Field Report

First State National Park
Brandywine-Piedmont Watershed Plan

Draft April 1, 2015

Prepared for:

The Nature Conservancy
Wilmington, Del.

National Park Service
Wilmington, Del.

Prepared by:

Asia Dowtin and Gerald Kauffman
University of Delaware
Water Resources Agency
Newark, Del.

Table of Contents

List of Figures

List of Tables

Table **Page**

Chapter 1: Introduction and Purpose

2.1. Introduction

On March 25, 2013 President Barack Obama signed an Executive Order by authority of Theodore Roosevelt's 1906 Antiquities Act that created First State National Monument that includes the 1,100 acre Woodlawn Unit along the west bank of the Brandywine Creek in Delaware and Pennsylvania. The Mt. Cuba Center provided funds to acquire the property from the Woodlawn Trustees and transferred the title to the National Park Service. In December 2014 Congress voted to create the First State National Historical Park (FSNP) in the National Defense Authorization Act of 2015 and the bill was signed by the President making it Delaware's first national park.

2.2. Purpose

The National Park Service is preparing a master plan for development of FSNP as part of a Foundation Document with input from the Woodlawn Coalition which is coordinated by The Nature Conservancy. During the summer of 2014, The Nature Conservancy and University of Delaware Water Resources Agency sponsored a field crew of university and high school students (Figure 1) to conduct field surveys and stream monitoring to prepare a watershed management plan for eventual inclusion to the Foundation Document of the First State National Park. The following report summarizes the summer 2014 field work and data collection for the Piedmont tributaries that flow west toward the Brandywine Creek through the Woodlawn Unit of the First State National Park and adjacent Brandywine Creek State Park (Figures 2 and 3).

Figure 1. University of Delaware student research field crew during the summer of 2014 Left to right: Kristen Wanner, Andrew Colletti, Kelli Platt, Asia Dowtin, Matt Bachman, Tobias Muller, Julie Swanson, Leah Harnish, Matt Bachman, Jillian Allen, Sharon Dutton, Radhika Samant, Sara Veale, Danielle Notvest, and Madeline Carr. Summer 2014 research students supported by Delaware Environmental Institute EPSCOR Summer Scholars, Delaware Water Resources Center (DWRC), USGS National Institutes for Water Resources (NIWR), The Nature Conservancy, University of Delaware Water Resources Agency, and National Park Service.

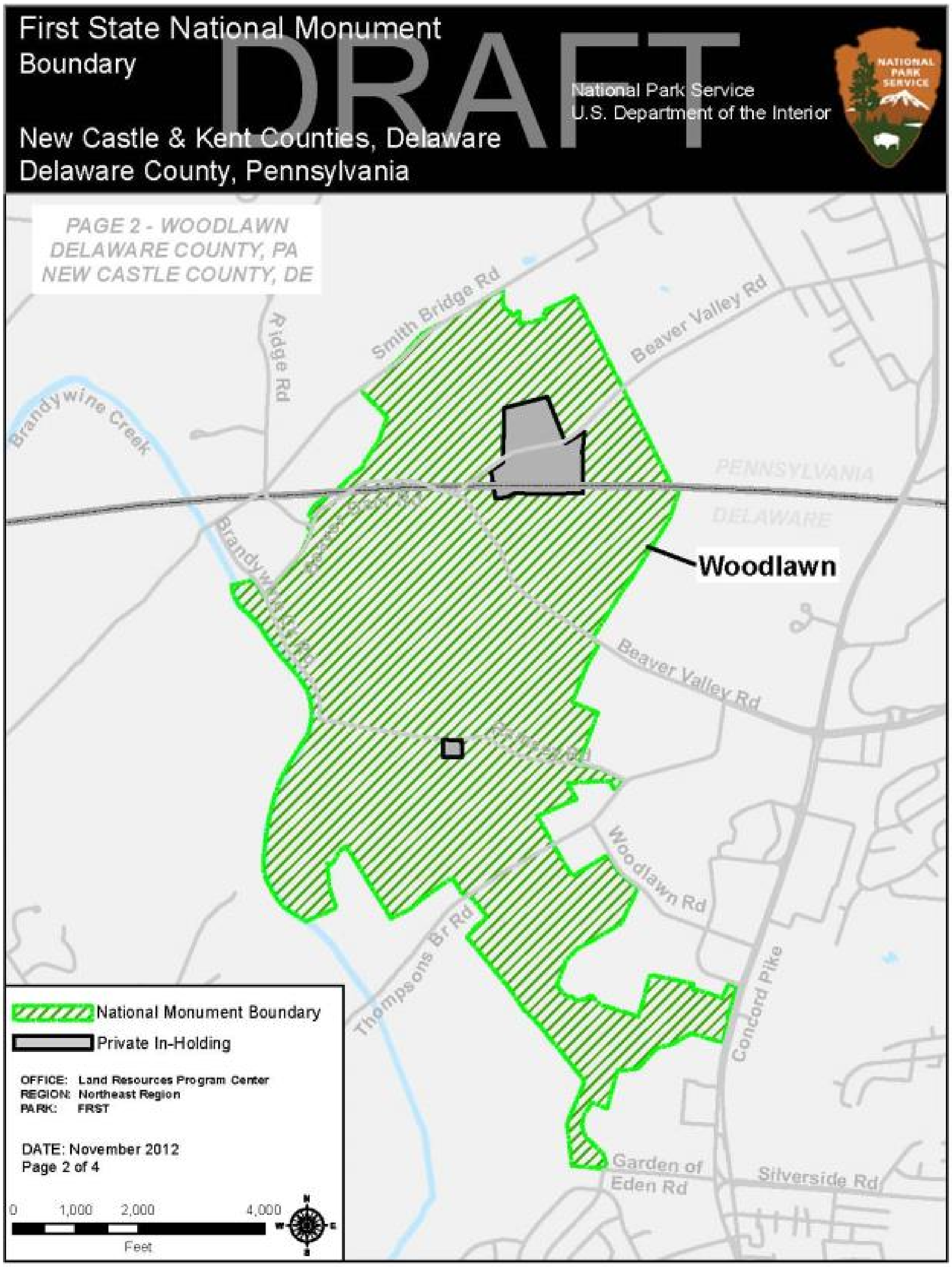


Figure 2. First State National Monument (National Park) boundary

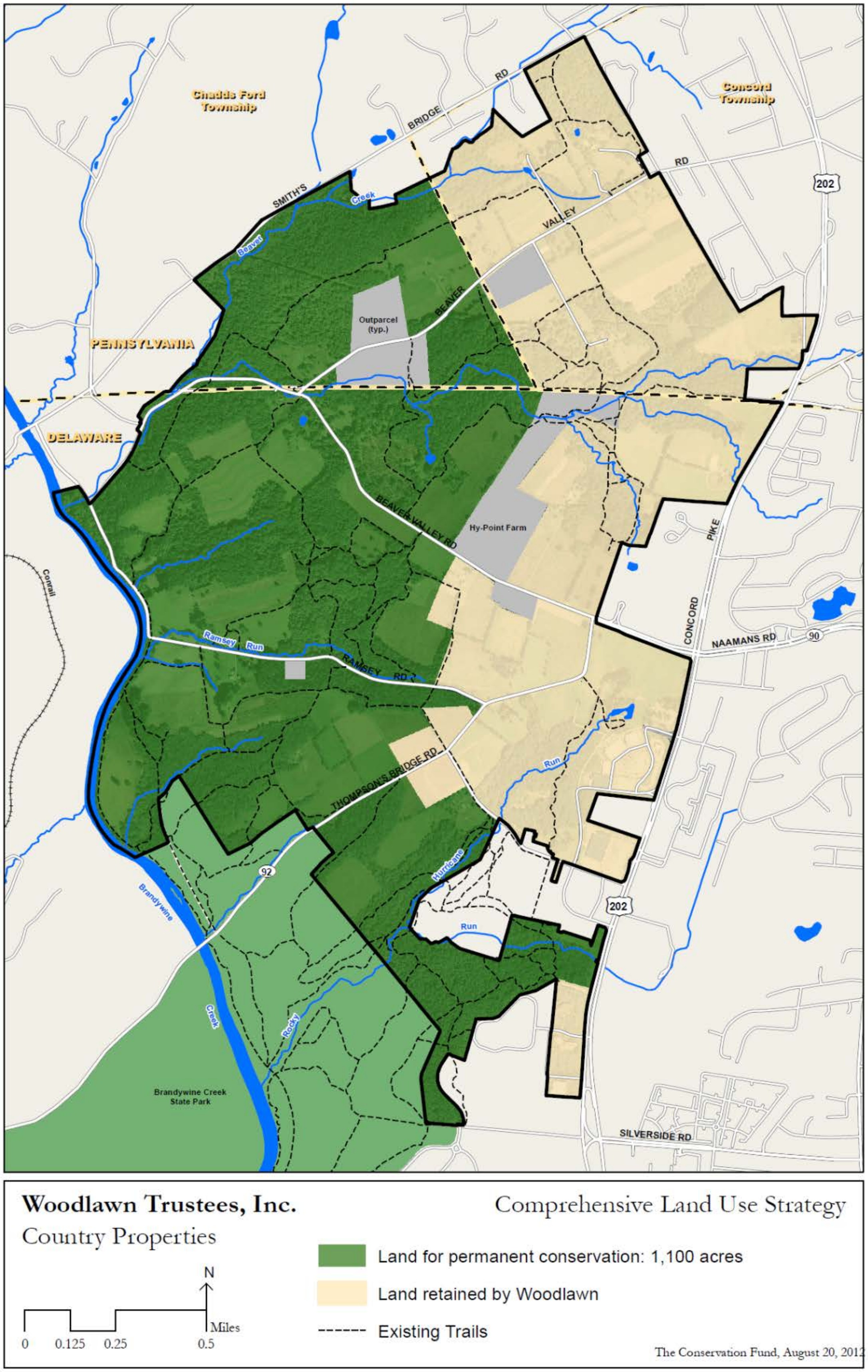


Figure 3. First State National Park – Woodlawn Unit

Chapter 2: Watershed Characterization

The Brandywine Piedmont Watershed Plan (BPWP) is designed to protect and restore the scenic watersheds that flow through the newly designated First State National Historical Park at Woodlawn operated by the National Park Service and adjacent Brandywine Creek State Park owned by the Delaware Division of Parks and Recreation. The summer 2014 field crews characterized these watersheds by land use, impervious cover, slope, soils, geology and monitored stream habitat, geomorphology, and water quality along the following tributaries that flow west toward the Brandywine Creek near the Delaware/Pennsylvania line (Figures 4 and 5).

Watershed	D.A (ac)
Three Sisters Brook	262
Beaver Creek	2,592
Jonkat Run	128
Ramsey Run	230
Thompson's Creek	122
Rocky Run	1,151
	4,485 ac (7.0 mi^2)

2.1. Land Use

The six streams that flow through the First State National Historical Park capture a drainage area of 4,485 acres or 7.0 square miles. Land use in the six watersheds covers 36% forest, 1% wetlands, 27% urban/suburban, and 36% agriculture with an overall impervious coverage of 10% (Table 1 and Figure 6). Watershed land use is mostly urban/suburban and commercial to the east on the 400 feet heights of the Piedmont plateau along Concord Pike (Route 202) and changes to agriculture as the streams flow west and downstream over 300 feet in elevation through the steeply sloped forested valleys to the Brandywine Creek. The flat Piedmont heights were developed and farmed and the forested, steeply sloped stream valleys were conserved in a nearly natural state. The least developed watersheds are small catchments (< 300 acres) such as Three Sisters Brook, Jonkat Run, Ramsey Run, and Thompson's Creek that do not extend too far east from the banks of the Brandywine into the urbanized/commercialized Route 202 corridor.

Table 1. Land use in the Brandywine Piedmont watersheds

Watershed	Area (ac)	Forest (ac)	Wetlands (ac)	Urban/Sub. (ac)	Agriculture (ac)	Impervious (ac)
Three Sisters Brook	262	47	1	13	202	0.8
Beaver Creek	2,592	1037	21	726	804	233
Jonkat Run	128	69	0	4	55	0
Ramsey Run	230	83	0	12	136	0.5
Thompson's Creek	122	74	0	4	44	0.1
Rocky Run	1,151	322	2	460	368	218
	4,485	**1,633**	**24**	**1,218**	**1,608**	**452**
Watershed	**(ac)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Three Sisters Brook	262	18%	0.4%	5%	77%	0.3%
Beaver Creek	2,592	40%	0.8%	28%	31%	9.0%
Jonkat Run	128	54%	0.0%	3%	43%	0.0%
Ramsey Run	230	36%	0.0%	5%	59%	0.2%
Thompson's Creek	122	61%	0.0%	3%	36%	0.1%
Rocky Run	1,151	28%	0.2%	40%	32%	19.0%
	4,485	**36%**	**1%**	**27%**	**36%**	**10.0%**

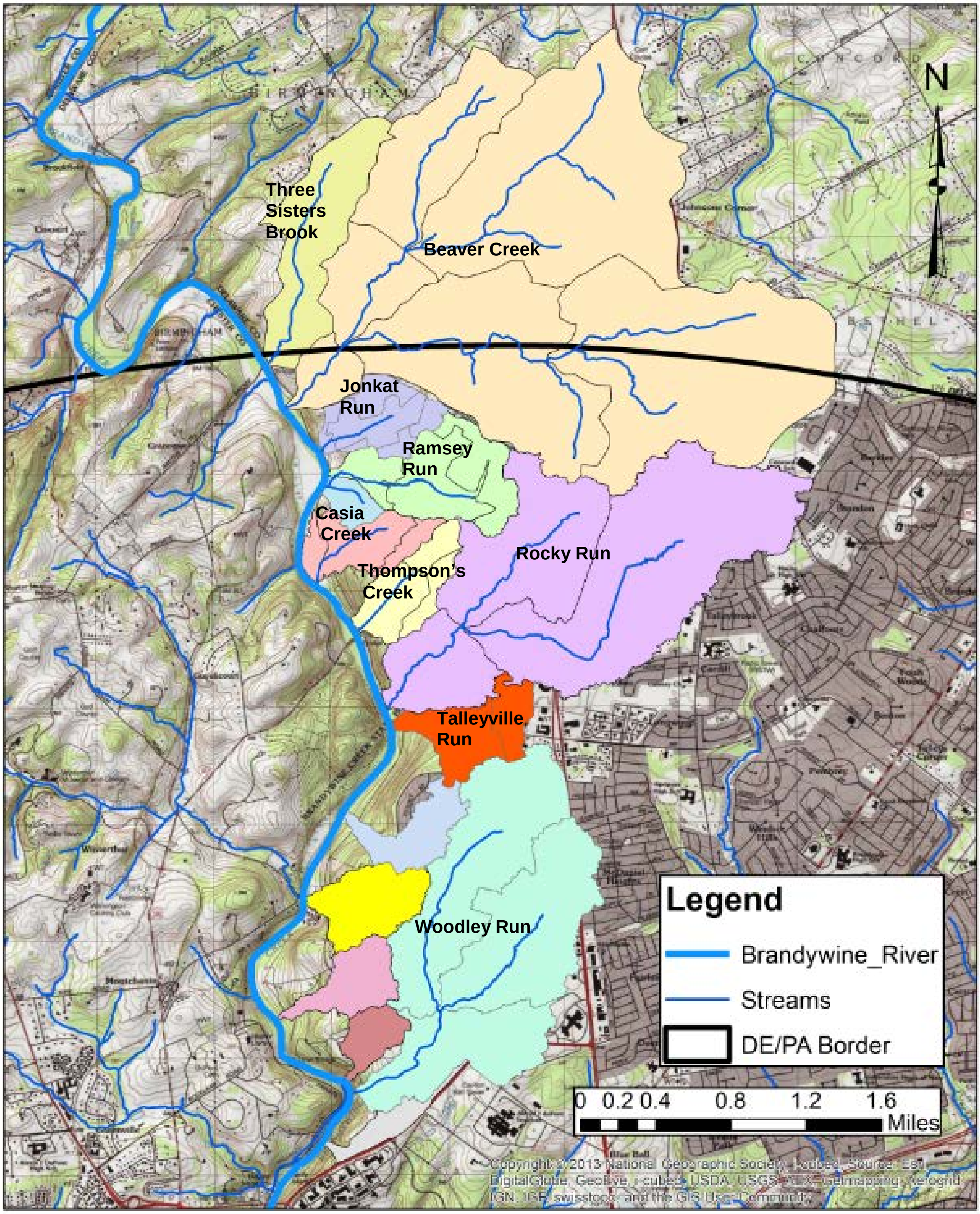


Figure 4. Brandywine Piedmont watersheds at First State National Park

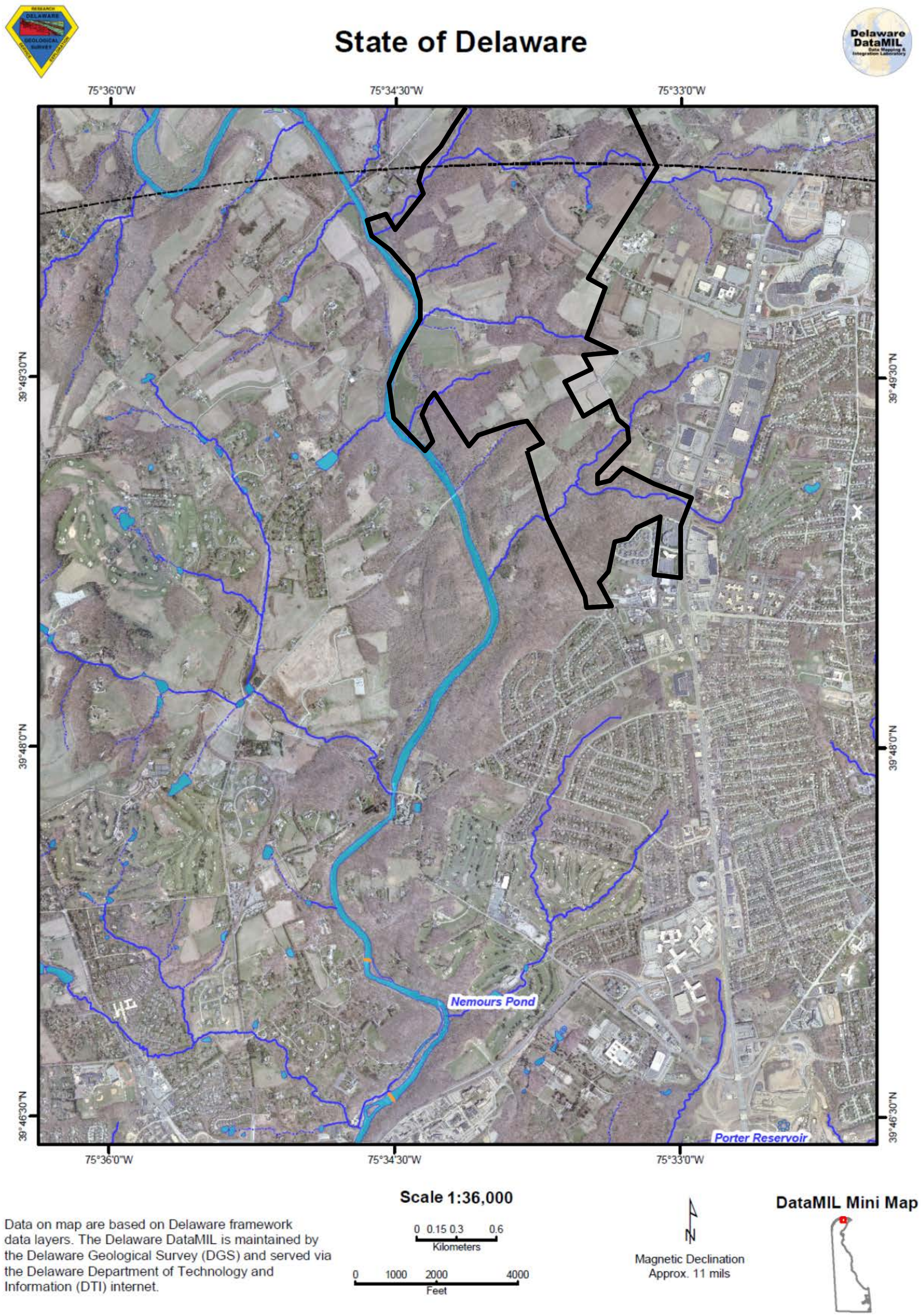


Figure 5. Aerial photograph of streams at First State National Park (2007)

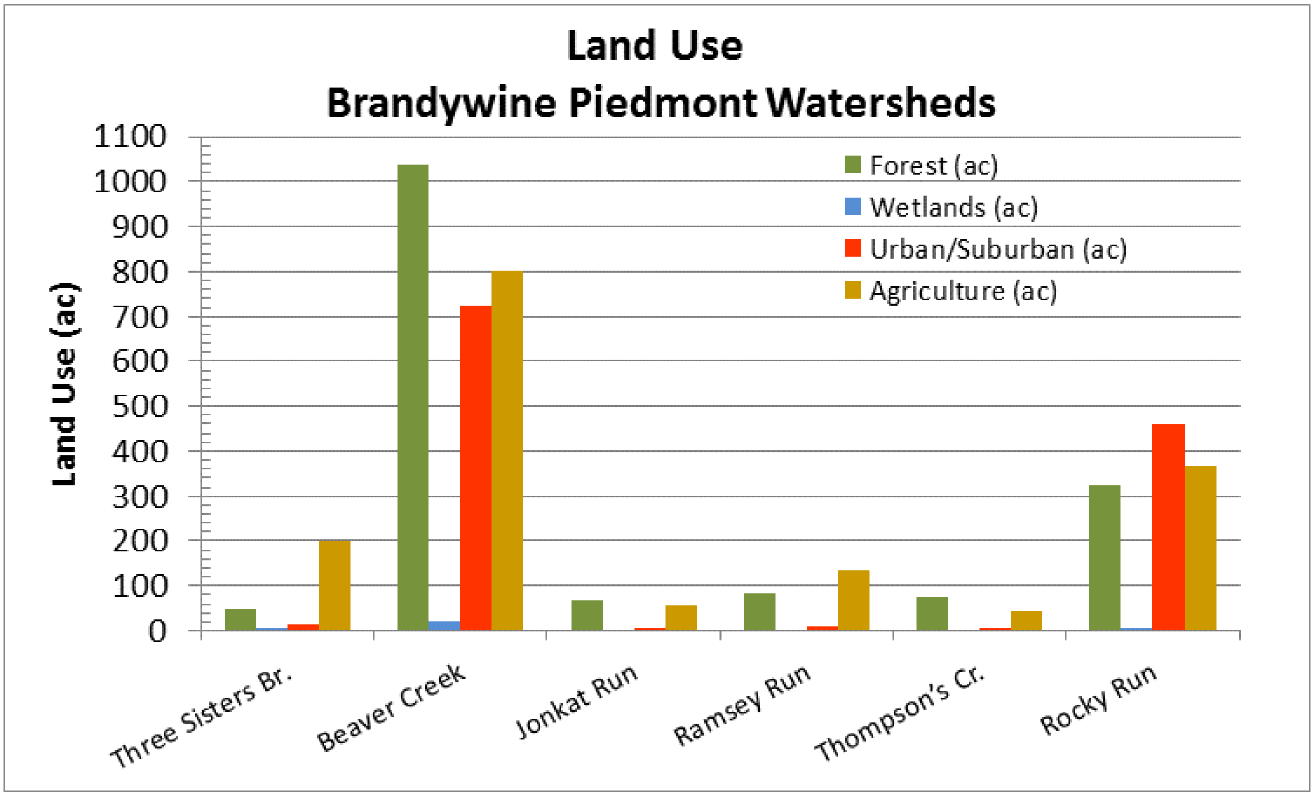


Figure 6. Land use in the Brandywine Piedmont watersheds at First State National Park

2.2. Basin Characteristics

The USGS Streamstats model (Table 2) indicates the watersheds are steeply sloped (6%-15% slopes), at least 15% forested (18%-61%), with minimal wetland coverage (0.2%-0.8%). The small watersheds are mostly undeveloped with impervious coverage less than 0.3% of the catchment area. The larger watersheds, Beaver Creek and Rocky Run, are covered by higher amounts of impervious cover (9.0% and 19.0%) as these watersheds form in the neighborhoods and shopping centers along the commercialized Concord Pike (Route 202) corridor (Figure 7).

