Exhibit B

Proposed Changes to the Waters of the United States (WOTUS) Definition – Summary of M&N Conclusions

Presented to:

Geoff Gisler, Southern Environmental Law Center (SELC)
Chapel Hill, NC

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Prepared by:

Moffat & Nichol

1. Introduction:

What follows is a technical analysis of the proposed definition of "Waters of the United States" (WOTUS), 84 Fed. Reg. 4154 (Feb. 2019). These comments were prepared by current environmental consultants and retired state and federal employees with more than 100 years of combined regulatory experience, largely related to Sections 404/401 permitting, wetland and stream delineation, and stream determinations for riparian buffer rules (Appendix 1). These comments are based on the authors' extensive field and regulatory experience. While much of this experience relates to work in North Carolina, our experience can be extrapolated to other Southeastern states with similar geography and hydrology. Where supported by the scientific literature, these comments have also been extrapolated to other areas within the United States. This report evaluates different scenarios raised by the proposed rule and requests for comment.

2. Overall Conclusions About the Proposed Rule with a Focus on the Southeastern U.S.: Compliance with Clean Water Act

The primary objective of the Clean Water Act (CWA) (33 U.S.C. § 1251) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. However, the current administration has proposed a new definition of WOTUS, which delineates the scope of federal regulatory authority under the CWA and fails to achieve this objective. The proposed rule would limit regulated WOTUS, by definition, to traditional navigable waters, only tributaries that contribute perennial or intermittent flow to traditional navigable waters, and only wetlands that abut or have a direct hydrological surface connection to other WOTUS in a typical year as well as some other water features. The proposed rule focuses only on the presence or absence of flow of a water body or the proximity of that water body to traditional navigable waters and fails to recognize the other critical functional aspects specifically defined in the Act, namely, the physical, biological, and chemical functions necessary for clean water and the integrity of the Nation's waters.

The EPA Connectivity Report (US EPA. 2015) made the following point very clear: "The scientific literature clearly shows that wetlands and open waters in riparian areas (transitional areas between terrestrial and aquatic ecosystems) and floodplains are **physically**, **chemically,** and **biologically** integrated with rivers via functions that improve downstream water quality" (emphasis added). Further, the Connectivity Report specifically identifies the key role of interconnectivity in protecting water quality in keeping with Clean Water Act objectives: "Variations in the degree of connectivity are determined by the **physical, chemical,** and **biological** environment, and by human activities. These variations support a range of stream and wetland functions that affect the integrity and sustainability of downstream waters" (emphasis added). Contrary to statements made in the proposed rule's supporting documentation (e.g., 84 Fed. Reg. at 4176, 4187), the proposed rule ignores the Connectivity Report. For example, the proposed rule categorically excludes ephemeral streams and requires that any wetland connection to a WOTUS be by intermittent or perennial channels contrary to science, as documented in the Connectivity Report. In fact, the proposed rule fails to incorporate science at all.

By failing to recognize science and the full range of functions provided by small streams and wetlands, the proposed rule does not comply with the CWA. In general, the proposed rule does not preserve and restore the chemical, physical, and biological integrity of the Nation's waters. The much narrower proposed definition of WOTUS will remove CWA protections from many highly functional wetlands and ephemeral streams, as detailed in the analysis below. At-risk wetlands provide the essential functions of water quality improvement, groundwater recharge, low flow augmentation for nearby streams, floodwater storage, aquatic life habitat, and, in some cases, habitat for threatened and endangered aquatic species, such as amphibians. Wetlands often provide these benefits *because* they lack permanent surface water connections to intermittent or perennial streams, characteristics that could eliminate existing protections under the proposed rule. The scientific literature (as described below) demonstrates that ephemeral streams, especially in the Southwestern US, provide important hydrological functions and habitat. Therefore, in our opinion, the CWA's overall goal to protect and restore the Nation's waters cannot be accomplished with the rule as proposed. To the extent the final rule goes even farther, excluding, for example, intermittent streams, which provide significant water quality, water storage, and aquatic life functions, the result on water quality would be even more detrimental.

3. General Comments on the Specific Categories of Waters in the Proposed Rule

3.1. Tributaries (Streams)

The following discussion addresses the proposal's impact on ephemeral, intermittent, and perennial streams. The differences between these types of streams generally relate to rate and source of flow: 1) ephemeral streams carry stormwater and are not connected to the local ground water table, 2) intermittent streams carry stormwater and are connected to the local ground water table seasonally (usually in the winter in the Southeastern US), and 3) perennial streams carry stormwater and are connected to the local ground water table continuously during a year of normal rainfall. These definitions are generally consistent with the definitions presented in the proposed rule.

In general, the rule as proposed would result in the loss of jurisdiction over ephemeral channels but retain jurisdiction over most intermittent and perennial tributaries. However, the agencies are soliciting comment on whether the definition of "tributary" should be limited to perennial waters only as well as whether a minimum flow limit should be set. These scenarios are discussed below.

Scenario 1: Removal of Ephemeral Stream Jurisdiction

The critical role that ephemeral streams play in the Southwestern US has been well documented in the scientific literature as summarized by a 2008 EPA report by Levick, et al. (2008) who stated that "ephemeral and intermittent stream systems comprise a large portion of southwestern watersheds, and contribute to the hydrological, biogeochemical, and ecological health of a watershed." In addition, in the Southeastern US ephemeral streams can have important aquatic life and hydrology functions during periods of protracted rainfall and related high local water tables. Ephemeral streams are also important because they connect many wetlands in the North Carolina Piedmont and Inner

Coastal Plain with physical, chemical, and biological functions to downstream WOTUS (see discussion below).

Scenario 2: Removal of Intermittent Stream Jurisdiction

If the final rule is modified to remove jurisdiction from intermittent channels, this would result in a significant loss of channel length in watersheds across the country. As described below, we have conducted an analysis in various Level IV ecoregions[1] of North Carolina demonstrating the significance of those streams. In general, intermittent streams are ecologically important because these streams have significant aquatic life functions (Eaton and Vander Vorste. 2012) as well as contribute to nutrient removal and water transport. Intermittent streams are also important because they connect many wetlands in the North Carolina Piedmont and Inner Coastal Plain with physical, chemical, and biological functions to downstream WOTUS.

The attached M&N Stream report based on field-collected stream origin data in 19 Level IV ecoregions of North Carolina (Moffatt & Nichol. 2019- Appendix 2) demonstrates the prevalence of the intermittent streams with the greatest amounts of intermittent streams in the Atlantic Southern Loamy Plains (96%), Mid-Atlantic Flatwoods (53%), Sand Hills (46.5%), and Triassic Basins (35.3%) ecoregions. Based on a weighted average of the percentage of intermittent streams by the area of each Level IV ecoregion, we estimate that intermittent streams make up at least 27% of the state's stream length.

3.2. Wetlands

Under the proposed rule, "wetlands that abut or have a direct hydrologic surface connection to otherwise jurisdictional waters" are jurisdictional. 84 Fed. Reg. at 4187. This definition is one more example of the agencies' effort to create certainty which ends up creating significant confusion instead. The term ''abut'' in the proposed definition, means ''to touch at least at one point or side of'' a jurisdictional water. 84 Fed. Reg. 4187. Based on the information provided in the proposed rule, it appears that a "direct hydrologic surface water connection" would have to qualify as a tributary to result in a wetland being jurisdictional. Therefore, all wetlands would be required to "abut" a jurisdictional water. The proposed rule, however, highlights a situation where a wetland would have a "direct hydrologic surface connection" but not "abut" a jurisdictional water: where "Surface water from a wetland that overtops a berm and connects the wetland to a jurisdictional water or connections from a wetland to a jurisdictional water through upland or through a barrier as mediated by a culvert, tide gate, or similar structure would constitute direct hydrologic surface connections so long as such connections are perennial or intermittent as defined in this proposal and occur in a typical year." 84 Fed. Reg. at 4188. If such flow exists for long enough to create an intermittent connection, it appears likely that the connection will meet the definition of a tributary, which would also abut the connected wetland.

[1] There are 27 Level IV ecoregions (Griffith, et al. 2002) in North Carolina that represent areas of "general similarity in ecosystems and in the type, quality, and quantity of environmental resources".

Wetlands at Risk Due to the Narrowed Definition of WOTUS

There would likely be a major overall reduction in regulated wetlands as a result of the proposed rule, but, in North Carolina, that reduction will vary greatly by physiographic region and wetland type (Table 1). These results are based on (1) extensive knowledge of wetlands in North Carolina; (2) analysis of a relatively new database on reference wetlands gathered for the ATLAS effort (North Carolina Department of Transportation, 2019); and (3) analysis of field data on 34 headwater forest wetlands in the piedmont and coastal plain of North Carolina which were used to calibrate the North Carolina Wetland Assessment Method (NC WAM) model for this wetland type (Savage and Baker, 2010; Dorney, et al. 2015).

In this section, we evaluate the impact of four scenarios outlined in the proposed rule or derived from the agencies' requests for comments. The first three scenarios evaluated include the loss of protection for wetlands that require a surface water connection to a WOTUS via (a) an intermittent or perennial stream, (b) a perennial stream; or (c) a stream with a flow rate of greater or equal to 5 cubic feet per second. The fourth scenario evaluated wetlands that may be part of a "complex of wetlands," jointly connected to a jurisdictional water via a direct hydrologic connection, but are beyond 500 feet from the jurisdictional water. These scenarios would have differing implications for wetland jurisdiction as shown below in Tables 1 and 2, and in the text. Finally, the risks to endangered and threatened species posed by the wetland loss is also presented.

Overall, wetland losses in North Carolina would likely be greatest in the Piedmont and Inner Coastal Plain mainly since many wetlands in these ecoregions are connected by ephemeral streams or ditches to downstream WOTUS or are connected by intermittent streams to downstream WOTUS. Losses would be somewhat less in the Middle Atlantic Coastal Plain (Outer Coastal Plain) mainly since large parts of this landscape are wetlands that are continuously connected to downstream waters. Since the mountains in North Carolina have a very high density of perennial streams, the change in extent in this physiographic region would probably be less than in the rest of the state.

