.gov. July 1992. National Oceanic and Atmospheric Administration National Weather Service. 22 July 2009.

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