Table 2. Characteristics of the Brandywine Piedmont watersheds

Watershed	Area (mi^2)	Basin Slope (%)	Forest (%)	Wetlands (%)	Impervious (%)
Three Sisters Brook	0.4	12%	18%	0.4%	0.3%
Beaver Creek	4.2	9%	40%	0.8%	9.0%
Jonkat Run	0.2	13%	54%	0%	0.0%
Ramsey Run	0.4	11%	36%	0%	0.2%
Thompson's Creek	0.2	15%	61%	0%	0.1%
Rocky Run	1.8	6%	28%	0.2%	19.0%
	7.0 mi^2				

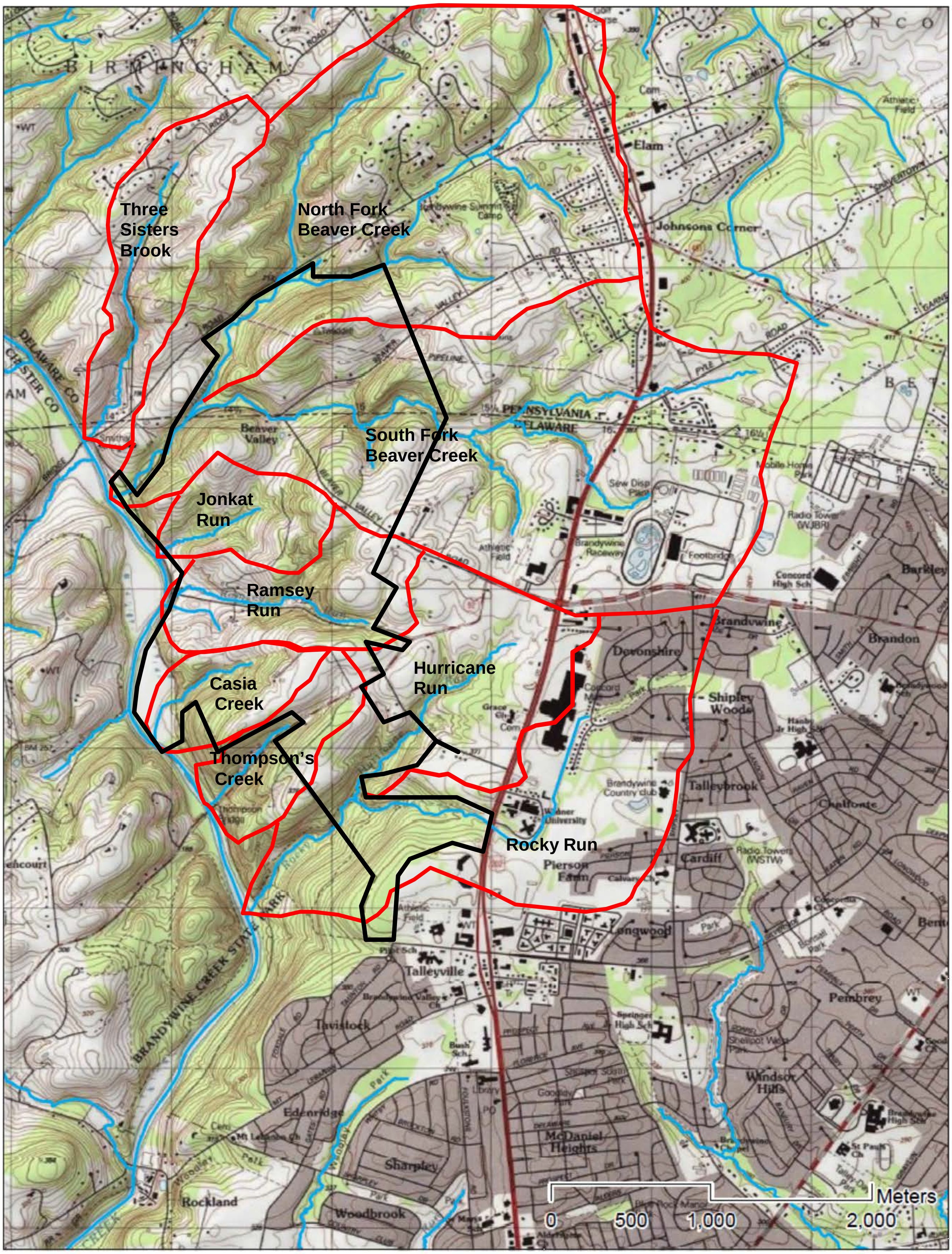


Figure 7. Watersheds and topography at First State National Park

2.3. Soils

According to the USDA soil survey (Figure 8 and Table 3), 2.9% of the FSNP watershed soils are classified as quarry/water/urban bed rock, 10.2% are hydrologic soil group A (moderate permeability), 57% are HSG B (moderately drained), 28.5% are HSG C (low permeability), and 0.8% are HSG D (poorly drained/wetlands). The four hydrologic soil groups are:

Group A soils have a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B soils have a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C soils have a slow infiltration rate that impedes the downward movement of water or soils of moderately fine texture with a slow rate of water transmission.

Group D soils have a very slow infiltration rate (high runoff potential) when wet and are commonly hydric or wetland soils. These soils have a very slow rate of water transmission.

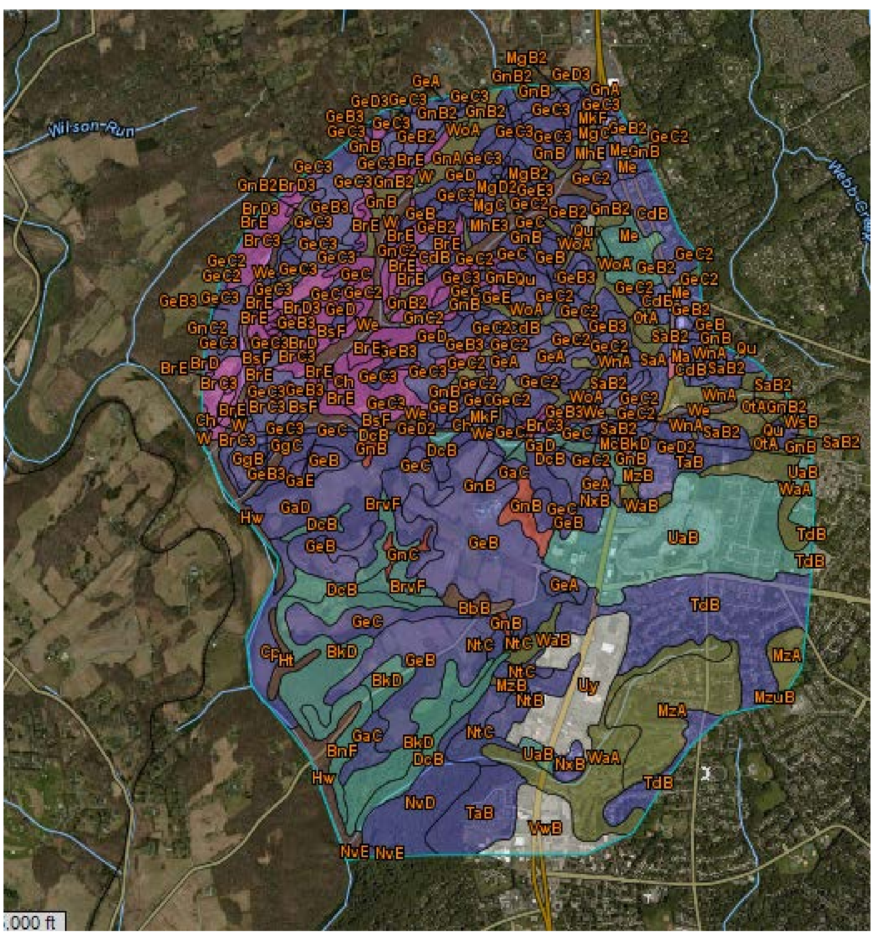


Figure 8. Hydrologic soil groups in the watersheds of the First State National Park

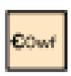
Table 3. Soils in the Brandywine Piedmont watersheds

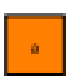
Symbol	Map unit name	Rating	Acres	Percent
Qu	Quarries		14.5	0.3%
W	Water		4.0	0.1%
Uy	Urban land, bedrock substratum		127.6	2.5%
			146.1	**2.9%**
VwB	Urban land-Wheaton complex, 0 to 8 percent slopes	A	66.9	1.3%
BrB2	Brandywine loam, 3 to 8 percent slopes, moderately eroded	A	9.0	0.2%
BrC3	Brandywine loam, 8 to 15 percent slopes	A	126.6	2.4%
BrD3	Brandywine loam, 15 to 25 percent slopes, severely eroded	A	150.0	3.1%
BrE	Brandywine loam, 25 to 40 percent slopes	A	157.6	3.1%
Ma	Made land, gravelly materials	A	4.3	0.1%
		A	**514.4**	**10.2%**
BsD	Brandywine very stony loam, 8 to 25 percent slopes	B	0.6	0.0%
BsF	Brandywine very stony loam, 25 to 50 percent slopes	B	23.9	0.5%
CdA2	Chester silt loam, 0 to 3 percent slopes	B	5.3	0.1%
CdB	Chester silt loam, 3 to 8 percent slopes	B	69.2	1.3%
GeA	Glenelg channery silt loam, 0 to 3 percent slopes	B	13.2	0.3%
GeB2	Glenelg channery silt loam, 3 to 8 percent slopes	B	399.7	7.7%
GeC	Glenelg channery silt loam, 8 to 15 percent slopes	B	375.3	7.3%
GeD	Glenelg channery silt loam, 15 to 25 percent slopes	B	96.3	1.9%
GeE	Glenelg channery silt loam, 25 to 35 percent slopes	B	20.9	0.4%
MgB2	Manor loam, 3 to 8 percent slopes	B	11.1	0.2%
MgC	Manor loam, 8 to 15 percent slopes	B	33.9	0.7%
MgD2	Manor loam, 15 to 25 percent slopes	B	8.4	0.2%
MhE3	Manor loam and channery loam, 25 to 35 percent slopes	B	16.0	0.3%
MkF	Manor soils, 35 to 60 percent slopes	B	6.4	0.1%
SaA	Sassafras loam, 0 to 3 percent slopes	B	7.8	0.2%
SaB2	Sassafras loam, 3 to 8 percent slopes, moderately eroded	B	100.3	1.9%
Cp	Comus silt loam, 0 to 3 percent slopes, occasionally flooded	B	48.9	0.9%
GaC	Gaila loam, 8 to 15 percent slopes	B	74.3	1.4%
GaD	Gaila loam, 15 to 25 percent slopes	B	165.8	3.2%
GaE	Gaila loam, 25 to 45 percent slopes	B	51.4	1.0%
GeA	Glenelg loam, 0 to 3 percent slopes	B	25.1	0.5%
GeB	Glenelg loam, 3 to 8 percent slopes	B	390.8	7.6%
GeC	Glenelg loam, 8 to 15 percent slopes	B	125.9	2.4%
GgB	Glenelg silt loam, 3 to 8 percent slopes	B	19.9	0.4%
GgC	Glenelg silt loam, 8 to 15 percent slopes	B	2.9	0.1%
NtB	Neshaminy silt loam, 3 to 8 percent slopes	B	31.8	0.6%
NtC	Neshaminy silt loam, 8 to 15 percent slopes	B	58.6	1.1%
NvD	Neshaminy-Montalto silt loams, 15 to 25 percent slopes, very stony	B	93.0	1.8%
NvE	Neshaminy-Montalto silt loams, 25 to 45 percent slopes, very stony	B	2.5	0.0%
NxB	Neshaminy-Urban land complex, 0 to 8 percent slopes	B	28.9	0.6%
TaB	Talleyville silt loam, 3 to 8 percent slopes	B	132.1	2.6%
TdB	Talleyville-Montalto-Urban land complex, 0 to 8 percent slopes	B	265.5	5.1%
Ch	Chewacla silt loam	B	32.8	0.6%
We	Wehadkee silt loam	B	106.8	2.1%
BbB	Baile-Glenville complex, 0 to 8 percent slopes	B	16.6	0.3%
Ht	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B	16.0	0.3%
Hw	Hatboro-Codorus complex, 0 to 3 percent slopes, frequently flooded	B	69.3	1.3%
		B	**2,947.2**	**57.0%**
ByB2	Butlertown silt loam, 3 to 8 percent slopes	C	1.9	0.0%
Mc	Made land, silt and clay materials	C	0.6	0.0%
Me	Made land, schist and gneiss materials	C	53.2	1.0%
BkD	Brinklow channery loam, 15 to 25 percent slopes	C	193.8	3.8%

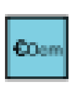
Symbol	Map unit name	Rating	Acres	Percent
BnF	Brinklow-Blocktown complex, 25 to 65 percent slopes	C	40.8	0.8%
BrvF	Brinklow channery loam, 25 to 65 percent slopes, very stony	C	33.9	0.7%
DcB	Delanco-Codorus-Hatboro complex, 0 to 8 percent slopes, flooded	C	123.9	2.4%
UaB	Udorthents, bedrock substratum, 0 to 8 percent slopes	C	316.7	6.1%
GnA	Glenville silt loam 0 to 3 percent slopes	C	28.0	0.5%
GnB	Glenville silt loam, 3 to 8 percent slopes	C	172.4	3.4%
GnC2	Glenville silt loam, 8 to 15 percent slopes	C	6.7	0.1%
OtA	Othello silt loam	C	24.5	0.5%
WnA	Woodstown loam, 0 to 3 percent slopes	C	68.0	1.3%
WoA	Worsham silt loam, 0 to 3 percent slopes	C	28.2	0.5%
WsB	Worsham very stony silt loam, 0 to 8 percent slopes	C	5.8	0.1%
MzA	Mount Lucas silt loam, 0 to 3 percent slopes	C	166.8	3.2%
MzB	Mount Lucas silt loam, 3 to 8 percent slopes	C	12.8	0.2%
MzuB	Mount Lucas-Urban land complex, 0 to 8 percent slopes	C	2.4	0.0%
WaA	Watchung silt loam, 0 to 3 percent slopes	C	170.9	3.3%
WaB	Watchung silt loam, 3 to 8 percent slopes	C	28.4	0.6%
		C	**1,479.7**	**28.5%**
GnB	Glenville silt loam, 3 to 8 percent slopes	D	31.6	0.6%
GnC	Glenville silt loam, 8 to 15 percent slopes	D	7.9	0.2%
		D	**39.5**	**0.8%**
Totals			**5,161.6**	**100.0%**

2.4. Geology

FSNP watersheds are underlain by outcrops of the Wissahickon Formation gneiss (Wilmington Blue Rock) which are blue-green in color and form large erosion resistant boulder and cobble complexes in the beds of the streams that tumble through the Piedmont (Figures 9 and 10).

Wissahickon Formation  : Interlayered psammitic and pelitic gneiss with amphibolite. Psammitic gneiss is a medium- to fine – grained biotite- plagioclase- quartz gneiss with or without small garnets. Contacts with pelitic gneiss are gradational. Pelitic gneiss is medium – to coarse – grained garnet – sillimanite – biotite – plagioclase – quartz gneiss. Unit has a streaked or flasered appearance owing to the segregation of garnet – sillimanite – biotite stringers that surround lenses of quartz and feldspar. Throughout, layers of fine to medium – grained amphibolite composed of plagioclase and hornblende, several inches to <30 feet thick or as large massive bodies are in sharp contact with the psammitic and pelitic gneisses.

Amphibolite  : Fine to medium grained amphibolite composed of plagioclase and hornblende in sharp contact with the psammitic and pelitic gneisses.

Cockeysville Marble  : In Delaware, predominately a pure, coarsely crystalline, blue – white dolomite marble interlayered with calc-schist. Major minerals in the marble include calcite and dolomite with phlogopite, diopside, olivine, and graphite. Major minerals in the calc-schist are calcite with phlogopite, microcline, diopside, tremolite, quartz, plagioclase, scapolite, and clinozoistite Pegmatites and pure kaolin deposits and quartz occur locally.

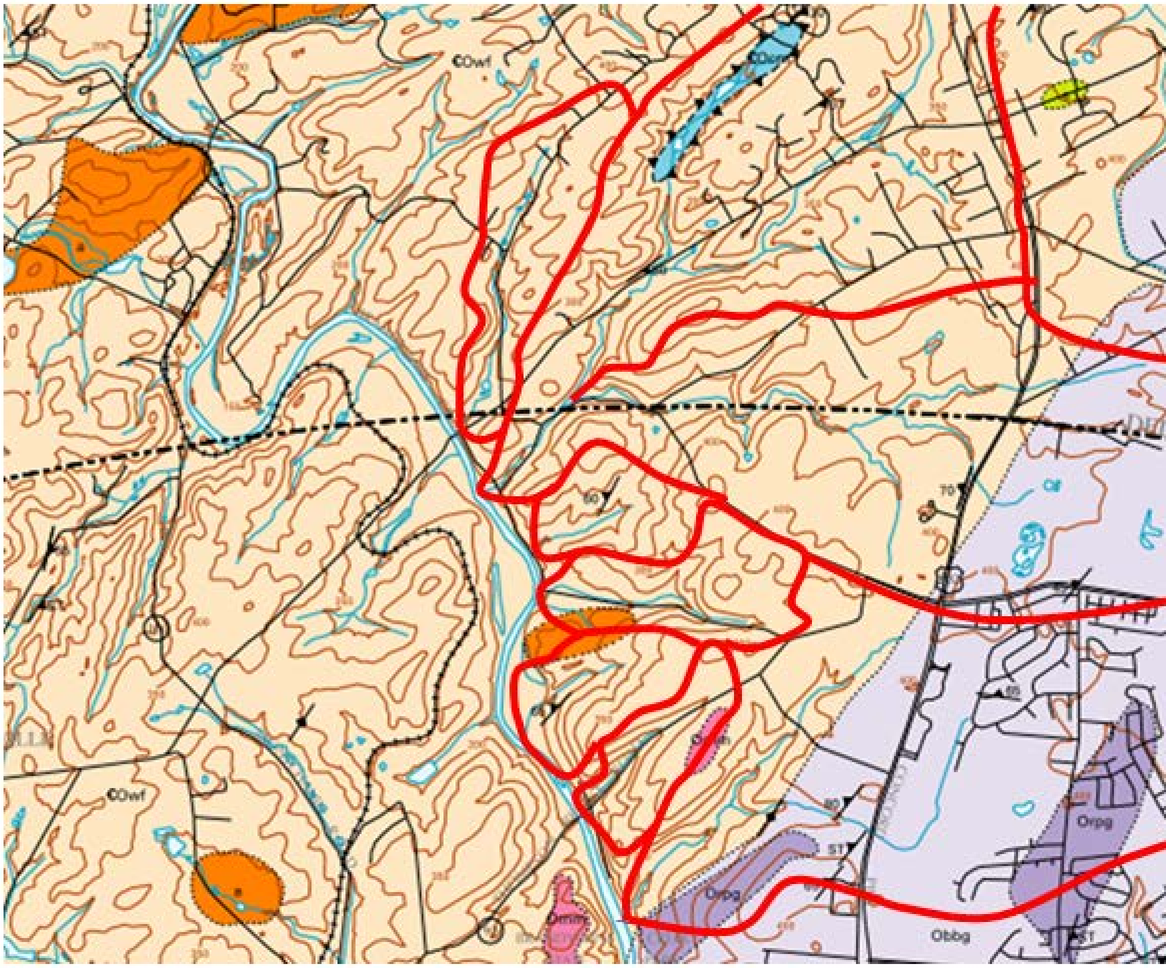


Figure 9. Geologic map in watersheds of First State National Park
(Schenck, Planck, and Srogi 2000)

Figure 10. Wilmington Blue Rock boulder complex in Beaver Creek in First State National Park

Chapter 3: Field Monitoring Methods

3.1. Methods

During the summer of 2014, the student field crews characterized and monitored Brandywine Piedmont tributaries at First State National Park based on the following field methods:

1. Stream Cross-Sections: Using a surveying rod, level, and tape; survey stream cross sections in 100 foot reaches along perennial (blue line) and intermittent streams tied to mean sea level (msl) datum.

