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Appendix A

Geologic Formations in the Morrison Cove Study Area

LOWER SILURIAN

Tuscarora Formation (400 feet):

Light to medium-gray sandstone and minor interbedded shale.

UPPER ORDOVICIAN

Juniata Formation (1250 feet):

Brownish to grayish-red sandstone, some siltstone, and shale.

Bald Eagle Formation (800 feet):

Gray to olive-gray and grayish-red, fine to course-grained sandstone, and some conglomerate.

Reedsville Formation (1250 feet):

Mainly dark gray to black shale, with interbeds of buff siltstone; increasingly more carbonaceous, with calcareous interbeds near the base (Antes Member). A cleavage, both fracture and slaty, may be developed locally. Becomes olive-gray higher in the section.

MIDDLE ORDOVICIAN

Loysburg-Coburn Formations (undifferentiated: 600 feet):

Coburn:	Thin interbeds of dark gray argillaceous limestone and calcareous shale.
Salona:	Thin (5-15 cm) beds of gray limestone with shaly partings; weathers to platy slabs.
Nealmont:	Thick (91-2 m) interbeds of mottled gray, bioturbate limestone, and dove-gray micritic limestones.
Linden Hall:	Thick interbeds of bioturbated limestone and gray micritic limestone.
Snyder:	Finely laminated and relatively thinly bedded limestone and Mg-limestones, with local thin rip-up-clast conglomerates.
Hatter:	Cycles of micritic dark gray limestone with bioclastic interbeds.
Loysburg:	Interbeds of dove-gray limestone and limy dolostones; tiger-striped (1-2 cm) layering near base.

LOWER ORDOVICIAN

Bellefonte Formation (1200 feet):

Cycles of light gray, medium to thick bedded limy dolostones (packstones) capped with finely laminated micritic and locally algal dolostone. Three thick (1-3m) “beds” of chert, both massive white, and vemicular black (replaced bioturbation burrows) occur as regional markers. Elsewhere, chert is developed as rare nodules and thin (11-2 cm) beds. Dark gray to black mottled “pisolitic” beds occur in the cycles near the base.

Axemann Formation (180 feet):

Cycles of course bioclastic limestone capped by finely laminated, light gray to buff dolostone occur interlayered with dominantly fine-grained to micritic dolostones on a 10-meter scale.

Nittany Formation (1200 feet):

Mainly dark gray to mauve, medium-grained crystalline dolostone, with cycles of mottled dark and light gray dolostone, medium-grained crystalline dark gray dolostone, and cream to buff weathered, laminated, argillaceous dolostone. Nodules of dark gray and massive oolitic white chert are common, particularly near the base. In places cherty ridges are apparent in the float that are transverse to strike. Oolitic white chert is common. Some sandy (quartz-rich) lenses occur in the lower middle part of the section.

Stonehenge/Larke Formation (100 feet):

Interbeds of tan crystalline dolostone, finely laminated dolostone, coarse crystalline vuggy dolostone, and fine-grained, dark gray limestone. Some oolitic and pelletal dolostone near top.

CAMBRIAN

Gatesburg Formation (2000 feet):

Mines Member:	Medium and dark gray, medium crystalline dolostone, with abundant dark gray to black chert nodules, some of it algal and oolitic. (600 feet)
Upper Sandy Member:	Cycles of algal dolostone, mottled gray bioturbated crystalline dolostone, platy weathered laminated dolostone, and cross-bedded sandstone, with rare limestone interbeds and flat pebble conglomerates. (500 feet)
Ore Hill Member:	Mainly wavy-bedded, dove-gray micritic limestone, local bioclastic lenses. (120 feet)
Lower Sandy Member:	Similar to Upper Sandy units. Cycles of algal dolostone, mottled gray, bioturbated crystalline dolostone, platy weathered laminated dolostone, and cross-bedded sandstone. (700 feet)
Stacey Hill Member:	Dark gray, medium to coarse crystalline dolostone, interbedded with medium crystalline algal and oolitic dolostone (unknown thickness, but probably included in the basal portion of the Lower Sandy)

Warrior Formation (1200 feet):

Thinly interbedded limestone and calcareous shale, grading downward into crystalline dolostone with interbeds of sandstone up to 3-meters thick.

Pleasant Hill Formation (200 feet):

Gray, thin-bedded limestone interbedded with shale, siltstone, and sandstone.

Waynesboro Formation (unknown thickness, incomplete exposure):

Greenish-gray and grayish-purple shale interbedded with greenish-gray sandstone and conglomerate.

(from: Gold and Doden, 2002; Canich and Gold, 1985; and Taylor et al., 1982)