Table 1: Estimated Losses of wetlands[2]if, for jurisdiction, intermittent or perennial connections are required (Scenario 1(a)) or perennial connections are required (in ***bold and italics***) ***(Scenario 1(b))*** **See Appendix 5 for discussion of these wetland types.**

NC WAM Type	Outer Coastal Plain (Middle Atlantic Coastal Plain)	Inner Coastal Plain (Southeastern Plains)	Piedmont	Mountains	Statewide
Salt/Brackish Marsh	None ***None***	n/a	n/a	n/a	None ***None***
Estuarine Woody Wetland	None ***None***	n/a	n/a	n/a	None ***None***
Tidal Freshwater Marsh	None ***None***	n/a	n/a	n/a	None ***None***
Riverine Swamp Forest	None ***Some***	Few ***Some***	Most ***Most***	Some ***Some***	Some ***Some***
Seep	Few ***Few***	Few ***Few***	Most ***Most***	Most ***Most***	Most ***Most***
Hardwood Flat	Some ***Most***	Most ***Most***	n/a	n/a	Some ***Most***
Non-Riverine Swamp Forest	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pocosin	Some ***Most***	Most ***Most***	n/a	n/a	Some ***Most***
Carolina Bays[3]	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pine Savanna	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pine Flat	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Basin	All	All	All	All	All
Bog	n/a	n/a	n/a	Many ***Most***	Many ***Most***
Non-tidal Freshwater Marsh	Few ***Some***	Few ***Some***	Some ***Many***	Some	Some ***Some***
Floodplain pool	Some ***Some***	All ***All***	All ***All***	All ***All***	Most ***Most***
Headwater forest	Some ***Most***	Some ***Most***	Some ***Most***	Most ***Most***	Some ***Most***
Bottomland Hardwood Forest	Some	Some ***Most***	Most ***Most***	Most ***Most***	Many ***Most***

[2] *Assumptions for Table 1 are that 1) an intermittent or perennial connection is required to downstream waters, and 2) if the wetland is directly connected to downstream intermittent or perennial waters by a continual, unbroken wetland (i.e., "a complex of wetlands," 84 Fed. Reg. at 4189), then all those wetlands would still be jurisdictional.*

[3] Carolina Bays are generally a subset of pocosins in the NC WAM method. However, they are separated here since they are formed by different geologic and hydrologic processes and would be affected differently under the proposed rule.

The pending high loss of floodplain wetlands (such as floodplain pools, bottomland hardwood forest, riverine swamp forest, and headwater forest in NC WAM and in the above table) associated with ephemeral versus intermittent/perennial connections to nearby waters or only a perennial connection reflects the landscape ecology of streams in the Piedmont (Trimble 1974, 2008 (see Appendix 6 for a figure). Most Piedmont streams are deeply incised due to the fairly recent downcutting of the channels from the mid-1900s following widespread land abandonment and subsequent reforestation from the 1930s. Since then, piedmont streams have downcut through these legacy sediments which were deposited in the floodplains from before the 1930s with the result that piedmont streams are usually deeply incised. Piedmont wetlands tend to be located behind the natural, upland levees adjacent to channels or behind dredge spoils (especially in urban areas where stream channelization has been more common). These Piedmont wetlands are located in the floodplains of larger streams but only receive overbank flow during larger flow events (normally thunderstorms, tropical storms, and hurricanes). During normal stream flow, Piedmont wetlands are connected by localized drainages that are not incised deeply enough to contain perennial or intermittent flow but generally have ephemeral flow. If these connections were deep enough to have intermittent or perennial flow, the adjacent floodplain would most likely drain more quickly and therefore reduce the likelihood of wetland presence. Therefore, in many instances in the Piedmont, these floodplain wetlands exist only because the drainages from them contain ephemeral flow.

Based on the proposed rule, a large portion of the Piedmont wetlands would no longer be protected. The same condition is present along many streams in North Carolina's Inner Coastal Plain; accordingly, many floodplain wetlands would no longer be jurisdictional in this physiographic province, even though these systems are in very close proximity to jurisdictional waters and provide significant functional benefits such as storing significant amounts of local stormwater and overbank stormwater during higher flows (thus decreasing floods downstream), removing significant amounts of sediment and other pollutants such as nutrients, and providing aquatic life habitat.

Scenario 1A: Assumes that an intermittent or perennial stream connection is required for wetland jurisdiction and that ephemeral connections and most ditches[4] do not provide a jurisdictional connection. This scenario is outlined in the proposed rule.

i. *Summary by Wetland Type*

Wetlands lost under Scenario 1A will vary by wetland type. For North Carolina and other similar states in the Southeast (e.g., Virginia, South Carolina), the greatest losses will likely occur in floodplain pools, seeps, non-riverine swamp forest, pine savanna, pine flat, headwater forest, bog, and bottomland hardwood forest communities (Table 1). These specific wetland community types are most at risk because they are often connected by ephemeral drainages or ditches to downstream jurisdictional

[4] These include all ditches that do not meet the proposed definition of WOTUS. See 84 Fed. Reg. at 4179 (ditches are jurisdictional if they (1) are traditional navigable waters; (2) are constructed in a tributary and also satisfy the conditions of the tributary definition; or (3) are constructed in an adjacent wetland and also satisfy the conditions of the tributary definition).

waters rather than by intermittent or perennial streams, and/or do not immediately abut systems with intermittent or perennial flow

ii. *Closer look at Headwater Forests*

To more accurately estimate the extent of loss for headwater forests, an analysis was conducted on a dataset of 34 sites (16 sites in the Piedmont and 18 sites in the Coastal plain) used to calibrate the NC WAM for this wetland type (Dorney, et al. 2015) to determine which types of streams (ephemeral, intermittent or perennial) provided a downstream connection to a WOTUS (Table 2) (Personal communication, Rick Savage and Virginia Baker, March 27, 2019). This analysis revealed that an estimated 29% of these sites would no longer be jurisdictional if ephemeral connections are not sufficient to determine jurisdiction. The percentage of headwater forests no longer jurisdictional is a little higher in the Piedmont (31%) than the Coastal plain (28%). Headwater forests provide critical water quality protection for downstream waters since they are located in the landscape at the head of tributaries and therefore filter pollutants from the immediate watershed before they enter the tributary channel (Appendix 5). In addition, these wetlands store large amounts of floodwaters and release them slowly thereby reducing downstream flooding. Finally, they provide habitat for a wide variety of amphibians (Savage and Baker 2010). Therefore, the loss of jurisdiction of these wetlands would have result in significant increases in downstream pollution including nutrient delivery to downstream eutrophic waters and increased flooding risks.

Table 2: Summary of Changes in Headwater Forest Jurisdiction based on the Proposed Rule

	Headwater Forest Wetlands Lost because Ephemeral Connection Only	Headwater Forest Wetlands Lost because of Ephemeral or Intermittent Connection Only
Coastal Plain	5 out of 18 will no longer be jurisdictional (28%)	14 out of 18 will no longer be jurisdictional (78%)
Piedmont	5 out of 16 will no longer be jurisdictional (31%)	12 out of 16 will no longer be jurisdictional (75%)
Total	10 out of 34 no longer jurisdictional (29%)	26 out of 34 no longer jurisdictional (76%)

iii. *Case Studies*

The proposed rule acknowledges the shortcomings of existing data bases (84 Fed. Reg. at 4201). To further evaluate the impacts of the rule, we examined eight large public and private project sites in Virginia, North Carolina, and South Carolina. From this dataset, we identified three projects that contain wetland maps and stream flow information sufficient to allow a comparison to the proposed rule. This analysis (Appendix 3) was done for one project in Virginia and two in North Carolina. To summarize:

- The project in the Virginia mountains (Doe Branch Mine) would lose jurisdiction over 100% of the site's wetlands, while the project in North Carolina's Inner Coastal Plain (Global TransPark) would lose jurisdiction over 76% of the site's wetlands.

- The project in North Carolina's Outer Coastal Plain (PCS Phosphate) would lose jurisdiction over 8% of the site's wetlands. The lower rate of loss for the Outer Coastal Plain site reflects the fact that wetlands in this much flatter landscape tend to be directly and continuously connected by broad swaths of wetlands to downstream perennial streams. The loss for the PCS Phosphate site would be significantly greater, however, if the agency were to set a distance limit beyond which wetlands within the "complex of wetlands" (84 Fed. Reg. at 4189) are no longer jurisdictional, an issue solicited for comment in the agency's proposal.

iv. NC WAM Reference Wetland Database Analysis

An intensive effort was undertaken statewide on public property during the summer of 2018 to locate at least two reference-quality examples (defined as wetlands that rate high for Hydrology, high for Water Quality, and high for Habitat (using NC WAM (NC Wetland Functional Assessment Team 2016)) in each of seven focus areas across the state. These wetlands will be used for training purposes and serve as a database of some of the highest quality wetlands in the state. The NC WAM reference wetland database was examined to determine what percentage of sites would no longer be regulated based on the proposed rule since the sites were known to be connected only by ephemeral tributaries or nonjurisdictional ditches based on field visits during the summer of 2018 (Table 3). In the coastal plain, jurisdiction would be lost over 18.2% of the site wetlands, while in the piedmont, jurisdiction would be lost over 62.9% of the site wetlands, and in the mountains, jurisdiction would be lost over 29.2% of the site wetlands. Overall, at least 30.6% of the NC WAM Reference wetland sites would no longer be jurisdictional.

Table 3: NC WAM Reference Wetland Database – summary by physiographic region

Level III Ecoregion	Still Regulated	No Longer Regulated	Uncertain	Total
Coastal Plain	72	16	2	90
Piedmont	13	22	12	47
Mountains	17	7	2	26
Total	102	45	16	163

Scenario 1B: Assumes that only a perennial stream can provide a connection for wetland jurisdiction and that ditches[5], and intermittent or ephemeral connections, do not provide a jurisdictional connection. This scenario is presented in the proposed rule in the request for comment on whether to limit jurisdiction to only perennial tributaries.

[5] These include all ditches that do not meet the proposed definition of WOTUS, as described above.

If only perennial streams connections are covered, then as shown on Table 1, the vast majority of freshwater wetland types in NC would experience a loss of jurisdiction with the greatest losses likely to be for floodplain pools, seeps, non-riverine swamp forest, pine savanna, pine flat, headwater forest, bog, bottomland hardwood forest communities, hardwood forests, pocosins, and Carolina bays.