2. Soils: Map and characterize soils in the watersheds based on the USDA Natural Resources Conservation Service (NRCS) Soil Survey for New Castle Count, Delaware and Delaware County, Pennsylvania.

3. Hydrogeology: Map and characterize the geology of the watersheds based on data from the U.S. Geological Survey and Delaware Geological Survey.

4. Stream Geomorphology: Using the Rosgen (1994) Stream Geomorphology Classification system, classify each stream reach according to the following parameters (Figure 11):
- Single Thread Channels
- Entrenchment ratio (Floodprone width/bankfull width)
- Channel Width-to-Depth Ratio (Channel width/bank full depth)
- Sinuosity (Length stream channel/straight line distance between points on stream)
- Slope (change in elevation of stream/distance)
- Channel Material (percent bedrock, boulders, cobble, gravel, sand, silt/clay)
- Stream Classification (classify potential for recovery from erosion)

5. Stream Habitat: Record stream habitat along each reach as optimal (16-20), suboptimal (11-15), marginal (6-10), and poor (0-5) based on ten parameters using a 0 to 200 point metric adapted from the the EPA rapid stream bioassessment technique (Barbour, Gerritsen, Snyder, and Stribling 1999) for steeply sloped (Piedmont) streams (Figure 12):
- Epifaunal Substrate (% mix of stable habitat, logs, snags, rock complex, etc.)
- Embeddedness (% gravel, cobble, boulder embedded by sediment)
- Velocity/Depth Regime (slow, deep, shallow)
- Sediment Deposition (% covered by sediment)
- Channel Flow Status (water depth at stream banks)
- Channel Alteration (channelization, dredging)
- Channel Sinuosity (frequency of riffles and bends)
- Bank stability (evidence of erosion)
- Vegetative Protection (stream bank vegetation)
- Riparian Vegetative Zone (floodplain covered by native vegetation)

6. Water Quality: Along each tributary, sample water quality for a base (low) flow and storm (high) flow event for pH, dissolved oxygen, turbidity, and conductivity. Parameters such as nutrients (nitrogen/phosphorus), bacteria, sediment, metals, and organics will be sampled during summer 2015 and analyzed by the City of Wilmington Water Quality Laboratory.

7. Biology: Measure macroinvertebrate density and quality using the Delaware Nature Society and Stroud Water Research Center volunteer stream sampling technique (Future summer 2015).

8. Field Report: Prepare a field report that summarizes the summer work to characterize the watersheds according to the following parameters: stream cross-sections, stream habitat, biology, water quality, geomorphology, soils, and hydrogeology.

3.2. Schedule

Kickoff Meeting	Jun 9, 2014
1. Stream cross-sections	Jun 16
2. Stream habitat	Jun 23
3. Biology	Jun 30
4. Water quality	Jul 5
5. Geomorphology	Jul 5
6. Soils	Jul 12
7. Hydrogeology	Jul 19
8. Field Report	Aug 1, 2014

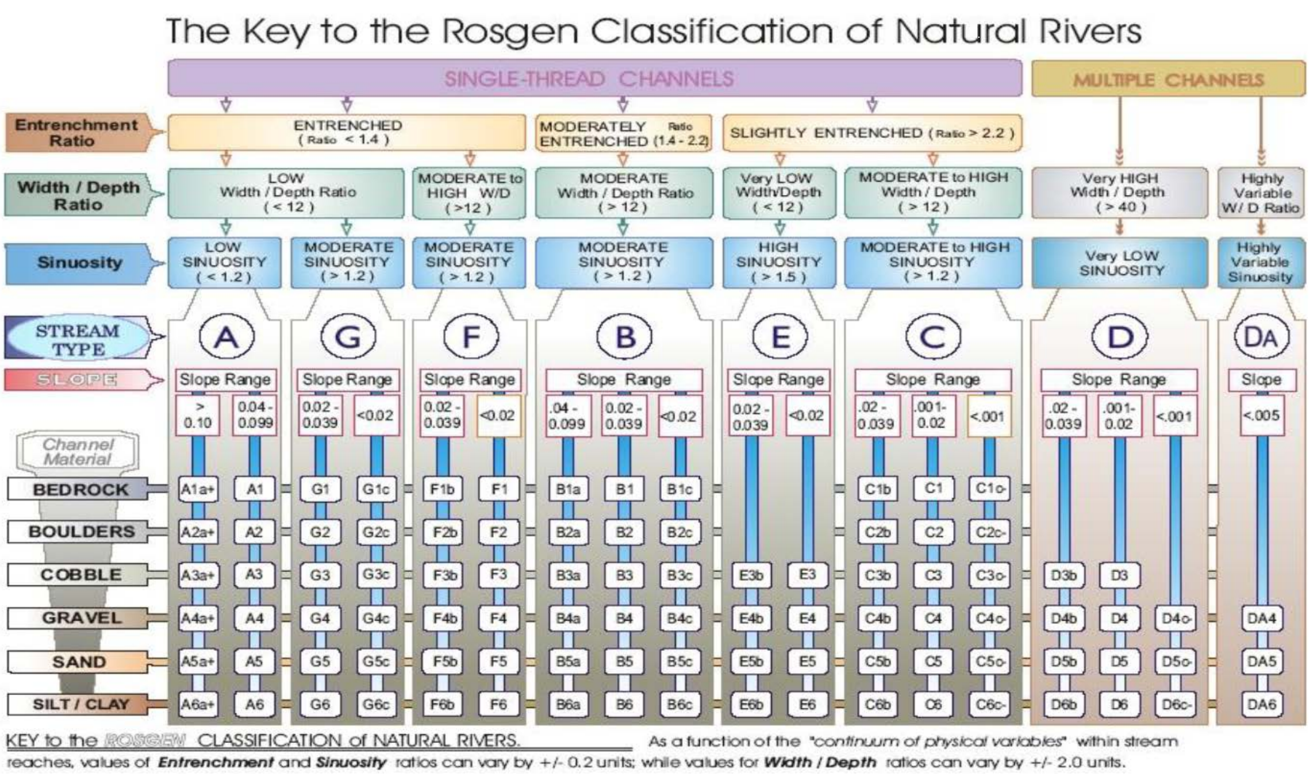


Figure 11. Rosgen classification of natural rivers (Rosgen 1994)

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 12. EPA rapid stream habitat bioassessment technique (Barbour, Gerritsen, and Stribling 1999)

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

Figure 12. EPA rapid stream bioassessment technique (Barbour, Gerritsen, and Stribling 1999)

Chapter 4: Field Monitoring Results

4.1. EPA Rapid Stream Bioassessment

Based on the EPA rapid stream habitat bioassessment (Tables 4 and 5 and Figure 13); Jonkat Run, Ramsey's Run, Thompson's Creek, and the Beaver Creek Main Stem, Smithbridge tributary, and South Fork have optimal habitat quality (scores between 151 and 200). Three Sisters Brook, Beaver Creek North Fork and Snake Tributary have suboptimal quality (scores between 101 and 150) due to impact of development from roads and neighborhoods. Jonkat Run has the highest quality habitat in a watershed covered by 54% forest and little impervious cover with a score of 173 or 91% of the Delaware reference stream score of 190. The researchers found good correlation between the EPA habitat bioassessment score and forested land in the watershed (R^2 = 0.77). Watersheds with more forested land have better stream habitat (Figure 14). Reforestation of these watersheds can improve habitat of suboptimal streams to the optimal range. Protection of forested watersheds especially in headwaters along the Concord Pike corridor is needed to preserve streams such as Beaver Creek that have optimal habitat quality.

Table 4. Median scores of EPA rapid stream bioassessment at First State National Park

	Reach Length	Epifaunal Substrate	Pool Substrate	Pool Variability	Sediment Deposition	Channel Flow Status	Channel Alteration	Channel Sinuousity	Bank Stability	Veget. Protection	Riparian Veget. Zone	Score	Rating	% DE Reference
Three Sisters Brook	6,553	16	16	12	16	16	19	16	6	5	1	**131**	**Suboptimal**	**69%**
Jonkat Run	2,900	19	18	18	15	13	19	20	8	9	10	**173**	**Optimal**	**91%**
Ramsey Run	2,978	18	17	15	16	16	19	17	6	9	2	**160**	**Optimal**	**84%**
Thompson's Creek	1,956	19	17	19	17	17	18	18	8	8	3	**164**	**Optimal**	**86%**
Beaver Creek Main Stem	2,100	18	19	19	18	18	18	17	5	8	6	**160**	**Optimal**	**84%**
Beaver Creek North Fork	4,224	16	17	16	14	15	18	16	6	9	10	**132**	**Suboptimal**	**70%**
Beaver Creek Smithbridge	2,925	18	17	18	16	16	17	17	7	8	7	**162**	**Optimal**	**85%**
Beaver Creek Snake Tributary	813	14	17	10	15	17	15	11	7	8	1	**134**	**Suboptimal**	**71%**
Beaver Creek South Fork Main	8,242	17	17	18	15	16	19	15	6	7	9	**153**	**Optimal**	**81%**
Beaver Creek South Fork North	2,520	18	17	13	14	14	18	16	7	7	9	**156**	**Optimal**	**82%**
Beaver Creek South Fork Middle	1,545	18	17	16	14	15	19	15	6	7.5	9	**159**	**Optimal**	**84%**

Table 5. EPA rapid stream bioassessment technique scores for First State National Park

Stream	**EPA Biohabitat Score**	**Rating**	**% DE Ref. = 190**
Three Sisters Brook	131	Suboptimal	69%
Jonkat Run	173	Optimal	91%
Ramsey Run	160	Optimal	84%
Thompson's Creek	164	Optimal	86%
Beaver Creek Main Stem	160	Optimal	84%
Beaver Creek North Fork	132	Suboptimal	70%
Beaver Creek Smithbridge	162	Optimal	85%
Beaver Creek Snake Tributary	134	Suboptimal	71%
Beaver Creek South Fork Main	153	Optimal	81%
Beaver Creek South Fork North	156	Optimal	82%
Beaver Creek South Fork Middle	159	Optimal	84%

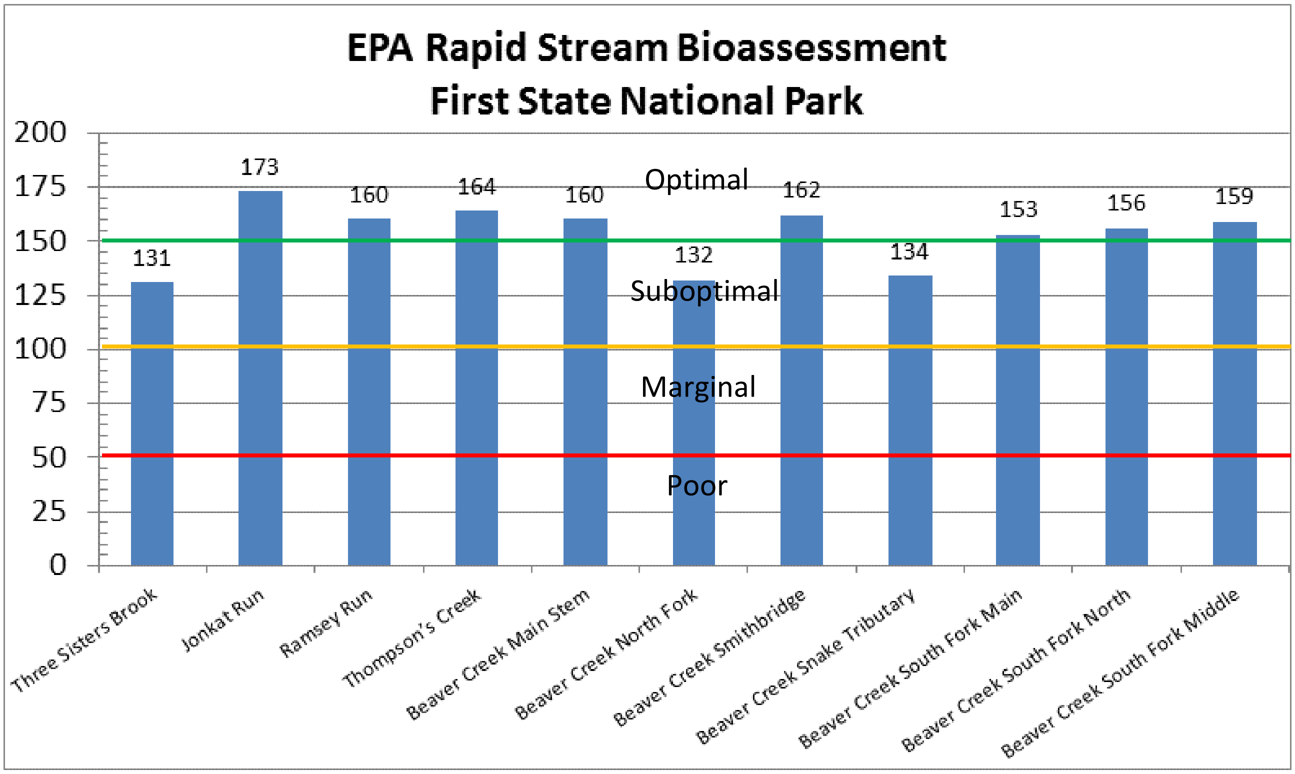


Figure 13. EPA rapid stream bioassessment at First State National Park

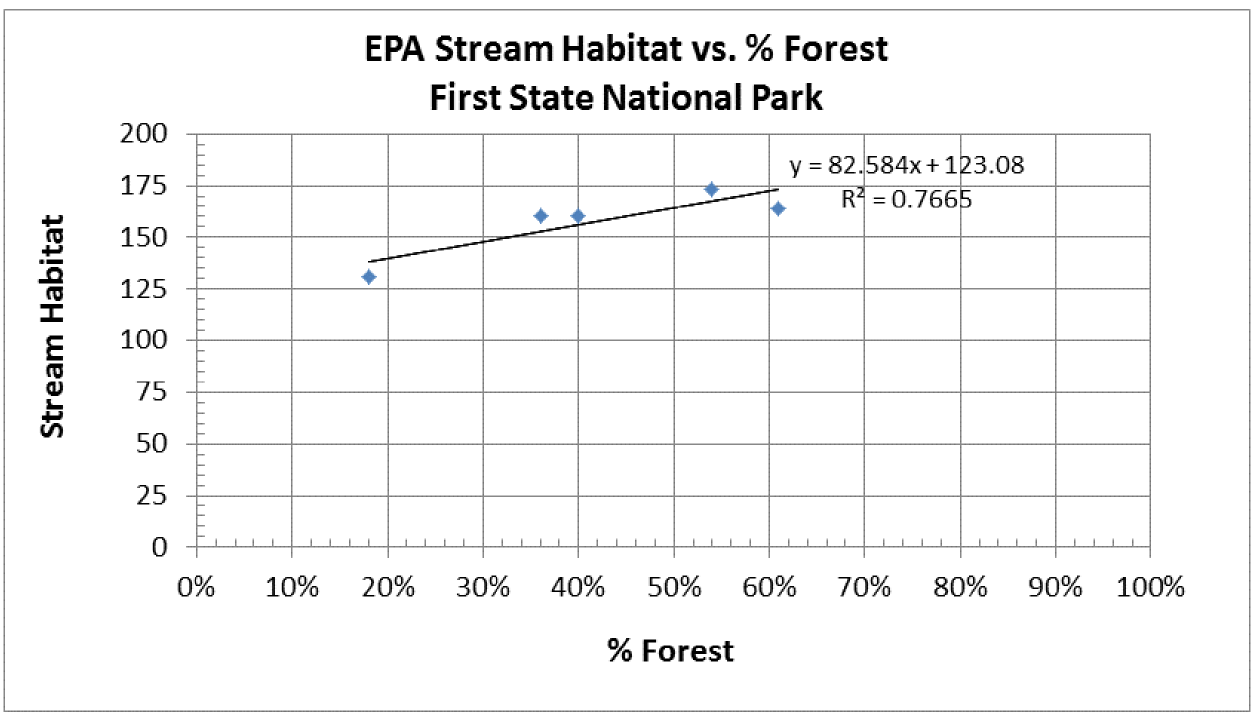


Figure 14. Correlation between EPA stream habitat and forest at First State National Park

4.2. Rosgen Classification of Natural Rivers

The Rosgen method classfies the morphology of streams based on shape, geometry, slope, and substrate type (Table 6 and Figure 15). Streams in the First State National Park are entrenched (streams are wide compared to floodprone width) and low bank width to channel depth ratio. The Beaver Creek South Fork and Ramsey's Run have moderate sinuousity (more meandering) and the other streams have low sinuousity. Channel slopes are moderately high (1% to 4%). Jonkat Run and Thompson's Creek are A4 and A5 streams that due to the dense boulder and cobble beds of Wilmington Blue Rock gneiss have very high capacity to resist erosion but once eroded have very poor erosion recovery potential. The other streams are G3, G4, or G5 that also have very high capacity to resist erosion but once eroded have very poor erosion recovery potential.

Table 6. Rosgen geomorphology classification of streams in First State National Park

Station	Flood Width	Bank Width	Entrenchment Ratio	Bank Width	Channel Depth	W/D Ratio	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
Three Sisters Brook	8	8.0	1.0 (Entrenched)	8	4.0	2.0	1.16 (Low)	0.020	cobble	G3	Very high	Poor
Beaver Creek Main Stem	46	11.6	0.3 (Entrenched)	46	5.8	7.9	1.13 (Low)	0.017	cobble	G3c	very high	poor
Beaver Creek North Fork	30	5.0	0.2 (Entrenched)	30	2.5	12.0	1.20 (Low)	0.012	sand	G5c	very high	very poor
Beaver Creek Smithbridge	11	6	0.6 (Entrenched)	11	3.2	3.5	1.12 (Low)	0.009	gravel	G4c	very high	very poor
Beaver Creek South Fork	23	4.5	0.2 (Entrenched)	23	2.3	10.2	1.37 (Moderate)	0.025	cobble	G3	very high	poor
Jonkat Run	11	8.2	0.7 (Entrenched)	11	4.1	2.7	1.12 (Low)	0.025	sand	A5	Very high	very poor
Ramsey's Run	17	8.6	0.5 (Entrenched)	17	4.3	4.0	1.21 (Moderate)	0.020	gravel	G4	very high	very poor
Thompson's Creek	9	5.6	0.6 (Entrenched)	9	2.8	3.2	1.04 (Low)	0.040	gravel	A4	very high	very poor

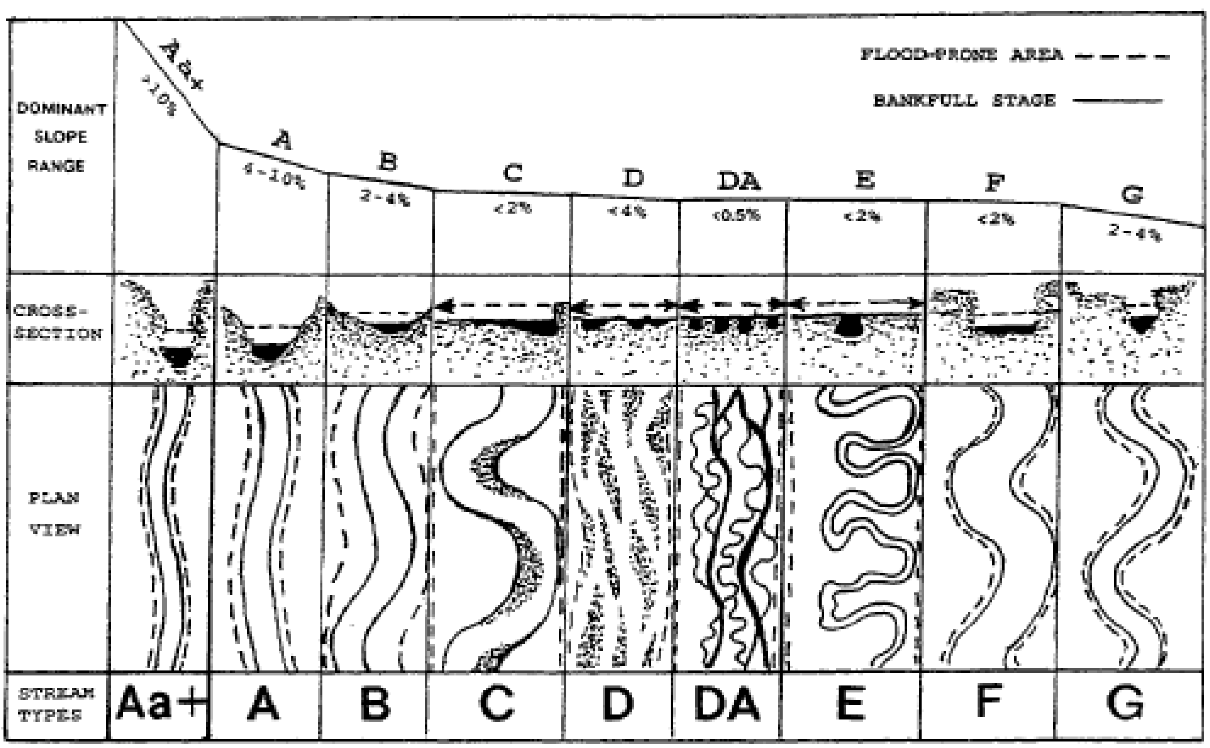


Figure 15. Morphology of major stream types (Rosgen 1994)

4.3. Water Quality

Streams in First State National Park have good water quality (Table 7 and Figure 16). Streams are relatively cool even in July due to shade from forested riparian buffers with water temperatures less that 23 deg C (73 deg F) except for Three Sisters Brook with a water temperature of 26.4 deg C in an unshaded stream reach. Dissolved oxygen levels exceeded 7 mg/l even during the warm days of July. pH ranged between 7.5 and 8.0 which is slightly basic due to limestone or carbonate rock outcrops in the watersheds. Specific conductivity which detects the presence of total dissolved solids was relatively low although South Fork of Beaver Creek near Concord Pike recorded SC of 630 µS. A comprehensive stream water quality sampling program will be conducted during the summer of 2015 to detect for nutrients (nitrogen/phosphorus), bacteria, sediment, metals, and organics.