Appendix B

Graphs of Discharge vs. Watershed Area in the Major Watersheds of Morrison Cove

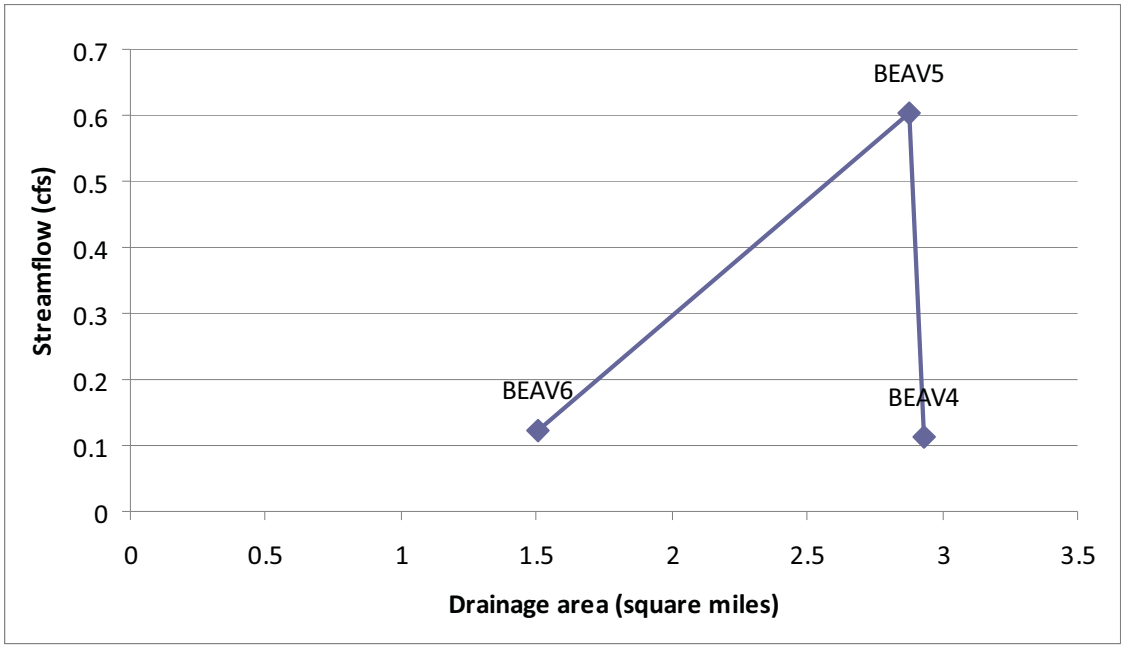

Figure B1. An Unnamed Mountainside Tributary to Beaver Creek (It picks up water in the mountainside siliciclastics, but abruptly loses it downstream of BEAV5.)

