

Cacapon Institute

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Final Report
Fecal Coliform Bacteria Monitoring for the
Sleepy Creek Watershed
319 Project Water Monitoring
15 Months at 7 sites

Prepared for: West Virginia Conservation Agency

Prepared by:

Cacapon Institute

W. Neil Gillies, Director of Science

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August 31, 2015

Participating Agencies and Organizations

West Virginia Conservation Agency

WV DEP

Sleepy Creek Watershed Association



*Sleepy Creek
Watershed Association*

Project Summary

Cacapon Institute (CI) under contract with the WV Conservation Agency and subject to review by the 319 project team, monitored Sleepy Creek and certain tributaries for fecal coliform bacteria as outlined below. (Appendix: Images of Watershed and Sample Sites; Attachment: Land Cover Analysis and carbon sequestration estimates using USDA Forest Service i-Tree Vue, 2011.)

Background

The Sleepy Creek (WVP-9, TMDL SWS 9001 – 9063) watershed is located in Morgan County, West Virginia (87%) and Fredrick County, Virginia (13%). Sleepy Creek flows 42 miles north into the Potomac River. Within the watershed two streams had a TMDL (Total Maximum Daily Load), Sleepy Creek (main stem) and Indian Run tributary (WVP-9-G). Both Sleepy Creek and Indian Run were listed as impaired “relative to numeric water quality criteria for fecal coliform bacteria” in the 2007 TMDL. Indian Run was officially delisted as of 2012 (See: [“Planting Trees and Upgrading Septic Systems Decreases Bacteria in Run”](#)). Sleepy Creek remains on the impaired list.

According to the TMDL, non-point source accounted for the majority of the fecal coliform bacteria. The WVDEP source tracker identified areas of high population density without access to public sewers in the watershed. The TMDL estimated 6,400 homes were not connected to a publicly owned treatment facility. Of all the homes in the entire watershed 14.18% were estimated to have failing individual sewer systems.

West Virginia Department of Environmental Protection set pre-TMDL sample sites in areas of Sleepy Creek where previous sampling efforts (targeted sampling based on their 5-year rotating plan) showed even a single 'hit' for fecal. A single sample (out of 11 pre-TMDL samples) had a result of 560 cfu/100ml. The pre-TMDL data was deemed sufficient to list the stream for the first time on the 2006 303(d) list. Data collected for the purpose of supporting TMDL development was put into the WVDEP 'decision database' that is used to track assessment decisions. This decision database produced the following description: *List for fecal from mouth to RM 18.0 and again from RM 26.7 to headwaters 2003/2004 TMDL data had 1/11 violations near mouth, 2/11 at RM 8.0, 0/12 at RM 18, 1/12 at RM 26.7, and 2/11 at RM 36.8.* (John Wirts, WVDEP, personal communication).

Cacapon Institute conducted 'implementation plan monitoring' for fecal coliform bacteria between March 2010 and September 2011. The purpose of this monitoring was to gather the additional data that is necessary to identify “hot spots” and possible sources of fecal pollution entering the main stem of Sleepy Creek. Sampling was done monthly at nine sites selected by the Sleepy Creek 319 Team. The study found that, as with the pre-TMDL monitoring, exceedences of the 400 cfu/100ml fecal coliform standard were infrequent and occurred during rainy periods. Indian Run was monitored because it had the greatest number of exceedences during the pre-TMDL monitoring period (3 out of 13 samples in excess of 400 cfu/100ml); Indian Run had zero exceedences during the implementation plan monitoring' study, which implies that the cause of fecal coliform bacteria impairment during the pre-TMDL period had been addressed. As a result, Indian Run is in the first stages of being delisted by WVDEP for fecal coliform impairment.

Four sites had more than one 400 cfu/100ml exceedence: Sleepy Creek (SC) at Shades Road, SC at Middle Fork, SC at Ruffed Grouse Road, and SC at Morgan Road. The Sleepy Creek 319 Team selected these sites for additional monitoring; with additional sites to aid in the goal of identifying tributaries that contribute to the fecal coliform problem in the Sleepy Creek mainstem.

- SC at Morgan Road, just upstream of West Virginia in Virginia, identifies the out-of-state fecal bacteria contribution.
- SC at Ruffed Grouse Road is located a short distance downstream of an area identified in the TMDL as having a high probability of septic failures.
- SC at Morgan Road will continue to be monitored as well as two of its feeder streams: the Middle Fork and South Forks of Sleepy Creek.
- SC at Shades Road will continue to be monitored as well as one of its feeder streams: Yellow Springs Run.