Table 7. Water quality along streams in the First State National Park

Site ID	Latitude	Longitude	Date	pH	Temp (°C)	DO (%)	DO (mg/L)	SC (µS)
Three Sisters Brook (TS1)	39.838015	75.578733	7/8/14	7.76	26.4	87	7.0	195
Jonkat Run (JR1)	39.831360	75.573390	7/7/14	7.37	20.0	83	7.5	134
Ramsey Run (RaR1)	39.828600	75.572900	7/7/14	7.59	20.5	87	7.0	196
Thompson Creek (TC1)	39.821200	75.573842	7/7/14	7.76	18.7	90	8.4	168
Beaver Creek (BC2)	39.834770	75.576480	7/7/14	7.86	20.2	91	8.2	338
Beaver Creek (BC3)	39.838600	75.572160	7/7/14	7.99	20.1	95	8.5	391
Beaver Creek (BC4)	39.839444	75.571111	7/7/14	7.81	20.4	84	7.6	307
Beaver Creek (BC5)	39.839427	75.571119	7/7/14	7.74	20.3	85	7.7	482
Beaver Creek (BC6)	39.846389	75.565278	7/7/14	7.96	20.5	88	7.9	329
Beaver Creek (BC7)	39.839173	75.548003	7/8/14	7.55	21.3	93	8.2	630
Rocky Run (RoR1)	39.811667	75.566667	7/7/14	7.74	21.9	88	7.5	368
Brandywine Creek (BR1)	39.835260	75.577460	7/7/14	7.93	22.2	91	7.9	328

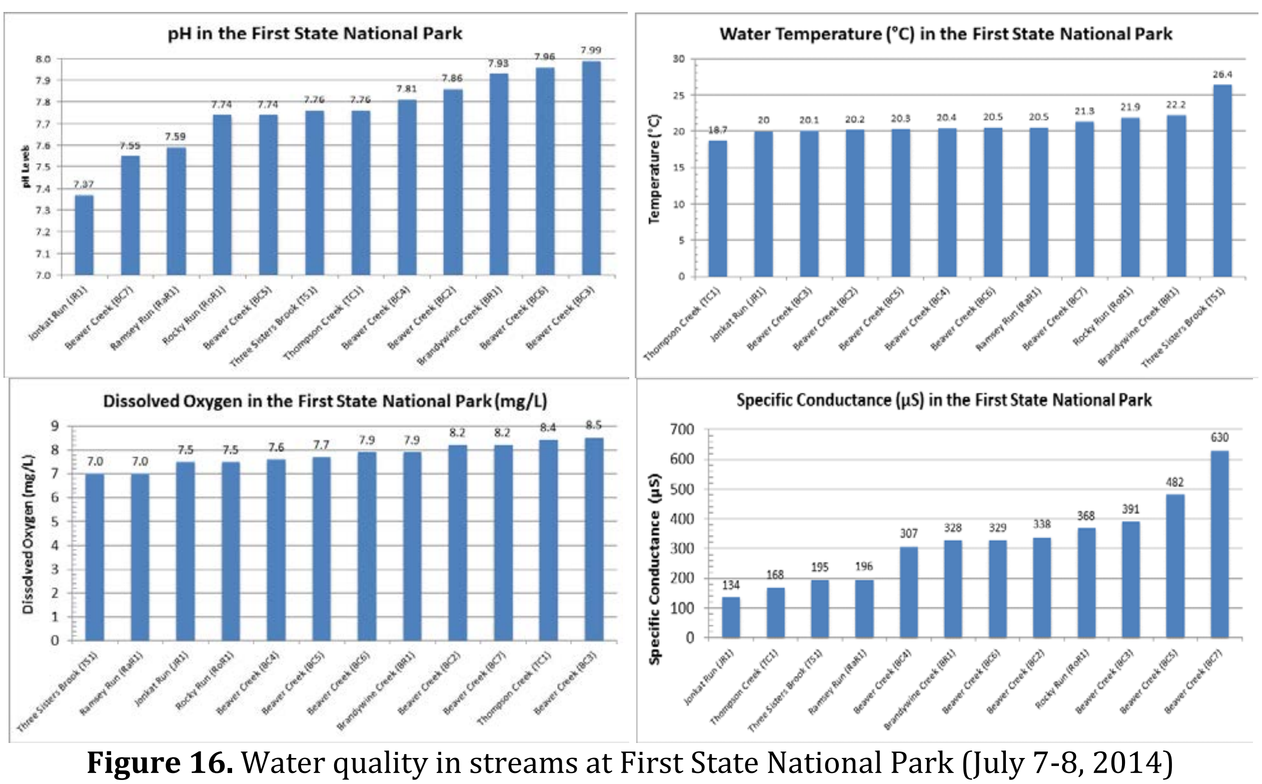


Figure 16. Water quality in streams at First State National Park (July 7-8, 2014)

Chapter 5: Watershed Summary

5.1. Three Sisters Brook

The 262-acre Three Sisters Brook watershed borders the northerly boundary of the FSNP Woodlawn unit and forms in the headwaters at 400 feet above sea level in Pennsylvania and flows for 1.5 miles into Delaware to the confluence with the Brandywine Creek at Smith's Bridge (Figures 17 and 18). The watershed is lightly developed (0.3% impervious) and land use is 19% forest/wetlands, 5% urban/suburban, and 77% agriculture primarily meadow, horse farms, and some corn and soybeans . The steeply sloped watershed (12% slopes) is covered by soils in hydrologic soil group A (%), B (%), C (%), and D (%). geology of the watershed is the Wissahickon Formation gneiss. The EPA stream habitat rating is 131 (suboptimal), the Rosgen classification is G3 cobble, water temperature is 26.4 deg C and dissolved oxygen level was 7.0 mg/l in July 2014.

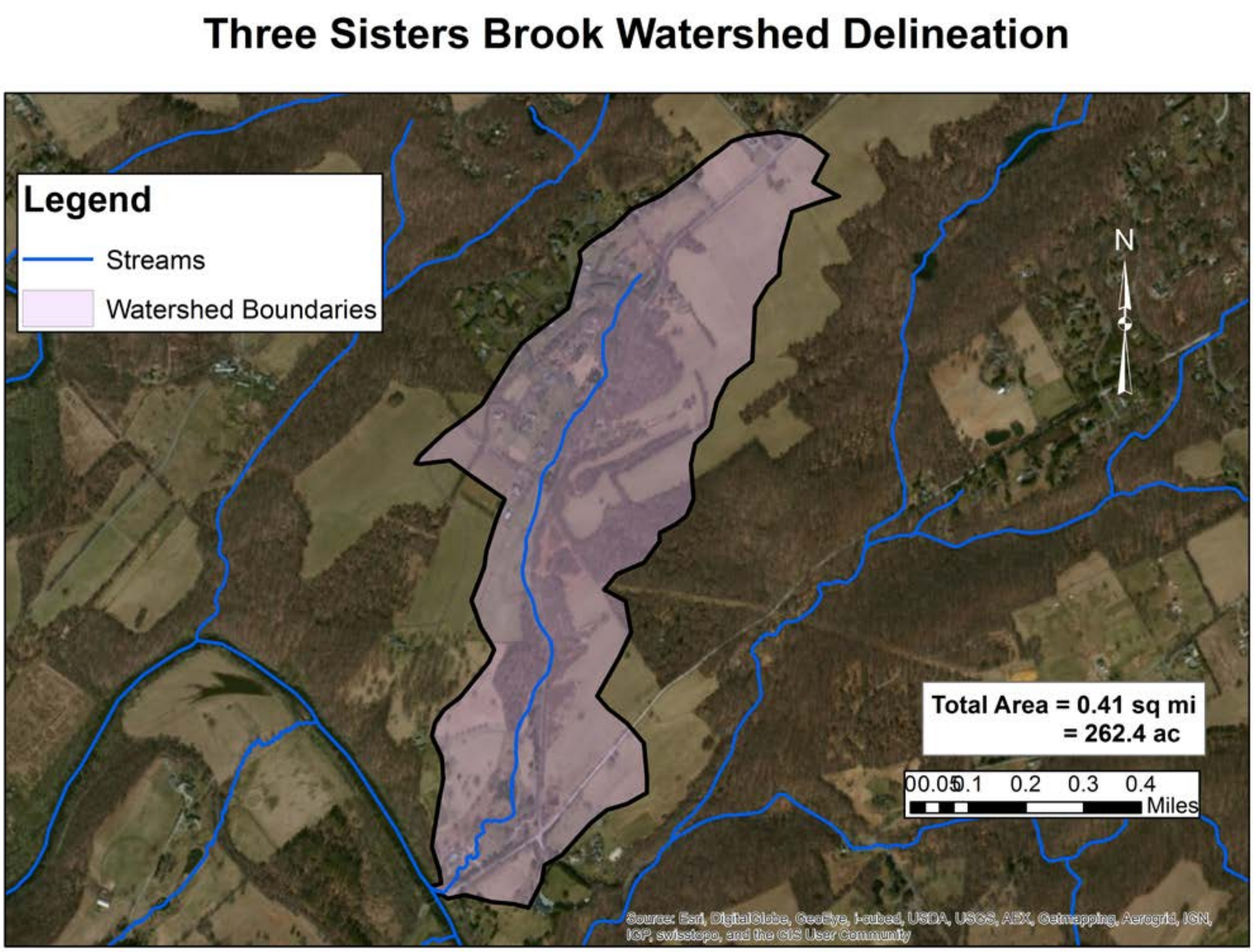


Figure 17. Three Sisters Brook watershed

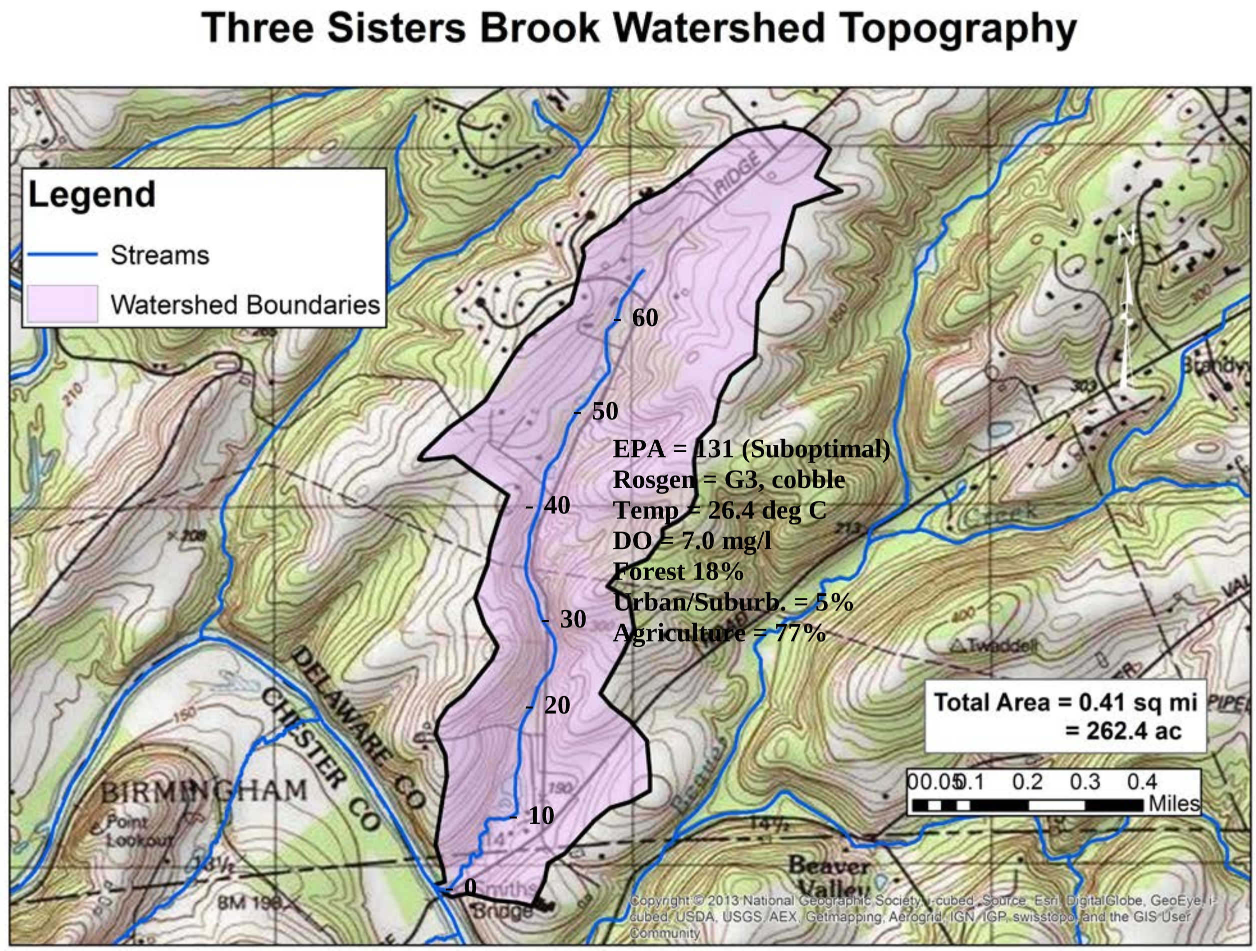


Figure 18. Three Sisters Brook watershed

5.2. Beaver Creek

The Beaver Creek watershed is the largest watershed surveyed and it drains 4 square miles from the north and south forks and main stem of the stream and covers the northerly third of the First State National Park (Figures 19 and 20). The north fork of Beaver Creek originates near the densely developed shopping centers and neighborhoods along Concord Pike in Pennsylvania and flows southwest for three miles through horse farms into the forested First State National Park before joining the main stem about a half mile upstream from the Brandywine Creek. The south fork forms along the Delaware/Pennsylvania state line near the Brandywine Town Center shopping mall and flows west for four miles under Concord Pike then through horse farms and the forested Woodlawn tract before combining with the north fork near Beaver Valley Road. The main stem flows for a half mile along Beaver Valley Road to the confluence with the Brandywine at a popular beach known as Peter's Rock. The watershed is moderately developed (9% impervious) mostly in the upper third near Concord Pike and mostly undeveloped in the stream valleys down below near the Brandywine. Watershed land use is 41% forest/wetlands, 28% urban/suburban, and 31% agriculture primarily horse farms and meadow. The steeply sloped watershed (9% slopes) is covered by soils of % hydrologic soil group A and. The geology of the watershed is mostly formed by the Wissahickon Formation gneiss although the north fork is underlain by an outcrop of the Cockeysville marble, a high water yield carbonate rock that provides buffering capacity to the stream for trout populations. The EPA stream habitat rating is

160 (optimal), the Rosgen classification is G3 cobble, water temperature is 20.2 deg C and dissolved oxygen level was 8.2 mg/l in July 2014.

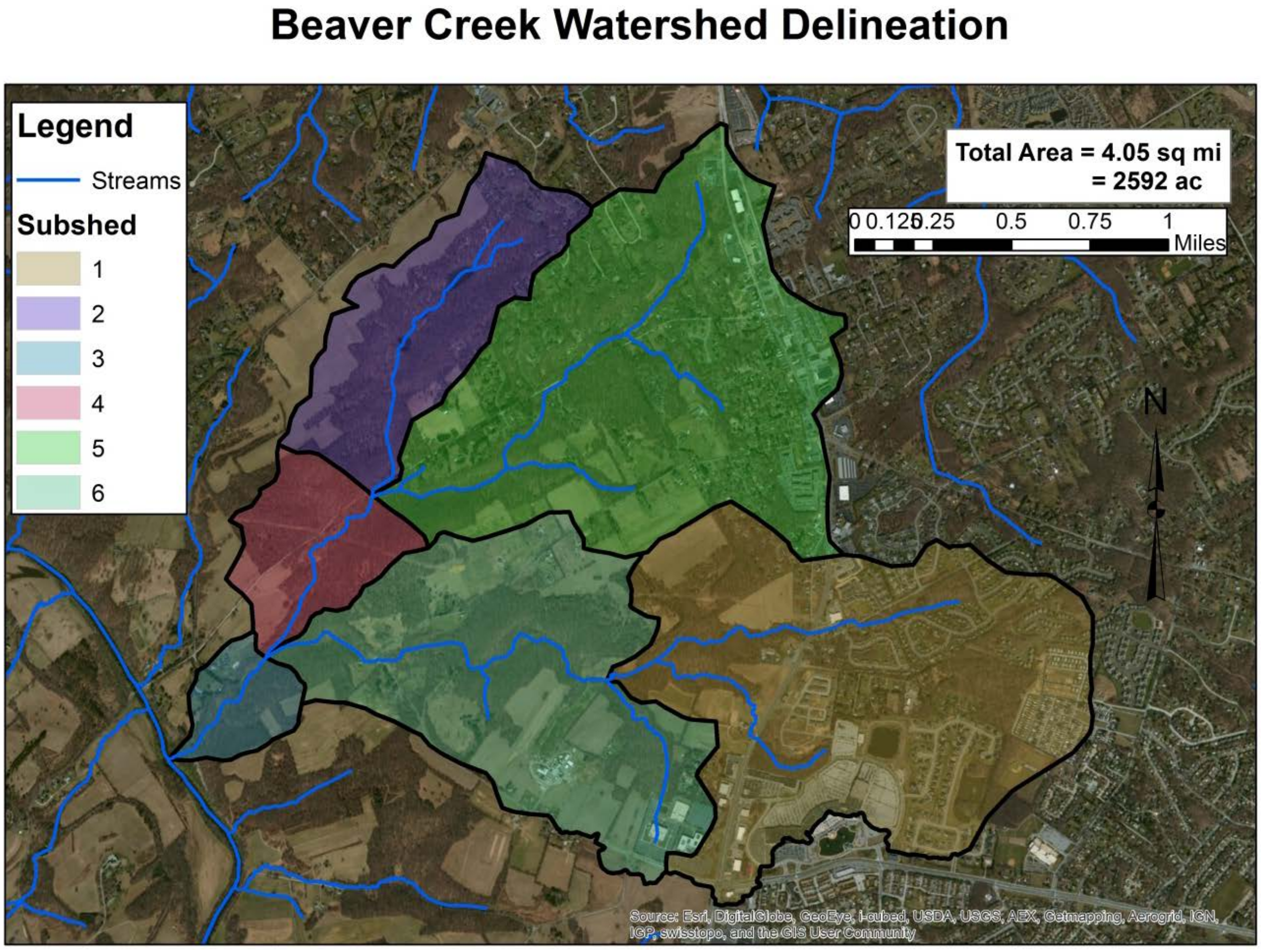


Figure 19. Beaver Creek watershed

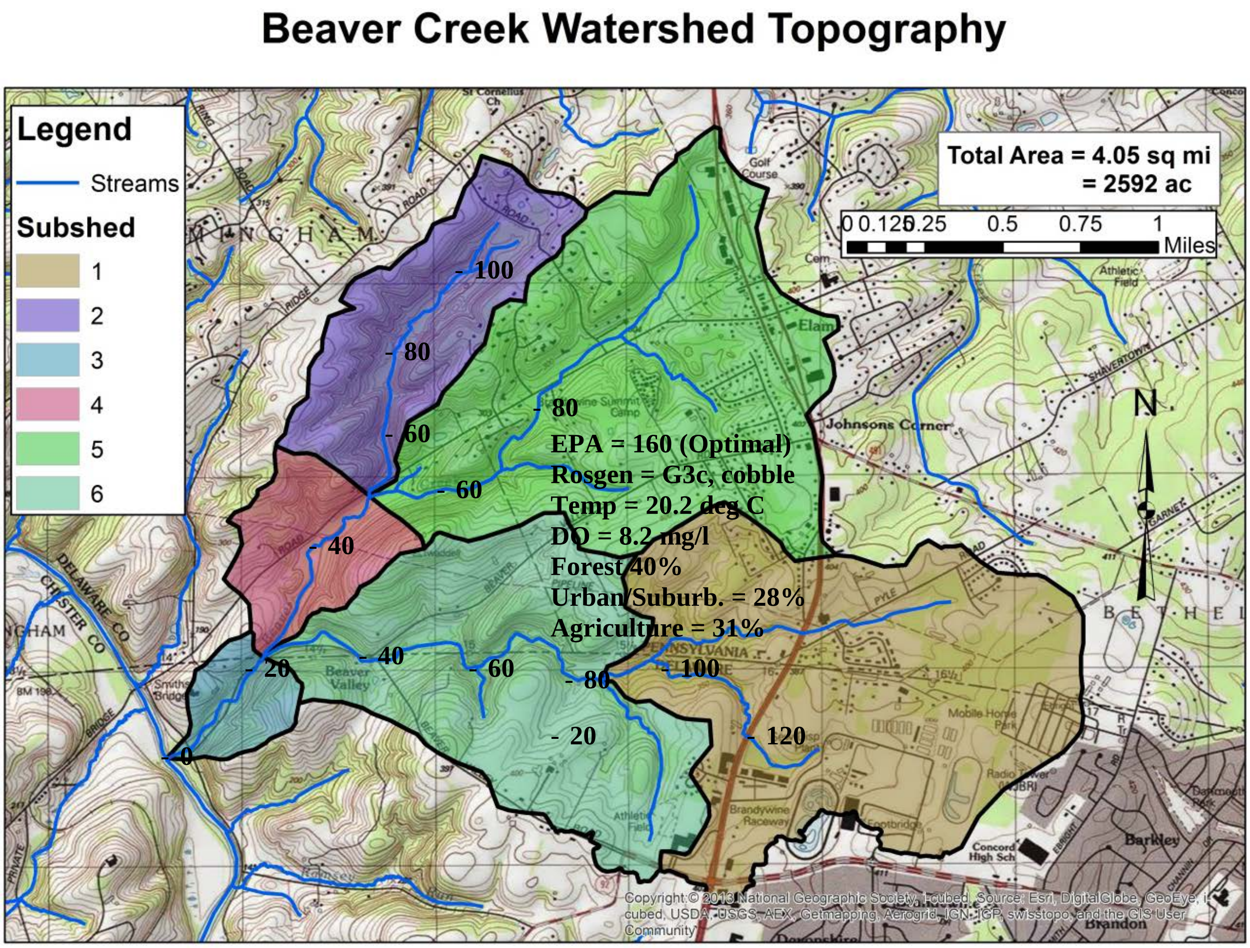


Figure 20. Beaver Creek watershed topography

5.3. Jonkat Run

The 128-acre Jonkat Run watershed lies entirely within Delaware in the Woodlawn tract of FSNP. The small creek forms on a 400 ft high hill near Beaver Valley Road and flows for ¾ mile through a beautiful valley cupped by trail system down to elevation 70 above mean sea level (msl) to feed the Brandywine Creek (Figure 21 and 22). The watershed is lightly developed (0% impervious) and land use is 54% forest/wetlands, 3% urban/suburban, and 43% agriculture primarily horse farm, meadow, and corn/soybeans. The steeply sloped (13%) watershed is covered by soils are % hydrologic soil group A and % hydrologic soil group B. The geology of the watershed is the Wissahickon Formation gneiss. The EPA stream habitat rating is 173 (optimal), the Rosgen classification is A5 sand, water temperature is 20.0 deg C and dissolved oxygen level was 7.5 mg/l in July 2014.