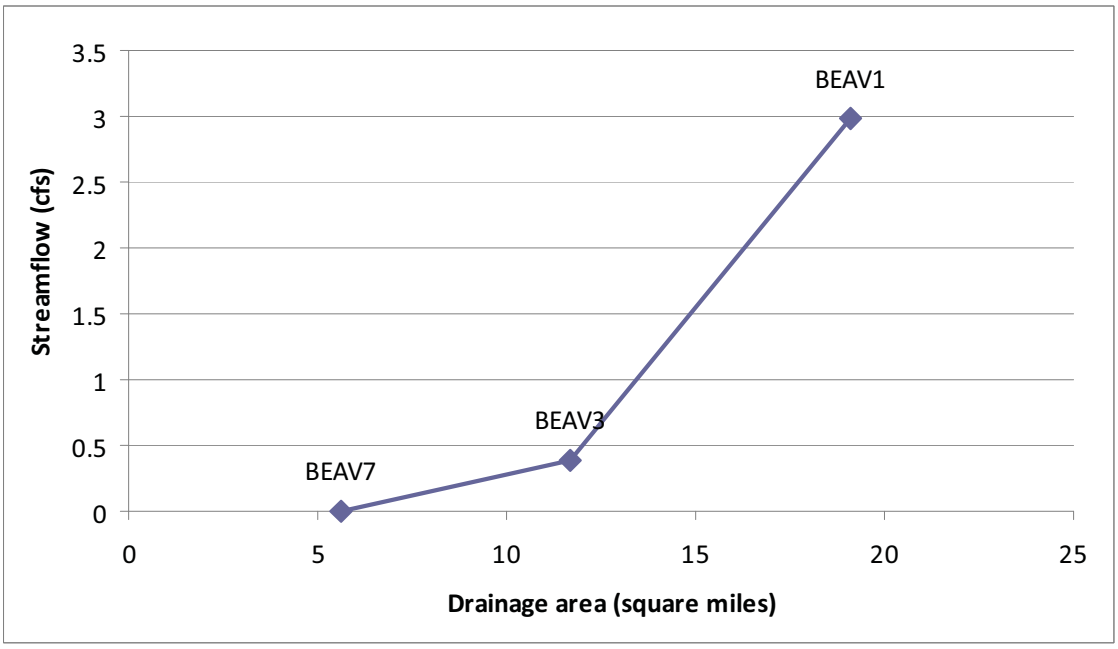

Figure B2. Beaver Creek Rapidly Picking up Water between BEAV1 and BEAV3

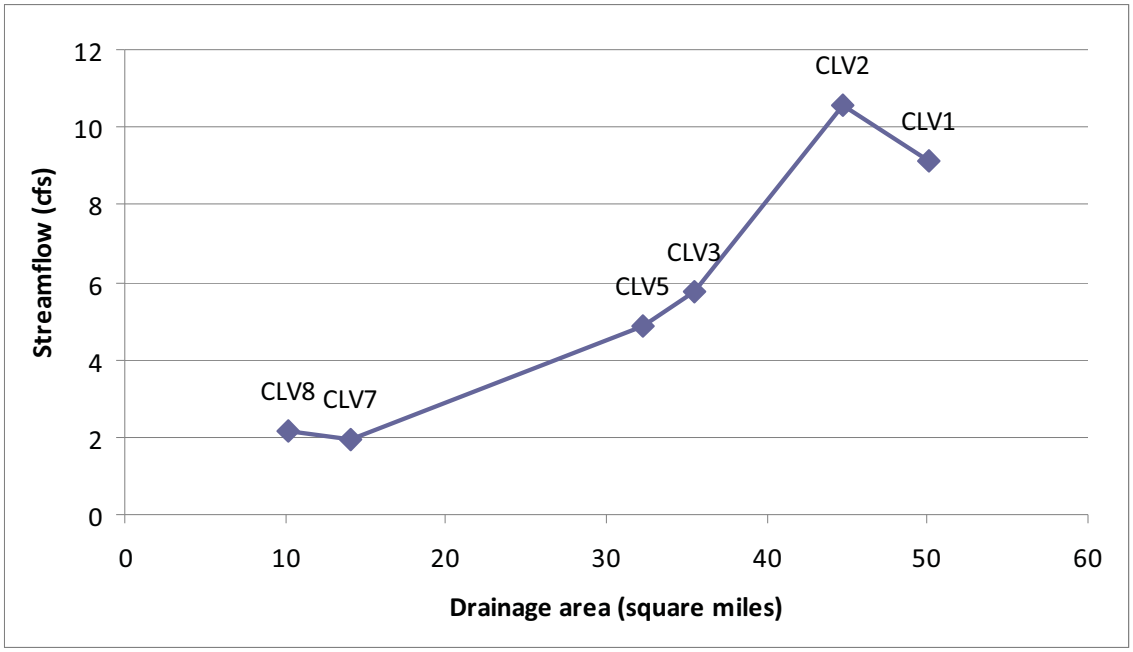

Figure B3. Clover Creek Picking up Flow Gradually between CLV2 and CLV 7 (although still below the trend from CLV2 through CLV8)