The extent of the loss for headwater forests in the 34-site dataset described above is further shown on Table 2. From this database, 76% of the headwater forests would no longer be jurisdictional with similar loss rates in the piedmont and coastal plain. For the same reasons as outlined above in section 1A(ii), this loss of jurisdiction would have major implications for downstream water quality and flooding.

Scenario 1C: Assumes that only streams with a flow of at least 5 cubic feet per second (cfs) or more could provide a connection for wetland jurisdiction (as solicited for comment) (84 Fed. Reg. at 4178)

This scenario would eliminate from jurisdiction connections by intermittent or ephemeral streams as well as many smaller perennial streams because this flow rate is much higher than the normal flow in most of perennial streams. Therefore, the losses of jurisdiction by wetland type shown in Table 1 above would even be more severe. There would likely be a loss of jurisdiction over all the headwater forests shown in Table 2 because, although connected by perennial streams, those perennial streams have flows much less than 5 cfs.

Scenario 2: This scenario assumes that a specific distance (for instance 500 feet) is used in the final rule. (Comments on the use of a distance is sought in the proposed rule (84 Fed. Reg. at 4189))

Presumably wetlands beyond the set distance would no longer be regulated regardless of their physical, chemical, or biological connection to any WOTUS. Given the overall low level of accuracy for wetland mapping in North Carolina, it is impossible to quantify the effect of a limit. However, based on our extensive field experience, most wetlands are found at distances well beyond 500 feet from a perennial or intermittent stream or other WOTUS[6].

The proposed rule provides no support for setting a specific distance beyond which wetlands would not be jurisdictional. Most wetlands have at least portions of them that go beyond 500 feet. If this distance were used as a hard cutoff to eliminate jurisdiction over a portion of hydrologically connected wetlands, and therefore ignore the obvious connection of wetlands to WOTUS, it would not have a scientific basis.

To the extent any distance limitation is coupled with a requirement that further narrows jurisdiction (i.e., perennial connection required, perennial or intermittent connection required, or flow greater than 5 cfs required), the outcome would ignore the scientific importance of these waters and would

[6] Although there are instances where ditches intersect non-adjacent wetlands, these ditches would only rarely if ever satisfy the proposed definition of a jurisdictional ditch.

make it impossible to protect the chemical, physical, and biological integrity of downstream navigable waters.

Federally Listed Threatened and Endangered Species Found in NC Wetland Types most affected by the Proposed WOTUS Rule

To illustrate the implications of the proposed rule change on listed species, we identified some of the federally threatened and endangered species that rely on bogs, pine savanna, floodplain pools, basin wetlands, and headwater forests in North Carolina (Table 4). A full analysis is provided in Appendix 4.

In general, wetland types at-risk in North Carolina provide important habitat for identified federally and threatened endangered species, so loss of Section 404 jurisdiction would present a major challenge to the federally approved recovery plans for the species as well as continued existence of these species.

Table 4: Federal threatened (T) and endangered (E) species present in North Carolina wetland types that are likely to have the largest loss of extent under the proposed WOTUS rule.

Bog	Pine Savanna	Floodplain Pool	Basin Wetland	Seep	Headwater Forests
Bog Turtle (T(S/A), Green Pitcher Plant (E), Mountain Sweet Pitcher Plant (E)	Red-Cockaded Woodpecker (E), Canby's Dropwort (E), Cooley's Meadowrue (E), Golden Sedge (E)	Canby's Dropwort(E), Cooley's Meadowrue (E), Golden Sedge (E), Pondberry (E)	Canby's Dropwort (E), Pondberry (E)	Bunched Arrowhead (E), Green Pitcher Plant (E), Small-Anthered Bittercress (E)	Dwarf-Flowered Heartleaf (T), Small-Anthered Bittercress (E)

3.3. Ditches

In general, the proposed rule would exclude ditches unless the ditch currently meets the tributary definition (has a perennial/intermittent flow and direct surface water connection to WOTUS) and was initially constructed in (1) a jurisdictional tributary (perennial/intermittent flow and direct surface water connection to WOTUS); or (2) an adjacent jurisdictional wetland (adjacent to or abutting WOTUS). This is true even for those ditches that have an OHWM.

The proposed rule ignores the fact that ditches that drain wetlands such as wet flats, hardwood and pine flats, pocosins, or Carolina bays downslope to intermittent or perennial streams. By the very nature of their direct connection to downstream waters, these ditches provide essential hydrology and water quality functions to downstream waters. Without jurisdictional protection, wetlands such as wet flats, pocosins, or Carolina bays could readily be drained and developed, and become sources of waters for downstream flooding and water quality degradation due to uncontrolled nutrient input into already eutrophic waters. This is a critical reason to continue to regulate ditches that provide water quality functions.

In addition, the proposed rule discusses intermittent versus perennial ditches, but it is very difficult (impossible in many cases) to determine the flow duration of a ditch. Water quality in ditches is invariably poor, and the aquatic community is usually insufficient to determine if a ditch has ephemeral, intermittent, or perennial flow. None of the existing flow duration methods for streams that are discussed below (Section 4 ¶ 3 of this report) address the determination of flow duration in ditches because they use the OHWM indicator. The EPA and USACE would need to develop a process to make this determination before proposing a final rule that considers flow duration in ditches.

4. Specific Comments on Additional Issues Raised by the Proposed WOTUS Rule[7]

The following comments are in response to issues solicited by the agencies for comment and represent best professional judgement and an analysis of jurisdictional systems undertaken in North Carolina with extrapolation to South Carolina and Virginia.

1. **Appropriate treatment of natural or man-made breaks in jurisdictional tributaries (84 Fed. Reg. at 4177).** Interruptions in flow are commonly found in small headwater streams in North Carolina and the Southeastern U.S. and should not alone be enough to break jurisdiction; the proposed rule as written is also too vague and subject to interpretation. We suggest that the existing protocols for dealing with these breaks in jurisdiction be used, namely that evidence of continuous surface flow is sufficient to establish connectivity for continued jurisdiction and/or suggest that the USACE use other tools to determine continuity of jurisdiction (such as the use of non-toxic dye to show connection beneath a debris field).

2. **Definition of intermittent, specifically the effect of:**

   i. **Requiring 6 months of flow (84 Fed. Reg. at 4178).** If the final rule is changed and suggests more than three months of flow for intermittent streams, this would greatly reduce the amount of intermittent streams that are regulated since research by Williams (2005) shows that intermittent streams in North Carolina generally flow (or contain water) for about three months.

   ii. **Relying on groundwater monitoring to evaluate flow (84 Fed. Reg. at 4178).** Groundwater monitoring would be impractical and very costly since it would require installation of shallow groundwater wells in transects parallel to the channel with a sufficient number of wells monitored for months or longer, in a "typical" (rainfall) year, to demonstrate the flow regime. Any such study plan would need to be approved by the appropriate agencies (which is not a quick process). Groundwater monitoring is simply not realistic during a typical delineation process.

   The definition of jurisdictional wetlands explicitly excludes consideration of groundwater, while the stream definitions explicitly use groundwater and the definition of lakes allows consideration of subsurface flows. This is inconsistent and should be reconciled in the final rule

[7] Unless otherwise noted, these comments relate to the application of the proposed rule in the Southeast.

to allow the use of groundwater and other subsurface flows in the wetland definition as has been done for many decades in the United States with the consideration of soil saturation in addition to flooding.

iii. **Requiring certain flow rates, specifically 5 cfs (84 Fed. Reg. at 4178).** This would be an extremely complex proposal and difficult to implement in the field since it would require installation of stream gauges, a very costly exercise that is impractical on small streams. The suggested flow of 5 cfs is very high and would likely eliminate all intermittent and many small perennial streams from jurisdiction in the Southeast. Most intermittent and small perennial streams have very low flow rates (except right after storms) and it is impossible to determine (or model) that flow.

iv. **Flow Duration:** The proposal also discusses the potential for a specific flow duration (30, 60, or 90 days) (**84 Fed. Reg. at 4178**). Again, this is impractical since it assumes some sort of continuous monitoring during a "typical" year. Such monitoring is extremely expensive to install and would greatly increase the cost of delineation and permitting.

3. **Determination of stream jurisdiction:** Presently, the U.S. Army Corps of Engineers (USACE) uses the easily observable presence of an Ordinary High Water Mark (OHWM) to determine stream jurisdiction. This rapid process, which normally takes seconds to conduct at each site, is based on long-standing regulatory guidance from USACE as captured in their 2005 Regulatory Guidance Letter (USACE 2005) as well as long-established training processes conducted by USACE across the United States (for example, see USACE 2014). It is very effective at defining the entire length of a tributary. The proposed rule, however, would require that the agencies separate each tributary into ephemeral, intermittent, and perennial sections. Although there are protocols for performing this analysis, they require more time and would involve extensive training.

   In North Carolina, these determinations have been made for the past two decades using the North Carolina Stream Identification Method (North Carolina Division of Water Quality 2010). The North Carolina Method is relatively rapid, requiring about 15 minutes per site to conduct the evaluation (Dorney and Russell. 2018). As outlined in the methodology, a total of 26 field metrics are observed and rated on a scale of absent, weak, moderate, or strong. The field metrics are separated into three major categories of geomorphology, hydrology, and biology including bank stability, bed composition, riparian canopy cover, and the existence of insects and amphibians. The overall purpose of the method is to identify the origins of intermittent and perennial streams and to characterize stream segments in terms of their flow duration.

   This proposed change from reliance on the OHWM to determination to flow duration will greatly increase the workload (and thereby permitting cost) for public and private projects since consultants and agencies will need to determine flow duration, which is a more complex, time consuming process than the simple, rapid, on-site determination of the presence of an OHWM.

   Contrary to what the rule proposes, the use of intermittent or perennial (or non-ephemeral) flow as opposed to the OHWM as currently used will not be simple for landowners to understand.

Indeed, determination of the OHWM is vastly simpler for consultants and landowners to determine in the field than flow duration, which requires specialized training and equipment.

