APPENDICES

Appendix A Site Maps

Figure A-1. Map of all 16 project site locations.

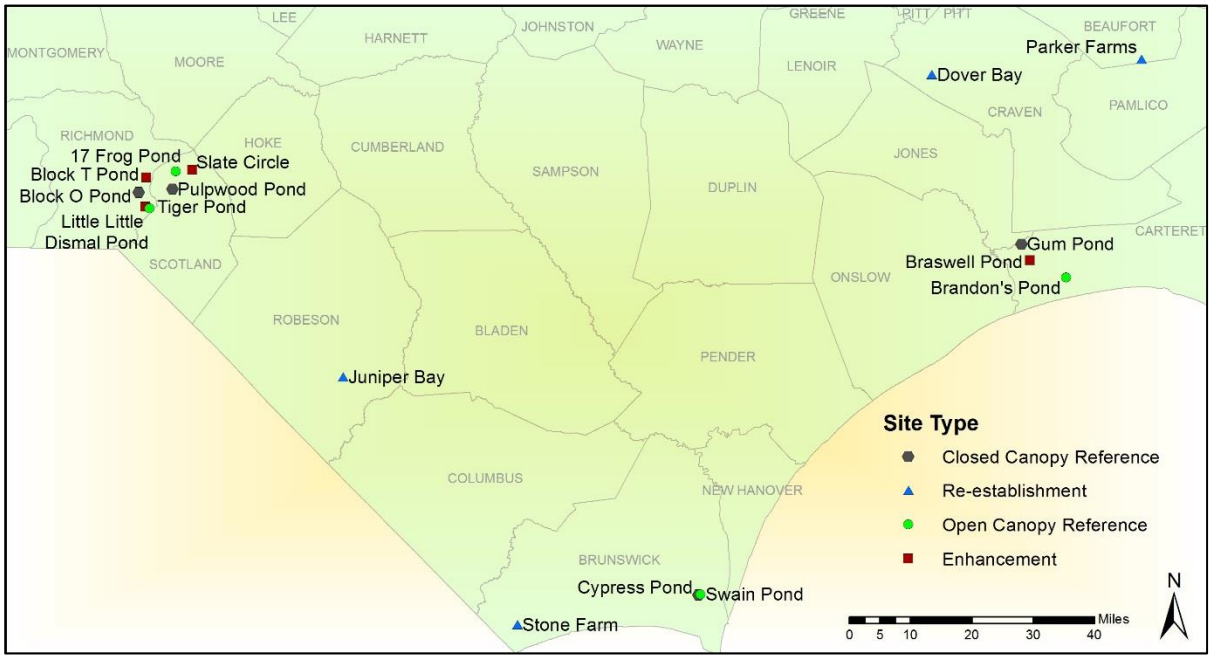


Figure A-2. Topographic map of Block O Pond – closed canopy reference site.

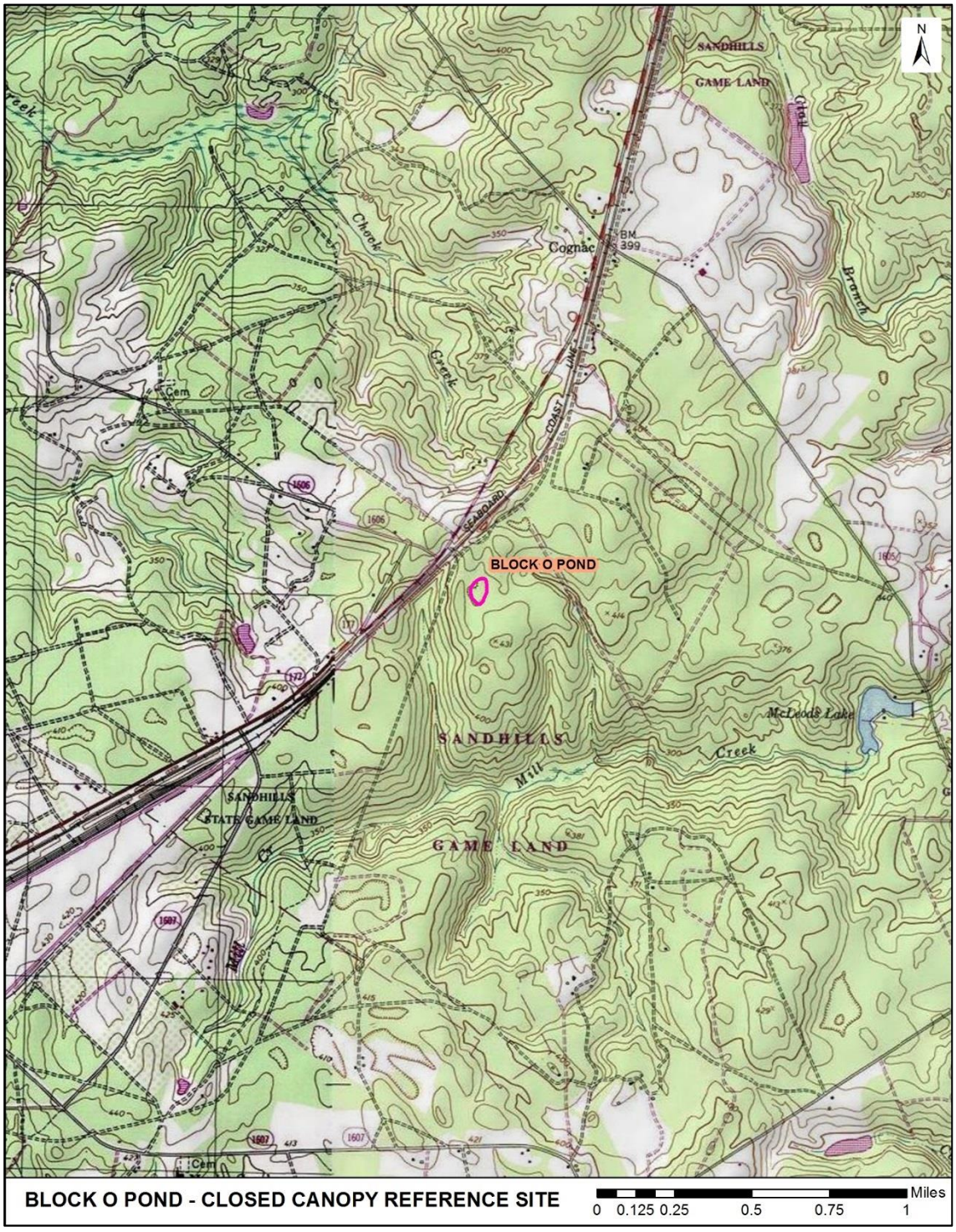


Figure A-3. Topographic map of Cypress Pond – closed canopy reference site.

Figure A-4. Topographic map of Gum Pond – closed canopy reference site.

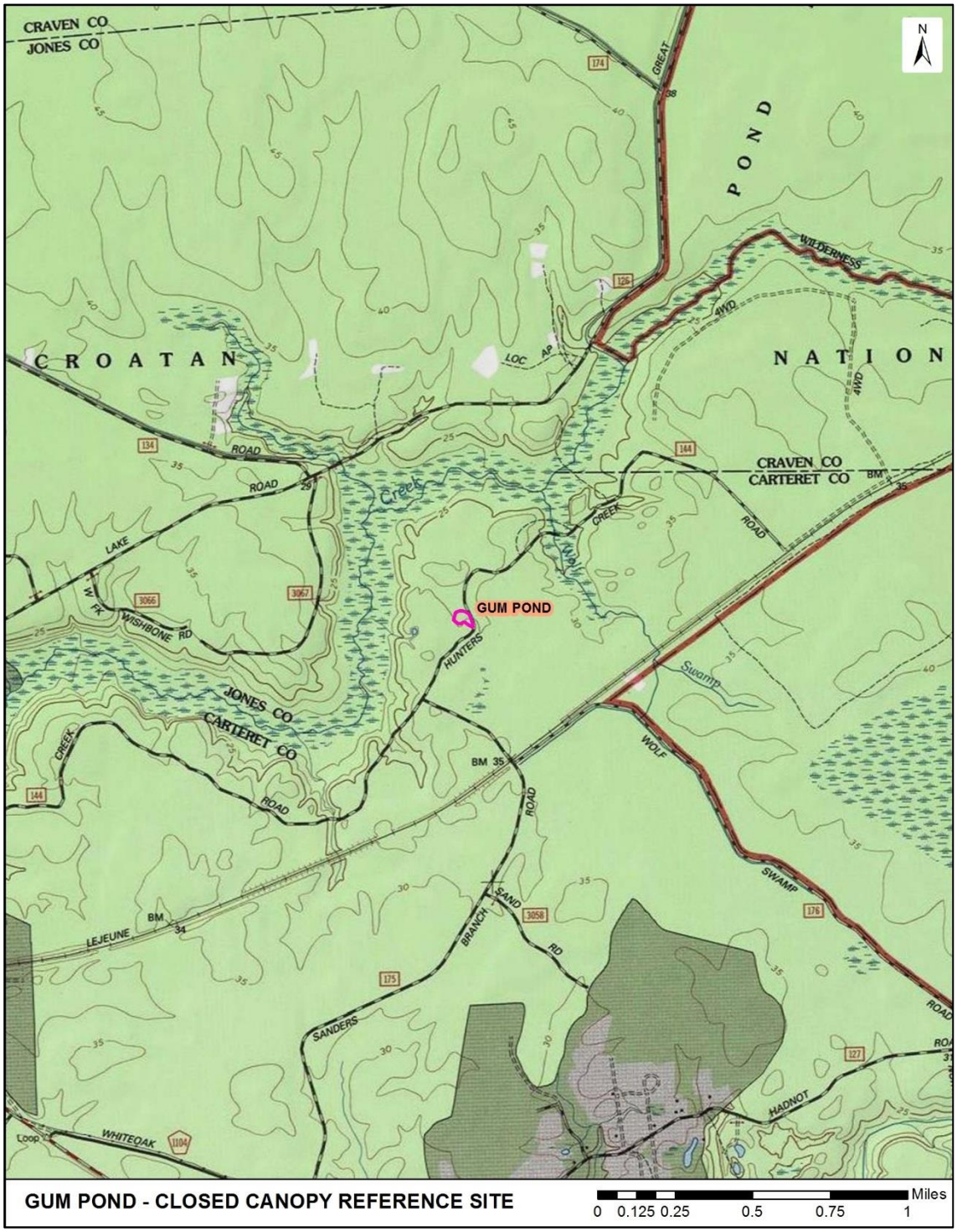


Figure A-5. Topographic map of Pulpwood Pond – closed canopy reference site.

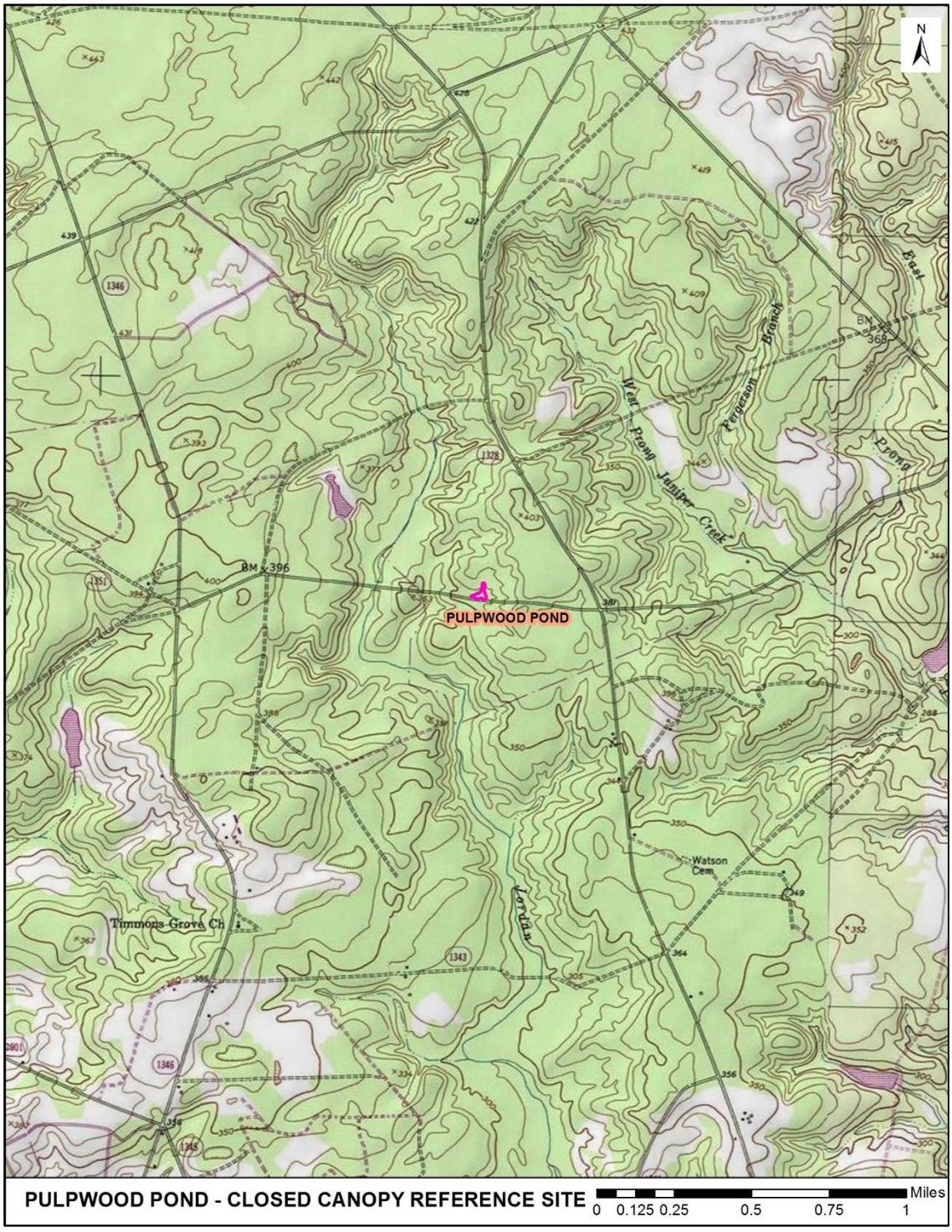


Figure A-6. Topographic map of Dover Bay – wetland re-establishment site.