Monitoring Plan

CI sampled the seven (7) locations described above in an effort to locate sources of fecal coliform contamination. The original intent was for sampling to be done at these sites monthly for 15 months; however, field conditions (summer/autumn drought in 2014 and frozen streams in winter 2015) resulted in fewer samples being taken during those periods and twice monthly samples were taken to complete the work in the required time frame. As budgeted, a total of 17 sampling trips were accomplished. On two dates (8/19/2014 and 9/25/2014) only four sites were sampled because the other three sites were dry.

Field and Laboratory Methods

Cacapon Institute is a West Virginia Certified Laboratory, and performed field collections and laboratory analyses as laid out in the organization's approved SOPs.

Water samples were collected midstream 10-15 cm below the surface. When water levels precluded wading into the river, samples were collected from shore or bridges using an extension sampler. Sampling containers, storage conditions and holding times followed APHA (APHA, 1992). One daily duplicate sample was collected.

Fecal Coliform Bacteria were determined using the Membrane Filtration Method by filtering three known volumes of sample (3 ml, 10 ml, 30 ml) through three separate 0.45 micrometer filters, transferring the filters to petri dishes containing a selective growth medium (PourRite m-FC/Rosalic Acid Broth Ampules -Hach Cat# 24285-20), incubating the petri dish at a selective temperature of 44.5 °C + 0.2 °C in a Millepore Dual Chamber Incubator (Cat# XX63 LK1 15), and counting the number of resulting colonies at 24 hours (\pm 2 hours). Results were expressed as number of colony forming units per 100 ml.

Statistical methods

The methods used to analyze data were statistical. Data distributions were displayed in tables of summary statistics. Non-parametric one-way analysis of variance (ANOVA) was run on rank transformed data for comparison of median concentration distributions and of the deviation from daily medians to compare sites and dates. An alpha value of 0.05 was used to determine the significance of test results. If a significant difference among group medians was detected, Tukey's multiple comparison test was used on the rank transformed data to determine where differences were located (Helsel and Hirsh, 1992). Statistics were calculated using JMP Statistical Discovery Software (version 4).

Results

The West Virginia standard for fecal coliform bacteria specifies that the maximum allowable level of fecal coliform for primary contact recreation shall not exceed 200 cfu/100 mL as a monthly geometric mean (based on not less than 5 samples per month). The fecal coliform count also shall not exceed 400 cfu/100 mL in more than 10 percent of all samples taken during any one month. The data collected during this study does not allow a direct comparison to the state standard of 200 cfu/100 mL as a monthly geometric mean because samples were only collected at each site at most two times per month. When fewer than five samples are collected per month, the applicable standard becomes 400 cfu/100 mL. For that reason, the results of this study will be discussed in the context of the 400 cfu/100ml part of the fecal coliform bacteria standard. 200 cfu/100 ml is discussed as a "warning" level.

Table 1 (next page) provides descriptive statistics for each of the sampling sites; the last two columns provide the total number of samples that exceeded 400 and 200 cfu/100 ml, respectively. The table includes original summary data for the sites that were repeated for this study, as well as the new feeder stream data. Mean values varied much more widely than median values and tended to be higher, sometimes much higher. This is characteristic of non-point source data that is skewed by a few high values recorded during precipitation events. The median is the preferred "measure of central tendency" for this parameter, while the mean and maximum values are more reflective of the tendency of each site towards high concentrations during runoff events. Sleepy Creek at Ruffed Grouse Road had the highest median and mean values in both the 2010-2011 study and the 2014-2015 study. However, no statistically significant differences were detected between sites.

During the latter fifteen month study period, only the Yellow Springs and Sleepy Creek at Shades Rd. sites never exceeded the 400 cfu/100ml standard, Yellow Springs never exceeded 200 cfu/100ml. All of the other five sites had at least one exceedence of 400 cfu/100 ml. The Sleepy Creek at Ruffed Grouse had five bacteria counts greater than 400 cfu/100 ml, Sleepy Creek at Morgan Road had two, and Sleepy Creek below Middle Fork, Middle Fork, and South Fork each had one.

Table 1. Fecal coliform bacteria at five sampling sites in the Sleepy Creek watershed from the 2010-2011 study repeated in 2014-2015. Results reported in colony forming units per 100 ml.