Methodologies to identify stream flow duration only exist in North Carolina, Tennessee Department of Environment and Conservation, 2011), and Pacific Northwest (Washington, Oregon, and Idaho) (Dorney and Russell, 2018; Nadeau, 2018). Other locations would need to have methods developed and related training conducted. The North Carolina method has been successfully used in Virginia, South Carolina, and Georgia, but scientifically developed and vetted methods are certainly not available for the rest of the country. It takes at least two years to develop these methods and at least two years to train a critical mass of agency personnel to properly use the method. Therefore, accurate implementation of a flow duration-based regulatory program cannot be done quickly without massive inconsistencies in implementation in the field.

Under the proposed rule, each Corps district or each state would have to develop or adopt a protocol for determining where ephemeral streams begin and end. There are only three in the country—one used in NC, one used in TN, and one used in the Pacific Northwest. Two are described in Dorney, et al. (2018, Chapters 4.1.1 and 4.1.2). To develop a new protocol and provide the necessary training will take years. At the very least, the USACE and EPA need to provide guidance to the Districts who would develop and implement the methods. For instance, the rules could state that rapid methods be developed on a USACE District, USACE Division, or EPA Regional level to determine flow durations that are based on easily observable geomorphology, hydrology, and biological characteristics during a single site visit (i.e., bed, banks, OHWM). These methods need to be developed by a team of local experts and fully tested and validated before they are used (like the process that the EPA recently used in the Pacific Northwest – Nadeau 2018).

For instance, the North Carolina Stream Identification Method (North Carolina Division of Water Quality 2010) is a field-based, rapid assessment method which requires successful completion of a four-day training class which includes a written test and two field tests (Dorney and Russell. 2018). The method contains 26 metrics which must be carefully observed or evaluated in the field and requires use of a soil auger, Munsell soil chart, an aquatic insect sampling net (normally a “D net”) and white sorting pan. The method normally takes about 15 minutes per site in the field to properly evaluate a stream reach. In comparison, the current method used by the US Army Corps of Engineers to identify the OHWM at the upgradient terminus of an ephemeral stream takes about 10 seconds per field site. Therefore, use of ephemeral versus intermittent versus perennial tributary determinations are much more time intensive and require specialized training to implement consistently.

4. **Watershed Scale (84 Fed. Reg.at 4154, 4178-79):** The rule suggests the use of watershed scale as a way to determine stream flow duration. While watershed size is certainly a factor, so is slope, physiographic region, soils, vegetation cover, land use, etc. (Russell, et al. 2015). Watershed scale by itself is much too simple a criterion.

5. **Effect of limiting adjacency, such as setting a distance limitation for adjacent wetlands (84 Fed. Reg. 4154, 4189):** The agencies request comment on whether to use distance from another

jurisdictional water as the basis for asserting jurisdiction over wetlands; they also request comment on establishing a jurisdictional cut-off in a contiguous wetland. As described above, the scientific literature does not provide any scientifically supportable distance, so any distance chosen will be arbitrary (USEPA 2015). Also use of a distance invariably means that some wetlands beyond that distance will lose jurisdiction even though they are connected (hydrologically, functionally, etc.) to the wetland that happens to be within the distance. Because of their connection, this approach would hinder the water quality function of all the wetlands, whether jurisdictional or not, and of any adjacent or abutting jurisdictional waters.

6. **Requirement for an intermittent or perennial surface connection for wetlands coverage:** As noted above, the requirement for an intermittent or perennial connection will eliminate a large amount of highly functional riparian and non-riparian wetlands, especially in the piedmont and inner coastal plain (see Table 1 and Table 2), from jurisdiction including a large number of wetlands in floodplains which receive periodic overbank flow. The scientific literature (and EPA's connectivity report, US EPA 2015) strongly support the importance of all wetlands in floodplains but again the scientific literature and the connectivity report do not provide guidance on any specific distance.

7. **Trespassing will be required to implement this rule.** If a delineator needs to determine if a wetland has an intermittent or perennial connection or if a stream is an intermittent or perennial tributary to a Traditionally Navigable Water, additional field work often involves going off the property (and thereby trespassing) to determine connectivity. No existing data source is accurate enough to use in lieu of field work. As noted before, the USACE does not have the power of eminent domain and allowable trespass onto private property without owner consent which sets up an impossible process to implement.

   To make a jurisdictional determination, the rule also would require the delineator to determine if the stream or wetland is connected to a downstream WOTUS via an intermittent or perennial stream. This will also likely require going offsite and therefore trespassing onto adjacent property. Plus, additional field work will be needed which would likely consist of an additional field visit, which will then increase the cost of permitting. We expect that for public work (such as for the North Carolina Department of Transportation or a public utility), consultants would not be authorized to go outside the study area due to trespass concerns and therefore consultants or landowners may have difficulty in making a jurisdictional determination in these cases. The USACE would then have to make that determination later and address the trespass issue; however, USACE agency staff does not generally have trespass rights unless specifically provided by the property owner verbally or through application for a USACE permit.

8. **The rule discusses the use of State/Tribal/Federal geospatial databases** to make jurisdictional determinations, but these databases either do not exist or are wildly inaccurate. For instance, the rules suggest the use of LiDAR to determine stream flow duration. LiDAR is a very powerful tool and is widely used in North Carolina for a variety of purposes since it is available for the entire state. However, LiDAR cannot be used to determine stream flow duration; without additional extensive field work. Finally, statewide LiDAR is available in only a few locations in the U.S.

Therefore, these databases either do not exist or are not useable for the anticipated purposes. For example, the state of North Carolina has begun to develop and implement the so-called ATLAS project (NC DOT, 2019) to use the latest GIS tools to expedite the delineation process and especially expedite environmental screening for projects. However, even this very sophisticated product does not eliminate the need for site visits. These site visits are critical to make valid, scientifically-sound determinations of the existence of streams and wetlands in the landscape.

9. **Does the proposed rule provide clarity in determining jurisdiction?** No, despite the overall goal of the proposed rule is to develop "simple, understandable, and implementable terms" and "bright jurisdictional lines that are easily comprehensible and implementable" (84 Fed. Reg. 4197). For the reasons outlined above, this is simply not true. North Carolina has almost two decades of experience in determining stream flow duration with the original goal being a determination that could be made by a landowner/layperson. This was not achieved and cannot likely be achieved based on our extensive experience. Based on our two decades of experience in implementing the riparian buffer rules in North Carolina, the determination of ephemeral versus intermittent versus perennial flow requires specialized training and expertise. The new rule provides so little guidance that determining jurisdiction will be very difficult, even with expert guidance.

10. **Ponds**: Whether ponds are or were built in streams, they are jurisdictional. They should also be jurisdictional if they have a "significant nexus" to downstream waters of the United States. That is the only way to protect water quality in the downstream waters.

11. **Maps**: The rule requests information on maps of jurisdictional features. There are no maps of streams or wetlands with any accuracy for the Southeastern U.S. In fact, the more accurate stream map in North Carolina (the hard copy NRCS soil surveys) are not even digitized (North Carolina Division of Water Resources, 2019a; Colson, et al. 2008). The streams shown on the Web Soil Survey are completely misleading. There are modeling efforts underway (see Russell et al., 2015 and the NC ATLAS project (NC DOT 2019)) but those are not yet complete. Based on our extensive experience, field visits are essential.

5. References

Colson, T, J. Gregory, J. Dorney and P. Russell. 2008. Topographic maps do not accurately depict headwater stream networks. National Wetlands Newsletter 30(3): 25-28.

Dorney, J.R., L. Paugh, A.P. Smith, T. Allen, M.T. Cusack, R. Savage, E.B. Hughes and B. Munoz. 2015. The North Carolina Wetland Assessment Method (NC WAM): Development of a Rapid Wetland Assessment Method and Use for Compensatory Mitigation. Environmental Practice 17 (2):145-155.

Dorney, Savage, Tiner, and Adamus (eds). 2018. Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

Dorney and Russell. 2018. North Carolina Division of Water Quality Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Chapter 4.1.1 Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

Eaton, L. and R. Vander Vorste. 2012. Final Report: Documenting Significant Nexus to Navigable Waters in the Southeast CD 95415609-0. NC Division of Water Quality, Raleigh, NC. Available at http://ofmpub.epa.gov/apex/grts/f?p=101:150:8728681756582::NO::P150_GRT_SEQ:100807#final. Accessed December 30, 2014.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The ecological and hydrological significance of ephemeral and intermittent streams in the Arid and Semi-Arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, AR/ 233046, 116 pgs.

Moffatt & Nichol. 2019. The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina. Available from Southern Environmental Law Center, Chapel Hill, North Carolina. Update from 2018 version.

Nadeau. 2018. A Rapid Assessment Method for Classifying Flow Permanence of Stream Reaches in the Pacific Northwest, United States. Chapter 4.1.2. Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

NC Department of Transportation. 2019. ATLAS project. NC WAM Reference Wetlands. Website pending later in 2019.

NC Administrative Code (NCAC) 2B .0233 (Neuse River Buffer Rules). The rule says the 2015 Rule may have failed to appropriately recognize that the EPA Connectivity report is “not [legally] dispositive” (page 158). In contrast, this rule totally ignores that report.

NC Division of Water Quality. 2010. Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Version 4.11. September 1, 2010. Available at http://www.xerces.org/wp-content/uploads/2009/03/NC_2010_Methodology_identification_intermittent_perennial_streams.pdf.

NC Division of Water Resources. 2019a. Surface Water Identification Training and Certification Class (SWITC) Manual. Chapter 4 – Stream Maps.

NC Division of Water Resources. 2019b. North Carolina State Water Program Summary from the Association of State Wetland Managers report. Available at https://www.aswm.org/pdf_lib/state_summaries/north_carolina_state_wetland_program_summary_083115.pdf

NC Wetlands Functional Assessment Team. 2016. NC Wetland Assessment Manual, Version 5.0. Available at http://www.xerces.org/wp-content/uploads/2009/03/NC_2010_Methodology_identification_intermittent_perennial_streams.pdf

Russell, P. S. Gale, B. Munoz, J. Dorney and M. Rubino. 2015. A spatially explicit model for mapping headwater streams. Journal of the Water Resources Research Association 51(1): 226-239.

Savage, R. and V. Baker. 2010. Field verification of wetland functional assessment methods within local watershed planning areas- Draft report. Department of Environment and Natural Resources. NC Division of Water Quality, Raleigh, NC. EPA Final Report CD-996433105-01. Available at https://sewwg.rti.org/LinkClick.aspx?fileticket=iBF4Fd4cOHM%3d&tabid=60. Accessed on March 27, 2019.