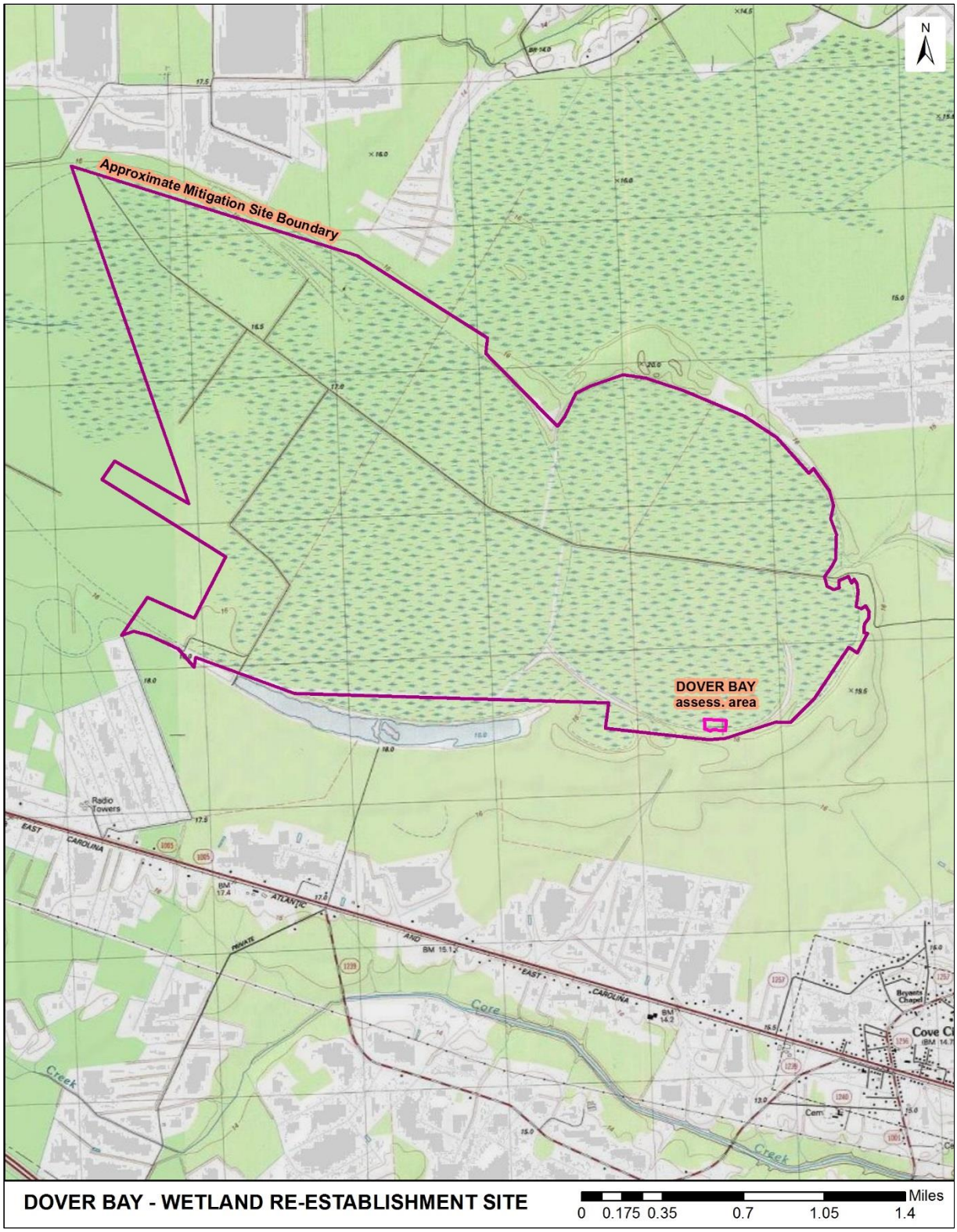


Figure A-7. Topographic map of Juniper Bay – wetland re-establishment site.

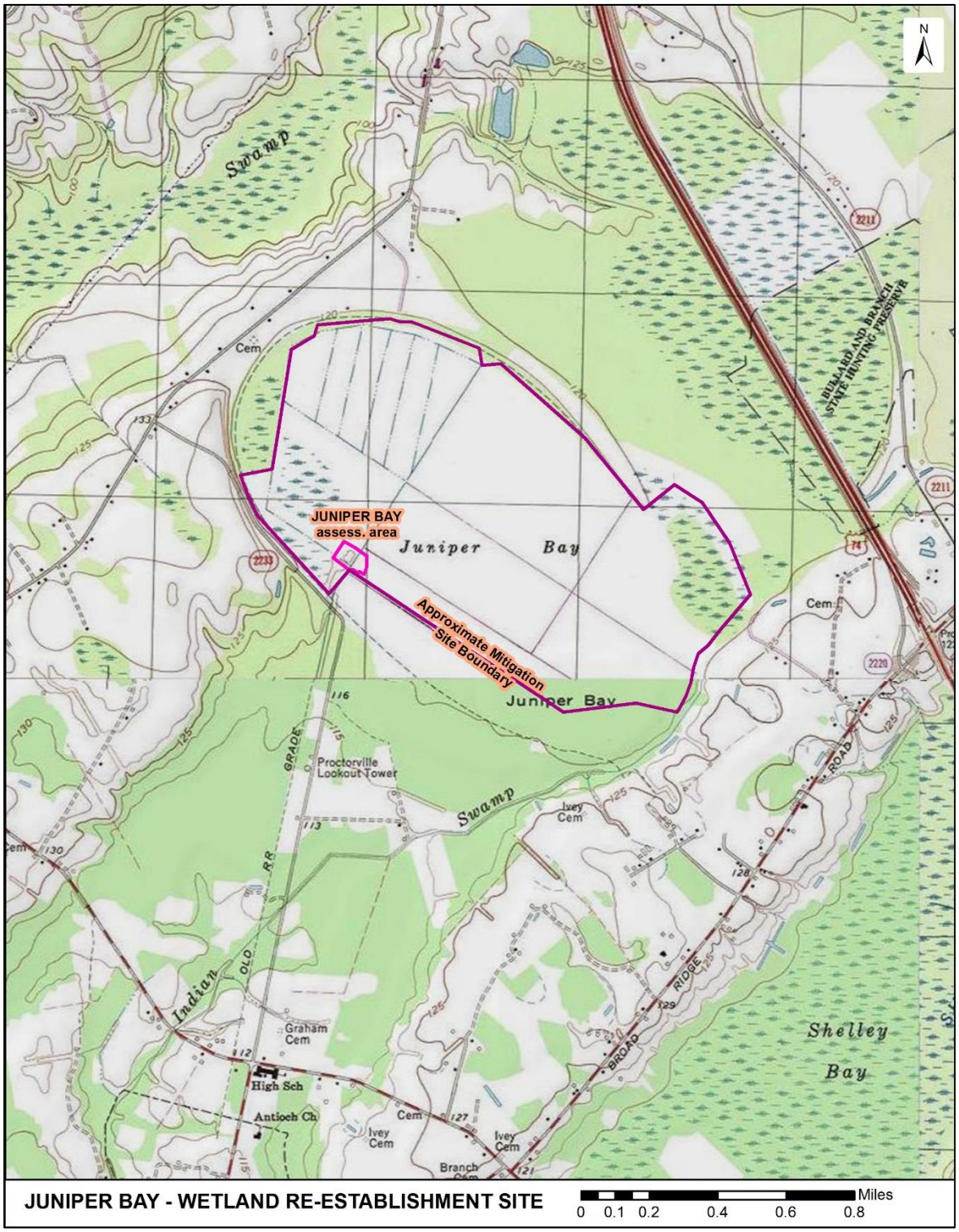


Figure A-8. Topographic map of Parker Farms site – wetland re-establishment site.

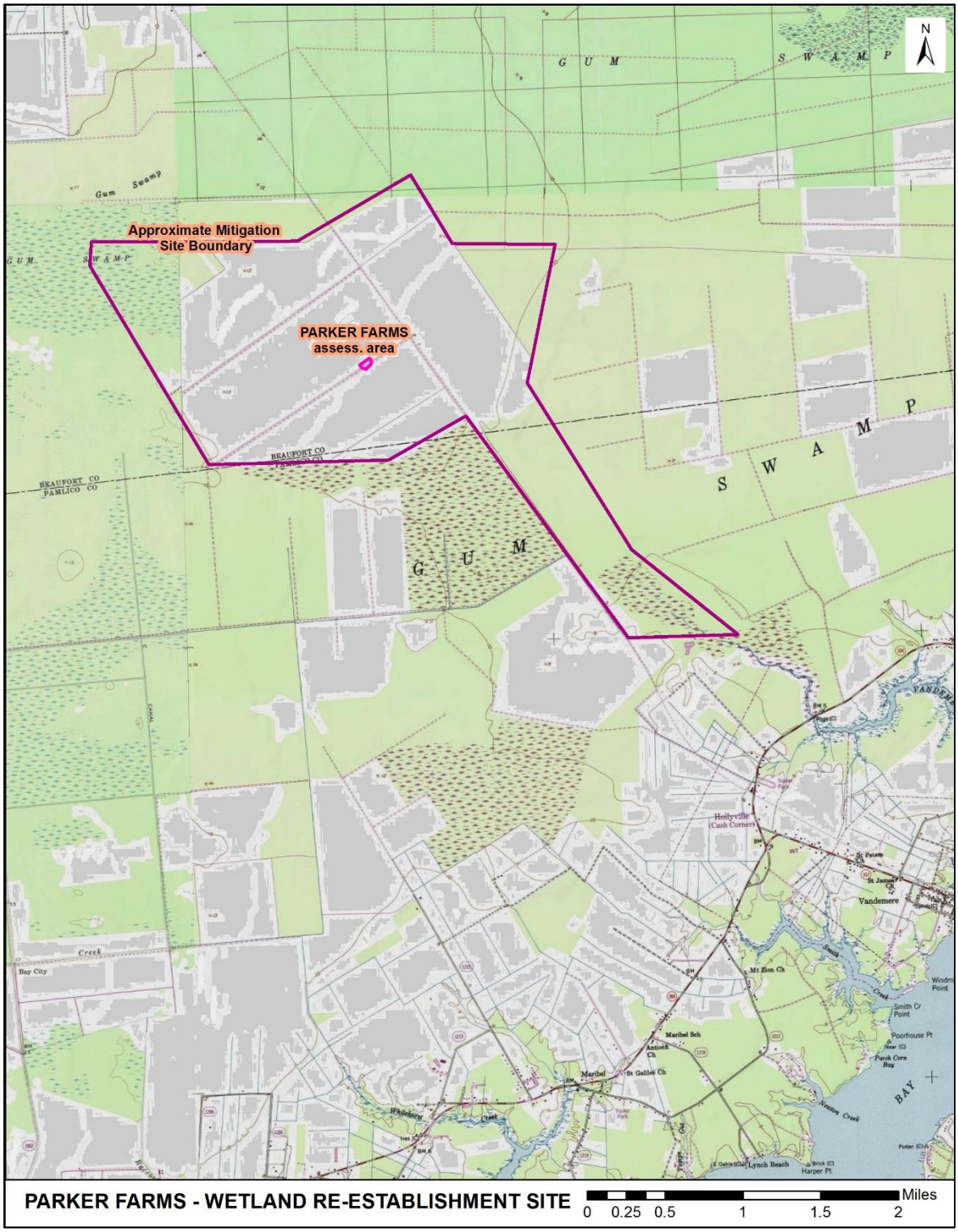


Figure A-9. Topographic map of Stone Farm site – wetland re-establishment site.

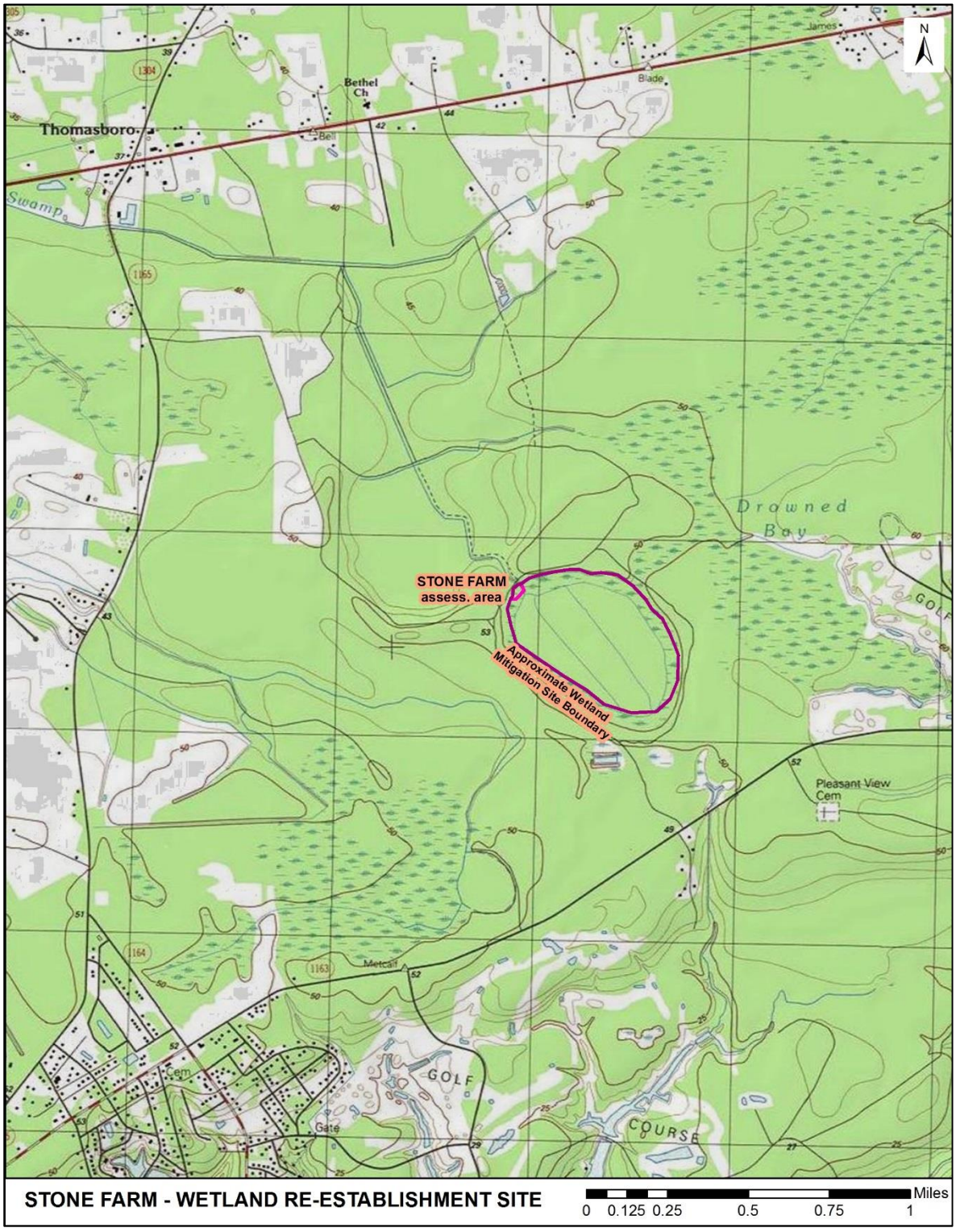


Figure A-10. Topographic map of 17 Frog Pond – open canopy reference site.