Sampling Site	Number of Samples	Minimum	25th Quartile	Median	Mean	75th Quartile	Maximum	No. >= 400	No. >= 200		
SC at Shades Road 2010-2011	17	13	38.5	77.0	192.6	130.0	1067	3	3		
SC at Shades Road 2014-2015	17	1	16.5	50.0	79.4	95.0	350	0	2		
SC At Middle Fork 2010-2011	18	3	41.5	70.0	199.5	285.0	1000	3	6		
SC below Middle Fork 2014-2015	17	1	13.0	100.0	135.4	185.0	630	1	4		
SC at Ruffed Grouse Rd. 2010-2011	18	3	35.8	103.0	231.5	285.0	1033	3	5		
SC at Ruffed Grouse Rd. 2014-2015	17	1	20.0	130.0	224.5	455.0	666	5	7		
SC at Morgan Road 2010-2011	18	3	12.3	73.0	166.7	184.3	1333	2	4		
SC at Morgan Road 2014-2015	17	3	15.0	53.0	165.4	255.0	733	2	5		
Feeder streams added for the 2014-2015 sampling											
Middle Fork 2014-2015			15	1	7	80	129.5	140	733	1	2
South Fork 2014-2015			15	1	3	46	125.5	110	1100	1	2
Yellow Springs 2014-2015			15	1	3	10	42.8	63	193	0	0

Table 2 (next page) provides descriptive statistics for all sites on each of the sampling dates; the last two columns provide the total number of samples that exceeded 400 and 200 cfu/100 ml, respectively.

The mean and media values generally varied much more narrowly on each sampling date than in Table 1, which provided statistics by site. This would seem to indicate that bacteria levels at all or most sites were responding to similar “drivers” on any given day. 9/25/2014 had the highest median and mean values (395 and 406 cfu/100 ml, respectively) of all the sampling days; but this period was abnormal as the feeder streams were not sampled because they were dry (as they also were on 8/19/2014).

Weather Underground precipitation records indicate no significant precipitation during the week leading up to the 9/25/2014 sample collection. <http://www.wunderground.com/personal-weather-station/dashboard?ID=KWVBERKE2#history/s20140918/e20140925/mweek>)

There were no 400 cfu/100 ml exceedances on eleven of the fifteen sampling days. Three dates stand out as having more than one sample exceeding the 400 cfu/100 ml standard: 9/25/2014, 6/18/2015, and 7/30/2015, with two, two and three exceedances, respectively. Field notes for those dates indicate it was dry, wet, and variable conditions on these dates, respectively.

Precipitation was often associated with dates on which any samples exceeded 400 cfu/ 100 ml, but not always. The lack of a particular pattern does not help in determining possible sources of the higher counts. Bacteria counts were extremely low throughout the winter sampling period, which was also true for the previous study.

Table 2.

Sampling Site	Number of Samples	Minimum	25th Quartile	Median	Mean	75th Quartile	Maximum	No. >= 400	No. >= 200
6/30/2014	7	47	50	80	99.571	157	210	0	1
8/19/2014	4	73	77.25	125	124.75	172	176	0	0
9/25/2014	4	100	162.5	395	405.75	659.75	733	2	3
10/27/2014	7	7	10.0	23.0	62.7	43.0	300	0	1
12/4/2014	7	3	10	20	19.857	33	36	0	0
12/19/2014	7	3	3	7	13.714	13	50	0	0
1/19/2015	7	1	3	3	6.571	10	23	0	0
3/16/2015	7	1	1	3	2.429	3	3	0	0
3/26/2015	7	1	1	1	4.429	7	13	0	0
4/21/2015	7	46	110	136	143.429	166	260	0	1
4/30/2015	7	13	20	37	37	56	63	0	0
5/18/2015	7	43	50	77	280.429	370	1100	1	3
5/29/2015	7	10	17	110	143.857	147	550	1	1
6/4/2015	7	60	80	113	141.857	250	270	0	2
6/18/2015	7	73	130	193	306.429	666	700	2	3
7/13/2015	7	73	110	137	209	350	470	1	3
7/30/2015	7	10	73	260	332.286	630	733	3	4

Discussion and Conclusions

Exceedences of the 400 cfu/100ml fecal coliform standard during the pre-TMDL monitoring period in Sleepy Creek were infrequent and occurred during rainy periods. The same pattern was also the case during the 2010-2011 study. It is less certain that rain was a driver of high fecal bacteria counts during the 2014-2015 study.