Tennessee Department of Environment and Conservation, Division of Water Pollution Control. 2011. Guidance for Making Hydrologic Determinations. Version 1.4, May 2011. Available at https://www.tn.gov/content/dam/tn/environment/documents/guid_hydro_det.pdf.

Trimble, S. W. 1974, 2008. Man-Induced Soil Erosion on the Southern Piedmont, 1700-1970. Enhanced Edition with a new foreword by Andrew Goudie. Soil and Water Conservation Society, Ankeny, Iowa.

US Army Corps of Engineers. 2005. Regulatory Guidance Letter: Ordinary High Water Mark Identification. December 7, 2005. RGL 050-05.

U.S. Army Corps of Engineers. 2014. Ordinary High Water Mark (OHWM) Research, Development, and Training, Improving Corps regulatory practices. Available at: https://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/486085/ordinary-high-water-mark-ohwm-research-development-and-training/. Accessed on March 26, 2019.

U.S. EPA. Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence (Final Report). 2015. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-14/475F, 2015. Available at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=296414

Williams, N.B. 2005. Relationship between flow regime and aquatic macroinvertebrate abundance in headwater streams in the piedmont region of North Carolina. MS Thesis. North Carolina State University, Natural Resources, Hydrology.

6. Appendices

Appendix 1: Author Biographies

John Dorney – Mr. Dorney has been employed by Moffatt & Nichol since March 2014 after working three years with another private consulting firm and working with the Water Quality Section of the NCDivision of Water Quality for about twenty-nine years. At Moffatt & Nichol, he is responsible for doing environmental permitting as well as being involved in stream and wetland functional assessment. When Mr. Dorney started at the Division of Water Quality, he spent three years working on water quality standards. After that he was the supervisor of the Special Projects Group in Water Quality Planning for three additional years. From 1990 to

2004, Mr. Dorney was responsible for the 401 Water Quality Certification Program in North Carolina and was supervisor of the Wetlands/401 Unit that is responsible for regulatory review of development projects to ensure compliance with the state's wetland and buffer regulations. From 2004 to 2011, he oversaw the Wetlands Program Development Unit which is responsible for developing and implementing new or modified wetland regulatory policies including developing policy for cumulative and indirect impact as well as FERC permitting and watershed monitoring. Previously Mr. Dorney worked for environmental consulting firms in Wisconsin and Ontario, for local governments and a Native American tribe doing land use and recreational planning and at a research lab at NC State University.

Mr. Dorney has a BS degree in Biology, an MS degree in Botany, and an MS degree in Civil Engineering. He has prepared numerous government agency reports and has published scientific articles concerning wetlands and water quality. In addition, he has been an expert witness for wetlands and water quality for several court cases. He has also done numerous presentations on water quality issues and wetland/buffer regulations for various groups. Recently, he was the main editor on a book published by Elsevier entitled "Wetland & Stream Rapid Assessments: Development, Validation, and Application" edited by John Dorney, Rick Savage, Ralph Tiner, and Paul Adamus (2018).

Jerry McCrain – Dr. McCrain has a background in wetland ecology, permitting, mitigation banking, environmental policy development, watershed planning, and complex project management. With 44 years of highly diversified experience in the environmental field, including 30 years of progressive consulting experience, Dr. McCrain has managed several hundred environmental projects throughout the Southeast US, Africa, and the Caribbean in the past 15 years. He is a Certified Environmental Professional through the Academy of Board of Certified Environmental Professionals and a Professional Wetland Scientist.

His current and previous experience is directly related to this work. As principal-in-charge and senior project manager for a $3 million, three-year contract for policy-level support at EPA headquarters, his work involved support for economic and regulatory impact analysis under the Clean Water Act, Section 404 permitting program, as well as reviewing and evaluating direct, secondary, and cumulative impacts associated with proposed alternatives; compliance with Section 404(b) (1) guidelines; stakeholder involvement; technical assessments; and QA/QC review of technical reports.

He managed a $4.7 million oyster reef project for the NC Division of Mitigation Services involving design, engineering, and environmental services. The 42-acre reef structure will be located in Pamlico Sound and will be one of the largest artificial reef projects in the US once constructed.

Most recently, Jerry has served as the environmental, safety, social, and sustainability lead review consultant to International Finance Corporation/World Bank for a $1.5 billion port project in Tema, Africa – the largest infrastructure project on the continent. His work includes

site visits; analysis of submitted environmental, social, and safety documentation; and stakeholder interactions to insure compliance with World Bank performance standards.

Ken Jolly – Mr. Jolly graduated from NC State University with a B.S. in Wildlife Biology in 1977. He has 34 years of experience with all aspects of the USACE Regulatory Program in Wilmington District, performing all technical duties from Regulatory Specialist to Regulatory Chief. As the Wilmington District Regulatory Chief from 2002 to 2012, he planned, directed, monitored, and executed the Wilmington District throughout North Carolina, leading a staff of 54 technical and administrative personnel. During the period January to June 2010, he completed a developmental assignment with the Assistant Secretary of the Army for Civil Works, serving as liaison with Headquarters-level staff of all federal agencies, including USACE; tribal representatives; congressional, senate, and state government staff; and the public on policy matters involving national USACE Civil Works issues. From 1987 to 2001, he served as the Section/Field Office Chief for the Raleigh Regulatory Field Office, managing and executing the Regulatory Program throughout a 30-county area of North Carolina while leading a staff of 7 technical and administrative staff. As Field Office Chief, he worked as the senior technical Regulatory specialist, interacting daily with state and federal agency representatives, local government representatives, and the public regarding Regulatory issues and concerns. From May to September 2017, he served as a Regulatory Project Manager/Supervisor Mentor with Alaska District USACE, assisting in preparation and review of NEPA documentation for controversial projects with significant, major impacts on the human environment.

Adam Efird – Mr. Efird is a senior environmental scientist at Moffatt & Nichol with 10 years of experience and expertise in the areas of wetland and wildlife ecology, species modeling, GIS, natural resource management, urban ecology, air quality analysis, traffic noise modeling, NEPA/SEPA, and environmental permitting. He has a BS in Biology from Campbell University, and a Master of Natural Resources from Virginia Tech.

Rebeckah Hollowell – Ms. Hollowell is an environmental scientist at Moffatt & Nichol. She has a BS in Biological Sciences and MS in Plant and Environmental Sciences from Clemson University. She has been with Moffatt & Nichol almost two years. Her expertise includes wetland and stream ecology, natural resource management, environmental planning, NEPA/SEPA, GIS, stream restoration, mitigation, and environmental permitting. Ms. Hollowell provides GIS support for various environmental, planning, and project development tasks.

Appendix 2: The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina with Extrapolations to Virginia, South Carolina, and Georgia

Final Report

The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina with Extrapolations to Virginia, South Carolina, and Georgia

Presented to:

Geoff Gisler, Southern Environmental Law Center (SELC)
Chapel Hill, NC

April 7, 2019

Prepared by:

Moffat & Nichol

1. Legal Background

The definition of Waters of the United States (WOTUS), especially in the context of the 404 Permit Program, has been the subject of three main US Supreme Court cases (Riverside Bayview, Solid Waste Authority of Northern Cook County [SWANCC], and most recently, the Rapanos/Carabell case in 2006). As a result of the Rapanos/Carabell decision (Rapanos v. United States, 547 U.S. 715), the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) have used either the "relatively permanent" test outlined by the opinion of Justice Scalia (described below) or the "significant nexus" test outlined by the opinion of Justice Kennedy. In 2008, the agencies issued guidance interpreting the Rapanos decision (2008 Guidance). In most situations, the significant nexus test has been used by USACE since it is the broader definition, with strong reliance on the 1987 Manual and its Regional Supplements.

In 2011, the Obama Administration began a formal process to define WOTUS based on the significant nexus test. This process involved an in-depth examination of the scientific literature, as well as proposed rulemaking and public comment. After this lengthy process, the Obama Administration formally published the new definition of WOTUS on June 29, 2015. A day before the final rule became effective on August 28, 2015, it was stayed in 13 states by a district court. On October 9, 2015 the U.S. Court of Appeals for the Sixth Circuit stayed the Clean Water Rule nationwide. The Sixth Circuit directed EPA and USACE to use the 2008 Guidance to make jurisdictional determinations. On February 28, 2017 the Trump Administration issued an Executive Order directing EPA to repeal and then replace the CWR with a new rule consistent with the Scalia test. On July 27, 2017 EPA issued a proposed rule that would repeal the CWR. On February 14, 2019, EPA proposed a new definition of WOTUS.

The new proposed definition is largely consistent with the test for making jurisdictional determinations articulated by Justice Scalia in the Rapanos case. Under the proposed WOTUS definition, federal jurisdiction under the Clean Water act would be limited to "relatively permanent flowing and standing waterbodies that are traditional navigable waters in their own right or that have a specific connection to traditional navigable waters, as well as wetlands abutting or having a direct hydrologic surface connection to those waters." Revised Definition of "Waters of the United States", 84 Fed. Reg. 4154, 4170 (Feb. 14, 2019). The proposed rule expressly excludes ephemeral streams. It also requests comments on numerous ways jurisdiction could be narrowed, including on whether intermittent streams should be jurisdictional.

The work described in this report examined the potential effect of a "relatively permanent" definition of waters with respect to streams in Level IV ecoregions of North Carolina where field data exist to conduct the analysis. For this analysis, we assume that "relatively permanent" is synonymous with perennial flow.

2. Purpose of this Work

The purpose of this work is to gather and analyze data on intermittent and perennial stream origins and their lengths from field-collected data in selected Level IV ecoregions in North Carolina. These origins have been collected using the most current (at the time of data collection) version of the NC

Stream Identification Method (NC Division of Water Quality, 2010). These data were then analyzed by Level IV ecoregion (Griffith et al., 2002) to estimate the percent of stream length in these ecoregions that is intermittent and the percent of steam length in these ecoregions that is perennial. Conclusions were then made as to whether these results could be extrapolated to the same ecoregions in Virginia, South Carolina, and Georgia. Note that various technical issues with these data are described in Appendix 1 of this report.