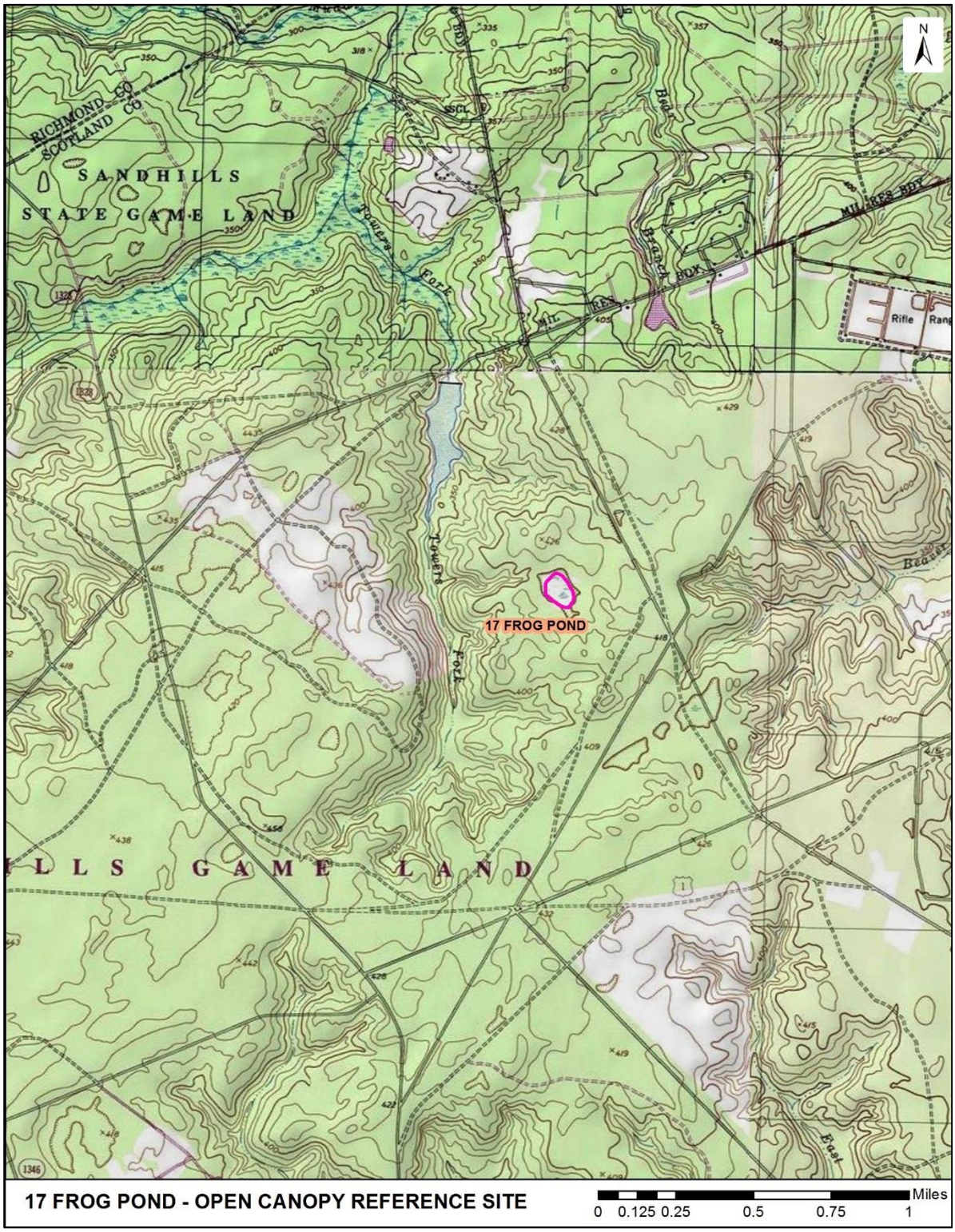


Figure A-11. Topographic map of Brandon's Pond – open canopy reference site.

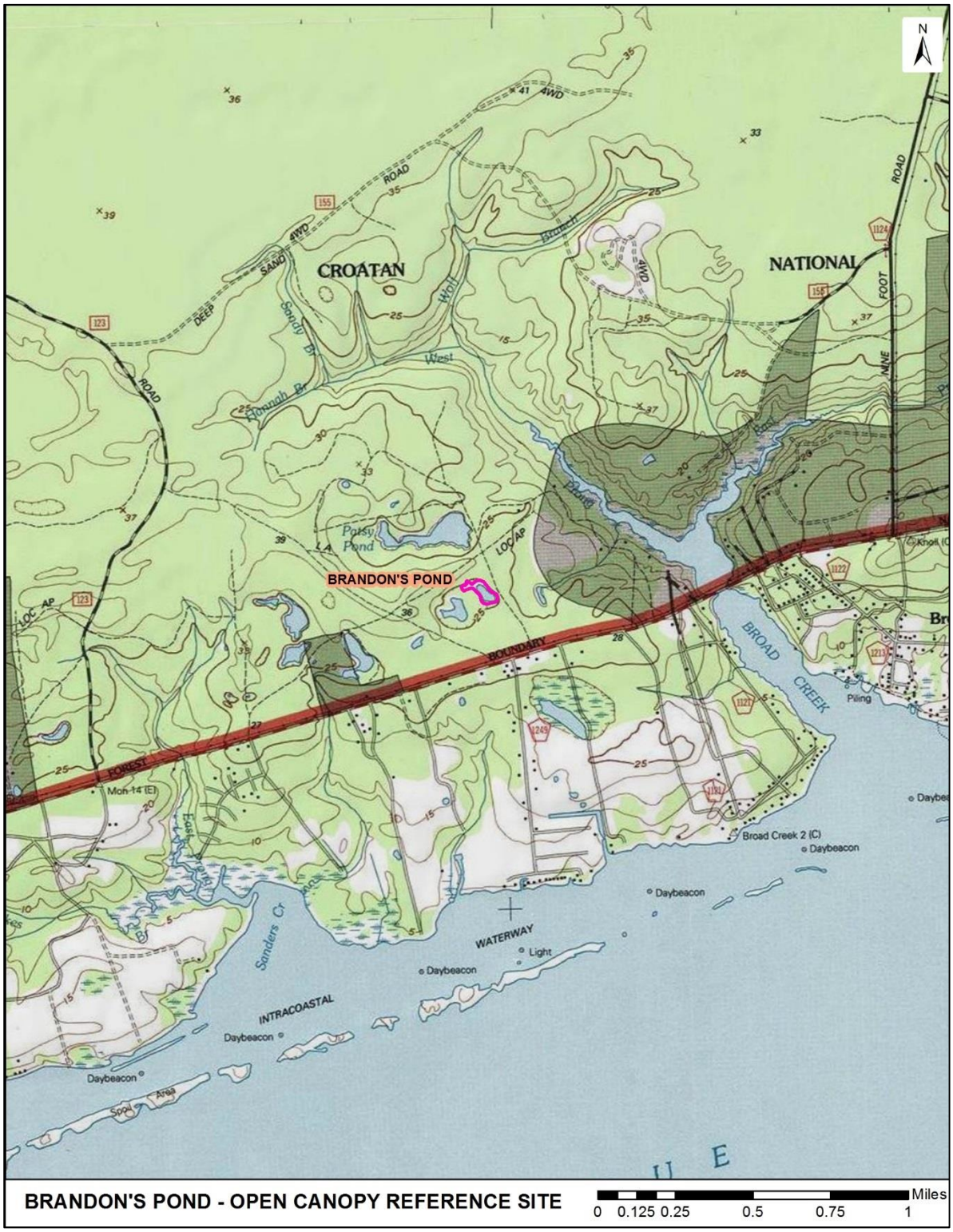


Figure A-12. Topographic map of Swain Pond – open canopy reference site.

Figure A-13. Topographic map of Tiger Pond – open canopy reference site.

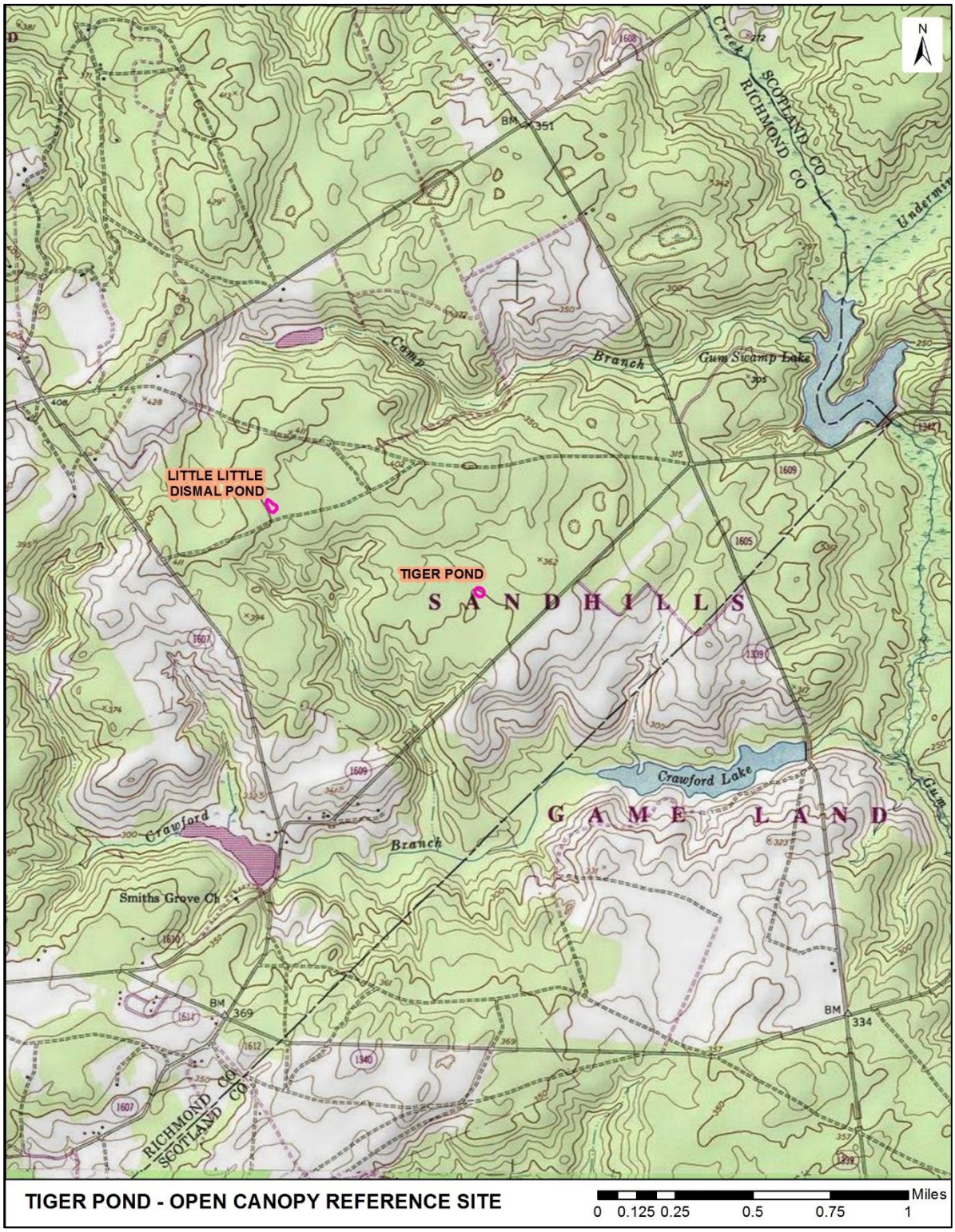


Figure A-14. Topographic map of Block T Pond – enhancement site.

Figure A-15. Topographic map of Braswell Ponds – enhancement site.

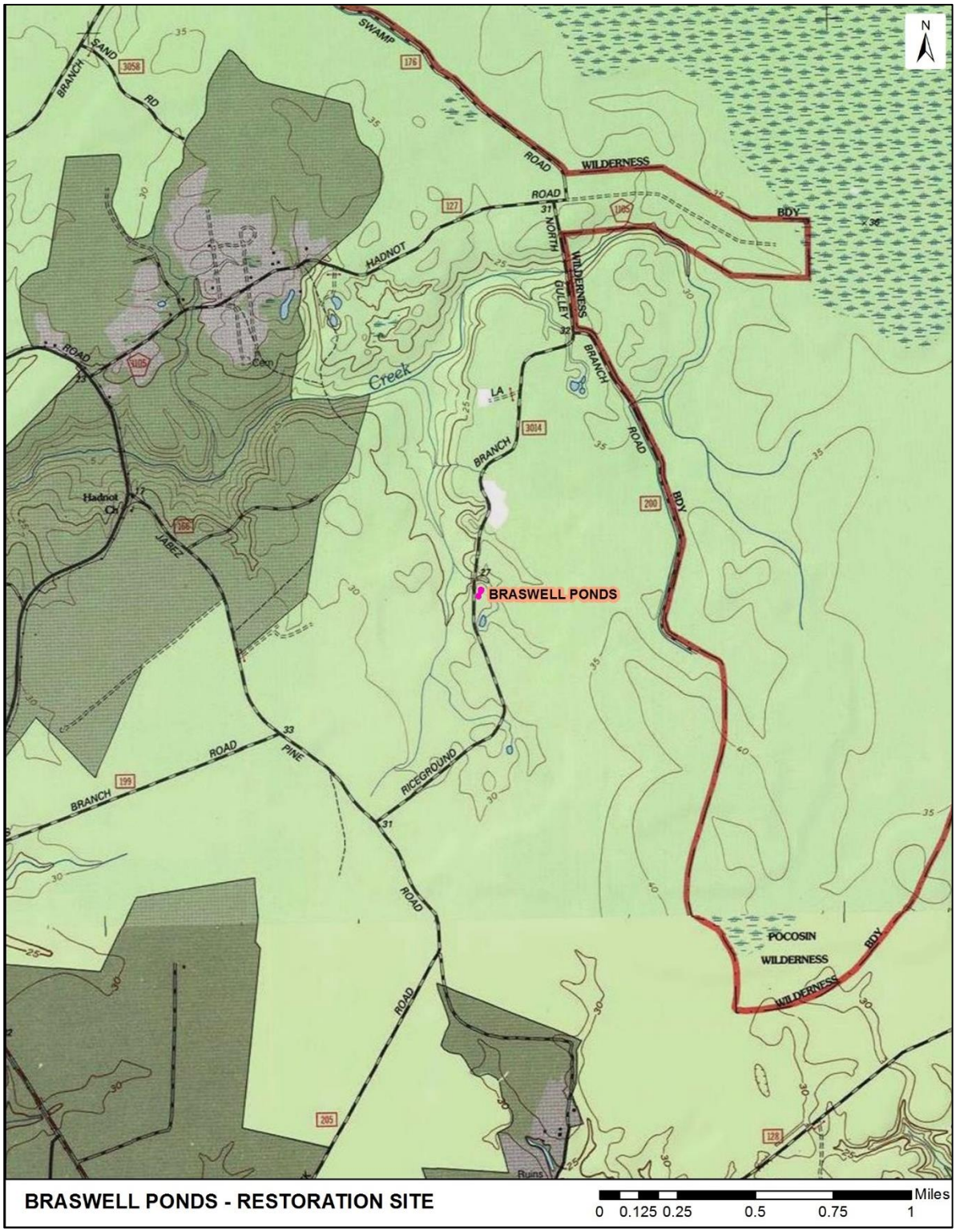


Figure A-16. Topographic map of Little Little Dismal Pond – enhancement site.