South Fork, Middle Fork, and Yellow Springs were monitored to determine if those tributaries were notable contributors of fecal bacteria to the Sleepy Creek main stem sites that that frequent violations during the 2010-2011 study. South Fork and Middle Fork both had occasional exceedences of the standard (see Table 1 above) but not frequently. Yellow Spring had no exceedences.

Acknowledgments

Field work was conducted by Frank Rodgers and Neil Gillies, and Mr. Gillies conducted laboratory work. This report was prepared by Neil Gillies, Cacapon Institute. This project supported by funding from the US EPA 319 Sleepy Creek Watershed Incremental 319 Project.

Citations

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Reference

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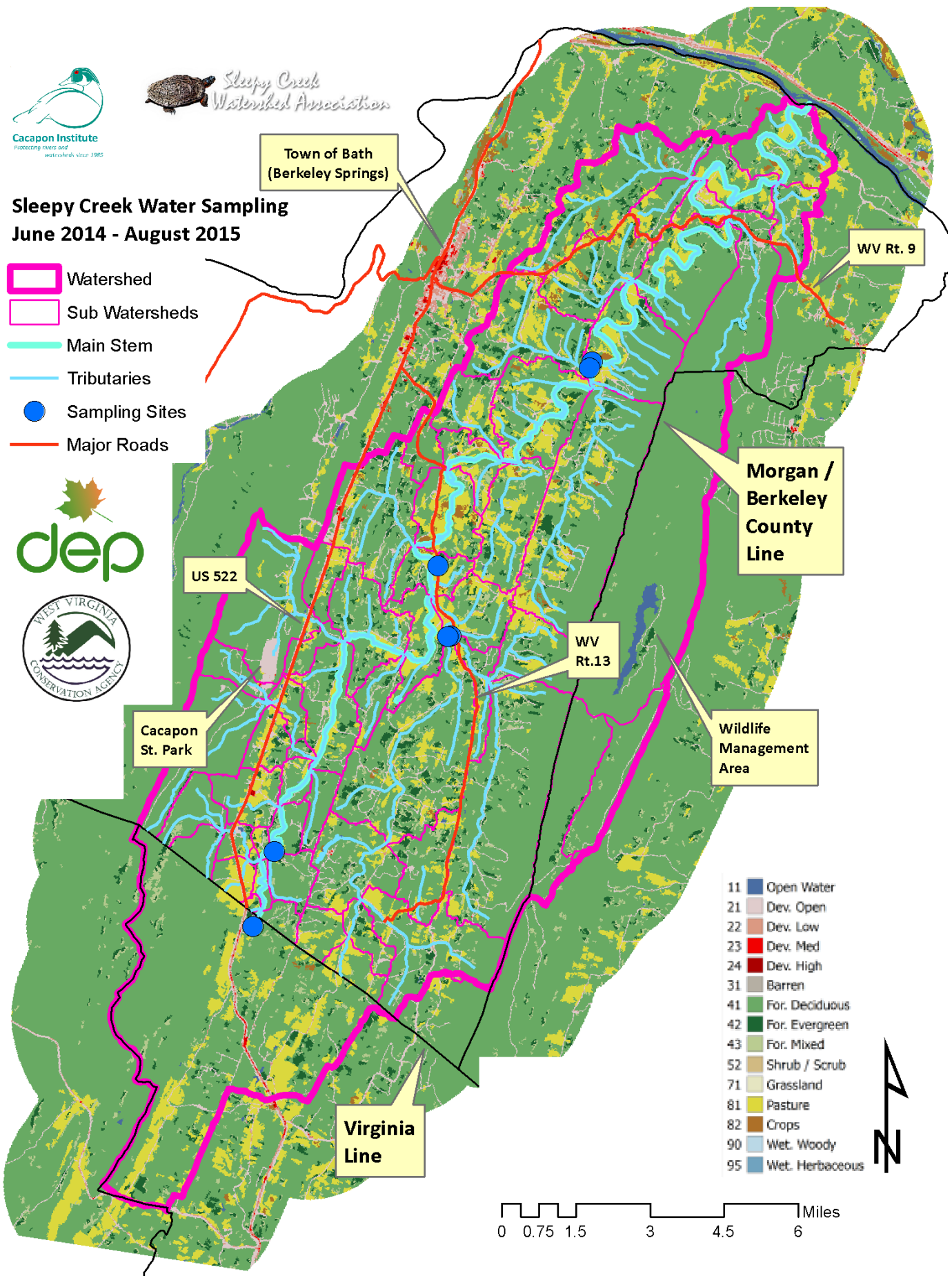
Sleepy Creek Watershed Association. www.sleepycreekwatershed.org