Jonkat Run Watershed 20 Foot Contours

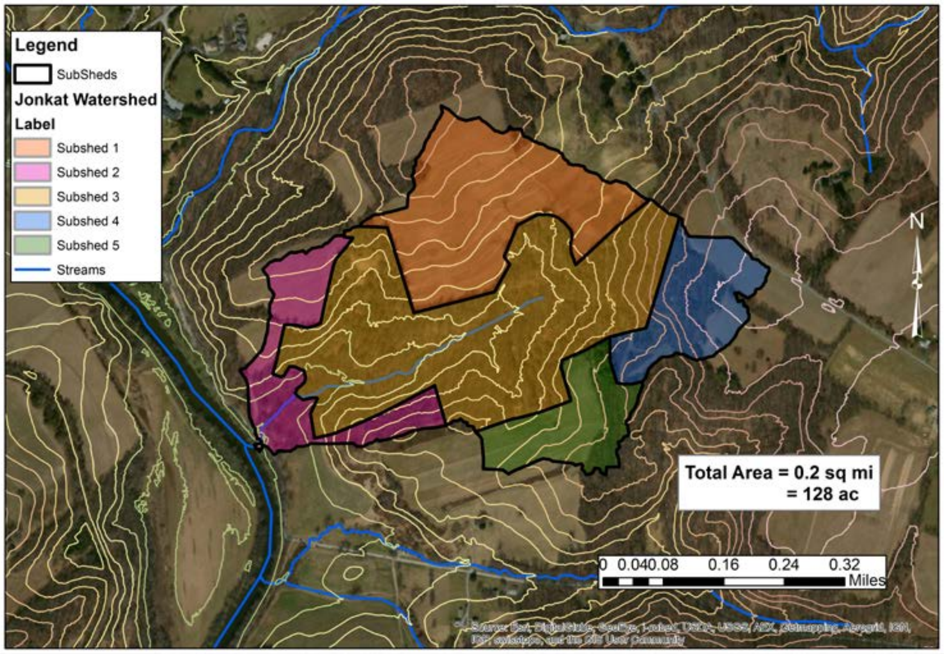


Figure 21. Jonkat Run watershed

Jonkat Run Watershed Topography

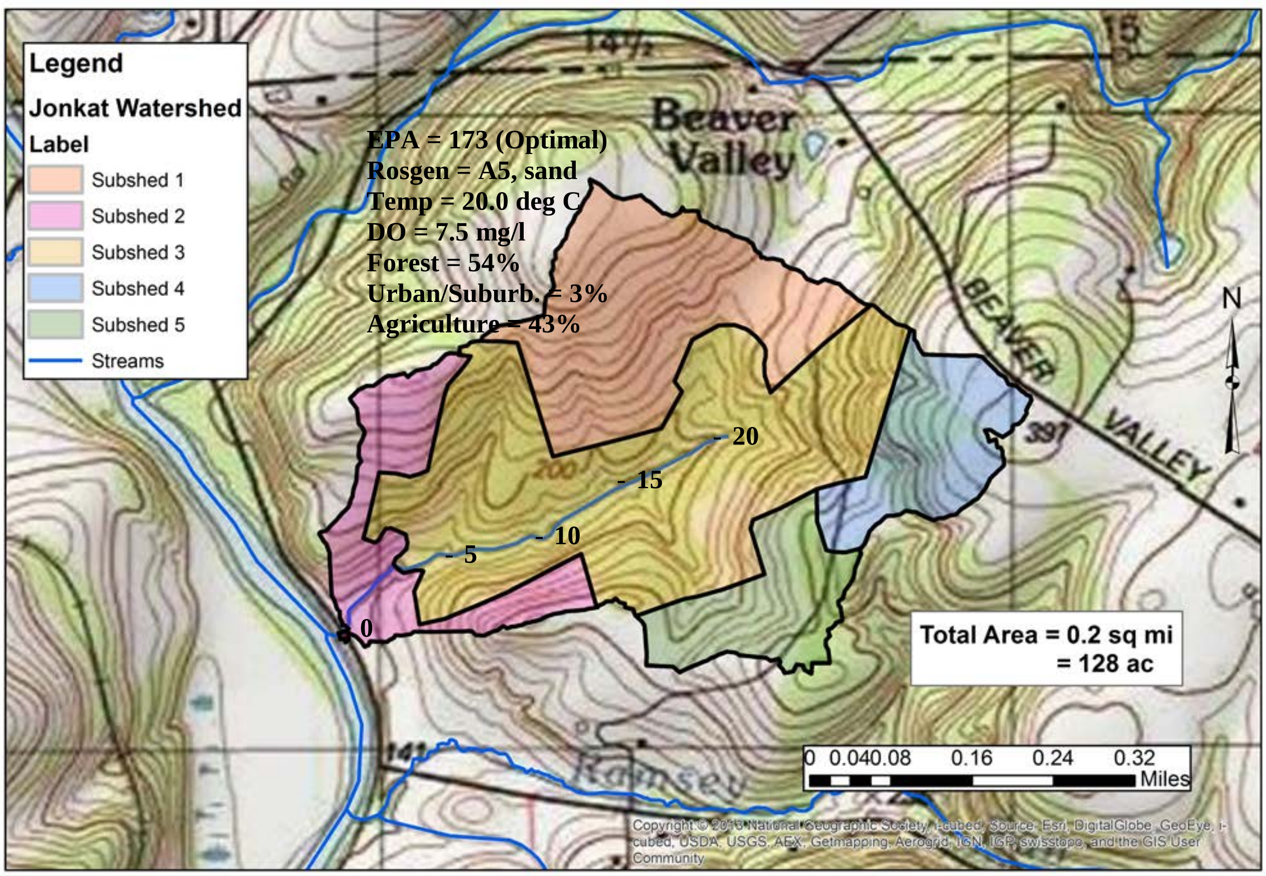


Figure 22. Jonkat Run watershed topography

5.4. Ramsey Run

The 230-acre Ramsey Run watershed drains the Ramsey Farm and rises at 420 feet msl and flows for a mile along the road and then through a bridge under the foot trail along Brandywine Creek (Figures 23 and 24). The watershed is almost entirely undeveloped (0.2% impervious) and land use is 36% forest/wetlands, 5% urban/suburban, and 59% agriculture primarily pumpkin farm, meadow, and horse farm. The steeply sloped (11%) watershed is covered by soils are % hydrologic soil group A and. The geology of the watershed is the Wissahickon Formation gneiss with an outcrop of amphibolite downstream near the Brandywine. The EPA stream habitat rating is 160 (optimal), the Rosgen classification is G4 gravel, water temperature is 20.5 deg C and dissolved oxygen level was 7.0 mg/l in July 2014.

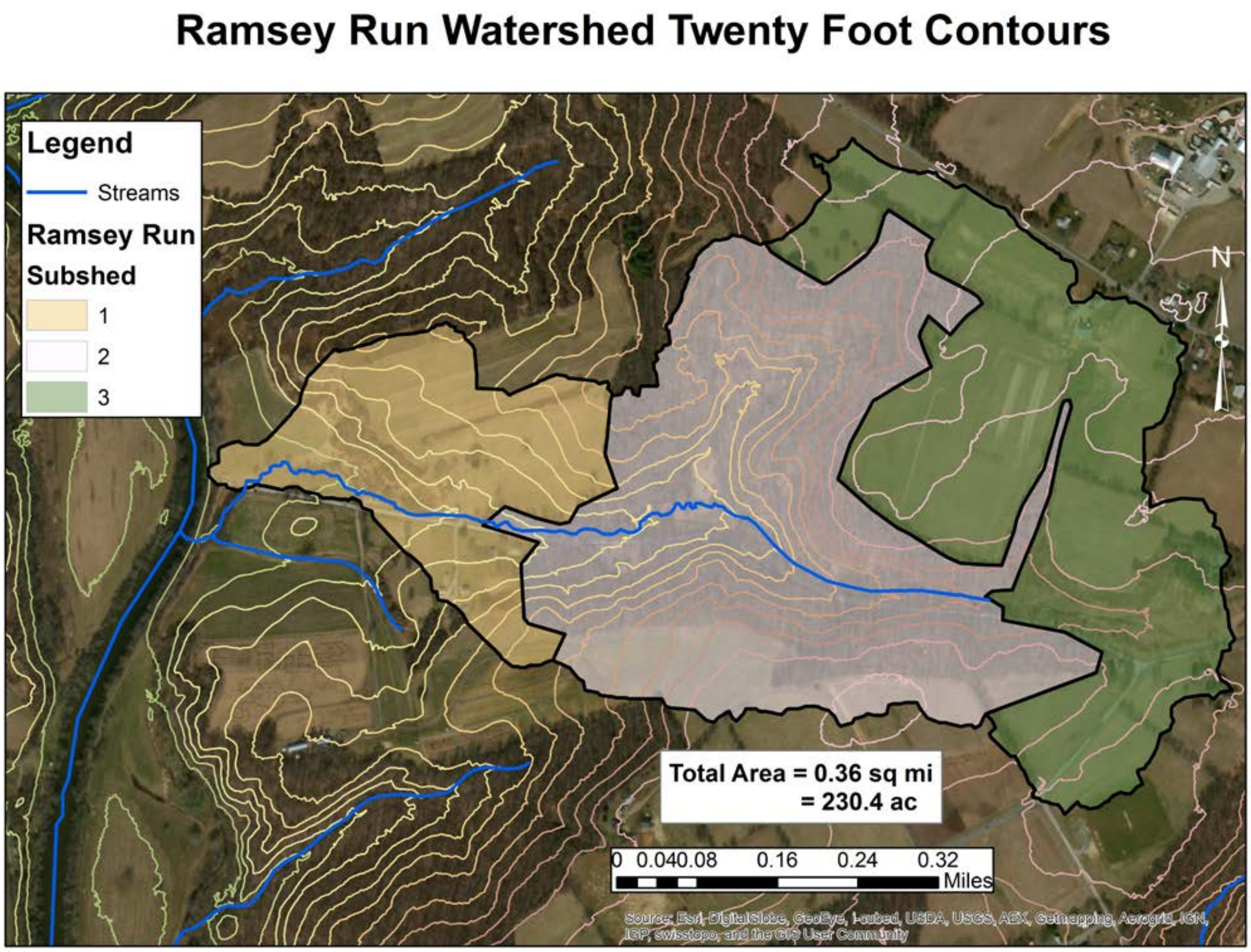


Figure 23. Ramsey Run watershed

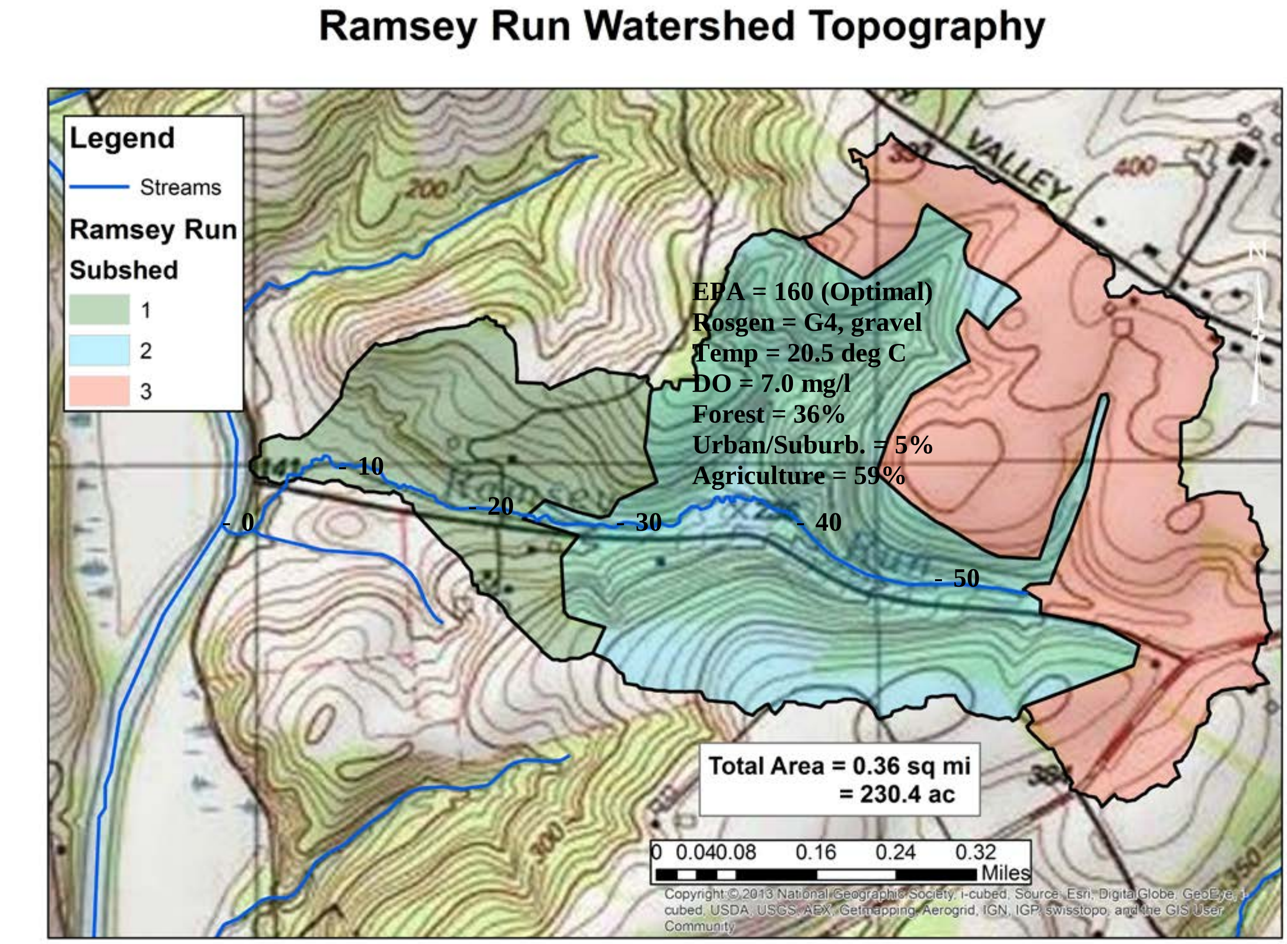


Figure 24. Ramsey Run watershed topography

5.5. Thompson's Creek

The 122-acre Thompson's Creek watershed originates at 400 ft above sea level and flows for almost a mile along the road to join the Brandywine Creek just upstream from Thompson Bridge (Figures 25 and 26). The watershed is lightly developed (0.1% impervious) and land use is 61% forest/wetlands, 3% urban/suburban, and 36% agriculture primarily horse farm, meadow, and corn/soybeans. The steeply sloped (15%) watershed is covered by soils are % hydrologic soil group A and. The geology of the watershed is the Wissahickon Formation gneiss. The EPA stream habitat rating is 164 (optimal), the Rosgen classification is A4 cobble, water temperature is 18.7 deg C and dissolved oxygen level was 8.4 mg/l in July 2014.