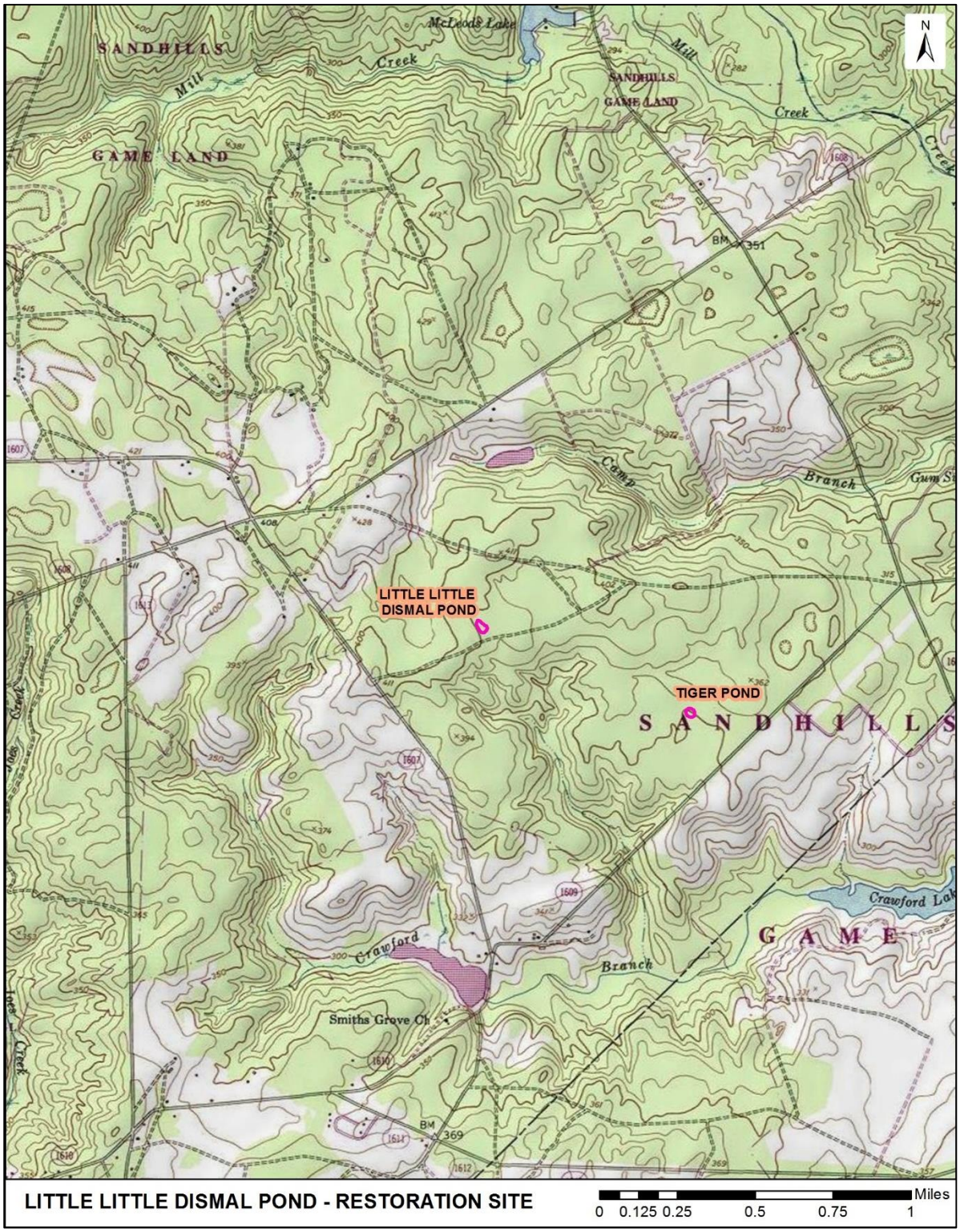
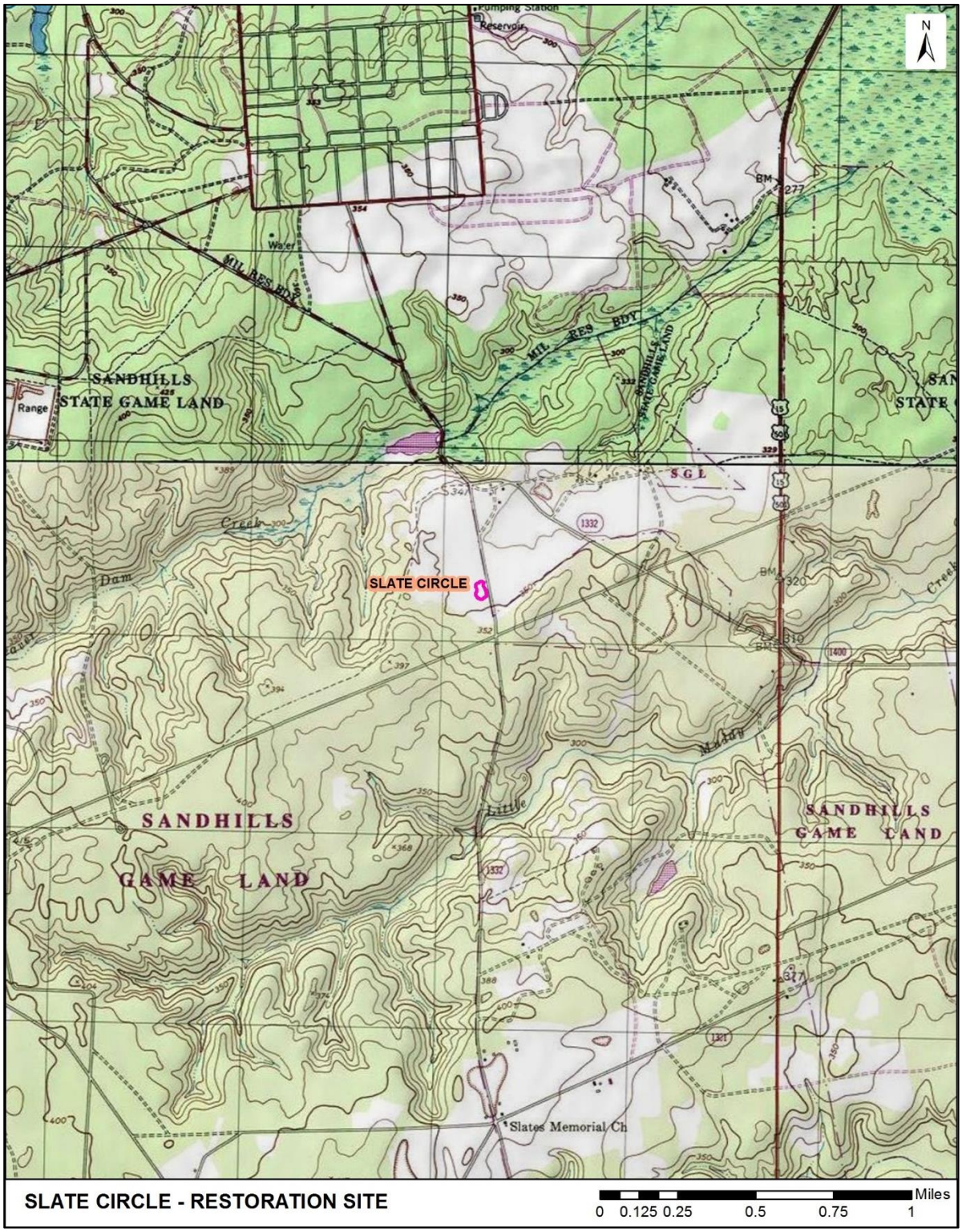


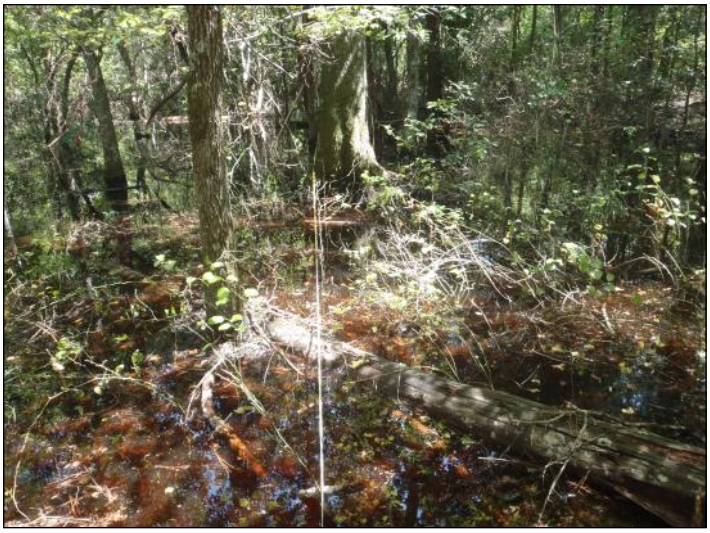
Figure A-17. Topographic map of Slate Circle – enhancement site.



Appendix B Site Photographs

Block O Pond - Closed Canopy Reference Site

January 2013



July 2013: first vegetation survey looking southwest

February 2014

July 2014: well data download

March 2015

June 2015: last vegetation survey looking northeast

Cypress Pond – Closed Canopy Reference Site

April 2013

July 2013: first vegetation survey looking southwest

July 2014

December 2014

July 2015: last vegetation survey looking southwest

November 2015: wellhead barely visible in center

Gum Pond – Closed Canopy Reference Site

April 2013: macroinvertebrate sampling

July 2014

August 2013: first vegetation survey looking northwest

December 2014: water quality station

May 2015: last vegetation survey looking northwest

December 2015: site decommissioning looking southeast

Pulpwood Pond – Closed Canopy Reference Site

April 2013

August 2013: full vegetation survey looking south

February 2014: northwest towards wellhead

July 2014

July 2015: last vegetation survey looking south

October 2015: water quality station

Dover Bay – Re-establishment Site - Re-established 1997

April 2013: macroinvertebrate sampling

July 2013: first vegetation survey looking west

July 2014

December 2014

July 2015: last vegetation survey looking west

October 2015: looking west

Juniper Bay – Re-establishment Site - Re-established 2005

January 2013

July 2013: first vegetation survey looking northwest

February 2014

March 2015

July 2015: last vegetation survey looking northwest

October 2015

Parker Farms – Re-establishment Site - Re-established mid-1990s

January 2013: looking east across center of site

July 2013: full vegetation survey looking southwest

December 2014: north transect looking northeast

March 2015: north transect looking northeast

July 2015: last vegetation survey looking southwest

October 2015: north transect looking southwest

Stone Farm – Re-establishment Site - Re-established 2012

April 2013

August 2013: first vegetation survey looking southeast

July 2014

December 2014

July 2015: last vegetation survey looking northwest

October 2015

17 Frog Pond - Open Canopy Reference Site

March 2013

July 2013: first full vegetation survey

February 2014

November 2014

May 2015 - last vegetation survey

Brandon's Pond – Open Canopy Reference Site

January 2013

April 2013: macroinvertebrate sampling

August 2013: first vegetation survey looking north

July 2014

December 2014

May 2015: last vegetation survey looking south

Swain Pond – Open Canopy Reference Site

April 2013

August 2013: first vegetation survey looking north

July 2014: looking south

December 2014

July 2015: last vegetation survey looking northeast

October 2015: wellhead submerged by hurricane Joaquin

Tiger Pond – Open Canopy Reference Site

January 2013

April 2013: only surface water on site

August 2013: first vegetation survey looking northwest

August 2013: looking southeast

February 2014

June 2015: last vegetation survey looking northwest

Block T Pond – WRC Enhancement Site

September 2009: pre-enhancement

December 2011: clearcut and burned

August 2012

April 2013: macroinvertebrate sampling

July 2013: first vegetation survey; looking northwest

July 2015: last vegetation survey; looking northeast

Braswell Ponds - WRC Enhancement Site

November 2010: south pond before enhancement

November 2010: north pond before enhancement

July 2011: north pond after enhancement (clearcut)

April 2013: macroinvertebrate sampling, north pond

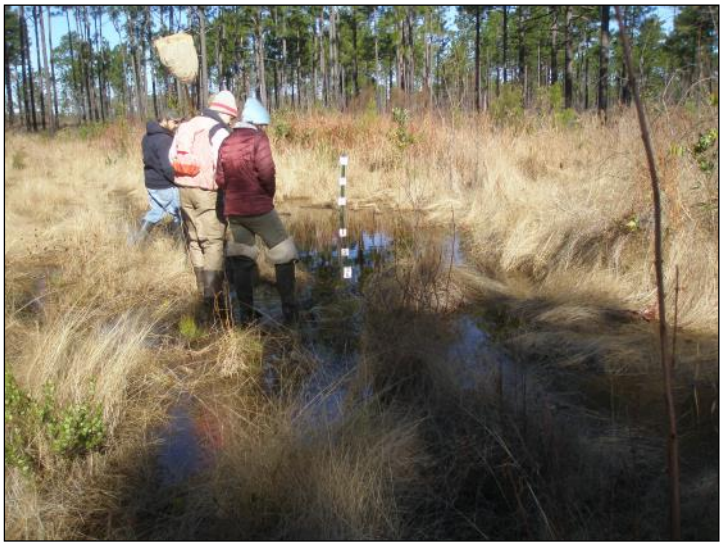
August 2013: first vegetation survey looking south