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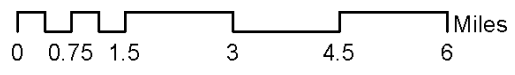


Sleepy Creek Water Sampling June 2014 - August 2015

- Watershed
- Sub Watersheds
- Main Stem
- Tributaries
- Sampling Sites
- Major Roads



- 11 Open Water
- 21 Dev. Open
- 22 Dev. Low
- 23 Dev. Med
- 24 Dev. High
- 31 Barren
- 41 For. Deciduous
- 42 For. Evergreen
- 43 For. Mixed
- 52 Shrub / Scrub
- 71 Grassland
- 81 Pasture
- 82 Crops
- 90 Wet. Woody
- 95 Wet. Herbaceous



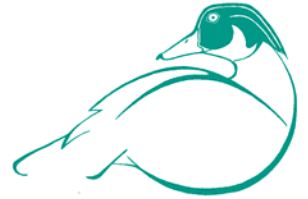
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**Sleepy Creek Watershed
i-Tree Vue Canopy Carbon Sequestration
ATTACHMENT to
Fecal Coliform Bacteria Monitoring for the
Sleepy Creek Watershed
319 Project Water Monitoring**

Prepared for: West Virginia Conservation Agency

Prepared by:

Cacapon Institute

Frank F. Rodgers, Executive Director

W. Neil Gillies, Director of Science

September 14, 2015

For the:



Sleepy Creek Watershed

Morgan County, WV

Landcover Analysis, i-Tree Vue

(Based on 2011 National Landcover Data)



To better inform the 2014-15 Sleepy Creek Fecal Coliform Bacteria Monitoring project Cacapon Institute used i-Tree Vue to assess the land cover of the watershed. Forest cover is the “gold standard” for watershed health so it was desirable to determine the areas of forest canopy coverage. This Attachment to the Fecal Coliform Bacteria study provides an analysis of landcover using the USDA Forest Service i-Tree Vue software. In the process of determining canopy cover i-Tree also provides an estimate, in broad terms, of the carbon sequestration and its monetary value.

i-Tree Vue is USDA Forest Service freeware that allow for use of National Land Cover Database (NLCD) satellite-based imagery to assess tree canopy and ecosystem services provided it. i-Tree Vue provides a broad estimate of tree canopy and associated air pollution removal, carbon storage, and annual carbon sequestration based on broad estimates of land cover and impervious cover for a study area, in this case the Sleepy Creek Watershed (including areas of Virginia). Estimates are based on 30 meter pixels from NLCD land cover data collected between 2006-2011. The carbon sequestration and monetary value of it are based on national averages. I-Tree is only intended for broad estimates and conclusions are, therefore, only broadly accurate based on national averages and the 30-meter NLCD.

Trees and their canopy are, in large part, made of carbon. In the process of growing, trees absorb and sequester carbon, i.e. they lock the carbon in their woody structure where it remains until the trees dies and decays. While the carbon in a tree will, eventually, be released again into the atmosphere it can remain lock as a solid for decades in the tree. In the case of long lived species, such as oak, the carbon can be held solid for more than a century. The sink of carbon sequestration in forests and wood products helps to mitigate climate change because it offsets sources of carbon dioxide in the atmosphere. In response to government, business, and individual commitments to reduce carbon dioxide emission, carbon is now a priced environmental commodity in the global marketplace. While the market is in its formative stages in the United States, the N.E. United States and Chesapeake Bay Watershed are leading areas in the development of the carbon market. In the near future there may be opportunities for communities (cities, counties, and states) to market the value of their forests capacity to sequester carbon and “sell” it on the carbon market. *More information is available at the USDA Forest Service: <http://www.fs.fed.us/ecosystems-services/carbon.shtml>

Land cover assessments for Jefferson and Berkeley County, the City of Martinsburg, and other i-Tree assessments, including an i-Tree Streets assessment for the Town of Bath and i-Tree studies for Warm Springs Watershed are available on Cacapon Institute’s website at: www.CacaponInstitute.Org/Forestry.htm