3. Scientific Background

Most studies of stream flow duration involve either simple mapping exercises or mapping of stream types in selected watersheds rather than comprehensive analyses over a large geographic region. Very few studies have been published on the distribution of stream flow in larger geographic areas, such as states or countries.

It is well known that analyses using existing maps to determine the distribution of ephemeral, intermittent, or perennial channels are problematic due to the low level of accuracy of the underlying maps (Colson, et al. 2008). Other studies use more accurate field determinations of stream origins often in association with GIS models of stream networks derived from field-determined origins (Russell, et al. 2015; Fritz, et al. 2013.; Williamson, et al. 2015; Caruso 2014) based on the analysis of selected (usually relatively undisturbed) watersheds. For instance, Russell, et al. (2015) reported that 35% of the streams in North Carolina's Triassic basin were intermittent, while Caruso (2014) reported that about 50% of the streams in his western Colorado study area were ephemeral, about 13% were intermittent, and about 37% were perennial. From an analysis of data presented by Fritz, et al. (2013) – Table 3), of intermittent and perennial steams in various selected study watersheds in the eastern U.S., an average of 57.9% were intermittent and 42.1% were perennial, but the percentage of streams that were intermittent ranged from zero to 82.6% depending on the watershed. It also has been shown that the percentage of ephemeral and intermittent streams is generally highest in arid climates (Levick, et al. 2008). In general, the ratio of intermittent to perennial streams varies considerably based on climate, geology, and past land use.

The analysis reported in this document examines the state of North Carolina, which has diverse physiography, from flat, sandy Coastal Plain, to rolling, clayey Piedmont, to steep mountain terrain of the Appalachian Mountains (and their foothills). In addition, because some of these ecoregions also occur in the neighboring states of Virginia, South Carolina, and Georgia, these results can be extrapolated to the same ecoregion in adjacent states. As far as we can determine, this is the first comprehensive analysis of stream flow duration on a statewide scale in the United States, which is especially notable in a state like North Carolina with greatly varying physiography.

4. Data Sources

4.1. Level IV Ecoregions

The EPA and respective state cooperating agencies have prepared maps of (the larger) Level III and (the smaller) Level IV ecoregions. The North Carolina ecoregion map dates to 2002 (Griffith, et al.

2002) and contains four Level III ecoregions (Middle Atlantic Coastal Plain, Southeastern Plains, Piedmont, and Blue Ridge Mountains) as well as 27 Level IV ecoregions (see Figure 2). Ecoregions are defined as areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Griffith et al., 2002). Ecoregions are designed to serve as a framework for research, assessment, management, and monitoring of ecosystems and are based on consideration of geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. As such, these Level IV ecoregions serve as an ideal framework to collect stream origin data and have been used by the NC Division of Water Resources as the framework for the data collection and modeling efforts used in this report.

4.2.NC Stream Identification

4.2.1.**Stream Definitions –** According to the NC Stream Identification Method (NC Division of Water Quality, 2010) and the underlying NC Riparian Buffer Rules (NC Environmental Management Commission, 2007), there are three basic types of streams ephemeral, intermittent, and perennial. Intermittent and perennial streams are discussed in this report. North Carolina's definitions for these streams, which differ slightly from the agencies' proposed definitions as described below, were used to collect data analyzed in this report. In addition, the NC rules contain definitions of "ditches" and "modified natural streams" that are not included in this analysis since these systems are not natural features and are only jurisdictional if they were originally constructed in another jurisdictional water.

4.2.1.1. **Ephemeral Streams:** The NC method is not used to determine the origin of ephemeral streams. Therefore, data on the length of ephemeral channels (which may or may not have an OHWM) is not available in NC or the surrounding states. However, based on our extensive field experience, the portion of ephemeral streams with Ordinary High Water Marks is located immediately upslope of the intermittent origin.

4.2.1.2. **Intermittent Streams:** "Intermittent stream means a well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological and hydrological characteristics commonly associated with the conveyance of water. [15A NCAC 02B .0233(2)(g)]." (NC Division of Water Quality, 2010).

Generally, in North Carolina and the southeastern U.S., intermittent streams are connected to the local high groundwater table usually in the winter (when evapotranspiration is limited) and have flowing water for three to four months during that time (Williams, 2005). In our experience, these channels always have OHWMs and are therefore considered jurisdictional by the USACE under the existing 404 permit program. These streams also include protected buffers where State riparian regulatory programs exist.

4.2.1.3. **Perennial Streams:** "Perennial stream means a well-defined channel that contains water year-round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water. [15A NCAC 02B .0233(2)(i)]." (NC Division of Water Quality, 2010).

Generally, in North Carolina and the southeastern U.S., perennial streams are connected to the local high groundwater table year around during a year of normal rainfall and have flowing or ponded water during that entire time. In our experience, these channels always have OHWMs and are therefore considered jurisdictional by the USACE for the 404 permit program and have protected buffers where State regulatory programs exist.

5. The NC Stream Identification Method (NC Division of Water Quality, 2010)

The NC Stream Identification Method was first developed in 1999 as a tool for state staff and the regulated public to use to determine the presence of intermittent and perennial streams for the Neuse River Riparian Buffer Rules (NC Environmental Management Commission, 2007). This program has since been expanded to be used throughout the state for buffer rules in other river basins and the definitions listed above have been adopted for determining and defining intermittent and perennial streams. The method has been updated several times and the most current version is the 4.11 version dated September 1, 2010. A modified version of the method has been used in the Chesapeake Bay area for the determination of buffers (DeBerry and Crayosky, 2018). A validation study on the method was published by Fritz et al. (2013).

The method uses 26 metrics that are usually scored from 0 to 3 (zero indicates that a respective metric is usually “absent” while three is usually “strong”). This methodology is designed to be a rapid assessment and completed on a uniform, selected stream reach in about 15 minutes, which includes time for sampling aquatic macroinvertebrates with a net as well as soil sampling with a soil auger.

If the system scores at least 19 points, this waterbody is generally considered intermittent while if the channel scores 30 points, it is generally considered perennial (absent unusual or extenuating circumstances judged on a case-by-case basis). The perennial determination can also be made based on the presence of specific aquatic life (including aquatic macroinvertebrates) which require permanent water for survival as listed in the Manual.

6. Peer-reviewed Literature in North Carolina

Russell et al. (2015) published the results of an analysis of stream origins in the Triassic basin in NC. Data were collected from 157 intermittent and perennial stream origins across seven rural watersheds

in the Triassic basin. "Stream origins" are defined as those locations on the ground where the stream type changes from ephemeral to intermittent (an intermittent origin) or from intermittent to perennial (a perennial origin). Statistical models were then developed to predict the origins of intermittent and perennial streams in this Level IV ecoregion. Data from this publication were used in Table 1 to characterize the percentage of intermittent and perennial streams in North Carolina's Triassic basins.

7. Data Collection

The NC Division of Water Resources (DWR – formerly the NC Division of Water Quality) has had an active program of locating intermittent and perennial stream origins in selected watersheds within Level IV ecoregions of the state since 2005. The purpose of this work is to gather field data to develop statistically valid, linear regression models of stream origins and then use those models to produce statistically valid maps of these intermittent and perennial streams for each of the 27 Level IV ecoregions of the state. As of the end of 2018, the DWR had gathered stream origin data from 173 watersheds in 19 Level IV ecoregions (personal communication, Andrew Kiley, NC Division of Water Resources, February 18, 2019). For this project, electronic copies of these data were obtained from the DWR under a Public Records request and then analyzed as described below. The critical assumption in this analysis (as in Russell, et al. 2015) is that the watersheds where the data were collected represent the Level IV ecoregion where they were collected.

8. Data Analysis

Data were separated either by project name/location or by Level IV ecoregion. DWR staff are actively engaged in organizing the data to analyze using the latest version of the state's LiDAR data. Therefore, the data as of the end of 2018 were in various states of being organized. Some data had already been sorted and updated by DWR staff, while other data contained raw data sets.

Stream-specific data were obtained from the state files and organized by ecoregion. For each ecoregion, a new ArcGIS map was created showing origin points for all identified stream systems and break points between ephemeral and intermittent, intermittent to perennial, etc. for each specific field verified watershed (see Figure 1 on the following page for an example). Each stream length, by type (intermittent, perennial, excluding ephemeral reaches), was measured and quantified. Data were tallied to provide an overall – and consistent – assessment of each stream type. Note that since the NC stream data set only contains locations for the origins of intermittent or perennial streams, that the length of ephemeral reaches is unknown and is not included in this dataset.

Analysis results were then copied into an Excel spreadsheet based on Level IV ecoregion where the size of the watershed, total length of stream, percent length of intermittent stream and percent length of perennial stream, as well as the number of intermittent and perennial origins, were recorded. This was completed for 13 separate Level IV Ecoregions and 66 distinct watersheds. In addition, the seven watersheds for the Triassic basin ecoregion from Russell, et al. (2015) were included in this analysis.