May 2015: last vegetation survey looking north

Little Little Dismal Pond - WRC Enhancement Site

2009: Before enhancement

2010: after enhancement



January 2013

August 2013: first vegetation survey looking north

February 2014: well-data download

June 2015: last vegetation survey looking north

Slate Circle Pond - WRC Enhancement Site

September 2009: beginning of enhancement

February 2010: after mechanical enhancement

May 2012: after prescribed burning

July 2013: first vegetation survey looking south

July 2014: well-data download, looking south

June 2015: last vegetation survey looking south

Appendix C Data Collection Forms

Coverage Classes are defined as -

Trace (T)- 1-2 individuals only or < 0.25m^2, >Trace - 1m^2, >1m^2-2m^2, >2m^2-5m^2, >5m^2-10m^2, >10m^2-25m^2, >25m^2-50m^2, >50m^2-75m^2, >75m^2-95m^2, >95m^2-100m^2

Record the range of the size class, and "0" for all zero coverages

PLOT NUMBER										
PLOT SIZE (Total size =)										
Ground Surface Attributes and Woody Debris / Snags										
1.Total exact cover of Water (% of veg plot with water = a+b+c+d ≥ 100%)										
a. Exact % of veg plot with water and no veg										
b. Exact % of veg plot with water, SAVs, floating aquatics, moss or algae										
c. Exact % of veg plot with water and vascular herbaceous emergents										
d. Exact % of veg plot with water and emergent woody vegetation										
2. Exposed Soil or Sediment										
3. Gravel 2 mm - 25 mm										
4. Rocks > 25 mm										
5. Litter broad leaf / pine needle (attached or detached dead herbaceous matter).	/	/	/	/	/	/	/	/	/	/
6. Dead woody debris < 5cm dbh										
7. Dead woody debris ≥ 5 cm dbh										
8. Standing dead woody shrubs or saplings < 5 cm dbh										
9. Standing dead snags ≥ 5 cm dbh										

Draw a diagram of the site. Indicate whether the survey layout used 10m x 10m plots, 10m x 5m half plots, or 5m wide belt transects. Label veg plot and buffer number and flagging and GPS locations. Put in North Arrow. Also draw in boundary of wetland / survey area and approximate location of buffer plots. Record pic numbers, camera, and an arrow indicating direction picture was taken. Draw/Indicate any other land features useful for relocating the survey (e.g. dirt roads, buffer features etc).

In the surrounding buffer for each site, survey 5 to 10 $10m^2$ plots for the vegetation categories listed below. Plots should be spread out approximately evenly around the wetland boundary or wetland survey area boundary. Flag center of plot with plot #, draw and label plots on Site Diagram Form. Use cover classes listed below to estimate cover of vegetation categories.
Cover Classes are defined as: Trace (T)- 1-2 individuals only or < $0.25m^2$, >Trace - $1m^2$, >$1m^2$-$2m^2$, >$2m^2$-$5m^2$, >$5m^2$-$10m^2$, >$10m^2$-$25m^2$, >$25m^2$-$50m^2$, >$50m^2$-$75m^2$, >$75m^2$-$95m^2$, >$95m^2$-$100m^2$

Record the range of the size class, and "0" for all zero coverages

PLOT NUMBER										
Coverage by Vegetation Category										
Herbaceouls vascular vegetation and matt forming mosses										
Shrubs and Saplings < 0.5m / ≥0.5-5m tall	/	/	/	/	/	/	/	/	/	/
Broadleaf trees ≥5 m tall										
Lianas, vines, and epiphytes										
Coniferous trees all sizes										

List the dominant site species and cover class for each herb, shrub, tree (including small trees), and vine/liana/epiphyte growth forms separately. Provide a Pseudoname and collection # for

Dominant Tree Species (≥ 10 % cover)	Cover	Coll#	Dominant Tree species (≥ 10 % cover)	Cover	Coll#
Dominant Shrub Species (≥ 10 % cover	Cover	Coll#	Dominant Shrub Species (≥ 10 % cover	Cover	Coll#
Dominant Vine/Liana/Epiphyte Species (≥ 10 % cover)	Cover	Coll#	Dominant Vine/Liana/Epiphyte Species (≥ 10 % cover)	Cover	Coll#
Dominant Herb Species (≥ 5 % cover)	Cover	Coll#	Dominant Herb Species (≥ 5 % cover)	Cover	Coll#

2. Record the pool depth along the center line of the 5 m wide belt transects or corners of plots. Indicate on plot diagram where each measurement was made.

3. Record the overall percent of the pool(s) with (1.) standing water and no vegetation, (2.) standing water and SAVs, moss/algae, (3.) standing water and emergent herbaceous vegatation, (4.) standing water and emergent woody vegetation.

1. GPS the Pool boundary and draw the Plot Layout Design and rough pool boundary. Label belt transect center line Depth Measurement Locations or plot corner Depth Measurements. Insert North Arrow and plot numbers.

2. Pool Depth Measurements in 10th of feet (Should correspond with Diagram)

Depth #	Veg Flag	Depth	Depth #	Veg Flag	Depth	Depth #	Veg Flag	Depth	Depth #	Veg Flag	Depth	Depth #	Veg Flag
Depth 1			Depth 5			Depth 9			Depth 13			Depth 17	
Depth 2			Depth 6			Depth 10			Depth 14			Depth 18	
Depth 3			Depth 7			Depth 11			Depth 15			Depth 19	
Depth 4			Depth 8			Depth 12			Depth 16			Depth 20	
Measurement Unit if NOT 10th of Feet:												Depth 21	

3. Pool Coverage = a + b + c + d

	Percent
Depth 10th/ft	
a. % of pool with standing water and no vegetation	
b. % of pool with standing water and SAVs,	
c. % of pool with standing water and emergent	
d. % of pool with standing water and emergent woody	

Appendix D Complete Macroinvertebrate Taxa Lists

Table D-1. Macroinvertebrate taxa found in closed canopy reference wetland sites, all sampling methods combined.

Closed Canopy Reference Sites	Total Frequency	Total Abundance
Amphipoda		
Crangonyctidae		
Crangonyx serratus	12	421
Crangonyx serricornis	1	12
Araneae		
Multiple Families		
Spider	3	3
Coleoptera		
Curculionidae		
Curculionidae	2	2
Dytiscidae		
Acilius mediatus	1	1
Acilius spp	1	1
Agabetes spp	1	1
Agabus stagninus	1	1
Bidessonotus spp	1	2
Copelatus spp	1	2
Hydroporus spp	2	8
Laccornis spp	1	1
Liodessus spp	1	1
Neoporus spp	4	40
Thermonectus basillaris	2	2
Thermonectus spp	1	1
Haliplidae		
Peltodytes spp	1	2
Helophoridae		
Helophorus spp	1	1
Hydrophilidae		
Derallus spp	1	1
Tropisternus collaris	1	1
Tropisternus spp	1	1
Multiple Families		
Terrestrial beetle	1	1
Terrestrial elmid-like beetle	2	3
Scirtidae		
Scirtes spp	2	3
Collembola		
Order Collembola	4	7
Diptera		
Ceratopogonidae		
Ceratopogonidae	1	2
Dasyhelea spp	3	5
Palpomyia spp	3	4
Chaoboridae		
Chaoborus punctipennis	2	212
Chaoborus spp	5	257
Mochlonyx cinctipes	1	2
Mochlonyx spp	2	4
Chironomidae		
Ablabesmyia mallochi	1	1
Ablabesmyia spp	1	1
Acamptocladius spp	1	9

Closed Canopy Reference Sites	Total Frequency	Total Abundance
Bryophaenocladius spp	1	2
Camptocladius spp	2	559
Chironomidae	1	3
Chironomini genus III	1	1
Chironomus cf. longipes	1	1
Chironomus ochreatus	1	1
Chironomus spp	14	214
Dicrotendipes modestus	1	2
Dicrotendipes nervosus	2	3
Goeldichironomus spp	1	2
Guttipelopia guttipennis	1	1
Gymnometriocnemus spp	1	2
Kiefferulus dux	8	27
Kiefferulus spp	3	26
Limnophyes spp	3	3
Nanocladius spp	1	1
Parachironomus chaetaolus	1	1
Parachironomus spp	1	1
Parachironomus tenuicaudatus	1	1
Polypedilum braseniae	1	1
Polypedilum illinoense gr	6	14
Polypedilum tritum	10	629
Procladius spp	3	13
Psectrocladius (Monopsectrocladius) spp	1	16
Psectrocladius flavus	2	11
Psectrocladius pilosus	2	5
Psectrocladius spp	1	1
Pseudosmittia spp	1	1
Smittia spp	5	25
Subfamily Chironominae	1	2
Culicidae		
Aedes spp	3	202
Anopheles spp	1	1
Culex spp	2	3
Culicidae	1	19
Orthopodomyia spp	1	1
Psorophora spp	1	12
Dolichopodidae		
Dolichopodidae	9	75
Empididae		
Empididae	2	3
Multiple Families		
Terrestrial orange maggot	1	4
Terrestrial white maggot	2	4
Muscidae		
Limnophora spp	1	1
Tiulidae		
Pseudolimnophila spp	1	2
Haplotaxida		
Enchytraeidae		
Enchytraeidae	2	4
Lumbriculidae		
Lumbriculidae	1	2
Tubificidae		
Aulodrilus pluriseta	1	1

Closed Canopy Reference Sites	Total Frequency	Total Abundance
Hemiptera		
Corixidae		
Corixidae	2	3
Sigara spp	4	14
Gerridae		
Gerridae	1	1
Notonectidae		
Buenoa spp	1	1
Notonecta spp	6	17
Hymenoptera		
Formicidae		
Ant	2	2
Isopoda		
Asellidae		
Asellus spp	4	51
Caecidotea spp	2	29
Multiple Families		
Terrestrial isopod	1	1
Lepidoptera		
Lepidoptera	2	2
Megaloptera		
Corydalidae		
Chauliodes rastricornis	1	1
Odonata		
Aeshnidae		
Anax longipes	1	1
Coenagrionidae		
Enallagma spp	1	1
Ischnura spp	3	4
Cordulegastridae		
Cordulegaster spp	1	4
Libellulidae		
Erythemis simplicicollis	2	5
Erythemis spp	1	1
Libellula incesta	1	3
Libellula spp	2	8
Pachydiplax longipennis	2	8
Tramea onusta	4	24
Tramea spp	2	5
Ostracoda		
Ostracod	8	395
Phylum Nematoda		
Nematode	6	74
Phylum Nemertea		
Nemertean ribbon worm	1	1
Subclass Copepoda		
Multiple Families		
Subclass Copepoda	4	1850
Trombidiformes		
Hydrachnidiae		
Hydracarina mite	1	2
Hygrobatidae		
Hygrobates spp	1	4
Tubificida		
Naididae		

Closed Canopy Reference Sites	Total Frequency	Total Abundance
Tubificidae with hair	2	4
Unknown		
Multiple Families		
Bristletail	1	1

Table D-2. Macroinvertebrate taxa found on re-establishment wetland sites, all sampling methods combined.

Re-establishment Sites	Total Frequency	Total Abundance
Amphipoda		
Crangonyctidae		
Crangonyx serratus	4	61
Crangonyx spp	21	584
Synurella spp	1	8
Araneae		
Spider	8	17
Basommatophora group		
Lymnaeidae		
Pseudosuccinea columella	5	34
Planorbidae		
Menetus dilatatus	4	180
Class Arachnida		
Pseudoscorpion	1	1
Class Diplopoda		
Millipede	1	4
Class Gastropoda		
Slug	1	2
Planorbidae		
Ferrissia spp	3	11
Menetus pedellus gr	1	1
Coleoptera		
Dytiscidae		
Agabetes spp	1	2
Agabus spp	9	102
Brachyvatus apicatus	1	1
Copelatus spp	2	6
Cybister spp	1	1
Dytiscidae	1	1
Hoperius planatus	2	2
Hydaticus bimarginatus	1	1
Hydaticus cinctipennis	1	2
Hydaticus spp	1	1
Hydroporus oblitus	1	1
Hydroporus spp	12	31
Ilybius spp	2	13

Re-establishment Sites	Total Frequency	Total Abundance
Laccophilus fasciatus	1	2
Laccophilus fasciatus rufus	1	1
Laccophilus gentolis	1	3
Laccophilus proximus	1	1
Laccophilus spp	2	2
Laccornis spp	3	9
Liodessus spp	1	2
Neoporus spp	4	17
Rhantus spp	3	9
Thermonectus basillaris	2	6
Thermonectus spp	3	11
Gyrinidae		
Dineutus spp	1	24
Gyrinus spp	1	1
Haliplidae		
Haliplus spp	1	3
Peltodytes spp	5	8
Hydrochidae		
Hydrochus spp	1	1
Hydrophilidae		
Berosus spp	11	51
Enochrus hamiltoni	1	7
Enochrus spp	1	1
Helocombus bifidus	1	1
Helocombus spp	1	4
Hydrochara spp	1	6
Phaenonotum spp	1	1
Sperchopsis tessellatus	1	1
Tropisternus spp	4	22
Multiple Families		
Terrestrial beetle	1	14
Noteridae		
Hydrocanthus atripennis	1	1
Hydrocanthus oblongus	1	3
Scirtidae		
Scirtes spp	1	1
Sphaeriusidae		
Sphaerius spp	1	1
Collembola		
Order Collembola	10	26
Decapoda		
Cambaridae		
Procambarus spp	9	25

Re-establishment Sites	Total Frequency	Total Abundance
Multiple Families		
Crayfish	1	1
Diplostraca		
Daphniidae		
Daphnia spp	4	36
Diptera		
Ceratopogonidae		
Bezzia/Palpomyia complex spp	14	40
Dasyhelea spp	4	19
Palpomyia spp	3	28
Chaoboridae		
Chaoborus punctipennis	2	2
Chaoborus spp	1	8
Mochlonyx spp	1	1
Chironomidae		
Ablabesmyia aspera	2	2
Ablabesmyia hauberi	1	7
Ablabesmyia idei	1	20
Ablabesmyia illinoense	1	3
Ablabesmyia janta	6	29
Ablabesmyia mallochi	2	16
Ablabesmyia parajanta group	3	11
Ablabesmyia peleensis	3	11
Ablabesmyia rhamphe gr	1	4
Camptocladius spp	1	1
Chaetocladius spp	1	1
Chironomus spp	21	491
Cladopelma spp	3	14
Cladotanytarsus spp	1	1
Clinotanypus spp	6	24
Conchapelopia spp	4	6
Constempellina brevicosta	1	1
Corynoneura spp	3	29
Cryptotendipes spp	2	29
Dicrotendipes leucoscelis	1	2
Dicrotendipes modestus	10	59
Dicrotendipes nemodeitus	1	2
Dicrotendipes nervosus	8	28
Endochironomus nigricans	1	9
Glyptotendipes spp	1	1
Guttipelopia guttipennis	6	38
Gymnometriocnemus spp	4	4
Hydrobaenus spp	1	1