Information on the USDA Forest Service i-Tree at www.itreetools.org



Cacapon Institute
Protecting rivers and
watersheds since 1985



*Sleepy Creek
Watershed Association*

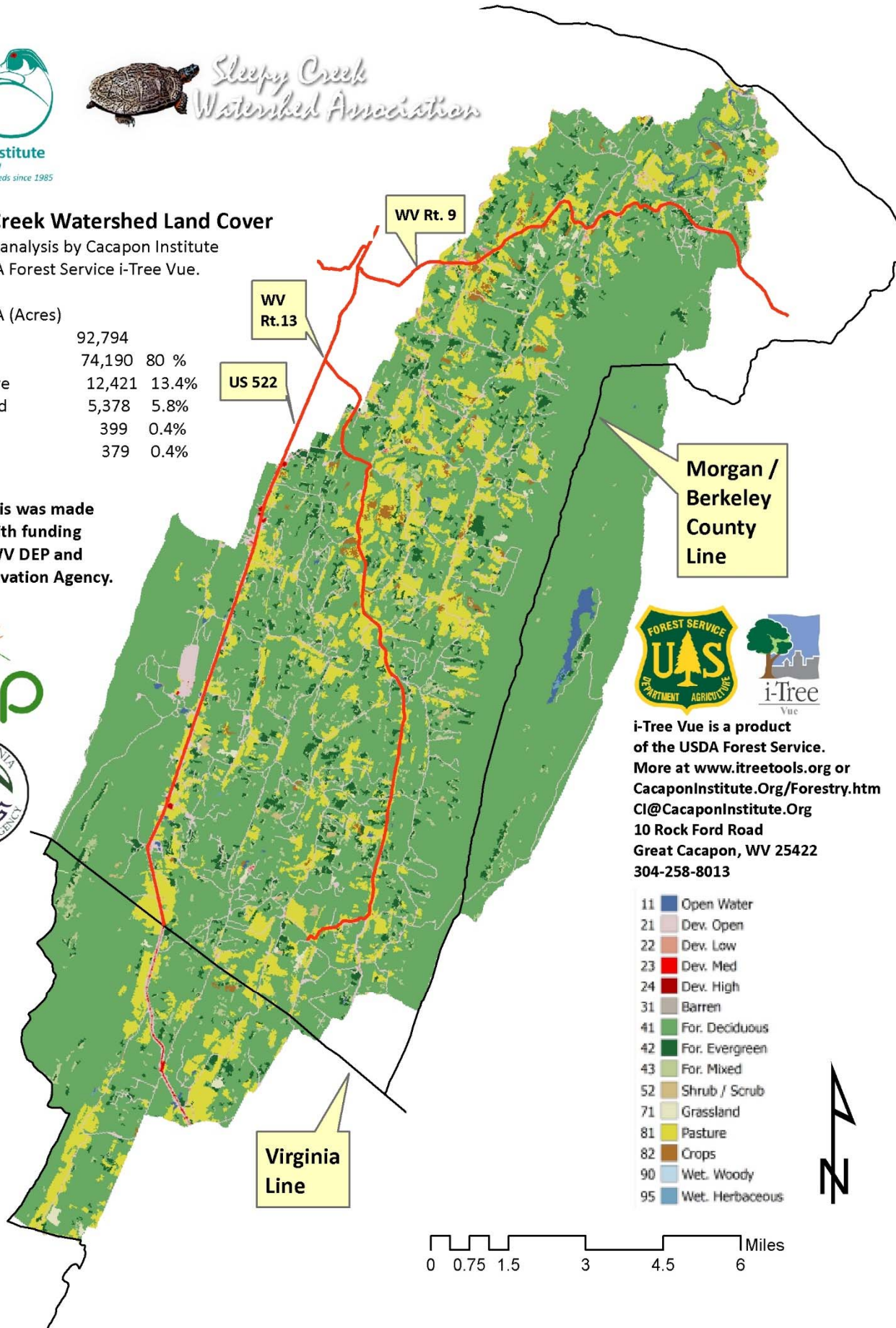
Sleepy Creek Watershed Land Cover

Landcover analysis by Cacapon Institute
using USDA Forest Service i-Tree Vue.

LAND AREA (Acres)

Total	92,794	
Forested	74,190	80 %
Agriculture	12,421	13.4%
Developed	5,378	5.8%
Water	399	0.4%
Other	379	0.4%

This analysis was made
possible with funding
from the WV DEP and
WV Conservation Agency.