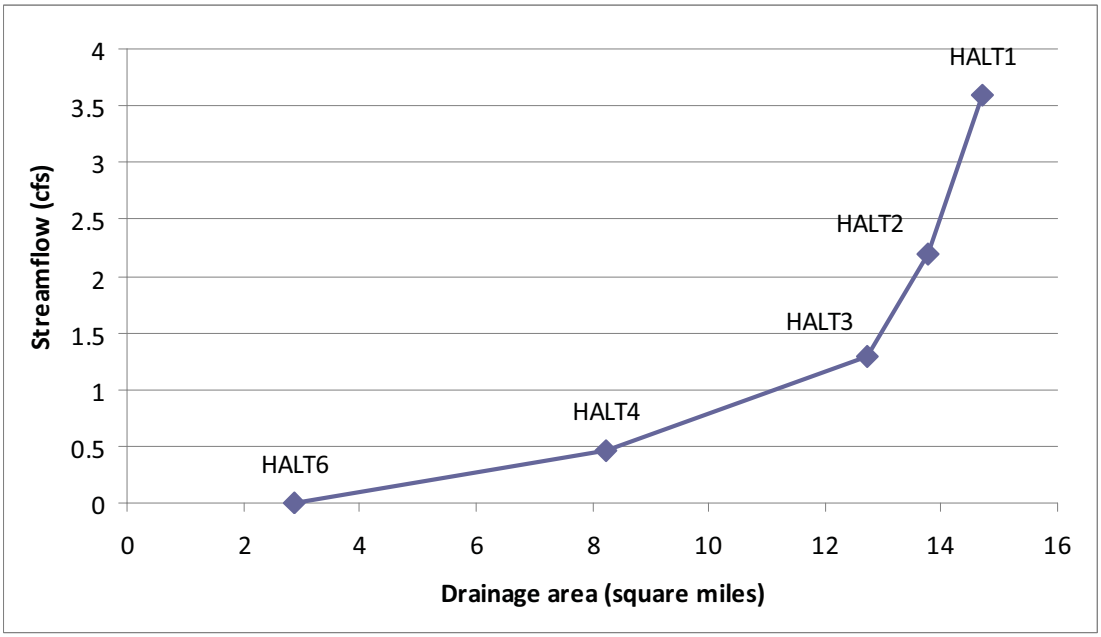

Figure B4. Halter Creek Picking up Most of Its Water Downstream of Halt3

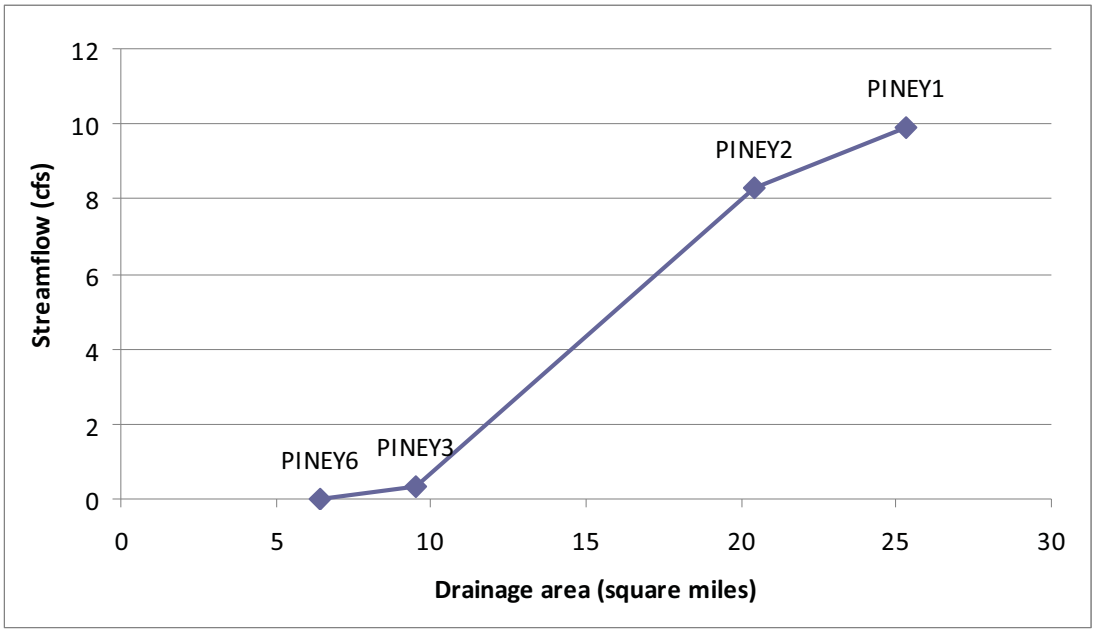

Figure B5. Piney Creek Picking up Most of Its Flow between Piney 2 and Piney 3

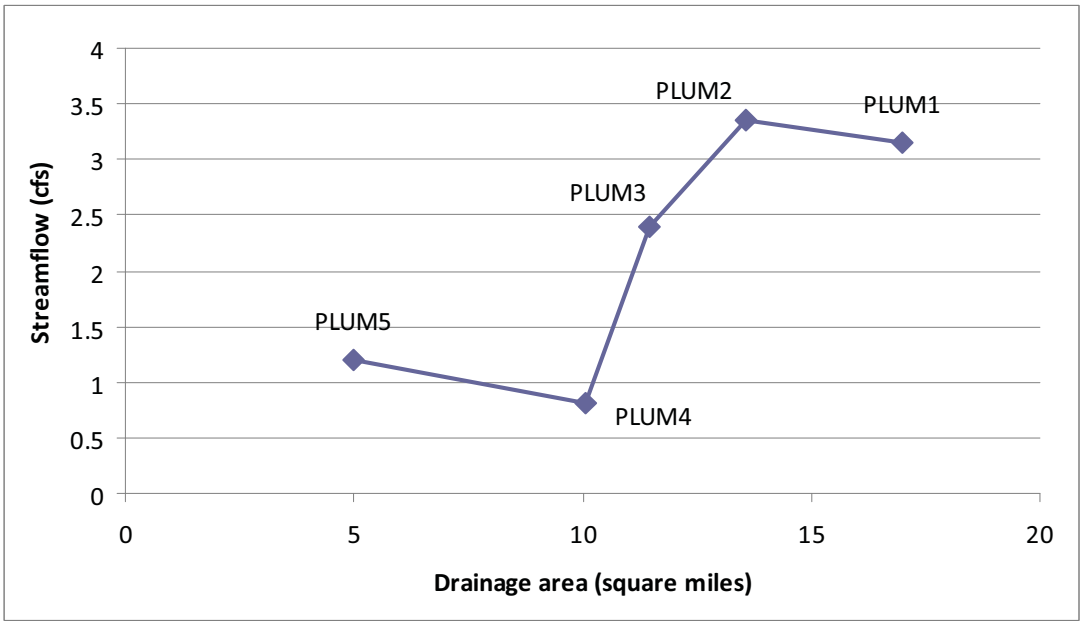

Figure B6. Plum Creek Picking up Spring Flow between Plum 3 and Plum 2

Appendix C

Hydrographs of the Roaring Spring and the Williamsburg Spring