Re-establishment Sites	Total Frequency	Total Abundance
Kiefferulus dux	7	37
Kiefferulus spp	2	7
Larsia spp	6	40
Limnophyes spp	7	22
Mesosmittia spp	2	4
Metriocnemus fuscipes	1	2
Nanocladius alternantherae	1	3
Nanocladius spp	1	1
Natarsia spp	3	22
Omisus spp	1	1
Parachironomus chaetaolus	3	14
Parachironomus spp	1	1
Parametriocnemus spp	1	1
Parasmittia spp	1	1
Paratanytarsus laccophilus	1	7
Paratanytarsus spp	4	36
Paratendipes subaequalis	1	3
Phaenopsectra spp	1	1
Polypedilum halterale gr	6	66
Polypedilum illinoense gr	16	143
Polypedilum tritum	16	403
Procladius spp	14	191
Psectrocladius (Monopsectrocladius) spp	7	41
Psectrocladius elatus	9	73
Psectrocladius flavus	5	130
Psectrocladius pilosus	3	204
Psectrocladius psilopterus	2	28
Psectrocladius psilopterus sp3	1	1
Psectrocladius sordidellus	1	1
Pseudochironomus spp	2	15
Pseudosmittia spp	3	5
Sublettea coffmani	2	5
Tanypus carinatus	2	113
Tanypus spp	9	325
Tanytarsus sp 1	3	9
Tanytarsus sp 15	1	1
Tanytarsus sp 2	1	1
Tanytarsus sp 3	2	7
Tanytarsus sp G	3	63
Tanytarsus sp V	1	10
Tanytarsus spp	1	1
Tribelos spp	1	1
Zalutschia sp A	1	1

Re-establishment Sites	Total Frequency	Total Abundance
Zavreliella marmorata	2	3
Culicidae		
Anopheles spp	3	4
Culex spp	1	3
Culicidae	1	1
Mosquitoe	2	8
Psorophora spp	2	3
Dolichopodidae		
Dolichopodidae	9	30
Limoniidae		
Limonia spp	2	3
Ormosia spp	4	11
Multiple Families		
Midge pupae	3	22
Terrestrial white maggot	2	2
Muscidae		
Limnophora spp	1	2
Syrphidae		
Neoascia spp	1	1
Tabanidae		
Chrysops spp	8	15
Tipulidae		
Hexatoma spp	1	3
Unknown Family		
Fly	1	1
Ephemeroptera		
Baetidae		
Baetidae (fragmented)	1	1
Callibaetis spp	3	20
Centroptilum spp	1	5
Caenidae		
Caenis spp	8	238
Haplotaxida		
Enchytraeidae		
Enchytraeidae	2	2
Lumbriculidae		
Lumbriculidae	7	12
Naididae		
Limnodrilus hoffmeisteri	3	89
Nais spp	3	47
Hemiptera		
Belostomatidae		
Belostoma spp	4	4

Re-establishment Sites	Total Frequency	Total Abundance
Corixidae		
Sigara spp	12	21
Trichocorixa spp	1	1
Naucoridae		
Pelocoris spp	3	7
Nepidae		
Ranatra spp	1	1
Notonectidae		
Notonecta spp	3	6
Hymenoptera		
Formicidae		
Ant	3	8
Isopoda		
Asellidae		
Asellus spp	14	827
Caecidotea spp	3	156
Lepidoptera		
Crambidae		
Paraponyx spp	1	3
Erebidae		
Spilosoma virginica	1	1
Multiple Families		
Lepidoptera	5	6
Pyralidae		
Pyralidae	3	19
Odonata		
Coenagrionidae		
Enallagma spp	10	144
Ischnura spp	7	35
Corduliidae		
Epitheca costalis	2	4
Lestidae		
Lestes spp	5	8
Libellulidae		
Celithemis spp	3	8
Erythemis simplicicollis	2	5
Erythemis spp	2	6
Ladona spp	2	2
Libellula luciosa	1	3
Libellula spp	5	8
Libellulidae	1	1
Pachydiplax longipennis	11	76
Sympetrum spp	3	3

Re-establishment Sites	Total Frequency	Total Abundance
Tramea spp	1	1
Ostracoda		
Multiple Families		
Ostracod	23	1011
Phylum Nematoda		
Multiple Families		
Nematode	1	1
Rhynchobdellida		
Glossiphoniidae		
Helobdella fusca	1	1
Subclass Copepoda		
Multiple Families		
Subclass Copepoda	2	15
Trichoptera		
Hydropsychidae		
Hydropsychidae	1	1
Hydroptilidae		
Hydroptilid caddisfly	3	16
Orthotrichia spp	2	2
Oxyethira spp	4	6
Leptoceridae		
Leptoceridae	1	1
Multiple Families		
Caddisfly case	1	1
Phryganeidae		
Ptilostomis spp	1	1
Trombidiformes		
Hydrachnidiae		
Hydracarina mite	2	2
Tubificida		
Naididae		
Haemonais waldvogeli	1	12
Tubificidae no hair	8	194
Tubificidae with hair	2	2

Table D-3. Macroinvertebrate taxa found on open canopy reference wetland sites, all sampling methods combined.

Open Canopy Reference Sites	Total Frequency	Total Abundance
Amphipoda		
Crangonyctidae		
Crangonyx serratus	1	3
Crangonyx spp	1	2
Araneae		
Spider	7	17
Blattodea		
Termite	2	23
Coleoptera		
Curculionidae		
Curculionidae	3	5
Weevil	1	1
Dytiscidae		
Agabus spp	3	5
Copelatus spp	4	10
Dytiscidae	1	1
Hydroporus spp	10	39
Hydrovatus spp	1	1
Ilybius spp	2	14
Laccophilus proximus	1	2
Laccophilus spp	1	2
Laccornis spp	3	3
Liodessus crothi	1	2
Liodessus spp	2	3
Neoporus spp	8	101
Rhantus spp	2	2
Erirhinidae		
Lissorhoptrus spp	1	26
Helophoridae		
Helophorus spp	2	3
Hydraenidae		
Hydraena spp	1	1
Hydrochidae		
Hydrochus sp 6	1	37
Hydrochus sp 7	1	24
Hydrochus spp	1	1
Hydrophilidae		
Berosus spp	8	17
Enochrus spp	4	12
Helocombus bifidus	1	1
Laccobius spp	1	1
Tropisternus blatchleyi	1	1
Tropisternus collaris	1	1
Tropisternus spp	2	2
Hydroptilidae		
Leucotrichia spp	1	1
Multiple Families		

Open Canopy Reference Sites	Total Frequency	Total Abundance
Terrestrial beetle	2	2
Unidentified beetle fly	2	8
Collembola		
Order Collembola	5	8
Diplostraca		
Daphniidae		
Daphnia spp	2	3
Diptera		
Ceratopogonidae		
Bezzia/Palpomyia complex spp	8	40
Dasyhelea spp	1	1
Forcipomyia spp	1	1
Palpomyia spp	1	3
Chaoboridae		
Chaoborus punctipennis	3	31
Chironomidae		
Ablabesmyia hauberi	1	2
Ablabesmyia illinoense	1	5
Ablabesmyia janta	4	45
Ablabesmyia mallochi	11	366
Ablabesmyia philosphagnos	1	5
Camptocladius spp	1	2
Chironomini genus III	4	144
Chironomus spp	9	1099
Clinotanypus spp	1	1
Conchapelopia Hudson sp.	1	6
Conchapelopia spp	2	5
Dicrotendipes modestus	2	6
Dicrotendipes nervosus	1	4
Gymnometriocnemus spp	1	1
Kiefferulus dux	2	13
Labrundinia pilosella	3	235
Larsia spp	2	16
Limnophyes spp	5	10
Macropelopia spp	1	5
Mesosmittia spp	2	2
Natarsia spp	2	18
Parachironomus chaetaolus	1	1
Polypedilum halterale gr	1	2
Polypedilum illinoense gr	17	1882
Polypedilum trigonum	2	3
Polypedilum tritum	4	13
Procladius spp	10	222
Psectrocladius (Monopsectrocladius) spp	11	326
Psectrocladius elatus	1	5
Psectrocladius flavus	1	1
Psectrocladius octumaculatus	1	1
Psectrocladius pilosus	6	183
Psectrocladius sordidellus	1	2
Pseudochironomus spp	4	31

Open Canopy Reference Sites	Total Frequency	Total Abundance
Pseudosmittia spp	3	3
Smittia spp	4	6
Tanytarsus sp 1	2	3
Tanytarsus sp 6	2	8
Tanytarsus sp C	1	5
Tanytarsus sp G	1	6
Tvetenia bavarica gr	1	1
Zavreliella marmorata	1	3
Culicidae		
Aedes spp	1	4
Anopheles spp	1	1
Culicidae	1	2
Psorophora spp	2	100
Dolichopodidae		
Dolichopodidae	11	50
Limoniidae		
Ormosia spp	1	6
Multiple Families		
Midge pupae	3	20
Terrestrial white maggot	2	2
Tabanidae		
Chrysops spp	5	8
Tipulidae		
Hexatoma spp	1	1
Rhabdomastix spp	1	1
Ephemeroptera		
Baetidae		
Callibaetis spp	1	2
Haplotaxida		
Enchytraeidae		
Enchytraeidae	2	3
Lumbriculidae		
Lumbriculidae	1	1
Naididae		
Ilyodrilus templetoni	1	79
Nais spp	3	5
Pristina spp	1	1
Hemiptera		
Corixidae		
Sigara spp	4	20
Naucoridae		
Pelocoris spp	2	2
Nepidae		
Ranatra spp	1	1
Notonectidae		
Buenoa spp	4	16
Notonecta spp	2	7
Hymenoptera		
Formicidae		
Ant	5	20

Open Canopy Reference Sites	Total Frequency	Total Abundance
Isopoda		
Asellidae		
Asellus spp	2	158
Lepidoptera		
Crambidae		
Paraponyx spp	1	2
Multiple Families		
Lepidoptera	1	1
Mentodea		
Unknown		
Mantis	1	1
Odonata		
Aeshnidae		
Anax longipes	3	5
Coenagrionidae		
Argia spp	2	2
Enallagma spp	9	113
Ischnura spp	5	111
Lestidae		
Lestes spp	5	10
Libellulidae		
Erythemis simplicicollis	2	15
Erythrodiplax connata	1	1
Libellula spp	7	20
Libellulidae	2	2
Pachydiplax longipennis	7	109
Tramea onusta	5	58
Ostracoda		
Ostracod	15	900
Parasitiformes		
Tick	1	1
Phylum Nematoda		
Nematode	2	13
Subclass Copepoda		
Subclass Copepoda	2	4
Superorder Megadrilacea		
Megadrile	1	4
Trichoptera		
Hydroptilidae		
Hydroptilid caddisfly	2	2
Oxyethira spp	1	4
Leptoceridae		
Triaenodes spp	2	11
Tricladida		
Planariidae		
Planaria spp	1	1
Trombidiformes		
Hydrodromidae		
Hydrodroma despiciens	1	1
Hygrobatidae		

Open Canopy Reference Sites	Total Frequency	Total Abundance
Hygrobates spp	1	1
Tubificida		
Naididae		
Spirosperma spp	1	40
Tubificidae no hair	2	49
Tubificidae with hair	1	1

Table D-4. Macroinvertebrate taxa found in enhancement wetland sites, all sampling methods combined.

Enhancement Sites	Total Frequency	Total Abundance
Amphipoda		
Crangonyctidae		
Crangonyx serratus	6	54
Araneae		
Spider	7	20
Blattodea		
Termite	1	4
Class Gastropoda		
Planorbidae		
Ferrissia spp	2	25
Coleoptera		
Carabidae		
Carabidae	1	2
Curculionidae		
Curculionidae	2	4
Dytiscidae		
Acilius spp	1	1
Agabus spp	6	8
Copelatus chevrolate	1	1
Copelatus spp	1	3
Dytiscus spp	1	1
Hydroporus spp	8	44
Ilybius spp	3	16
Laccophilus maculosus maculosus	1	3
Laccophilus proximus	2	4
Laccophilus spp	2	2
Laccornis spp	1	1
Liodessus crothi	1	1
Liodessus spp	4	49
Neoporus spp	3	8
Rhantus spp	2	2
Helophoridae		
Helophorus spp	2	6
Hydrochidae		
Hydrochus spp	3	4
Hydrophilidae		
Berosus spp	8	30
Enochrus spp	4	6
Helocombus bifidus	1	2
Helocombus spp	1	1

Enhancement Sites	Total Frequency	Total Abundance
Tropisternus collaris	1	1
Tropisternus natator	1	2
Tropisternus spp	1	1
Scirtidae		
Scirtes spp	1	4
Staphylinidae		
Staphylinidae	1	1
Collembola		
Order Collembola	10	19
Decapoda		
Astacidae		
Astacidae	1	1
Cambaridae		
Procambarus spp	3	20
Diptera		
Ceratopogonidae		
Bezzia/Palpomyia complex spp	5	37
Dasyhelea spp	2	8
Palpomyia spp	2	6
Chaoboridae		
Chaoborus punctipennis	1	2
Mochlonyx spp	2	5
Chironomidae		
Ablabesmyia aspera	2	18
Ablabesmyia hauberi	2	30
Ablabesmyia illinoense	2	54
Ablabesmyia mallochi	6	65
Ablabesmyia parajanta group	1	5
Ablabesmyia rhamphe gr	2	46
Camptocladius spp	2	44
Chaetocladius spp	3	18
Chironomini genus	1	1
Chironomus spp	11	526
Cladotanytarsus sp A	1	3
Conchapelopia spp	1	1
Dicrotendipes modestus	4	280
Dicrotendipes nervosus	3	28
Guttipelopia guttipennis	2	124
Gymnometriocnemus spp	1	1
Kiefferulus dux	3	17
Kiefferulus spp	5	307
Labrundinia pilosella	1	69
Larsia spp	4	43
Limnophyes spp	9	28
Natarsia spp	7	568
Orthocladiinae	1	2
Parachironomus carinatus	1	4
Parachironomus longistylus	1	11
Paramerina spp	1	1
Paratanytarsus spp	2	2
Paratendipes spp	1	1