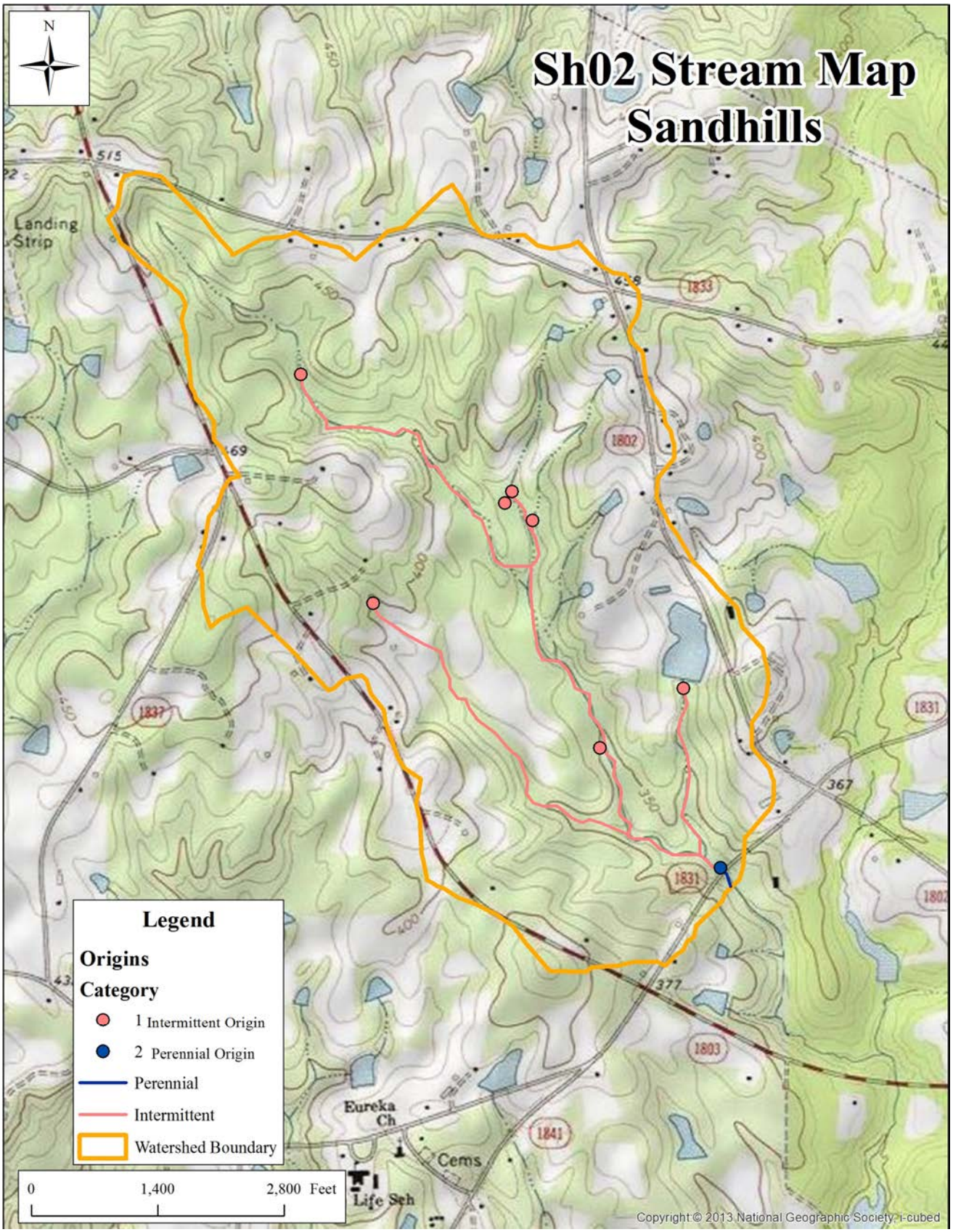


Figure 1: Example of Local Watershed showing locations of intermittent and perennial stream origins

9. Summary of Results by NC Ecoregion – Percentages of Intermittent versus Perennial Streams

The stream origin data gathered from 173 watersheds located in 19 separate Level IV ecoregions across North Carolina, totaled 141.4 square miles of watersheds with a total of 454.6 miles of streams. A total of 1,154 intermittent stream origins and 1,127 perennial stream origins were examined from this data set (Table 1, Figure 2).

Nineteen of the 27 Level IV ecoregions present in the state are represented in this analysis (three ecoregions from the Middle Atlantic Coastal Plain, three ecoregions from the Southeastern Plains, six ecoregions from the Piedmont, and seven ecoregions from the Blue Ridge Mountains) (Table 1). In general, the sample has good representation for the Blue Ridge Mountains (seven of nine ecoregions), the Piedmont (six of seven ecoregions), and the Southeastern Plains (three of the four ecoregions), while it has fair representation for the Middle Atlantic Coastal Plain (only three ecoregions out of seven).

The other eight of the 27 Level IV ecoregions do not have stream origin data in the NC DWR database. These are in the Middle Atlantic Coastal Plain (Nonriverine Swamps and Peatlands, Virginian Barrier Islands and Coastal Marshes Carolinian Barrier Islands and Coastal Marshes); in the Southeastern Plains (Southeastern Floodplains and Low Terraces); in the Piedmont (Kings Mountain); and in the Blue Ridge (Southern Sedimentary Ridges and the Sauratown Mountains). Most of these are fairly small ecoregions in NC.

In general, ecoregions in the Coastal Plain have watersheds containing anywhere from 20.9% to 39.4% intermittent streams based on length (Figure 3). A notable exception is the Sand Hills region with an average of 46.5% intermittent streams and the Atlantic Southern Loam Plains with an average of 96% intermittent streams. In the Sand Hills, this probably reflects the highly porous sandy soil in this ecoregion, which acts as a drain to groundwater rather than allowing surface water to accumulate in smaller valleys. The result is a higher percentage of intermittent streams in this particular ecoregion. In the South Atlantic Loam Plains, undisturbed streams were very difficult to find (Sandy Smith, Axiom Environmental, personal communication, March 18, 2019) which may have affected these results since disturbance (mostly ditching) makes is difficult to determine the undisturbed flow duration

Watersheds in the Piedmont ecoregions range from 19.7% to 24.8% intermittent streams. The Triassic Basin is an exception with intermittent streams averaging 35.3% of the stream length in this area. This probably reflects the relatively impervious soils in the Triassic Basin which severely restrict groundwater infiltration and results in lower local water tables.

Watersheds in the mountains seem to be bimodal in terms of their distribution of the percent intermittent streams. Many mountain ecoregions have percentages of intermittent streams in the single digits (ranging from 0% to 1.8%), but flatter areas (such as the Broad Basins where Asheville, Brevard, and Hendersonville are located) average 20.3% intermittent streams. The Eastern Blue Ridge Foothills ecoregion also averages 20.5%, but of the four watersheds in the sample, there were highly variable percentages of intermittent streams (respectively 2.32%, 4.95%, 33.26%, and 39.76%). This

appears to reflect a highly varied terrain in this particular ecoregion with higher percentages of intermittent streams in local watersheds of flatter relief and lower percentages in steeper terrain. The Amphibolite Mountains and New River Plateau ecoregions also average around 20% intermittent streams. One important caveat is that seeps are very common in the uppermost ends of small valleys in the mountains. These features are often delineated as small wetlands rather than streams but commonly have biota more characteristic of perennial streams such as presence of benthic macroinvertebrates (immature salamanders, larvae of stoneflies, caddisflies and mayflies). Since seeps are not normally delineated as streams, there may be additional small lengths of perennial or intermittent channels within these seeps that are not captured in the data for mountain stream length.

Overall, data for the percent of intermittent versus perennial streams account for about 93% of the land area of North Carolina based on data from these 19 Level IV ecoregions.

With respect to the average length of intermittent stream segments by Level IV ecoregion, in general the Coastal Plain (especially the Sand Hills at 1,378.3 feet and the Chesapeake-Pamlico Lowlands and Tidal Marshes at 1,940.8 feet) had the longest average lengths of intermittent streams while the steep mountainous ecoregions had the shortest average length. The Piedmont and the less steep mountains generally have intermediate average lengths of intermittent streams. The New River Plateau, part of the Blue Ridge Level III ecoregion, had an average lengths of intermittent streams with 1391.72 feet. In the Southeastern Loam Plains, the ecoregion with one of the greatest average lengths of intermittent streams was the Atlantic Southern Loam Plains, with an average of 1876.29 feet.

With respect to the percentage of streams that are first order (defined as either intermittent or perennial streams that do not have another stream draining into them), the data showed wide ranges between ecoregion with percentages ranging from 84.0% (Mid-Atlantic Flatwoods), to 52.8% (Sand Hills), to 35.4% (Slate Belt). The High Mountains ecoregion was less (16.2%) but since this represents only one watershed, it is unclear whether this is an accurate assessment of this particular ecoregion. There was no clear pattern between the Level III ecoregions as there was with the average length of intermittent streams, discussed above. Finally, Russell, et al. (2014) did not present this statistic so average stream length was not calculated for this particular ecoregion.

Table 1: Summary of local watershed data by Level IV ecoregion

Level III Ecoregion	Level IV Ecoregion	Number of Watersheds	Range of Watershed Sizes (mi2)	Average Watershed Size (mi2)	Average Number of Intermittent Origins per Watershed	Average Number of Perennial Origins per Watershed	Average % Intermittent Length per Watershed	Average % Perennial Length per Watershed	Average Length Intermittent Streams (feet)	Percent of Length of First Order Streams	Data Source	Ecoregion in VA?	Ecoregion in SC?	Notes
Middle Atlantic Coastal Plain	Carolina Flatwoods	5	1.0 - 6.1	2.9	9.4	8.8	20.9%	79.1%	665.6	46.8%	DWR 2017	No	Yes	
	Cheaspeake - Pamlico Lowlands and Tidal Marshes	11	n/a	n/a	3.18	2.27	39.4%	60.6%	1940.8	72.0%	DWQ 2006	Yes	No	Cannot determine watershed sizes due to mining disturbance in the watershed.
	Mid-Atlantic Flatwoods	41	2.91 to 339.4 acres	35.94	1	1	54.0%	46.0%	514.75	84.0%	DWR 2018	Yes	No	
	Mid-Atlantic Floodplains and Low Terraces	4	14.65 to 64.71 acres	35	2	1	40.0%	60.0%	643.91	66.0%	DWR 2018	No	Yes	
Southeastern Plains	Sand Hills	5	0.8 - 2.6	1.6	5	3.6	46.5%	53.50%	1378.3	52.8%	DWR 2017	No	Yes	
	Rolling Coastal Plain	7	2.73 to 6.32	4.0	18.3	10.6	26.6%	73.4%	665.6	47.5%	DWR 2017	Yes	No	
	Atlantic Southern Loam Plains	18	13.93 to 222.1 acres	97.77	1	0	96.0%	4.0%	1876.29	67.0%	DWR 2018	No	Yes	
Piedmont	Southern Inner Piedmont	19	7.54 to 477.39 acres	106.39	2	2	22.0%	78.0%	601.58	53.0%	DWR 2018	No	Yes	
	Southern Outer Piedmont	4	0.77 to 2.41	1.4	21.5	20.5	19.7%	80.3%	366.0	47.8%	DWR 2017	No	Yes	
	Carolina Slate Belt	5	1.2 to 6.2	2.8	16.6	13	24.8%	76.2%	644.6	35.4%	DWR 2017	Yes	Yes	
	Northern Inner Piedmont	7	0.74 to 2.88	1.8	30.4	18.1	20.0%	80.0%	367.9	36.9%	DWR 2017	Yes	No	
	Northern Outer Piedmont	6	0.65 to 2.39	1.3	14.3	9.3	19.9%	80.1%	366.0	47.1%	DWR 2017	Yes	No	
	Triassic	7	0.42 to 1.85	1.1	15	7.4	35.3%	64.7%	169.8	Unknown	Russell, et al. 2014. JAWRA	Yes	Yes	
Blue Ridge	Southern Crystalline Ridges and Mountains	2	5.0 to 10.9	7.9	18	98	1.8%	98.2%	211.7	39.1%	DWR 2017	Yes	Yes	Small number of watersheds
	Southern Metasedimentary Mountains	4	0.12 to 0.5	0.26	0.5	21.2	1.8%	98.2%	351.8	46.6%	DWR 2017	No	No	
	High Mountains	1	1.1	1.1	0	16	0%	100%	0.0	16.2%	DWR 2017	No	No	Small number of watersheds
	Broad Basins	5	0.4 to 2.5	1	13.4	13	20.3%	79.7%	554.4	46.7%	DWR 2017	No	No	
	Eastern Blue Ridge Foothills	4	1.1 to 2.8	2.1	25.5	25.8	20.5%	79.5%	576.8	49.0%	DWR 2017	No	No	Need more watersheds - two watersheds with <5% and two watersheds with > 30%. Average is misleading.
	Amphibolite Mountains	7	69.52 to 465.17 acres	245.95	2	3	18.0%	82.0%	1391.72	49.0%	DWR 2018	No	No	
	New River Plateau	11	10.98 to 89.03 acres	52.3	2	3	19.0%	81.0%	370.33	58.0%	DWR 2018	Yes	No	