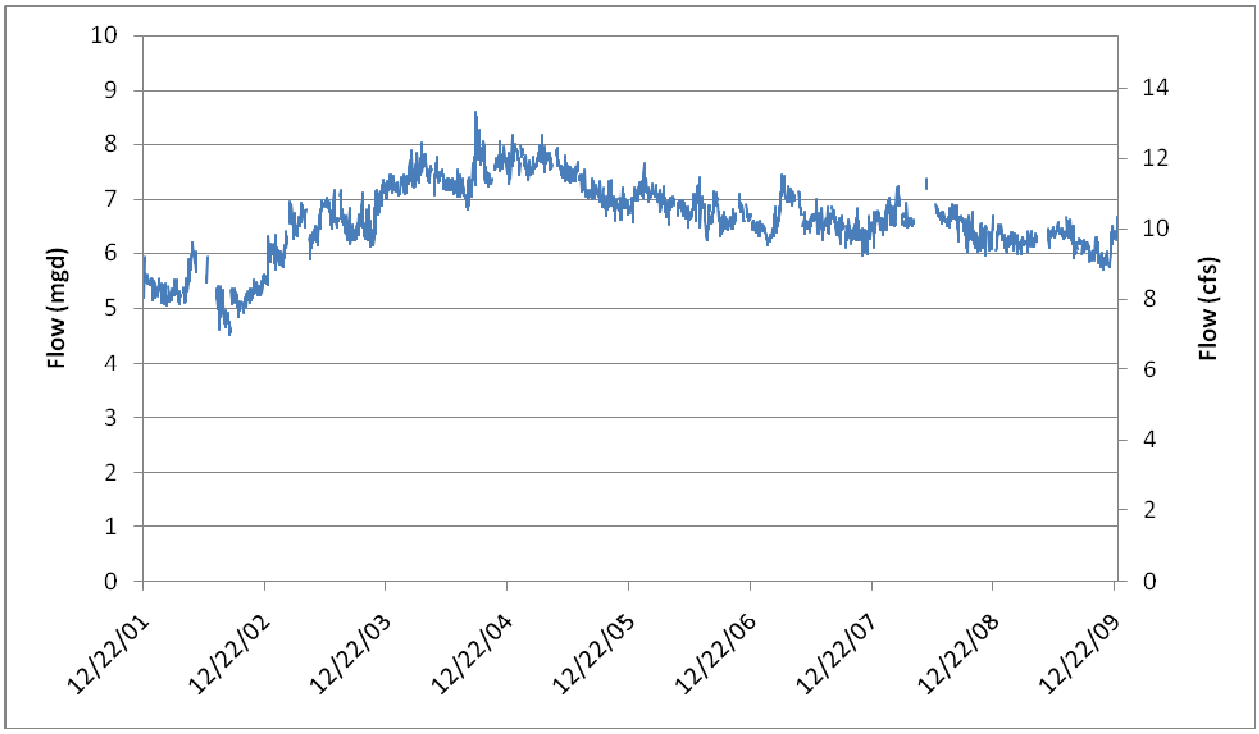

Figure C1. Hydrograph for the Roaring Spring

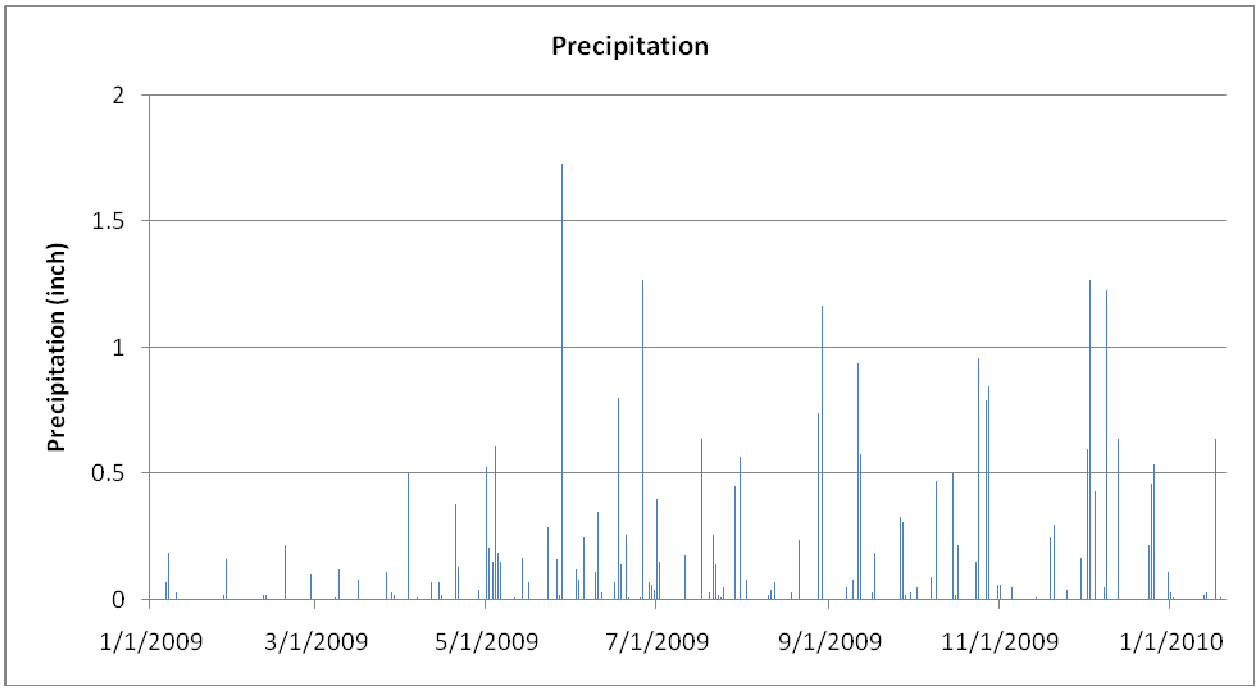

Figure C2. Precipitation at Martinsburg Airport during the Temporary Monitoring Period

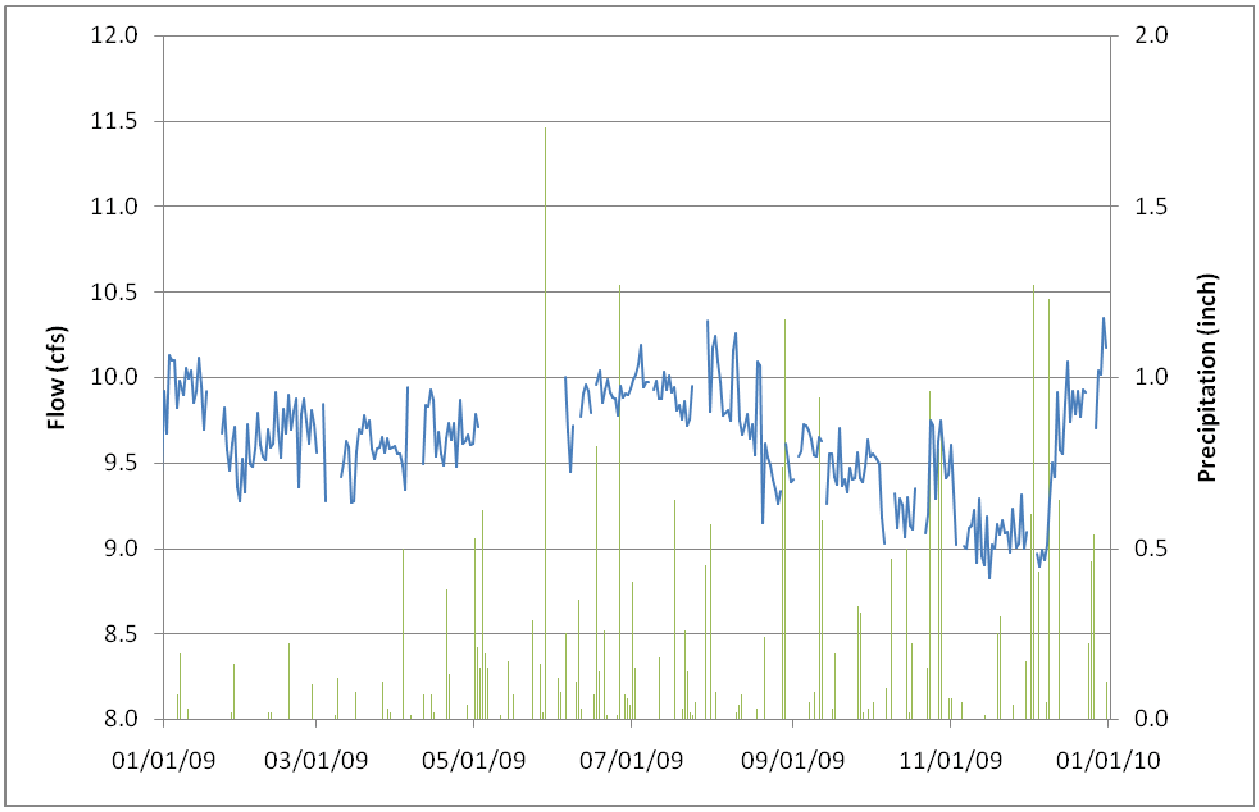

Figure C3. Hydrograph and Precipitation for the Roaring Spring during Temporary Monitoring Period (Note lack of correspondence between spring flow and precipitation.)