Enhancement Sites	Total Frequency	Total Abundance
Phaenopsectra obediens gr	1	13
Polypedilum aviceps	1	6
Polypedilum illinoense gr	18	1628
Polypedilum tritum	7	63
Procladius spp	8	158
Psectrocladius (Monopsectrocladius) spp	7	1699
Psectrocladius flavus	2	9
Psectrocladius pilosus	4	26
Psectrocladius psilopterus	1	1
Psectrocladius spp	1	2
Pseudochironomus spp	1	1
Pseudosmittia spp	3	18
Smittia spp	4	10
Tanytarsus sp G	3	29
Culicidae		
Aedes spp	1	2
Anopheles spp	3	4
Culiseta spp	1	15
Mosquitoe	2	17
Psorophora spp	3	23
Dolichopodidae		
Dolichopodidae	9	22
Limoniidae		
Antocha spp	1	1
Ormosia spp	3	6
Multiple Families		
Terrestrial white maggot	4	15
Tipulidae		
Tipula spp	1	1
Ephemeroptera		
Baetidae		
Callibaetis spp	3	105
Centroptilum spp	2	9
Caenidae		
Caenis spp	2	7
Haplotaxida		
Enchytraeidae		
Enchytraeidae	1	1
Lumbriculidae		
Lumbriculidae	5	29
Naididae		
Dero spp	2	16
Nais spp	2	6
Pristina aequiseta	1	5
Pristina spp	1	2
Hemiptera		
Corixidae		
Sigara spp	3	34
Notonectidae		
Notonecta spp	5	8
Heteroptera		

Enhancement Sites	Total Frequency	Total Abundance
Cicadellidae		
Cicadellidae	2	4
Hymenoptera		
Formicidae		
Ant	1	1
Isopoda		
Asellidae		
Asellus spp	3	226
Caecidotea attenuata	1	64
Caecidotea obtulus	1	286
Caecidotea spp	1	175
Lepidoptera		
Lepidoptera	4	4
Odonata		
Coenagrionidae		
Enallagma spp	3	22
Ischnura spp	1	2
Lestidae		
Lestes spp	4	15
Libellulidae		
Celithemis spp	1	1
Erythemis simplicicollis	1	1
Libellula spp	4	6
Pachydiplax longipennis	4	26
Tramea onusta	1	14
Ostracoda		
Multiple Families		
Ostracod	15	2319
Phylum Annelida		
Multiple Families		
Achaetous worm	2	9
Subclass Copepoda		
Subclass Copepoda	5	14
Superorder Megadrilacea		
Megadrile	2	47
Trichoptera		
Hydroptilidae		
Oxyethira spp	2	4
Phryganeidae		
Agrypnia vestita	1	1
Tubificida		
Naididae		
Tubificidae no hair	1	1

Appendix E Metric Definitions and Calculations

LANDSCAPE ATTRIBUTES METRICS

Landscape Development Intensity Index (LDI)

The Landscape Development Intensity Index (LDI) was calculated by delineating land uses/covers using recent aerial photography in GIS and calculating the percent of the total spatial extent occupied by each land use/cover. Each land use or land cover was assigned a coefficient (Table D-1), which was multiplied by the aerial extent of that land use/cover. The following equation from Brown and Vivas (2005) was used to determine the LDI value for each wetland 500 meter buffer and extended buffer (1 mile).

$$\mathrm{LDI} = \sum (\%\mathrm{Lu}_i * \mathrm{LDI}_i)$$

$\%Lu_i$ = percent of the total area of influence with land use i
LDI_i = LDI coefficient for land use i

Table E-1. LDI Coefficients used for various land cover/land use descriptions (adapted from Brown and Vivas, 2005).

Land Cover/Land Use Description	LDI Coefficient
Natural Area - land and water, wetlands	1
Natural Area with modifications, ie. ditches, ATV tracks, etc.	1.5
Unmanaged Herbaceous - woodland pastures, feed lots	2
Immature mitigation	2
Shrubby areas recovering from logging	2
Managed Herbaceous - pasture, regularly mowed areas	3
Pine Plantations	3
Logged - recently logged areas, clearcuts	3
Impounded water	4
Barren - dirt roads, land cleared for construction	4.4
Agriculture - row crops	5
Agriculture - poultry/swine houses and lagoons	7
Low Density Development - low to medium density residential, high intensity recreational/open space, 2 lane highways	7
High Density Development - high density residential, low intensity commercial, 4 lane highways	8
Industrial	8.5
Mining	10

Distance to Nearest Natural Wetland

This metric was calculated by measuring the distance (m) in GIS to the nearest wetland that would be accessible by amphibians, ie. not separated by a major road or railroad. Most of these wetlands were headwater or stream wetlands.

Distance to Nearest Paved Road

This metric was calculated by measuring the distance (m) in GIS to the nearest paved road.

Distance to Nearest Dirt Road

This metric was calculated by measuring the distance (m) in GIS to the nearest paved road.

Distance to Nearest Road (Paved or Dirt)

This metric was calculated by taking the smallest distance (m) of the two above metrics (distance to paved road or distance to dirt road).

Buffer

A wetland buffer was defined as the contiguous, vegetated natural area around the wetland area. Buffer width was assessed as Excellent (>150m mean width), Good (50-150m mean width), Fair (25-50 m), and Poor (25m or less). Dirt roads were not counted as interrupting the buffer, but paved roads were.

RAPID ASSESSMENTS

NCWAM

The North Carolina Wetland Assessment Method (NCWAM) was used to assess all wetland sites. This is a rapid assessment method that results in a rating (High/Medium/Low) for various wetland functions (hydrology, water quality, and habitat) as well as an overall rating for the wetland area. (See NC Division of Water Resources' website for a copy of the NCWAM form and NCWAM Dichotomous Key to General NC Wetland Types.)

ORAM

The Ohio Rapid Assessment Method v.5.0 (ORAM) was another rapid assessment method used to gauge habitat quality of each of the wetland sites (See Ohio EPA's website for a copy of the ORAM form and manual). ORAM contains six rapid assessment metrics which produce a numeric score for the habitat quality of a wetland: 1) wetland area, 2) upland buffers and surrounding land use, 3) hydrology, 4) habitat alteration and development, 5) special wetlands, and 6) plant communities, interspersion, and microtopography. Metric 5, which is specific to Ohio wetlands, was not used in the assessment. The maximum score for a high quality wetland was 90 without the use of metric 5.

WATER QUALITY AND HYDROLOGY METRICS

Mean pH

Mean water pH was obtained by calculating the average of all water quality meter measurements taken for all site visits within each year.

Mean Specific Conductivity

Mean specific conductivity (µS/cm) was obtained by calculating the average of all water quality meter measurements taken for all site visits within each year.

Mean Dissolved Oxygen

Mean Dissolved Oxygen (mg/mL and % saturation) was obtained by calculating the average of all water quality meter measurements taken for all site visits within each year.

Mean Water Temperature

Mean water temperature (degrees C) was obtained by calculating the average of all water quality meter measurements taken for all site visits within each year.

Mean Water Depth

Water depth was recorded at vegetation sampling plot corners or every 10 meters along the center-line of the 5m wide belt transects. Mean water depth is the average depth measured at these points for each wetland site.

Water Volume

Water depth measurements and pool boundaries were input into ArcGIS ArcScene software (ESRI 2014) to create a three-dimensional TIN (triangulated irregular network) surface of the bottom of the pool, from which volume was calculated using the Polygon Volume tool. When multiple pools were present on a site, volumes were added together to obtain a total volume.

Percent Days with Water (Inundation Time)

This metric utilized hydrology well records for each site. For each year, the following formula was used:

$$\%\ \text{Days with Water (Inundation Time)} = \frac{\text{number of days with water above ground surface}}{\text{total number of days}}$$

Total Annual Precipitation

Daily precipitation summary data were obtained from the National Oceanic and Atmospheric Administration's National Center for Environmental Information (Menne et al. 2012a) for climate data collection stations that were nearest to each wetland site. (An overview of this data collection network is available at Menne et al. 2012b.) These data were obtained for every day of 2013 through 2015, and daily totals were added to calculate total annual precipitation for each year at each site.

VEGETATION METRICS

Coverage was defined as "the percentage of ground surface obscured by the vertical projection all above ground parts of a given species onto that surface". Individual species that were either rooted in or overhanging the survey plot were included in the cover estimates. Percent cover was estimated using the midpoint of each cover class.

- Trace (1–2 individuals only, ≤ 0.25m^2)
- Trace - 1 m^2
- 2 m^2
- 2-5 m^2
- 5–10 m^2
- 10-25 m^2
- 25–50 m^2
- 50–75 m^2
- 75–95 m^2
- 95–100 m^2

Vegetation Coverage by Vertical Stratum

Mean percent cover was calculated for each of the following vertical stratum categories:

- 0-0.5m (herbaceous plants, low shrubs, and tree seedlings)
- >0.5-1m (herbaceous plants, low shrubs, and tree seedlings)
- >1-2m (tall herbaceous plants, medium sized shrubs, and tree saplings)
- >2-5m (very tall herbaceous plants, tall shrubs, and tree saplings and short trees)
- >5-15m (very tall shrubs, short to mid-sized trees)
- >15-30m (tall trees)
- >30m (very tall trees)

Vegetation Coverage by Growth Form

Mean percent cover was calculated for each of the following growth form categories:

- Filamentous or matt forming algae
- Ground lichens (total cover of lichens on the ground substrate and fallen logs or roots)
- Bryophytes (mat-forming mosses, sphagnums, and thalloid liverworts)
- Submerged aquatic vegetation (SAV)(Aquatic vegetation that would be found under water during normal conditions)
- Floating aquatic vegetation (Vascular species not rooted in sediment, floating on the water surface)
- Emergent vascular vegetation (Vascular species that under normal conditions emerge above the water surface when standing water exists)
- Shrubs
- Broad leaf small trees and large trees (e.g. *Ilex opaca* and *Fraxinus pennsylvatica*)
- Lianas, vines, and epiphytes
- Coniferous trees (e.g. *Juniperus* spp., *Pinus* spp., *Taxodium* spp.)

Ground Surface Attributes and Woody Debris/Snags

Ground surface attribute coverages were estimated using defined cover classes and mean percent cover (across plots) was calculated for each of the following:

- Standing water with no vegetation (B)
- Standing water with SAVs, moss, floating aquatics or algae (C)
- Standing water with herbaceous emergents (D)
- Standing water with woody emergents (E)
- All standing water = B+C+D+E (from above)
- Exposed soil/sediment
- Broadleaf litter (attached or detached dead herbaceous matter or broadleaf tree litter)
- Coniferous litter
- All litter (broadleaf + coniferous)
- Dead woody debris <5 cm dbh
- Dead woody debris $\geq$5 cm dbh

- Standing dead shrubs and saplings <5 cm dbh
- Standing dead shrubs and saplings ≥5 cm dbh
- Standing dead snags ≥5 cm dbh

Dominant Plant Species Richness

Dominant Plant Species Richness is the total number of dominant plant species recorded within the sampling area on a site. Dominant species were those individual tree, shrub, and vine species with ≥10% cover and herbaceous species with ≥5% cover in the sampling area.

Dominant Plant Species Total Cover

Dominant Plant Species Total Cover was defined as the cumulative percent cover of all dominant plant species. Dominant species were those individual tree, shrub, and vine species with ≥10% cover and herbaceous species with ≥5% cover in the sampling area.

Dominant Plant Species Mean C

Dominant plant species mean C is the average of Coefficients of Conservatism (C values) for all dominant plant species in each site sampling area. Dominant species were those individual tree, shrub, and vine species with ≥10% cover and herbaceous species with ≥5% cover in the sampling area. C values are ratings assigned by expert botanists to individual species within an ecoregion to describe their ability to tolerate anthropogenic disturbance. The values are on a 0 to 10 scale, with 10 representing those species found only in the highest quality habitat, very sensitive to man-made disturbance, and with the most specific habitat requirements. Low C values are assigned to weedy species with broad habitat requirements and high tolerance to disturbance. Non-natives are assigned a value of zero.

C values for wetland species were obtained from the Southeast Region Wetland Plant Coefficient of Conservatism Database (Gianopulos 2014) and for upland species from Baker et al. (2013). Species that could not be identified beyond genus level were not included in the calculations.

Dominant Plant Species Floristic Quality Assessment Indices (FQAI)

The Floristic Quality Assessment Index is an evaluation of ecological integrity that incorporates the affinity of plant species for natural pristine habitats and the total number of species in a sample (Taft et al. 1997). Coefficients of Conservatism (C values) are ratings given by expert botanists to individual species within an ecoregion to describe their ability to tolerate anthropogenic disturbance. The values are on a 0 to 10 scale, with 10 representing those species found only in the highest quality habitat, very sensitive to man-made disturbance, and with the most specific habitat requirements. Low C values are assigned to weedy species with broad habitat requirements and high tolerance to disturbance. Non-natives are assigned a value of zero.

Plant species information was used to calculate the FQAI for dominant species within the sampling areas. Dominant species were those individual tree, shrub, and vine species with ≥10% cover and herbaceous species with ≥5% cover in the sampling area.

The $FQAI_{cov}$ metric, which incorporates species percent cover into the equation, was also used in this study (as in Rocchio 2007). C values for wetland species were obtained from the Southeast Region

Wetland Plant Coefficient of Conservatism Database (Gianopulos 2014) and for upland species from Baker et al. (2013). Species that could not be identified beyond genus level were not included in the calculations; however, in this project, 88% of all species records could be matched with a C value.

$$FQAI = \frac{\sum C_i}{\sqrt{N}} \qquad FQAI_{cov} = \frac{\sum(C_i * Cov_i)}{\sqrt{(N * Cov_{tot})}}$$

C_i - Coefficient of Conservatism for species *i*
N - Number of species with C values, including non-native species
Cov_i - Percent cover of species *i*
Cov_{tot} – Total percent coverage, including non-native species

Upland Buffer Metrics – Vegetation Type Cover

In the buffers around the wetland sites, five to ten 10m^2 plots were surveyed using defined coverage classes for various growth forms and woody debris. The midpoints of the coverage classes were used as raw data to calculate mean percent cover for the following metrics:

- Herbaceous vascular vegetation and matt forming mosses
- Small shrubs and saplings (<0.5m)
- Larger shrubs and saplings (≥0.5-5m)
- Broadleaf trees (≥5m)
- Lianas, vines, and epiphytes
- Coniferous trees (all sizes)

Total Number of Strata in Wetland

This metric is a count of the vertical structure categories present in the wetland sampling area.