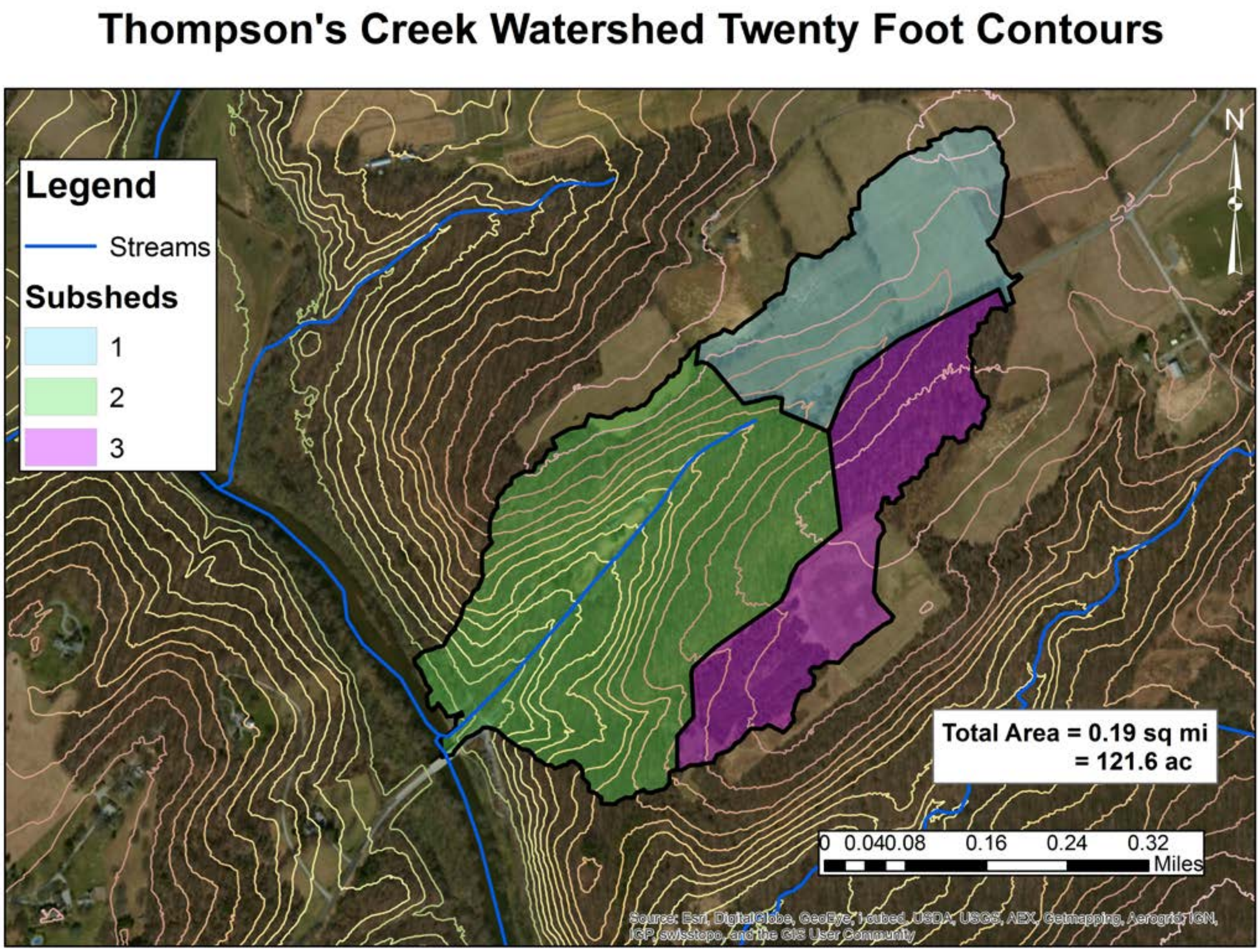


Figure 25. Thompson's Creek watershed

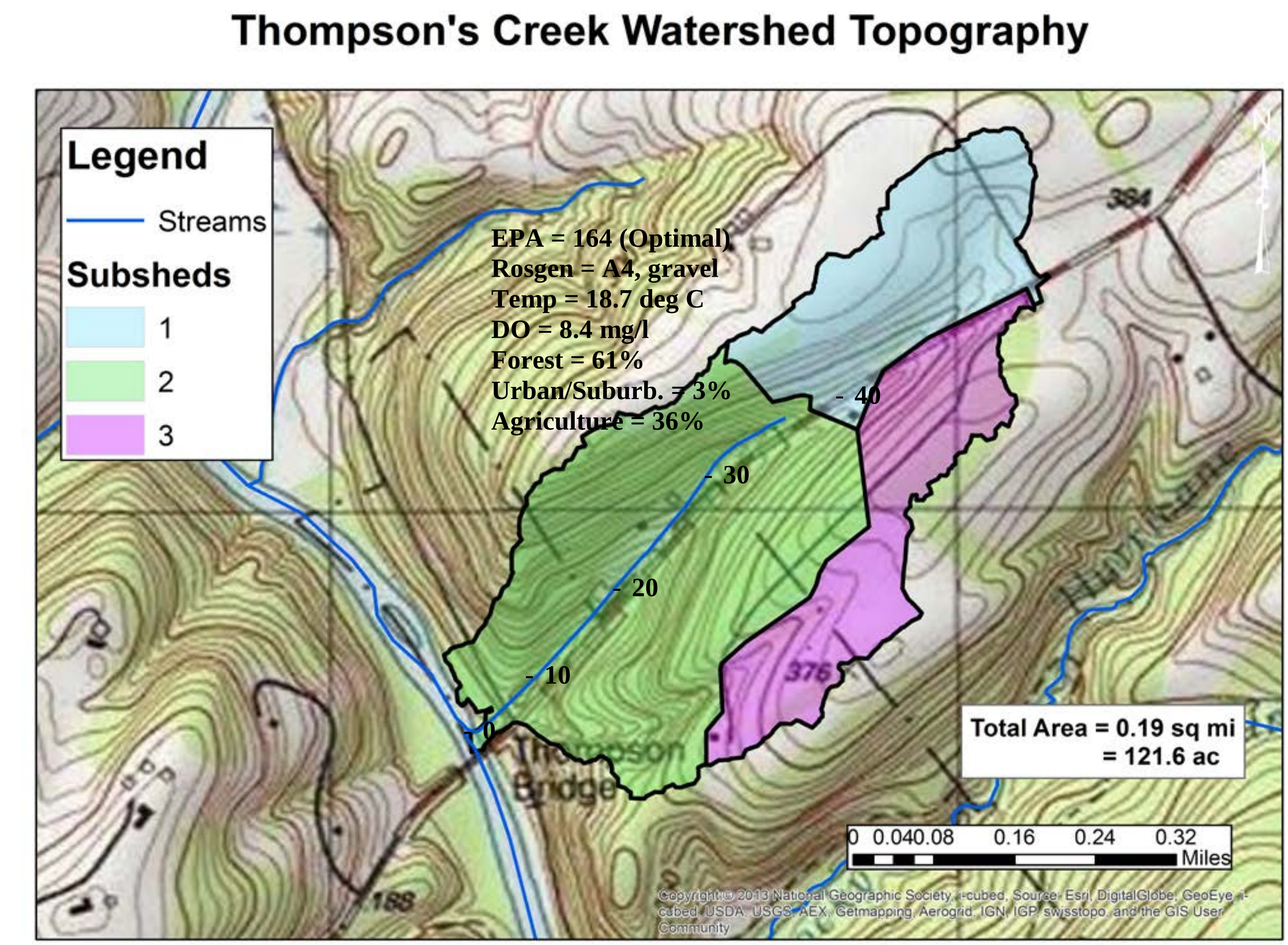


Figure 26. Thompson's Creek watershed topography

5.6. Rocky Run

The Rocky Run watershed drains 1.8 square miles from the north (Hurricane Run) and south forks and main stem of the stream and covers the southerly portion of the First State National Park before flowing west through the Brandywine Creek State Park (Figures 27 and 28). Hurricane Run originates near the densely developed shopping centers and neighborhoods along Concord Pike in Pennsylvania and flows southwest for two miles through into the forested First State National Park before joining the main stem about a half mile upstream from the Brandywine Creek. The south fork forms in the neighborhoods of New Castle County behind Concord Mall near the Brandywine Town Center shopping mall and flows west for four miles under Concord Pike then into the forested Brandywine Creek State Park. The main stem flows for a half mile to the confluence with the Brandywine about a half mile south of Thompson's Bridge. The watershed is highly developed (19% impervious) in the upper third near Concord Pike and mostly undeveloped in the stream valleys down below near the Brandywine. Watershed land use is 28% forest/wetlands, 40% urban/suburban, and 32% agriculture primarily corn, soybean, and meadow. The steeply sloped watershed (10% slopes) is covered by soils are % hydrologic soil group A and. The geology of the watershed is mostly formed by the Wissahickon Formation gneiss although the north fork is underlain by an outcrop of the Cockeysville marble, a high water yield carbonate rock that buffers the acidity of the stream for trout populations. The water temperature is 21.9 deg C and dissolved oxygen was 7.5 mg/l in July 2014.

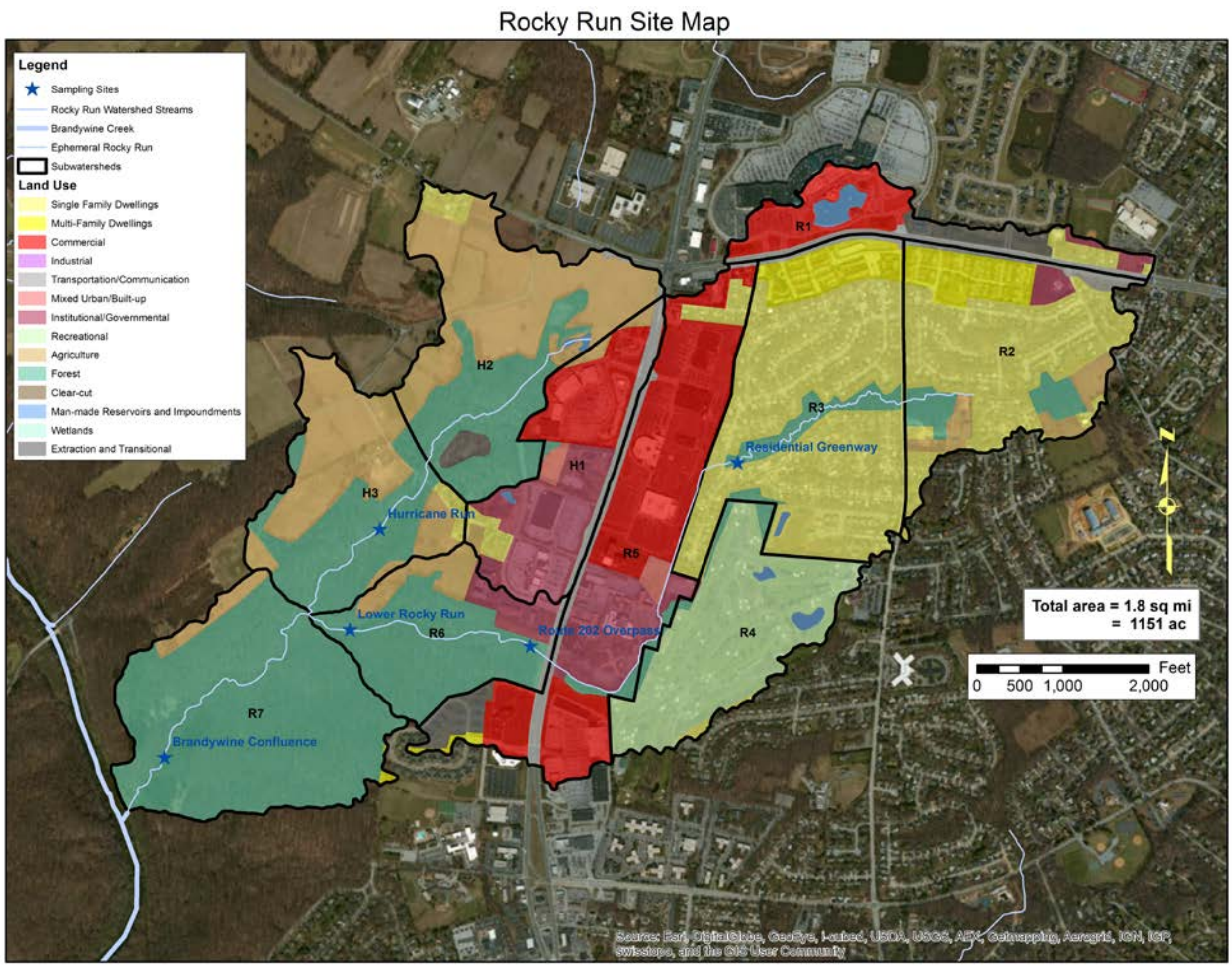


Figure 27. Rocky Run watershed

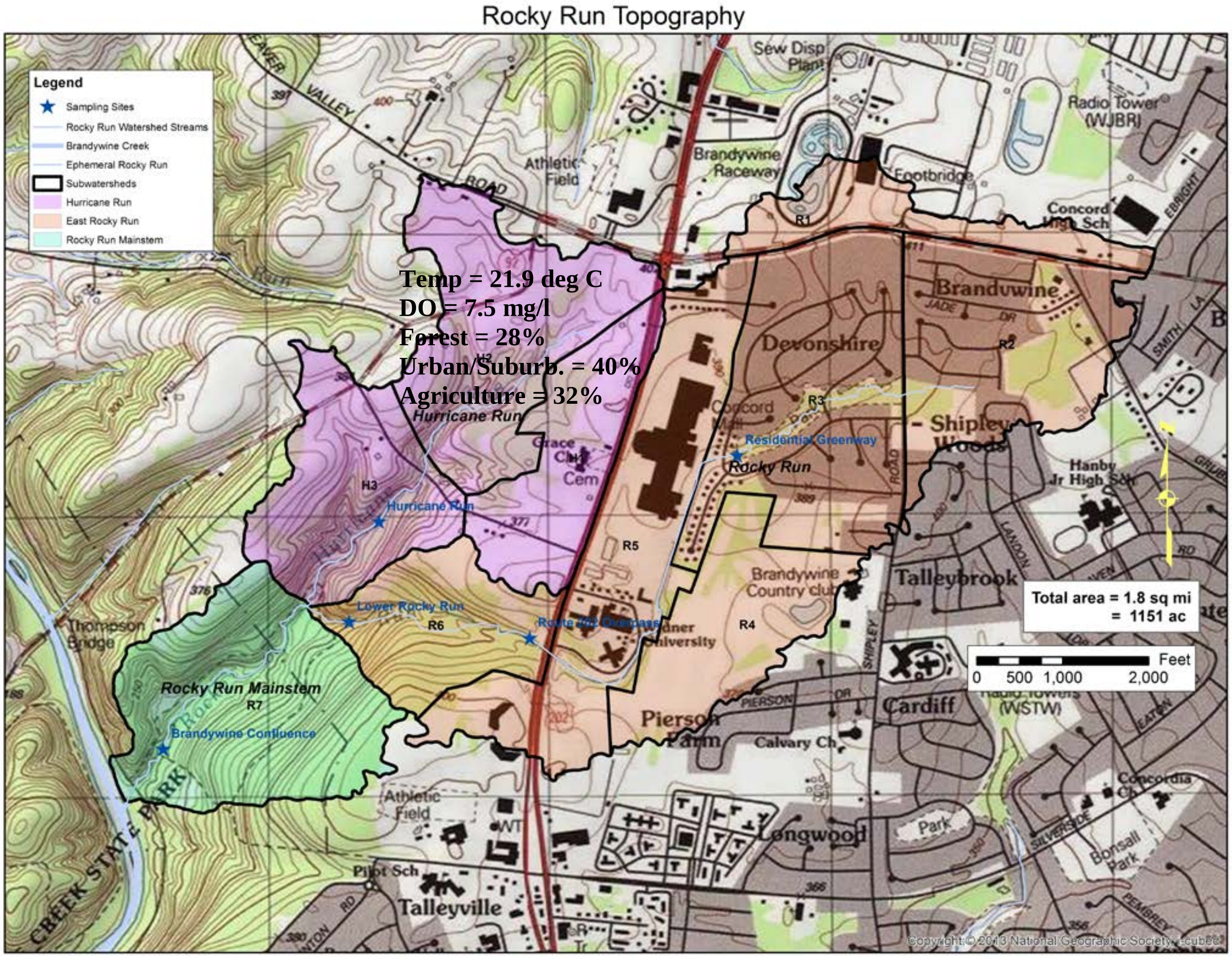


Figure 28. Rocky Run watershed topography

References

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C. 339 pp.

Rosgen, D. L., 1994. A Classification of Natural Rivers. Catena Elsevier. 22:169-199.

Schenck, W.S., M. O. Planck, and L. Srogi, 2000. Bedrock Geologic Map of the Piedmont of Delaware and Adjacent Pennsylvania. Delaware Geological Survey

Appendix

Appendix A: EPA Rapid Stream Habitat Bioassessment along streams in First State National Park

Three Sisters Brook	Epifaunal Substrate/ Cover		Pool Substrate Characterization		Pool Variability		Sediment Deposition		Channel Flow Status		Channel Alteration		Channel Sinuousity		Bank Stability		Vegetative Protection		Riparian Vegetative Zone		EPA Biohabitat Score		% DE reference = 190
2+00	15	S	18	O	17	O	16	O	20	O	18	O	20	O	8	S	4	M	1	P	148	Suboptimal	78%
4+00	17	O	16	O	18	O	16	O	17	O	14	S	20	O	8	S	4	M	1	P	142	Suboptimal	75%
6+00	18	O	18	O	18	O	18	O	19	O	17	O	19	O	4	M	7	S	2	P	160	Optimal	84%
8+00	17	O	17	O	18	O	18	O	16	O	13	S	19	O	9	O	7	S	2	P	150	Suboptimal	79%
Road	16	O	9	M	11	S	10	M	17	O	19	O	17	O	5	M	9	O	6	S	131	Suboptimal	69%
Road	16	O	9	M	11	S	10	M	S	S	19	O	17	O	5	M	9	O	6	S	114	Suboptimal	60%
12 +66	17	O	15	S	12	S	16	O	S	S	19	O	13	S	8	S	9	O	8	S	130	Suboptimal	68%
47+53	12	S	14	S	9	M	16	O	18	O	19	O	15	S	3	M	2	P	1	P	115	Suboptimal	61%
49+53	17	O	15	S	10	M	16	O	14	S	19	O	16	O	4	M	2	P	1	P	121	Suboptimal	64%
51+53	16	O	16	O	15	S	16	O	16	O	19	O	16	O	6	S	5	M	1	P	137	Suboptimal	72%
53+53	15	S	9	M	S	S	16	O	15	S	17	O	15	S	1	P	1	P	2	P	95	Fair	50%
55+53	15	S	14	S	S	S	15	S	14	S	19	O	16	O	6	S	5	M	1	P	116	Suboptimal	61%
57+53	16	O	16	O	16	O	14	S	15	S	19	O	15	S	7	S	5	M	1	P	135	Suboptimal	71%
59+53	18	O	16	O	12	S	14	S	13	S	19	O	15	S	8	S	6	S	1	P	134	Suboptimal	71%
61+53	17	O	15	S	10	M	16	O	16	O	19	O	14	S	7	S	3	M	1	P	130	Suboptimal	68%
63+53	16	O	16	O	10	M	15	S	15	S	19	O	13	S	5	M	7	S	2	P	136	Suboptimal	72%
65+53	16	O	16	O	9	M	15	S	13	S	19	O	11	S	7	S	7	S	2	P	129	Suboptimal	68%
Median	**16**	**O**	**16**	**O**	**12**	**S**	**16**	**O**	**16**	**O**	**19**	**O**	**16**	**O**	**6**	**S**	**5**	**M**	**1**	**P**	**131**	**Suboptimal**	**69%**

Jonkat Run	Epifaunal Substrate / Cover		Pool Substrate Characterization		Pool Variability		Sediment Depositio n		Channel Flow Status		Channel Alteration		Channel Sinuousity		Bank Stability		Vegetative Protection		Riparian Vegetative Zone		EPA Biohabitat Score		% DE reference = 190
1+00	18	O	16	O	16	O	15	S	16	O	15	S	20	O	7	S	9	O	10	O	157	Optimal	83%
3+00	18	O	18	O	18	O	13	S	16	O	17	O	20	O	8	S	8	S	10	O	172	Optimal	91%
5+00	20	O	13	S	18	O	15	S	16	O	20	O	20	O	7	S	10	O	10	O	175	Optimal	92%
7+00	18	O	17	O	16	O	13	S	12	S	19	O	20	O	10	O	9	O	10	O	174	Optimal	92%
9+00	19	O	19	O	19	O	16	O	13	S	19	O	20	O	9	O	10	O	10	O	179	Optimal	94%
11+00	13	S	18	O	18	O	5	P	11	S	19	O	20	O	7	S	10	O	10	O	159	Optimal	84%
13+00	20	O	15	S	16	O	15	S	13	S	17	O	20	O	5	M	7	S	9	O	164	Optimal	86%
15+00	19	O	19	O	18	O	13	S	13	S	19	O	20	O	6	S	9	O	10	O	172	Optimal	91%
17+00	18	O	19	O	17	O	12	S	19	O	18	O	20	O	7	S	10	O	10	O	173	Optimal	91%
19+00	19	O	20	O	18	O	16	O	12	S	18	O	20	O	5	M	7	S	10	O	173	Optimal	91%
21+00	18	O	19	O	19	O	13	S	13	S	19	O	20	O	9	O	9	O	10	O	177	Optimal	93%
23+00	18	O	19	O	18	O	17	O	15	S	19	O	20	O	9	O	9	O	10	O	190	Optimal	100%
25+00	20	O	18	O	18	O	18	O	19	O	19	O	20	O	10	O	10	O	10	O	190	Optimal	100%
27+00	19	O	17	O	5	P	10	M	10	M	18	O	20	O	8	S	10	O	10	O	151	Optimal	79%
29+00	19	O	10	M	4	P	19	O	14	S	20	O	20	O	8	S	10	O	10	O	162	Optimal	85%
Median	**19**	**O**	**18**	**O**	**18**	**O**	**15**	**S**	**13**	**S**	**19**	**O**	**20**	**O**	**8**	**S**	**9**	**O**	**10**	**O**	**173**	**Optimal**	**85%**