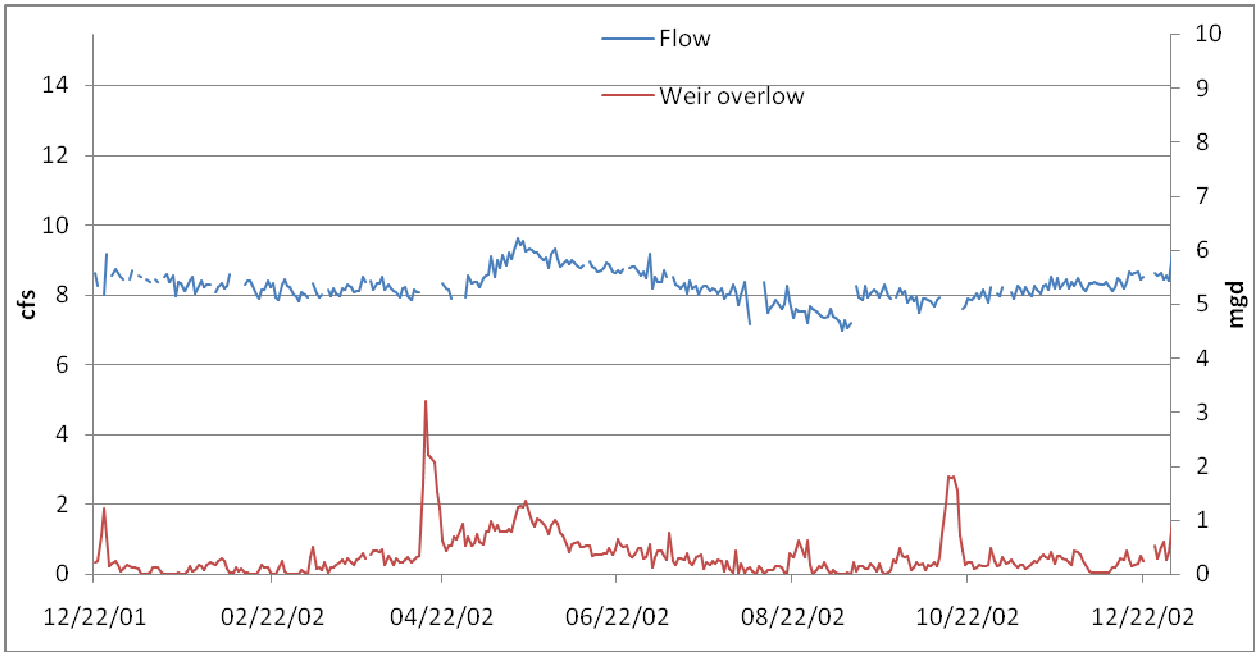

Figure C4. Hydrograph of Spring Flow and Spring Pool Discharge for the Roaring Spring

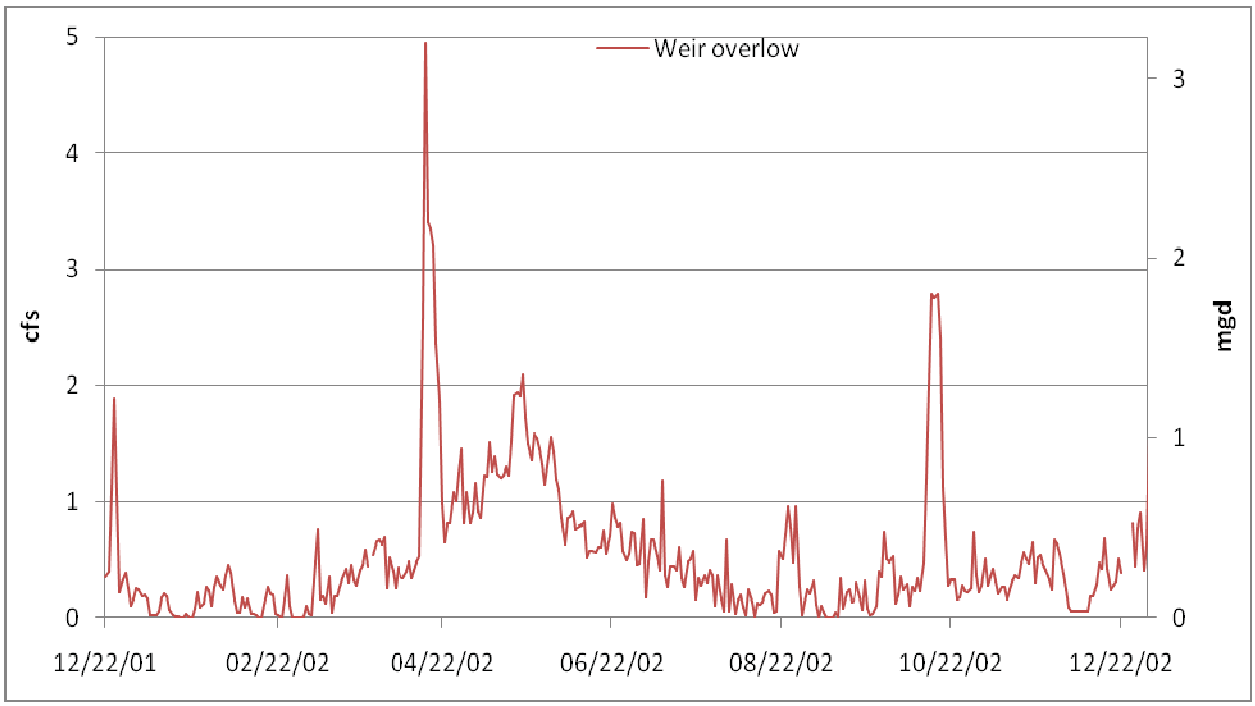

Figure C5. ***Hydrograph of the Spring Pool Discharge at the Roaring Spring during the 2002 Drought (Note several short periods of zero or near zero flow leaving the spring pool.)***