Total Number of Height Classes in Wetland

This metric is a count of the number of height classes present in the wetland sampling area.

Total Number of Strata in Upland Buffer

This metric is a count of the vertical structure categories present in the upland buffer sampling area.

MACROINVERTEBRATE METRICS

All macroinvertebrate metrics were calculated from data gathered using one sweep sample and one bucket sample.

Percent of Taxonomic Groups

Percent taxa was calculated for the following groups using this formula (Dipterans used as an example):

$$\%\ \text{taxa Diptera} = \frac{\#\ \text{taxa Diptera}}{\text{total}\ \#\ \text{taxa}}$$

- % taxa Coleoptera
- % taxa Crustacea
- % taxa Diptera
- % taxa Ephemeroptera
- % taxa Trichoptera
- % taxa Ephemeroptera + Trichoptera (found by adding % for both groups)
- % taxa Hemiptera
- % taxa Mollusca
- % taxa Odonata
- % taxa Worms
- % taxa other taxa (mainly ants, spiders, lepidopterans, nematodes, and springtails)

Macroinvertebrate Richness

Richness (total number of species) was calculated at various taxonomic levels for each year of sampling. Richness was recorded at the order level (Order Richness), family level (Family Richness), genus level (Genus Richness), and lowest identifiable taxonomic level (Taxon Richness). Lowest identifiable taxonomic level sometimes was genus, species, family, or higher. Richness of Ephemeroptera and Trichoptera taxa (ET Richness) was also calculated. (Often EPT Richness is calculated, but no Plechoptera [P] taxa were found.)

Macroinvertebrate Abundance

Total abundance is the total number of individual macroinvertebrates gathered from one sweep sample and one bucket sample per year.

Macroinvertebrate Taxon Frequency

Taxon frequency was the number of times a taxon occurred within all samples collected (sample types noted in table captions).

Macroinvertebrate Density

Density (number/m^2) was calculated using quantitative abundance data from bucket samples for each year. Buckets were 26.25 cm in diameter, so the formula used to calculate density was as follows:

$$\text{macroinvertebrate density} = \frac{\text{abundance in bucket sample}}{0.0514\ \text{m}^2}$$

Macroinvertebrate Diversity

Shannon Index (H') was used to calculate macroinvertebrate diversity. It takes into account the number of individuals as well as the number of taxa (lowest taxonomic level). The index value varies from zero for communities with only a single taxon to high values for communities with many taxa, each with few individuals. PAST software Version 3.12 (Hammer et al. 2001) was used to calculate this index. The formula used is as follows:

$$H = -\sum_i \frac{n_i}{n} ln \frac{n_i}{n}$$

where n_i = the number of individuals of taxon *i*

Macroinvertebrate Species Evenness

Simpson's (1-D) Index was used as a measure of species evenness on a scale from 0 to 1, which indicates how evenly distributed the species abundances are across all species detected. PAST software Version 3.12 (Hammer et al. 2001) was used to calculate this index. The formula used is as follows:

$$Simpson's\ Index = 1 - \sum_i \left(\frac{n_i}{n}\right)^2$$

where n_i is the number of individuals of taxon *i*.

Macroinvertebrate Biotic Index

The original Macroinvertebrate Biotic Index (MBI) metric uses a method created by David Lenat of the NC DEQ Division of Environmental Management (now called the Division of Water Resources) for use in southeastern streams (Lenat 1993). Lenant assigned pollution tolerance values (TV) to macroinvertebrates, from 0 to 10, with the higher numbers indicative of species with high tolerance of pollution and other environmental variation. For the purposes of this work, the original MBI equation was inverted so that high index values indicate highly sensitive organisms are present (a desirable outcome), and low values denote the presence of stressors (tolerant organisms). The inverted Macroinvertebrate Biotic Index was calculated as follows:

$$\mathrm{MBI}_{\mathrm{inverted}} = 10 - \frac{\sum \mathrm{TV}_i n_i}{\mathrm{N}}$$

MBI = Macroinvertebrate Biotic Index
TV_i = Tolerance Value of *i*th taxa
n_i = Abundance of *i*th taxa
N = Total number of individuals in all taxa

The most recent TVs developed for benthic macroinvertebrates were obtained primarily from invertebrate biologists at the Biological Assessment Branch (NCDEQ, Biological Assessment Branch 2015; Lenat 1993). In any instances where TVs were unavailable in the NC DEQ/Lenat database, the literature

was searched for appropriate TVs, which were applied to complete the reference wetland macroinvertebrate TV database as much as possible (Bressler et al. 2006; Barbour et al. 1999).

Percent Sensitive Taxa

Percent sensitive macroinvertebrate taxa was calculated using the following formula:

$$\%\ \text{sensitive taxa} = \frac{\#\ \text{sensitive taxa (TV} < 4.4)}{\#\ \text{all taxa with a TV assigned}}$$

Percent Tolerant Taxa

Percent tolerant macroinvertebrate taxa was calculated using the following formula:

$$\%\ \text{tolerant taxa} = \frac{\#\ \text{tolerant (TV} > 7.5)}{\#\ \text{all taxa with a TV assigned}}$$

AMPHIBIAN METRICS

Amphibian Richness

Total number of amphibian species found on a site in each year was calculated both using dipnet data only (Amphibian Richness Dipnet) and dipnet plus froglogger data (Amphibian Richness Dipnet + Logger).

Amphibian Mean Abundance

Total abundance of amphibian found on a site in each year was calculated using dipnet data and egg mass survey data (Amphibian Mean Abundance Dipnet + Egg Survey). Since an equivalent survey effort was put into each site, multiple times per year, the average total number of individuals recorded was used as amphibian mean abundance. Abundance calculations used estimates of equivalent number of adults for larvae (20%=1 adult), juveniles (20% = 1 adult), and egg masses (1 egg mass = 1 adult).

Amphibian Species Diversity

Shannon Index (H') was used to calculate amphibian species diversity. It takes into account the number of individuals as well as the number of taxa (lowest taxonomic level). The index value varies from zero for communities with only a single taxon to high values for communities with many taxa, each with few individuals. PAST software Version 3.12 (Hammer et al. 2001) was used to calculate this index. The formula used is as follows:

$$H = -\sum_i \frac{n_i}{n} ln \frac{n_i}{n}$$

where n_i = the number of individuals of taxon *i*

Mean Amphibian Adult Body Size

Adult body size information for amphibian species was obtained by taking the midpoint of the adult size range given in Beane et al. (2010) for each species observed. Mean amphibian adult body size was then calculated for each site based on all species detected on each site each year (using dipnet surveys and frogloggers).

Table of amphibian adult body sizes by species, based on midpoint of size ranges given in Beane et al. (2010).

Species	Species Adult Body Size (mm)
Acris gryllus	24
Bufo quercicus	26
Bufo terrestris	71
Gastrophryne carolinensis	30
Hyla andersonii	40
Hyla chrysoscelis	47
Hyla cinerea	48
Hyla femoralis	31.5
Hyla gratiosa	60
Hyla squirella	31.5
Pseudacris crucifer	27
Pseudacris ocularis	16
Pseudacris ornata	31.5
Rana capito	83
Rana catesbeiana	142.5
Rana clamitans	70
Rana sphenocephala	70
Rana virgatipes	54
Scaphiopus holbrookii	58.5

Amphibian Quality Assessment Index (AQAI)

Wetland dependent amphibian species in North Carolina have been assigned a "quality rating", a Coefficient of Conservatism value (C value), similar to that used to assess plant communities (Gianopulos 2016). C values range from 0 to 10, with 10 representing species that are only found in the highest quality habitat, have specialized habitat requirements, and are very sensitive to disturbance or impacts caused by humans. The lowest values are given to species that can tolerate a broad range of conditions, including several impacted habitats such as suburban lawns and stormwater retention ponds. These species are considered to be habitat generalists and are not significantly affected by human habitat alterations. Non-native species are assigned a rating of zero. These species C values are used to determine an overall index of quality for a species assemblage, or Amphibian Quality Assessment Index (AQAI). A higher AQAI value would indicate a wetland is functioning to provide excellent habitat for amphibians that need high quality wetlands to survive and reproduce. The AQAI is currently being used by the state of Ohio to assess the success of wetland mitigation sites.

Amphibian C values (Coefficients of Conservatism) for each species were assigned from 1-10 with "1" being species that were considered to be generalists with the least specific habitat requirements and "10"

being species with the most specific habitat requirements and sensitivity to stress and/or anthropogenic disturbance.

These amphibian C values were assigned using best professional judgment and consensus opinion by five leading North Carolina herpetologists at a meeting convened by NC Division of Water Resources wetland staff in late 2015. Appendix E contains the database of C values assigned to each North Carolina wetland-dependent amphibian species.

The AQAI value for each site was determined using the following equation:

$$\text{AQAI} = \bar{C}\sqrt{N}$$

$\bar{C}$ = Mean C value for all species
N = Total number of native species

OTHER METRICS

Fish Presence

The presence of fish in any macroinvertebrate sampling or amphibian sampling was noted and included in multivariate analyses as presence/absence (1 and 0).

Appendix F Database of Amphibian Coefficient of Conservatism Values

Table F-1. Coefficient of conservatism values (C values) for North Carolina wetland dependent amphibian species. See Beane et. al. 2010 for habitat information.

Mountains	Piedmont	Coastal Plain	Scientific Name	Common Name	Average C Value
x	x		*Acris crepitans*	Eastern/Northern Cricket Frog	2.0
		x	*Acris gryllus*	Southern Cricket Frog	2.6
		x	*Ambystoma mabeei*	Mabee's Salamander	7.9
x	x	x	*Ambystoma maculatum*	Spotted Salamander	5.8
x	x	x	*Ambystoma opacum*	Marbled Salamander	5.6
x	x		*Ambystoma talpoideum*	Mole Salamander	7.1
	x	x	*Ambystoma tigrinum*	Eastern Tiger Salamander	8.8
		x	*Amphiuma means*	Two-toed Amphiuma	4.1
x	x	x	*Bufo americanus*	Eastern American Toad	2.0
x	x	x	*Bufo fowleri*	Fowler's Toad	2.0
		x	*Bufo quercicus*	Oak Toad	7.5
		x	*Bufo terrestris*	Southern Toad	2.0
x			*Cryptobranchus alleganiensis*	Hellbender	10.0
x			*Desmognathus aeneus*	Seepage Salamander	7.0
		x	*Desmognathus cf. auriculatus*	Southern Dusky Salamander	7.0
x			*Desmognathus carolinensis*	Carolina Mountain Dusky Salamander	5.6
x	x		*Desmognathus conanti*	Spotted Dusky Salamander	5.6
x			*Desmognathus folkertsi*	Dwarf Black-bellied Salamander	7.0
x	x	x	*Desmognathus fuscus*	Northern Dusky Salamander	4.4
x			*Desmognathus imitator*	Imitator Salamander	5.4
x			*Desmognathus marmoratus*	Shovel-nosed Salamander	7.0
x	x		*Desmognathus monticola*	Seal Salamander	5.4
x			*Desmognathus ocoee*	Ocoee Salamander	6.0
x	x		*Desmognathus orestes*	Blue Ridge Dusky Salamander	6.0
			Desmognathus organi	Northern Pigmy Salamander	9.0
x			*Desmognathus quadramaculatus*	Black-bellied Salamander	6.8
x			*Desmognathus santeetlah*	Santeetlah Dusky Salamander	7.0
x			*Desmognathus wrighti*	Southern Pigmy Salamander	9.0
	x	x	*Eurycea chamberlaini*	Chamberlain's Dwarf Salamander	6.0
x	x	x	*Eurycea cirrigera*	Southern Two-lined Salamander	2.6
x	x	x	*Eurycea guttolineata*	Three-lined Salamander	6.0
x			*Eurycea junaluska*	Junaluska Salamander	6.9
x			*Eurycea longicauda*	Longtail Salamander	6.9
		x	*Eurycea quadridigitata*	Dwarf Salamander	7.0
x			*Eurycea wilderae*	Blue Ridge Two-lined Salamander	4.0
	x	x	*Gastrophryne carolinensis*	Eastern Narrow-mouthed Toad	2.9
x			*Gyrinophilus porphyriticus*	Spring Salamander	6.3
x	x	x	*Hemidactylium scutatum*	Four-toed Salamander	8.2
		x	*Hyla andersonii*	Pine Barrens Treefrog	8.7
x	x	x	*Hyla chrysoscelis*	Cope's Gray Treefrog	2.1
	x	x	*Hyla cinerea*	Green Treefrog	1.6
		x	*Hyla femoralis*	Pine Woods Treefrog	4.8
	x	x	*Hyla gratiosa*	Barking Treefrog	7.9
	x	x	*Hyla squirella*	Squirrel Treefrog	2.6
x	x		*Hyla versicolor*	Gray Treefrog	2.1
	x	x	*Necturus lewisi*	Neuse River Waterdog	7.8
x			*Necturus maculosus*	Common Mudpuppy	6.6
	x	x	*Necturus punctatus*	Dwarf Waterdog	7.0
x	x	x	*Notophthalmus viridescens*	Eastern Newt	2.0
			Pseudacris sp.	Chorus Frog Species	4.0
x			*Pseudacris brachyphona*	Mountain Chorus Frog	3.3
		x	*Pseudacris brimleyi*	Brimley's Chorus Frog	4.6
x	x	x	*Pseudacris crucifer*	Spring Peeper	1.7
x	x	x	*Pseudacris feriarum*	Upland Chorus Frog	4.0
		x	*Pseudacris nigrita*	Southern Chorus Frog	7.0
		x	*Pseudacris ocularis*	Little Grass Frog	4.8
		x	*Pseudacris ornata*	Ornate Chorus Frog	10.0
x	x	x	*Pseudotriton montanus*	Mud Salamander	5.0
x	x		*Pseudotriton ruber*	Red Salamander	5.0
		x	*Rana capito*	Carolina Gopher Frog	10.0
x	x	x	*Rana catesbeiana*	American Bullfrog	1.0
x	x	x	*Rana clamitans*	Green Frog	1.0
x	x	x	*Rana palustris*	Pickerel Frog	3.0
	x	x	*Rana sphenocephala*	Southern Leopard Frog	2.2
x			*Rana sylvatica*	Wood Frog	4.1

Mountains	Piedmont	Coastal Plain	Scientific Name	Common Name	Average C Value
		x	*Rana virgatipes*	Carpenter Frog	5.4
x	x	x	*Scaphiopus holbrookii*	Eastern Spadefoot	5.0
		x	*Siren intermedia*	Lesser Siren	5.6
		x	*Siren lacertina*	Greater Siren	4.3
		x	*Stereochilus marginatus*	Many-lined Salamander	7.0