		Epifaunal Substrate/ Cover		Pool Substrate Characterization		Pool Variability		Sediment Deposition		Channel Flow Status		Channel Alteration		Channel Sinuosity		Bank Stability		Vegetative Protection		Riparian Vegetative Zone		EPA Biohabitat		% DE reference
Beaver Creek Main Stem	**Station**																					**Score**		**= 190**
	1+00	17	O	19	O	19	O	14	S	17	O	16	O	13	S	4	M	8	S	6	S	160	Optimal	84%
	4+62	19	O	20	O	19	O	16	O	17	O	15	S	18	O	6	S	4	M	3	M	162	Optimal	85%
	6+62	16	O	17	O	18	O	18	O	19	O	14	S	17	O	6	S	8	S	4	M	152	Optimal	80%
	8+62	18	O	19	O	18	O	17	O	18	O	18	O	19	O	5	M	2	P	3	M	164	Optimal	86%
	10+62	18	O	19	O	19	O	18	O	19	O	19	O	17	O	4	M	3	M	1	P	164	Optimal	86%
	12+62	19	O	20	O	20	O	17	O	13	S	18	O	13	S	5	M	9	O	9	O	160	Optimal	84%
	16+37	20	O	19	O	20	O	19	O	10	M	18	O	17	O	6	S	10	O	10	O	162	Optimal	85%
	18+37	16	O	18	O	20	O	19	O	19	O	19	O	10	M	4	M	10	O	10	O	156	Optimal	82%
	21+00	17	O	19	O	20	O	19	O	19	O	16	O	14	S	3	M	10	O	10	O	155	Optimal	82%
	Median	**18**	**O**	**19**	**O**	**19**	**O**	**18**	**O**	**18**	**O**	**18**	**O**	**17**	**O**	**5**	**M**	**8**	**S**	**6**	**S**	**160**	**Optimal**	**84%**
North Fork	0+00	14	S	12	S	17	O	17	O	19	O	19	O	10	M	6	S	7	S	5	M	126	Suboptimal	66%
	2+00	10	M	10	M	14	M	14	M	18	O	16	O	15	M	6	S	9	O	4	M	116	Suboptimal	61%
	4+00	18	O	11	S	18	O	13	S	15	S	19	O	18	O	7	S	10	O	10	O	139	Suboptimal	73%
	6+00	18	O	18	O	19	O	13	S	16	S	20	O	17	O	5	S	10	O	10	O	146	Suboptimal	77%
	8+00	16	O	18	O	19	O	17	O	17	O	19	O	15	S	7	S	9	O	10	O	147	Suboptimal	77%
	9+82	18	O	19	O	15	S	17	O	16	O	18	O	16	O	6	S	9	O	10	O	144	Suboptimal	76%
	11+82	16	O	18	O	10	S	13	O	12	S	18	S	7	M	3	M	9	O	10	O	116	Suboptimal	61%
	13+82	16	O	17	O	17	O	14	S	13	S	18	O	14	O	6	S	9	O	10	O	134	Suboptimal	71%
	15+82	18	O	15	S	14	S	17	O	17	O	18	O	16	O	6	S	10	O	10	O	141	Suboptimal	74%
	17+82	14	S	10	M	15	S	15	S	14	S	18	O	16	O	8	S	10	O	10	O	130	Suboptimal	68%
	19+82	18	O	15	S	15	S	13	S	12	S	18	O	15	S	7	S	9	O	10	O	132	Suboptimal	70%
	21+82	14	S	12	S	14	S	16	O	15	S	18	O	18	S	5	M	7	S	10	O	129	Suboptimal	68%
	23+82	18	O	14	S	14	S	18	O	16	O	18	O	14	S	3	M	10	O	10	O	135	Suboptimal	71%
	25+82	18	O	17	O	15	S	17	O	19	O	14	S	16	O	5	M	10	O	1	P	132	Suboptimal	70%
	27+82	18	O	17	O	17	O	13	S	9	M	18	O	16	O	5	M	7	S	10	O	130	Suboptimal	68%
	29+82	19	O	14	S	16	O	14	S	13	S	18	O	20	O	6	S	8	S	10	O	138	Suboptimal	73%
	31+82	16	O	18	O	17	O	14	S	13	S	18	O	18	O	6	S	8	S	10	O	138	Suboptimal	73%
	33+82	17	O	18	O	16	O	12	S	7	M	17	O	17	O	2	P	6	S	10	O	122	Suboptimal	64%
	35+82	18	O	18	O	16	O	12	S	10	M	18	O	19	O	8	S	9	O	10	O	138	Suboptimal	73%
	37+82	13	S	17	O	16	O	12	S	15	S	17	O	14	S	7	S	8	S	10	O	129	Suboptimal	68%
	40+24	16	O	17	O	13	S	15	S	16	O	12	S	11	S	8	S	6	S	0	P	114	Suboptimal	60%
	42+24	15	S	13	S	17	O	15	S	17	O	11	S	17	O	6	S	8	S	1	P	120	Suboptimal	63%
	Median	**16**	**O**	**17**	**O**	**16**	**O**	**14**	**S**	**15**	**S**	**18**	**O**	**16**	**O**	**6**	**S**	**9**	**O**	**10**	**O**	**132**	**Suboptimal**	**70%**
Smithbridge	1+00	18	O	16	O	18	O	17	O	16	O	18	O	19	O	7	S	8	S	3	M	162	Optimal	85%
	3+00	16	O	17	O	17	O	15	S	18	O	18	O	16	O	7	S	9	O	8	S	157	Optimal	83%
	5+00	15	S	15	S	17	O	16	O	13	S	17	O	20	O	8	S	9	O	3	M	154	Optimal	81%
	7+00	17	O	18	O	16	O	18	O	15	S	17	O	18	O	6	S	8	S	2	P	150	Suboptimal	79%
	8+00	16	O	17	O	9	M	14	S	16	O	16	O	15	S	7	S	4	M	2	P	150	Suboptimal	79%
	10+25	17	O	14	S	17	O	14	S	16	O	14	S	16	O	6	S	7	S	5	M	149	Suboptimal	78%
	13+03	19	O	18	O	20	O	18	O	16	O	19	O	18	O	6	S	10	O	10	O	171	Optimal	90%
	15+03	19	O	20	O	19	O	16	O	15	S	19	O	11	S	7	S	10	O	10	O	171	Optimal	90%
	17+03	19	O	17	O	20	O	18	O	15	S	18	O	17	O	8	S	8	S	10	O	172	Optimal	91%
	19+03	18	O	18	O	19	O	13	S	12	S	17	O	19	O	7	S	9	O	10	O	167	Optimal	88%
	21+03	19	O	18	O	19	O	13	S	17	O	17	O	19	O	7	S	10	O	10	O	172	Optimal	91%
	23+03	19	O	17	O	18	O	9	M	15	S	15	S	16	O	5	M	10	O	10	O	149	Suboptimal	78%
	25+03	18	O	18	O	19	O	17	O	18	O	18	O	18	O	7	S	9	O	5	M	165	Optimal	87%
	27+03	19	O	20	O	20	O	18	O	18	O	18	O	19	O	6	S	9	O	9	O	179	Optimal	94%
	29+25	17	O	17	O	18	O	17	O	18	O	17	O	17	O	5	M	6	S	3	M	156	Optimal	82%
	Median	18	O	17	O	18	O	16	O	16	O	17	O	17	O	7	M	8	S	7	M	162	Optimal	85%
Snake Tributary	1+00	10	M	17	O	10	M	20	O	20	O	15	S	6	M	6	S	8	S	2	P	139	Suboptimal	73%
	3+00	16	O	15	S	16	O	8	M	16	O	15	S	8	M	7	S	5	M	1	P	128	Suboptimal	67%

	6+13	13	M	18	O	10	M	12	S	12	S	13	S	15	S	7	S	8	S	1	P	129	Suboptimal	68%
	8+13	17	O	19	O	10	M	18	O	18	O	18	O	16	O	7	S	9	O	4	M	154	Suboptimal	81%
	Median	**14**	**S**	**17**	**O**	**10**	**M**	**15**	**S**	**17**	**O**	**15**	**S**	**11**	**S**	**7**	**S**	**8**	**S**	**1**	**P**	**134**	**Suboptimal**	**71%**
South Fork Main	1+00	18	O	16	O	10	M	11	S	9	M	16	O	6	M	8	S	8	S	1	P	125	Suboptimal	66%
	3+00	17	O	15	S	13	S	13	S	11	S	17	O	8	M	7	S	5	M	3	P	131	Suboptimal	69%
	5+00	17	O	15	S	11	S	12	S	12	S	16	O	8	M	4	M	7	S	1	P	126	Suboptimal	66%
	7+00	18	O	19	O	18	O	10	M	10	M	16	O	9	M	4	M	2	P	1	P	132	Suboptimal	70%
	9+00	17	O	16	O	18	O	11	S	10	M	16	O	11	S	3	M	8	S	5	P	141	Suboptimal	74%
	11+00	17	O	18	O	16	O	11	S	11	S	17	O	10	M	7	S	8	S	7	S	145	Suboptimal	76%
	13+00	17	O	19	O	20	O	19	O	19	O	18	O	14	S	8	S	7	S	10	O	173	Optimal	91%
	15+00	13	S	14	S	13	S	15	S	13	S	15	S	11	S	5	M	6	S	3	P	136	Suboptimal	72%
	17+00	19	O	20	O	20	O	15	S	15	S	13	S	15	S	7	S	7	S	1	P	157	Optimal	83%
	19+50	14	S	16	O	14	S	14	S	17	O	15	S	14	S	4	M	7	S	2	P	135	Suboptimal	71%
	22+37	19	O	20	O	20	O	16	O	18	O	13	S	15	S	6	S	7	S	1	P	156	Optimal	82%
	24+37	14	S	14	S	11	S	13	S	15	S	17	O	15	S	3	P	6	S	9	O	142	Suboptimal	75%
	26+37	20	O	18	O	18	O	17	O	15	S	19	O	17	O	8	S	9	O	8	S	174	Optimal	92%
	28+37	16	O	16	O	17	O	16	O	16	O	18	O	15	S	2	P	9	O	10	O	159	Optimal	84%
	30+37	18	O	20	O	18	O	16	O	18	O	20	O	12	S	3	M	10	O	10	O	172	Optimal	91%
	32+37	12	S	16	O	13	S	11	S	13	S	16	O	16	O	5	M	7	S	9	O	137	Suboptimal	72%
	34+37	20	O	19	O	20	O	19	O	15	S	20	O	14	S	6	S	10	O	10	O	178	Optimal	94%
	36+37	18	O	19	O	18	O	10	M	13	S	19	O	18	O	2	P	7	S	10	O	155	Optimal	82%
	38+37	19	O	17	O	18	O	12	S	18	O	19	O	14	S	9	O	9	O	10	O	173	Optimal	91%
	40+37	18	O	19	O	19	O	19	O	16	O	20	O	18	S	8	S	10	O	10	O	183	Optimal	96%
	42+37	12	S	15	S	19	O	13	S	16	O	5	P	18	O	5	M	6	S	10	O	145	Suboptimal	76%
	44+37	15	S	15	S	16	O	15	S	12	S	17	O	17	O	5	M	8	S	10	O	153	Optimal	81%
	46+37	20	O	20	O	20	O	19	O	20	O	20	O	15	S	3	M	8	S	10	O	182	Optimal	96%
	48+37	11	S	16	O	16	O	18	O	17	O	19	O	18	O	1	P	6	S	10	O	153	Suboptimal	81%
	50+37	20	O	20	O	20	O	18	O	17	O	20	O	18	O	7	S	10	O	10	O	186	Optimal	98%
	52+37	15	S	19	O	10	M	18	O	19	O	19	O	16	O	7	S	7	S	10	O	155	Optimal	82%
	54+37	19	O	17	O	18	O	17	O	16	O	19	O	17	O	8	S	7	S	10	O	174	Optimal	92%
	56+37	20	O	18	O	20	O	18	O	15	S	20	O	16	O	7	S	8	S	10	O	177	Optimal	93%
	58+37	19	O	19	O	18	O	15	S	17	O	19	O	19	O	9	O	9	O	10	O	178	Optimal	94%
	60+37	15	S	15	S	10	M	15	S	17	O	19	O	18	O	6	S	7	S	10	O	152	Optimal	80%
	62+37	16	O	18	O	19	O	15	S	19	O	20	O	16	O	6	S	9	O	10	O	175	Optimal	92%
	64+37	17	O	17	O	18	O	16	O	14	S	19	O	16	O	4	M	5	M	6	S	153	Optimal	81%
	66+37	17	O	17	O	16	O	18	O	18	O	16	O	15	S	9	O	9	O	4	P	158	Optimal	83%
	68+37	18	O	16	O	15	S	14	S	13	S	16	O	11	S	5	M	5	M	4	P	123	Suboptimal	65%
	70+37	15	S	13	S	17	O	11	S	19	O	18	O	18	O	8	S	9	O	8	S	147	Suboptimal	77%
	72+37	16	O	16	O	18	O	18	O	19	O	19	O	15	S	6	S	7	S	9	O	157	Optimal	83%
	74+42	16	O	15	S	15	S	17	O	16	O	19	O	14	S	6	S	8	S	9	O	153	Optimal	81%
	76+42	16	O	17	O	14	S	14	S	15	S	19	O	16	O	5	M	5	M	8	S	145	Suboptimal	76%
	78+42	17	O	16	O	16	O	14	S	15	S	19	O	16	O	8	S	7	S	9	O	158	Optimal	83%
	80+42	16	O	16	O	15	S	15	S	16	O	19	O	16	O	6	S	5	M	9	O	153	Optimal	81%
	82+42	16	O	18	O	18	O	13	S	8	M	17	O	15	S	6	S	7	S	10	O	150	Suboptimal	79%
	Median	**17**	**O**	**17**	**O**	**18**	**O**	**15**	**S**	**16**	**O**	**19**	**O**	**15**	**S**	**6**	**S**	**7**	**S**	**9**	**O**	**153**	Optimal	**81%**
South Fork North	1+00	16	O	17	O	18	O	18	O	14	S	15	S	16	O	5	M	4	M	6	S	156	Optimal	82%
	3+00	16	O	16	O	10	M	15	S	16	O	20	O	15	S	6	S	5	O	10	O	157	Optimal	83%
	5+00	14	S	13	S	8	M	9	M	6	M	15	S	14	S	7	S	8	S	9	O	123	Suboptimal	65%
	7+00	20	O	18	O	10	M	10	M	11	S	19	O	12	S	5	M	7	S	10	O	148	Suboptimal	78%
	9+00	15	S	16	O	17	O	18	O	12	S	16	O	15	S	4	M	5	M	9	O	150	Suboptimal	79%
	11+00	19	O	19	O	16	O	14	S	16	O	20	O	13	S	8	S	10	O	10	O	171	Optimal	90%
	13+00	18	O	14	S	13	S	11	S	11	S	18	O	16	O	6	S	7	S	8	S	143	Suboptimal	75%
	15+00	10	M	4	P	10	M	12	S	18	O	20	O	18	O	9	O	10	O	10	O	147	Suboptimal	77%
	17+00	17	O	17	O	16	O	17	O	14	S	17	O	16	O	6	S	7	S	6	S	163	Optimal	86%

	19+20	20	O	19	O	10	M	14	S	15	S	20	O	17	O	7	S	6	S	10	O	166	Optimal	87%
	21+20	18	O	18	O	17	O	9	M	11	S	18	O	16	O	9	O	9	O	6	S	148	Suboptimal	78%
	23+20	19	O	20	O	18	O	19	O	19	O	20	O	18	O	9	O	10	O	10	O	190	Optimal	100%
	25+20	18	O	19	O	10	M	19	O	17	O	18	O	18	O	9	O	9	O	9	O	173	Optimal	91%
	Median	**18**	**O**	**17**	**O**	**13**	**S**	**14**	**S**	**14**	**S**	**18**	**O**	**16**	**O**	**7**	**S**	**7**	**S**	**9**	**O**	**156**	**Optimal**	**82%**
South Fork Middle	2+00	16	O	16	O	14	S	14	S	14	S	19	O	17	O	6	S	7	S	7	S	154	Optimal	81%
	4+00	18	O	19	O	16	O	14	S	11	S	16	O	15	S	5	M	5	M	10	O	152	Optimal	80%
	6+00	18	O	17	O	15	S	15	S	16	O	19	O	16	O	7	S	8	S	7	S	161	Optimal	85%
	8+00	20	O	18	O	18	O	16	O	16	O	20	O	13	S	5	M	7	S	10	O	169	Optimal	89%
	10+00	14	S	12	S	18	O	16	O	15	S	19	O	16	O	8	S	8	S	8	S	157	Optimal	83%
	12+00	20	O	19	O	19	O	14	S	11	S	19	O	16	O	7	S	9	O	10	O	168	Optimal	88%
	14+00	16	O	16	O	17	O	14	S	15	S	18	O	15	S	6	S	6	S	6	S	151	Optimal	80%
	15+45	19	O	20	O	16	O	17	O	19	O	19	O	15	S	8	S	10	O	10	O	182	Optimal	96%
	Median	**18**	**O**	**17**	**O**	**16**	**O**	**14**	**S**	**15**	**S**	**19**	**O**	**15**	**S**	**6**	**S**	**7.5**	**S**	**9**	**O**	**159**	Optimal	**84%**

Ramsey Run	**Station**	**Epifaunal Substrate/ Cover**		**Pool Substrate Characterization**		**Pool Variability**		**Sediment Deposition**		**Channel Flow Status**		**Channel Alteration**		**Channel Sinuosity**		**Bank Stability**		**Vegetative Protection**		**Riparian Vegetative Zone**		**EPA Biohabitat Score**		**% DE reference = 190**
	1+00	19	O	18	O	15	S	14	S	14	S	18	O	19	O	8	S	10	O	10	O	170	Optimal	89%
	11+65	20	O	19	O	19	O	17	O	19	O	20	O	20	O	9	O	10	O	8	S	189	Optimal	99%
	13+65	18	O	18	O	15	S	19	O	19	O	13	S	20	O	8	S	10	O	0	O	178	Optimal	99%
	15+65	20	O	18	O	17	O	18	O	20	O	19	O	20	O	7	S	10	O	5	M	181	Optimal	95%
	17+25	19	O	18	O	15	S	20	O	19	O	18	O	20	O	8	S	10	O	4	M	179	Optimal	94%
	19+25	20	O	20	O	17	O	14	S	13	S	18	O	19	O	0	O	9	O	S	S	172	Optimal	91%
	19+78	16	O	14	S	9	M	15	S	14	S	19	O	17	O	6	S	5	M	1	P	136	Suboptimal	72%
	21+78	17	O	17	O	16	O	13	S	15	S	19	O	16	O	3	M	7	S	2	P	147	Suboptimal	77%
	23+78	14	S	13	S	15	S	16	O	16	O	19	O	16	O	6	S	9	O	2	P	150	Suboptimal	79%
	25+78	16	O	14	S	14	S	14	S	14	S	19	O	15	S	6	S	8	S	3	M	141	Suboptimal	74%
	27+78	16	O	14	S	17	O	18	O	18	O	19	O	14	S	2	P	7	S	2	P	142	Suboptimal	75%
	29+78	19	O	17	O	15	S	10	M	14	S	19	O	17	O	4	M	4	M	0	P	137	Suboptimal	72%
	Median	**18**	**O**	**17**	**O**	**15**	**S**	**16**	**O**	**16**	**O**	**19**	**O**	**17**	**O**	**6**	**S**	**9**	**O**	**2**	**M**	**160**	**Suboptimal**	**78%**

Thompson's Creek	**Station**	**Epifaunal Substrate/ Cover**		**Pool Substrate Characterization**		**Pool Variability**		**Sediment Deposition**		**Channel Flow Status**		**Channel Alteration**		**Channel Sinuosity**		**Bank Stability**		**Vegetative Protection**		**Riparian Vegetative Zone**		**EPA Biohabitat. Score**		**% DE reference = 190**
	2+55	20	O	20	O	20	O	19	O	19	O	19	O	18	O	9	O	10	O	8	S	190	Optimal	100%
	4+55	19	O	19	O	19	O	18	O	19	O	20	O	20	O	9	O	10	O	6	S	188	Optimal	99%
	6+55	20	O	20	O	20	O	16	O	16	O	18	O	19	O	9	O	10	O	6	S	182	Optimal	96%
	8+55	19	O	19	O	19	O	15	S	18	O	19	O	19	O	5	M	8	S	5	M	173	Optimal	91%
	10+91	18	O	17	O	17	O	18	O	17	O	18	O	16	O	9	O	8	S	3	M	166	Optimal	87%
	12+56	19	O	18	O	19	O	18	O	17	O	18	O	18	O	5	M	5	M	2	P	135	Suboptimal	71%
	14+56	19	O	18	O	18	O	18	O	19	O	18	O	18	O	8	S	5	M	1	P	162	Optimal	85%
	16+56	19	O	17	O	18	O	14	S	16	O	12	S	17	O	8	S	7	S	2	P	144	Suboptimal	76%
	17+70	19	O	18	O	19	O	12	S	11	S	15	S	18	O	6	S	6	S	1	P	143	Suboptimal	75%
	19+56	19	O	19	O	12	O	14	S	14	S	19	O	18	O	6	S	9	O	3	M	150	Suboptimal	79%
	Median	**19**	**O**		**O**	**19**	**O**	**17**	**S**	**17**	**O**	**18**	**O**	**18**	**O**	**8**	**S**	**8**	**O**	**3**	**M**	**164**	**Optimal**	**77%**

Appendix B: Rosgen stream geomorphology rating along streams in First State National Park

Three Sisters	Bank Width	Floodprone Width	Entrenchment Ratio		Bank Width	Channel Depth	W/D Ratio	W/D Ratio	Channel Length	Straight Dist	Sinuosity	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
0+0	6	5.0	0.8	Entrenched	6	2.5	2.4	low	6,853	5,917	1.16	low	0.020	cobble	G3	Very high	Poor
4+00	8	8.0	1.0	Entrenched	8	4.0	2.0	low	6,853	5,917	1.16	low	0.020	cobble	G3	Very high	Poor
6+00	6	3.0	0.5	Entrenched	6	1.5	4.0	low	6,853	5,917	1.16	low	0.020	cobble	G3	Very high	Poor
8+00	6	3.2	0.5	Entrenched	6	1.6	3.8	low	6,853	5,917	1.16	low	0.020	cobble	G3	Very high	Poor
Road)	8	4.4	0.6	Entrenched	8	2.2	3.6	low	6,853	5,917	1.16	low	0.027	gravel	G4	Very high	Very Poor
(Road)	7	3.2	0.5	Entrenched	7	1.6	4.4	low	6,853	5,917	1.16	low	0.027	gravel	G4	Very high	Very Poor
(road+66)	7	2.2	0.3	Entrenched	7	1.1	6.4	low	6,853	5,917	1.16	low	0.027	gravel	G4	Very high	Very Poor
47+53	11	9.4	0.9	Entrenched	11	4.7	2.3	low	6,853	5,917	1.16	low	0.027	gravel	G4	Very high	Very Poor
49+53	14	4.6	0.3	Entrenched	14	2.3	6.1	low	6,853	5,917	1.16	low	0.020	gravel	G4	Very high	Very Poor
51+53	4	2.2	0.6	Entrenched	4	1.1	3.6	low	6,853	5,917	1.16	low	0.020	gravel	G4	Very high	Very Poor
53+53	6	11.0	1.8	Entrenched	6	5.5	1.1	moderate	6,853	5,917	1.16	low	0.032	sand	G4	Very high	Very Poor
55+53	10	1.8	0.2	Entrenched	10	0.9	11.1	low	6,853	5,917	1.16	low	0.022	gravel	G4	Very high	Very Poor
57+53	4	4.6	1.0	Entrenched	4	2.3	1.7	low	6,853	5,917	1.16	low	0.022	sand	G5	Very high	Very Poor
59+53	8	3.0	0.4	Entrenched	8	1.5	5.3	low	6,853	5,917	1.16	low	0.027	gravel	G4	Very high	Very Poor
61+53	7	6.0	0.9	Entrenched	7	3.0	2.3	low	6,853	5,917	1.16	low	0.067	gravel	G4	Very high	Very Poor
63+53	7	1.6	0.2	Entrenched	7	0.8	8.8	low	6,853	5,917	1.16	low	0.067	cobble	G3	Very high	Poor
65+53	18	11.2	0.6	Entrenched	18	5.6	3.2	low	6,853	5,917	1.16	low		cobble	G3	Very high	Poor