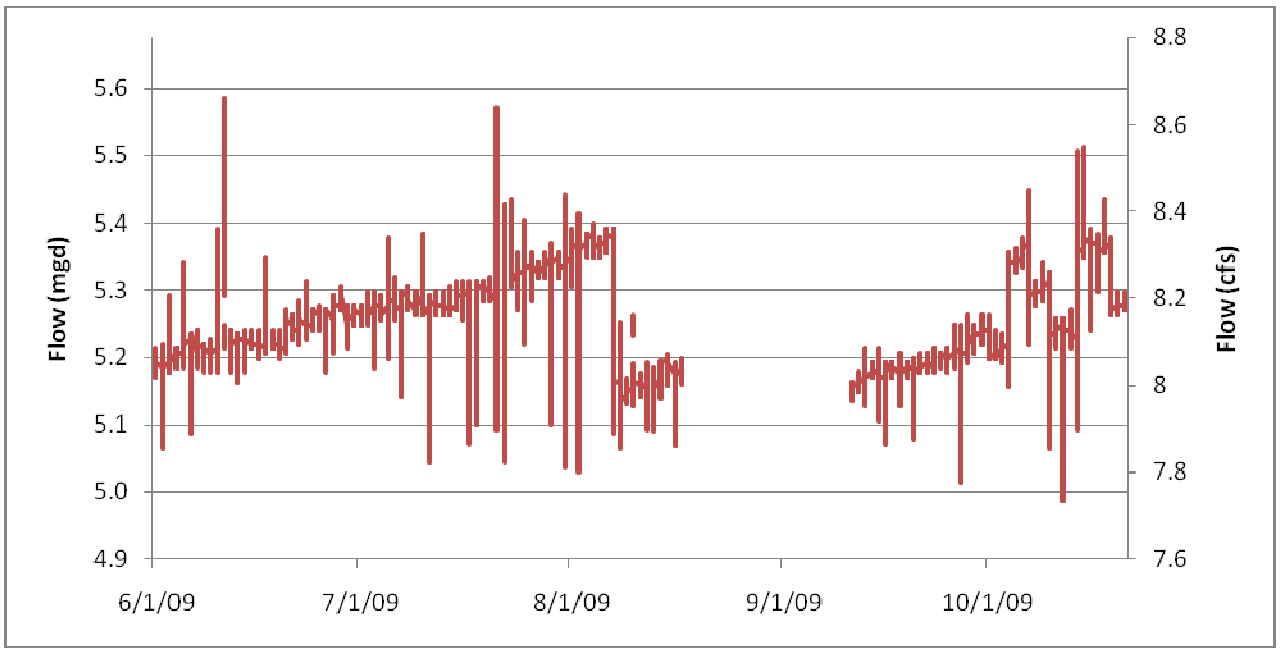

Figure C6. ***Hydrograph of Flow from the Williamsburg Spring during the Temporary Monitoring Period (Vertical scale choice intended to emphasize variability. All flow values were within the range of 7.7 to 8.6 cfs (4.9 – 5.6 mgd).)***

Appendix D

Major Watershed Flow Statistics

Table D1. Estimate of Monthly Percentiles for Clover Creek (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	12.1	14.6	17.7	19.5	21.4	23.6	26.6	30.1	37.4
Feb	15.9	19.0	21.4	23.5	26.3	28.9	32.1	35.4	42.5
Mar	27.4	33.1	37.9	42.3	47.8	51.8	57.1	63.3	76.2
Apr	29.8	33.6	38.0	41.8	45.6	49.8	54.0	58.0	68.2
May	21.9	24.8	27.7	30.4	33.2	36.2	39.5	42.8	50.0
Jun	15.1	16.8	18.2	19.7	21.0	22.4	23.7	25.2	28.2
Jul	10.2	11.8	12.9	13.8	14.6	15.4	16.1	16.9	18.8
Aug	8.9	10.3	11.2	11.8	12.4	12.9	13.5	14.1	15.6
Sep	7.9	9.0	9.8	10.5	11.2	11.7	12.2	12.7	13.7
Oct	8.2	9.2	10.0	10.6	11.2	11.7	12.2	12.6	13.6
Nov	9.1	10.8	11.7	12.8	13.7	15.2	17.0	18.6	22.9
Dec	11.4	13.5	15.3	17.4	19.7	21.8	24.7	27.3	33.7
Annual	10.1	11.8	13.1	14.6	16.4	18.4	20.5	23.1	29.6

Table D2. Estimate of Monthly Percentiles for Halter Creek (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	5.5	7.0	8.3	9.7	10.8	11.9	13.2	14.9	18.3
Feb	7.2	8.9	10.2	11.9	13.4	15.0	16.6	18.6	23.2
Mar	15.0	18.1	21.0	23.6	26.0	29.0	32.1	35.9	43.2
Apr	14.7	16.9	18.9	21.3	23.9	26.2	28.7	31.2	37.2
May	9.7	11.5	12.8	14.0	15.5	17.0	18.8	20.5	24.5
Jun	6.4	7.1	7.7	8.3	8.9	9.5	10.2	11.1	12.7
Jul	4.4	5.0	5.4	5.9	6.3	6.6	7.0	7.3	8.2
Aug	3.9	4.3	4.6	4.8	5.1	5.3	5.6	5.9	6.7
Sep	3.4	3.9	4.2	4.4	4.7	4.9	5.1	5.3	5.9
Oct	3.7	4.2	4.4	4.6	4.8	5.0	5.2	5.5	6.2
Nov	4.1	4.6	5.0	5.6	6.1	6.7	7.4	8.3	10.5
Dec	4.6	5.3	6.5	7.7	8.8	10.2	11.4	12.8	17.0
Annual	4.3	5.0	5.6	6.3	7.2	8.1	9.3	10.8	14.3