**Morgan /
Berkeley
County
Line**

**WV
Rt. 13**

WV Rt. 9

US 522

**Virginia
Line**



i-Tree Vue is a product
of the USDA Forest Service.
More at www.itreetools.org or
CacaponInstitute.Org/Forestry.htm
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- 11 Open Water
- 21 Dev. Open
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- 52 Shrub / Scrub
- 71 Grassland
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- 90 Wet. Woody
- 95 Wet. Herbaceous

0 0.75 1.5 3 4.5 6 Miles



Sleepy Creek Watershed

Morgan County, WV

Landcover Analysis, i-Tree Vue

(Based on 2011 National Landcover Data)



Tree Canopy

More than just beauty and shade, trees work for us all every day to clean the air we breathe.

LAND COVER						
	Total Area		Impervious Area		Tree Canopy Area	
	acres	%	acres	%	acres	%
Entire Area	92794	100.0	445	0.5	85039	92.0
Developed, All Classes	5378	5.8	444	8.3	4247	79.0
Open Space	4688	5.1	216	4.6	3813	81.3
Low Intensity	603	0.6	173	28.8	382	63.3
Medium Intensity	76	0.1	46	60.4	46	61.1
High Intensity	11	0.0	10	87.8	7	61.0
Forested, All Classes	74190	80.0	1	0.0	72639	97.9
Deciduous	67650	72.9	0	0.0	66218	97.9
Evergreen	3259	3.5	0	0.0	3198	98.1
Mixed	3076	3.3	0	0.0	3031	98.6
Shrub/Scrub	206	0.2	0	0.0	192	93.1
Wetlands, All Classes	28	0.0	0	0.0	20	71.1
Agriculture, All Classes	12421	13.4	1	0.0	7759	62.5
Cultivated Crops	599	0.6	0	0.0	376	62.7
Pasture/Hay	11821	12.7	0	0.0	7383	62.5
Miscellaneous, All Classes	379	0.4	0	0.0	373	98.5
Grassland/Herbaceous	379	0.4	0	0.0	373	98.5
Water	399	0.4	n/a	n/a	n/a	n/a

Estimates generated by Cacapon Institute with i-Tree Vue for tree canopy only. For more information, visit www.CacaponInstitute.Org/Forestry.htm or www.itreetools.org.



This analysis was made possible by the WV DEP and WV Conservation Agency.

Sleepy Creek Watershed

Morgan County, WV

Carbon Sequestration, i-Tree Vue

(Based on 2011 National Landcover Data)



Tree Canopy Ecosystem Services Benefits				
Pollution Removal: Total Carbon Storage				
CARBON DIOXIDE				
	Annual Sequestration		Total Storage	
	CO2 stored each year		total accumulated CO2	
	short tons	\$	short tons	\$
Entire Area	417,207	\$8,104,467	13,239,367	\$257,181,759
Developed, All Classes	20,838	\$404,783	661,249	\$12,845,106
Open Space	18,705	\$363,353	593,569	\$11,530,385
Low Intensity	1,873	\$36,393	59,451	\$1,154,861
Medium Intensity	227	\$4,404	7,195	\$139,757
High Intensity	33	\$634	1,035	\$20,104
Forested, All Classes	356,372	\$6,922,725	11,308,886	\$219,681,124
Deciduous	324,871	\$6,310,790	10,309,236	\$200,262,399
Evergreen	15,690	\$304,778	497,882	\$9,671,620
Mixed	14,872	\$288,905	471,951	\$9,167,906
Shrub/Scrub	940	\$18,252	29,816	\$579,199
Wetlands, All Classes	98	\$1,899	3,102	\$60,264
Woody Wetlands	22	\$424	693	\$13,452
Emergent Herbaceous W	76	\$1,475	2,410	\$46,812
Agriculture, All Classes	38,068	\$739,482	1,208,009	\$23,466,226
Crops	1,844	\$35,826	58,525	\$1,136,882
Pasture/Hay	36,223	\$703,656	1,149,484	\$22,329,343
Miscellaneous, All Classes	1,832	\$35,579	58,121	\$1,129,040
Grassland/Herbaceous	1,832	\$35,579	58,121	\$1,129,040

Estimates generated by Cacapon Institute with i-Tree Vue for tree canopy only. For more information, visit www.CacaponInstitute.Org/Forestry.htm or www.itreetools.org.



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