Beaver Creek	Bank Width	Floodprone Width	Entrenchment Ratio		Bank Width	Channel Depth	W/D Ratio	W/D Ratio	Channel Length	Straight Dist	Sinuosity	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
Main Stem																	
1+00	46	11.6	0.3	Entrenched	46	5.8	7.9	low	2667	2351	1.13	low	0.017	cobble	G3c	very high	poor
4+62	38	10.6	0.3	Entrenched	38	5.3	7.2	low	2667	2351	1.13	low	0.017	cobble	G3c	very high	poor
6+62	34	8.8	0.3	Entrenched	34	4.4	7.7	low	2667	2351	1.13	low	0.014	sand	G3c	very high	poor
8+62	38	8.6	0.2	Entrenched	38	4.3	8.8	low	2667	2351	1.13	low	0.014	sand	G3c	very high	poor
10+62	33	11	0.3	Entrenched	33	5.5	6.0	low	2667	2351	1.13	low	0.014	cobble	G3c	very high	poor
12+62	38	12.4	0.3	Entrenched	38	6.2	6.1	low	2667	2351	1.13	low	0.014	cobble	G3c	very high	poor
16+37	38	7.6	0.2	Entrenched	38	3.8	10.0	low	2667	2351	1.13	low	0.011	cobble	G3c	very high	poor
18+37	31	8.6	0.3	Entrenched	31	4.3	7.2	low	2667	2351	1.13	low	0.011	sand	G3c	very high	poor
21+00	21	8.6	0.4	Entrenched	21	4.3	4.9	low	2667	2351	1.13	low	0.028	boulders	G3c	very high	poor
North Fork																	
0+00	30	5.00	0.2	Entrenched	30	2.5	12.0	Low	4230	3530	1.20	low	0.0125	clay/sand	G5c	very high	very poor
2+00	23	4.80	0.2	Entrenched	23	2.4	9.6	low	4230	3530	1.20	low	0.0125	sand	G5c	very high	very poor
4+00	18	5.80	0.3	Entrenched	18	2.9	6.2	low	4230	3530	1.20	low	0.0125	sand	G5c	very high	very poor
6+00	13	7.80	0.6	Entrenched	13	3.9	3.3	low	4230	3530	1.20	low	0.0125	cobble	G3c	very high	poor
8+00	24	6.40	0.3	Entrenched	24	3.2	7.5	low	4230	3530	1.20	low	0.0125	cobble	G3c	very high	poor
9+82	19	4.84	0.3	Entrenched	19	2.4	7.9	low	4230	3530	1.20	low	0.0072	cobble	G3c	very high	poor
11+82	25	3.66	0.1	Entrenched	25	1.8	13.7	Moderate	4230	3530	1.20	low	0.0072	rocks	G4c	very high	very poor
13+82	34	4.84	0.1	Entrenched	34	2.4	14.0	Moderate	4230	3530	1.20	low	0.0072	boulders	G4c	very high	very poor
15+82	26	7.78	0.3	Entrenched	26	3.9	6.7	low	4230	3530	1.20	low	0.0072	sand	G5c	very high	very poor
17+82	20	7.84	0.4	Entrenched	20	3.9	5.1	low	4230	3530	1.20	low	0.0072	sand	G5c	very high	very poor
19+82	21	9.66	0.5	Entrenched	21	4.8	4.3	low	4230	3530	1.20	low	0.0072	sand	G5c	very high	very poor
21+82	17	7.84	0.5	Entrenched	17	3.9	4.3	low	4230	3530	1.20	low	0.0072	sand	G5c	very high	very poor
23+82	13	6.50	0.5	Entrenched	13	3.3	4.0	low	4230	3530	1.20	low	0.0071	sand	G5c	very high	very poor
25+82	15	5.34	0.4	Entrenched	15	2.7	5.6	low	4230	3530	1.20	low	0.0071	sand	G5c	very high	very poor
27+82	20	5.66	0.3	Entrenched	20	2.8	7.1	low	4230	3530	1.20	low	0.0071	cobble	G3c	very high	poor
29+82	18	10.50	0.6	Entrenched	18	5.3	3.4	low	4230	3530	1.20	low	0.0071	sand	G5c	very high	very poor

31+82	17	9.80	0.6	Entrenched	17	4.9	3.5	low	4230	3530	1.20	low	0.0071	sand	G5c	very high	very poor
33+82	23	12.00	0.5	Entrenched	23	6.0	3.8	low	4230	3530	1.20	low	0.0071	sand	G5c	very high	very poor
35+82	18	6.00	0.3	Entrenched	18	3.0	6.0	low	4230	3530	1.20	low	0.0071	cobble	G3c	very high	poor
37+82	9.5	1.40	0.1	Entrenched	9.5	0.7	13.6	Moderate	4230	3530	1.20	low	0.0071	cobble	G4c	very high	very poor
40+24	9.5	4.20	0.4	Entrenched	9.5	2.1	4.5	low	4230	3530	1.20	low	0.0071	gravel	G4c	very high	very poor
42+24	7	3.00	0.4	Entrenched	7	1.5	4.7	low	4230	3530	1.20	low	0.0071	gravel	G4c	very high	very poor
Smithbri																	
15+03	11	6	0.6	entrenched	11	3.2	3.5	low	6495	5796	1.12	low	0.009	gravel	G4c	very high	very poor
17+03	15	6	0.4	entrenched	15	3.2	4.7	low	6495	5796	1.12	low	0.009	gravel	G4c	very high	very poor
19+03	24	7	0.3	entrenched	24	3.3	7.4	low	6495	5796	1.12	low	0.009	sand	G5c	very high	very poor
21+03	24	5	0.2	entrenched	24	2.6	9.3	low	6495	5796	1.12	low	0.010	cobble	G3c	very high	very poor
23+03	22	6	0.3	entrenched	22	2.8	8.0	low	6495	5796	1.12	low	0.010	cobble	G3c	very high	very poor
25+03	31	7	0.2	entrenched	31	3.3	9.5	low	6495	5796	1.12	low	0.010	sand	G5c	very high	very poor
27+03	26	7	0.3	entrenched	26	3.6	7.3	low	6495	5796	1.12	low	0.010	sand	G5c	very high	very poor
29+25	28	7	0.3	entrenched	28	3.6	7.8	low	6495	5796	1.12	low	0.010	boulders	G1c	very high	very poor
Snake																	
1+00	11	5	0.5	entrenched	11	2.6	4.2	Low	6495	5796	1.12	Low	0.050	gravel	A4	very high	very poor
3+00	22	11	0.5	entrenched	22	5.4	4.1	Low	6495	5796	1.12	Low	0.050	sand	A4	very high	very poor
6+13	15	7	0.4	entrenched	15	3.3	4.5	Low	6495	5796	1.12	Low	0.019	gravel	A4	very high	very poor
8+13	12	9	0.8	entrenched	12	4.7	2.6	Low	6495	5796	1.12	Low	0.019	gravel	A4	very high	very poor
South Fk.																	
1+00	42.5	5.84	0.1	entrenched	42.5	2.9	14.6	Moderate	8479	6202	1.37	Moderate	0.113	cobble	G3	very high	poor
3+00	30.5	8.00	0.3	entrenched	30.5	4.0	7.6	low	8479	6202	1.37	Moderate	0.113	cobble	G3	very high	poor
5+00	23	4.50	0.2	entrenched	23	2.3	10.2	low	8479	6202	1.37	Moderate	0.025	cobble	G3	very high	poor
7+00	21	3.50	0.2	entrenched	21	1.8	12.0	low	8479	6202	1.37	Moderate	0.009	cobble	G5c	very high	very poor
9+00	29	8.00	0.3	entrenched	29	4.0	7.3	low	8479	6202	1.37	Moderate	0.009	cobble	G5c	very high	very poor
11+00	36	8.16	0.2	entrenched	36	4.1	8.8	low	8479	6202	1.37	Moderate	0.009	sand	G5c	very high	very poor
13+00	25	1.80	0.1	entrenched	25	0.9	27.8	Moderate	8479	6202	1.37	Moderate	0.009	cobble	F5	very high	poor
15+00	27	6.84	0.3	entrenched	27	3.4	7.9	low	8479	6202	1.37	Moderate	0.009	cobble	G5c	very high	very poor
17+00	18	4.80	0.3	entrenched	18	2.4	7.5	low	8479	6202	1.37	Moderate	0.009	gravels	G4c	very high	very poor
19+50	20	14.66	0.7	entrenched	20	7.3	2.7	low	8479	6202	1.37	Moderate	0.009	cobble	G4c	very high	very poor
22+37	21	3.80	0.2	entrenched	21	1.9	11.1	low	8479	6202	1.37	Moderate	0.015	cobble	G4c	very high	very poor
24+37	20	2.00	0.1	entrenched	20	1.0	20.0	Moderate	8479	6202	1.37	Moderate	0.015	rocks	F4	very high	poor
26+37	26	3.60	0.1	entrenched	26	1.8	14.4	Moderate	8479	6202	1.37	Moderate	0.015	sand	F3	very high	poor
28+37	24	6.50	0.3	entrenched	24	3.3	7.4	low	8479	6202	1.37	Moderate	0.014	sand	G3c	very high	poor
30+37	26	2.80	0.1	entrenched	26	1.4	18.6	Moderate	8479	6202	1.37	Moderate	0.014	sand	F3	very high	poor
32+37	16.5	6.34	0.4	entrenched	16.5	3.2	5.2	low	8479	6202	1.37	Moderate	0.014	sand	G3c	very high	poor
34+37	38	10.00	0.3	entrenched	38	5.0	7.6	low	8479	6202	1.37	Moderate	0.014	gravel	G3c	very high	poor
36+37	18	4.34	0.2	entrenched	18	2.2	8.3	low	8479	6202	1.37	Moderate	0.026	cobble	G3	very high	poor
38+37	32	7.00	0.2	entrenched	32	3.5	9.1	low	8479	6202	1.37	Moderate	0.026	cobble	G3	very high	poor
40+37	36	7.00	0.2	entrenched	36	3.5	10.3	low	8479	6202	1.37	Moderate	0.026	cobble	G3	very high	poor
42+37	16	5.00	0.3	entrenched	16	2.5	6.4	low	8479	6202	1.37	Moderate	0.026	gravel	G4	very high	very poor
44+37	22	5.50	0.3	entrenched	22	2.8	8.0	low	8479	6202	1.37	Moderate	0.018	gravel	G4c	very high	very poor
46+37	29	11.20	0.4	entrenched	29	5.6	5.2	low	8479	6202	1.37	Moderate	0.018	cobble	G3c	very high	poor
48+37	26	14.20	0.5	entrenched	26	7.1	3.7	low	8479	6202	1.37	Moderate	0.018	gravel	G4c	very high	very poor
50+37	36	8.80	0.2	entrenched	36	4.4	8.2	low	8479	6202	1.37	Moderate	0.018	sand	G3c	very high	poor
52+37	24	10.16	0.4	entrenched	24	5.1	4.7	Low	8479	6202	1.37	Moderate	0.018	cobble	G3c	very high	poor
54+37	20	3.00	0.2	entrenched	20	1.5	13.3	Moderate	8479	6202	1.37	Moderate	0.018	cobble	F3	very high	poor
56+37	38	7.80	0.2	entrenched	38	3.9	9.7	low	8479	6202	1.37	Moderate	0.018	sand	G3	very high	poor
58+37	22	9.84	0.4	entrenched	22	4.9	4.5	low	8479	6202	1.37	Moderate	0.018	cobble	G3c	very high	poor
60+37	38	6.34	0.2	entrenched	38	3.2	12.0	low	8479	6202	1.37	Moderate	0.032	gravel	G4	very high	very poor
62+37				entrenched	0				8479	6202	1.37	Moderate	0.032	sand	G3	very high	poor
64+37	21	8.00	0.4	entrenched	21	4.0	5.3	low	8479	6202	1.37	Moderate	0.009	sand	G4c	very high	very poor
66+37	21	8.34	0.4	entrenched	21	4.2	5.0	low	8479	6202	1.37	Moderate	0.009	cobble	G3c	very high	poor

68+37	24	8.00	0.3	entrenched	24	4.0	6.0	low	8479	6202	1.37	Moderate	0.009	cobble	G3c	very high	poor
70+37	13	5.00	0.4	entrenched	13	2.5	5.2	low	8479	6202	1.37	Moderate	0.009	rock	G4c	very high	very poor
72+37	24	10.00	0.4	entrenched	24	5.0	4.8	low	8479	6202	1.37	Moderate	0.009	rock	G4c	very high	very poor
74+42	21	11.00	0.5	entrenched	21	5.5	3.8	low	8479	6202	1.37	Moderate		gravel	G3c	very high	poor
76+42	38	6.66	0.2	entrenched	38	3.3	11.4	low	8479	6202	1.37	Moderate	0.014	gravel	G4c	very high	very poor
78+42	36	11.34	0.3	entrenched	36	5.7	6.3	low	8479	6202	1.37	Moderate	0.014	rock	G4c	very high	very poor
80+42	28	3.84	0.1	entrenched	28	1.9	14.6	Moderate	8479	6202	1.37	Moderate	0.014	cobble	F3	very high	poor
82+42	39	4.34	0.1	entrenched	39	2.2	18.0	Moderate	8479	6202	1.37	Moderate		cobble	F3	very high	poor
S. Fk. N.																	
1+00	14	3.80	0.3	entrenched	14	1.9	7.4	low	3188	2589	1.23	Moderate	0.012	gravel	G4c	very high	very poor
3+00	18	6.34	0.4	entrenched	18	3.2	5.7	low	3188	2589	1.23	Moderate	0.012	cobble	G3c	very high	poor
5+00	22	6.20	0.3	entrenched	22	3.1	7.1	low	3188	2589	1.23	Moderate	0.012	gravel	G4c	very high	very poor
7+00	20	9.50	0.5	entrenched	20	4.8	4.2	low	3188	2589	1.23	Moderate	0.012	gravel	G4c	very high	very poor
9+00	11	5.80	0.5	entrenched	11	2.9	3.8	low	3188	2589	1.23	Moderate	0.017	gravel	g4c	very high	very poor
11+00	8	4.50	0.6	entrenched	8	2.3	3.6	low	3188	2589	1.23	Moderate	0.017	cobble	G3c	very high	poor
13+00	14	5.20	0.4	entrenched	14	2.6	5.4	low	3188	2589	1.23	Moderate	0.017	gravel	G4c	very high	very poor
15+00	9	5.66	0.6	entrenched	9	2.8	3.2	low	3188	2589	1.23	Moderate	0.016	boulder	G2c	moderate	fair
17+00	20	4.20	0.2	entrenched	20	2.1	9.5	low	3188	2589	1.23	Moderate	0.016	cobble	G3c	very high	poor
19+20			0.3	entrenched	13	2.0	6.5	low	3188	2589	1.23	Moderate	0.016	cobble	G3c	very high	poor
21+20			0.4	entrenched	16	2.8	5.7	low	3188	2589	1.23	Moderate	0.016	gravel	G4c	very high	very poor
23+20			0.5	entrenched	11	2.6	4.3	low	3188	2589	1.23	Moderate	0.016	gravel	G4c	very high	very poor
25+20			0.9	entrenched	6	2.6	2.3	low	3188	2589	1.23	Moderate	0.016	gravel	G4c	very high	very poor
S. Fk. Mid.																	
2+00			0.3	Entrenched	24	3.5	6.9	low	3050	2074	1.47	low	0.016	cobble	G3c	very high	poor
4+00			0.4	Entrenched	19	3.9	4.8	low	3050	2074	1.47	low	0.016	cobble	G3c	very high	poor
6+00			0.2	Entrenched	26	3.1	8.4	low	3050	2074	1.47	low	0.016	cobble	G3c	very high	poor
8+00			0.3	Entrenched	26	4.0	6.5	low	3050	2074	1.47	low	0.016	cobble	G3c	very high	poor
10+00			0.1	Entrenched	30	2.0	15.0	Moderate	3050	2074	1.47	low	0.015	gravel	F3	very high	poor
12+00			0.2	Entrenched	34	3.9	8.7	low	3050	2074	1.47	low	0.015	cobble	G3c	very high	poor
14+00			0.4	Entrenched	22	4.3	5.1	low	3050	2074	1.47	low	0.038	cobble	G3c	very high	poor
15+45			0.6	Entrenched	10	3.1	3.2	low	3050	2074	1.47	low	0.012	cobble	G3c	very high	poor

Jonkat Run	Bank Width	Floodprone Width	Entrenchment Ratio		Bank Width	Channel Depth	W/D Ratio	W/D Ratio	Channel Length	Straight Dist	Sinuosity	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
1+00	11	8.2	0.7	Entrenched	11	4.1	2.7	low	2,557	2,273	1.12	low	0.025	sand	A5	Very high	very poor
3+00	11	6.0	0.5	Entrenched	11	3	3.7	low	2,557	2,273	1.12	low	0.025	sand	A5	Very high	very poor
5+00	7	3.1	0.4	Entrenched	7	1.55	4.8	low	2,557	2,273	1.12	low	0.025	sand	A5	Very high	very poor
7+00	8	3.4	0.4	Entrenched	8	1.7	4.7	low	2,557	2,273	1.12	low	0.025	gravel	A4	Very high	very poor
9+00	7	6.8	1.0	Entrenched	7	3.4	2.1	low	2,557	2,273	1.12	low	0.017	gravel	A4	Very high	very poor
11+00	11	3.6	0.3	Entrenched	11	1.8	6.4	low	2,557	2,273	1.12	low	0.017	sand	A5	Very high	very poor
13+00	8	1.6	0.2	Entrenched	8	0.8	10.0	low	2,557	2,273	1.12	low	0.017	gravel	A4	Very high	very poor
15+00	25	4.2	0.2	Entrenched	25	2.1	11.9	low	2,557	2,273	1.12	low	0.017	gravel	A4	Very high	very poor
17+00	18	1.6	0.1	Entrenched	18	0.8	22.5	moderate	2,557	2,273	1.12	low	0.017	gravel	G4	Very high	very poor
19+00	26	4.2	0.2	Entrenched	26	2.1	12.4	moderate	2,557	2,273	1.12	low	0.017	gravel	G4	Very high	very poor
21+00	22	9.8	0.4	Entrenched	22	4.9	4.5	low	2,557	2,273	1.12	low	0.050	gravel	A5	Very high	very poor
23+00	9	9.8	1.1	Entrenched	9	4.9	1.8	low	2,557	2,273	1.12	low	0.050	gravel	A4	Very high	very poor
25+00	11	14.0	1.3	Entrenched	11	7	1.6	low	2,557	2,273	1.12	low	0.050	gravel	A4	Very high	very poor
27+00	12	9.8	0.8	Entrenched	12	4.9	2.4	low	2,557	2,273	1.12	low	0.025	gravel	A4	Very high	very poor
29+00	8	0.8	0.1	Entrenched	8	0.4	20.0	moderate	2,557	2,273	1.12	low		sand	G5	Very high	very poor

Ramsey's Run	Bank Width	Floodprone Width	Entrenchment Ratio		Bank Width	Channel Depth	W/D Ratio	W/D Ratio	Channel Length	Straight Dist	Sinuosity	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
1+00	17	8.6	0.5	Entrenched	17	4.3	4.0	Low	4867	4035	1.21	Moderate	0.02	gravel	G4	very high	very poor
11+65	13	10.5	0.8	Entrenched	13	5.25	2.5	Low	4867	4035	1.21	Moderate	0.02	gravel	G4	very high	very poor
13+65	13	3.5	0.3	Entrenched	13	1.75	7.4	Low	4867	4035	1.21	Moderate	0.02	gravel	G4	very high	very poor
15+65	7	6.8	1.0	Entrenched	7	3.4	2.1	Low	4867	4035	1.21	Moderate	0.03	gravel	G4	very high	very poor
17+25	9	7.3	0.8	Entrenched	9	3.65	2.5	Low	4867	4035	1.21	Moderate	0.03	gravel	G4	very high	very poor
19+25	4.7		0.0	Entrenched	5				4867	4035	1.21	Moderate	0.03	gravel	G4	very high	very poor
19+78	13	6.0	0.5	Entrenched	13	3	4.3	Low	4867	4035	1.21	Moderate	0.03	gravel	G4	very high	Very poor
21+78	14	8.0	0.6	Entrenched	14	4	3.5	Low	4867	4035	1.21	Moderate	0.04	clay	G4	very high	very poor
23+78	12	10.0	0.8	Entrenched	12	5	2.4	Low	4867	4035	1.21	Moderate	0.03	clay	G4	very high	very poor
25+78	11	1.8	0.2	Entrenched	11	0.9	12.2	Moderate	4867	4035	1.21	Moderate	0.03	clay	F6b	very high	fair
27+78	11	6.2	0.6	Entrenched	11	3.1	3.5	Low	4867	4035	1.21	Moderate	0.02	gravel	G4	very high	very poor
29+78	8	6.0	0.8	Entrenched	8	3	2.7	Low	4867	4035	1.21	Moderate	0.02	clay	G4	very high	very poor

Thompson's Creek	Bank Width	Floodprone Width	Entrenchment Ratio		Bank Width	Channel Depth	W/D Ratio	W/D Ratio	Channel Length	Straight Dist	Sinuosity	Sinuosity	Slope	Channel Material	Stream Type	Erosion Capacity	Erosion Recovery
2+55	9	5.6	0.6	Entrenched	9	2.8	3.2	low	1971	1890	1.04	low	0.04	gravel	A4	very high	very poor
4+55	4	1.2	0.3	Entrenched	4	0.6	6.7	low	1971	1890	1.04	low	0.05	sand	A5	very high	very poor
6+55	8	3.8	0.5	Entrenched	8	1.9	4.2	low	1971	1890	1.04	low	0.06	sand	A5	very high	very poor
8+55	10	2.0	0.2	Entrenched	10	1	10.0	low	1971	1890	1.04	low	0.07	sand	A5	very high	very poor
10+91	7	3.4	0.5	Entrenched	7	1.7	4.1	low	1971	1890	1.04	low	0.08	gravel	A4	very high	very poor
12+56	8	3.0	0.4	Entrenched	8	1.5	5.3	low	1971	1890	1.04	low	0.08	gravel	A4	very high	very poor
14+56	5	2.6	0.5	Entrenched	5	1.3	3.8	low	1971	1890	1.04	low	0.09	gravel	A4	very high	very poor
16+56	7	2.4	0.3	Entrenched	7	1.2	5.8	low	1971	1890	1.04	low	0.09	gravel	A4	very high	very poor
17+70	6	3.2	0.5	Entrenched	6	1.6	3.8	low	1971	1890	1.04	low	0.08	gravel	A4	very high	very poor
19+56	14	7.2	0.5	Entrenched	14	3.6	4.0	low	1971	1890	1.04	low	0.07	gravel	A4	very high	very poor