Table D3. Estimate of Monthly Percentiles for HC-PC-Reservoir UNT (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	0.11	0.14	0.17	0.20	0.22	0.25	0.27	0.31	0.38
Feb	0.15	0.18	0.21	0.24	0.28	0.31	0.34	0.38	0.48
Mar	0.31	0.37	0.43	0.49	0.54	0.60	0.66	0.74	0.89
Apr	0.30	0.35	0.39	0.44	0.49	0.54	0.59	0.64	0.77
May	0.20	0.24	0.26	0.29	0.32	0.35	0.39	0.42	0.50
Jun	0.13	0.15	0.16	0.17	0.18	0.20	0.21	0.23	0.26
Jul	0.09	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.17
Aug	0.08	0.09	0.09	0.10	0.11	0.11	0.12	0.12	0.14
Sep	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12
Oct	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.13
Nov	0.08	0.10	0.10	0.11	0.13	0.14	0.15	0.17	0.22
Dec	0.10	0.11	0.13	0.16	0.18	0.21	0.23	0.26	0.35
Annual	0.09	0.10	0.12	0.13	0.15	0.17	0.19	0.22	0.30

Table D4. Estimate of Monthly Percentiles for Piney Creek (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	9.8	11.7	13.6	15.8	17.4	18.9	20.6	22.8	28.0
Feb	13.2	15.6	17.1	18.6	20.7	23.1	25.4	28.0	34.2
Mar	23.4	28.1	31.7	35.4	39.4	43.6	48.0	52.4	62.2
Apr	23.4	27.3	31.2	35.1	38.3	41.6	45.5	49.3	56.2
May	17.0	20.1	22.4	24.3	26.5	28.9	31.8	34.2	40.2
Jun	11.3	12.3	13.5	14.9	16.1	17.3	18.5	19.8	22.6
Jul	8.5	9.1	9.7	10.2	10.7	11.3	11.8	12.5	13.7
Aug	7.3	7.8	8.1	8.7	9.0	9.4	9.7	10.1	11.0
Sep	6.8	7.1	7.5	7.8	8.0	8.5	8.8	9.1	10.0
Oct	6.9	7.5	7.8	8.2	8.7	8.9	9.2	9.6	10.5
Nov	7.6	8.3	8.9	9.4	10.1	11.4	12.8	14.5	19.1
Dec	8.3	10.2	12.3	14.5	16.2	18.1	20.3	22.6	27.8
Annual	7.8	8.8	9.7	10.9	12.1	13.7	15.8	18.2	23.7

Table D5. Estimate of Monthly Percentiles for Plum Creek (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	3.6	4.6	5.5	6.4	7.1	7.9	8.7	9.8	12.1
Feb	4.8	5.8	6.7	7.8	8.8	9.9	10.9	12.3	15.3
Mar	9.9	11.9	13.8	15.5	17.1	19.1	21.1	23.6	28.4
Apr	9.6	11.1	12.5	14.0	15.7	17.2	18.9	20.5	24.5
May	6.4	7.6	8.4	9.2	10.2	11.2	12.4	13.5	16.1
Jun	4.2	4.7	5.1	5.5	5.8	6.3	6.7	7.3	8.4
Jul	2.9	3.3	3.5	3.9	4.1	4.4	4.6	4.8	5.4
Aug	2.6	2.8	3.0	3.2	3.4	3.5	3.7	3.9	4.4
Sep	2.2	2.6	2.8	2.9	3.1	3.2	3.4	3.5	3.9
Oct	2.4	2.7	2.9	3.0	3.1	3.3	3.5	3.6	4.1
Nov	2.7	3.1	3.3	3.7	4.0	4.4	4.9	5.5	6.9
Dec	3.1	3.5	4.3	5.1	5.8	6.7	7.5	8.4	11.2
Annual	2.8	3.3	3.7	4.2	4.7	5.3	6.1	7.1	9.4

Table D6. Estimate of Monthly Percentiles for Yellow Creek (cfs)

Month	P95	P90	P85	P80	P75	P70	P65	P60	P50
Jan	21.1	28.9	36.2	42.6	49.4	56.3	63.9	71.5	92.2
Feb	31.2	39.6	47.2	57.8	66.9	76.1	85.2	97.2	122.0
Mar	64.1	79.6	94.9	108.6	124.2	138.6	156.7	175.0	216.1
Apr	60.6	72.5	82.8	94.3	105.7	117.9	131.0	144.5	175.0
May	41.7	48.7	54.8	61.9	69.7	76.5	84.9	94.3	117.9
Jun	23.1	27.4	30.6	33.9	36.8	39.4	42.6	46.7	56.1
Jul	15.2	17.5	19.6	21.6	23.1	25.1	27.2	29.2	33.3
Aug	11.9	14.1	15.4	16.7	18.3	19.6	21.3	22.8	26.5
Sep	10.3	12.5	13.8	15.2	16.4	17.5	18.6	20.1	23.0
Oct	12.8	14.1	15.4	16.1	16.7	17.8	18.9	20.2	23.9
Nov	14.5	16.4	18.6	21.5	23.6	26.8	29.8	33.5	42.8
Dec	17.6	22.1	25.9	29.8	33.8	38.3	46.9	56.0	75.8
Annual	14.9	17.8	21.3	24.6	28.6	33.5	38.8	45.9	65.1