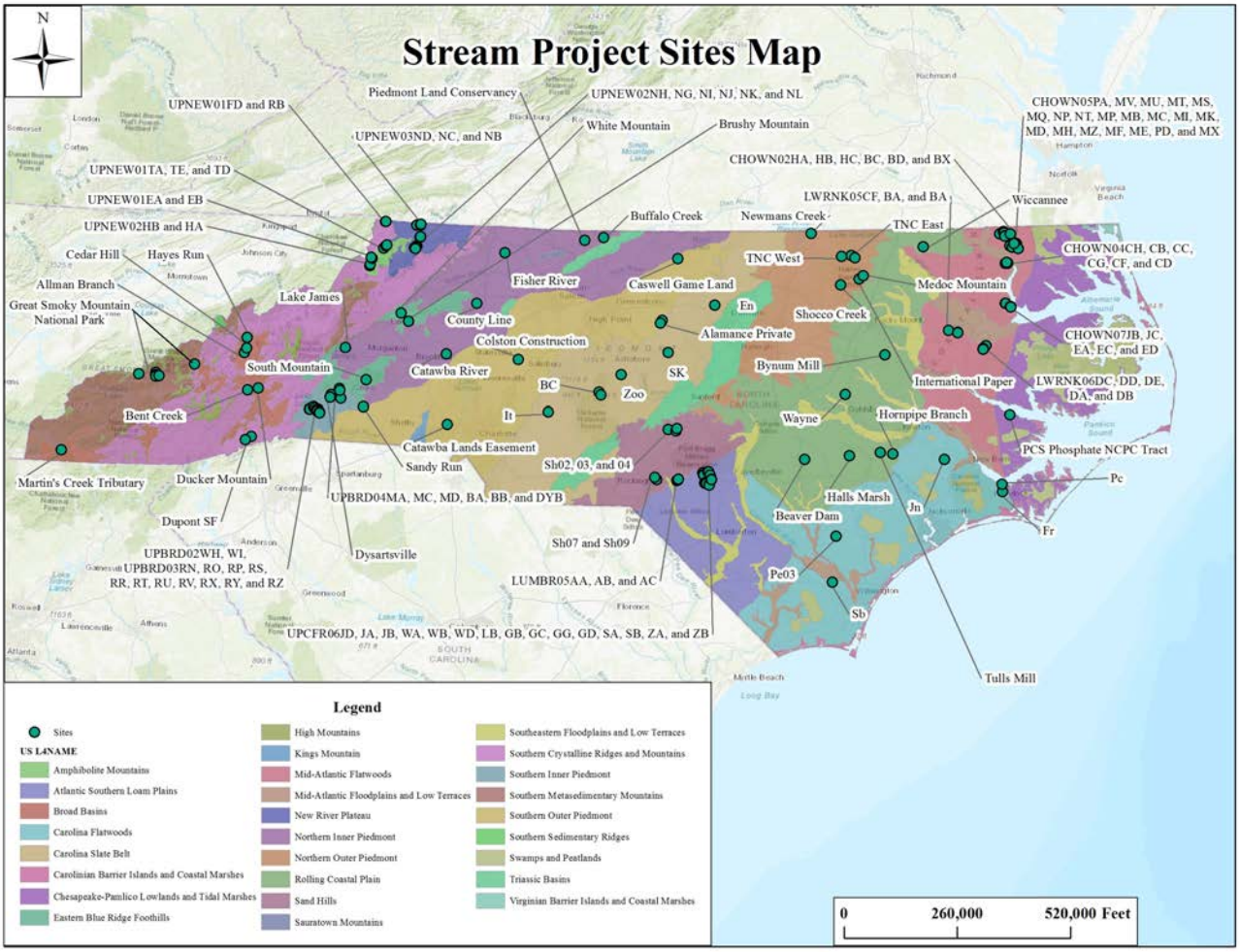


Figure 2: Watersheds studied by Level IV ecoregion in North Carolina

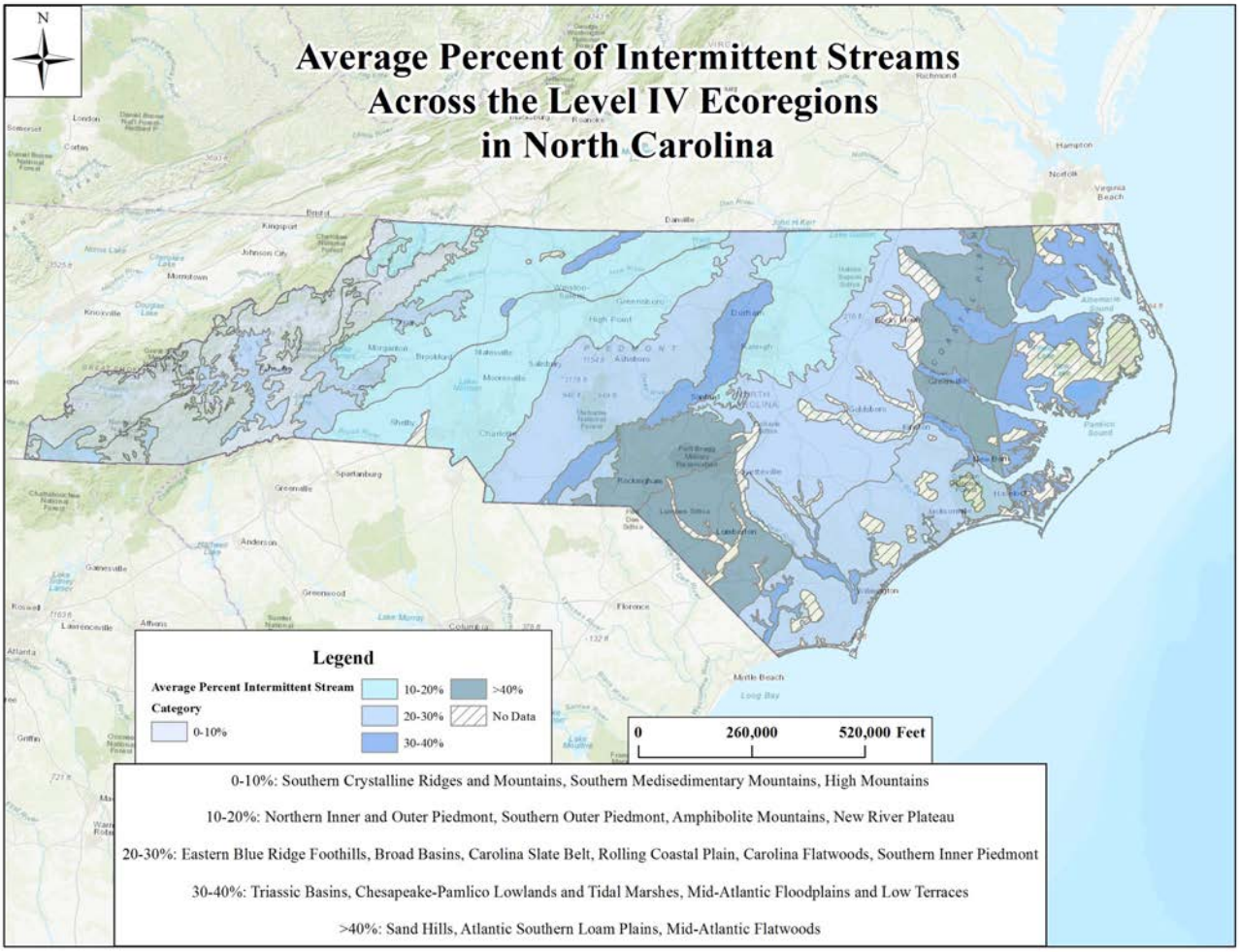


Figure 3: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in North Carolina

10. Extrapolation of Results to Similar Ecoregions in Virginia, South Carolina, and Georgia

Based on an initial examination of topography, soils, ecoregion descriptions, and our personal knowledge of some of the ecoregions, we believe that the percentage of intermittent and perennial streams would likely be similar across the same Level IV ecoregions among the three states (shown as "yes" in Table 1). However, to make a more definitive and quantitative conclusion, further data mining and analysis (grey literature or peer-reviewed literature) and/or field validation in these Level IV ecoregions in these three states would be required. Figure 4 shows the extrapolated average percent of intermittent streams across the Level IV ecoregions in Virginia, while Figure 5 depicts those streams in South Carolina. Finally, Figure 6 depicts those steams in Georgia. In summary, these data predict the intermittent stream percentage for 54% of Virginia, 88% of South Carolina, and 52% of Georgia.

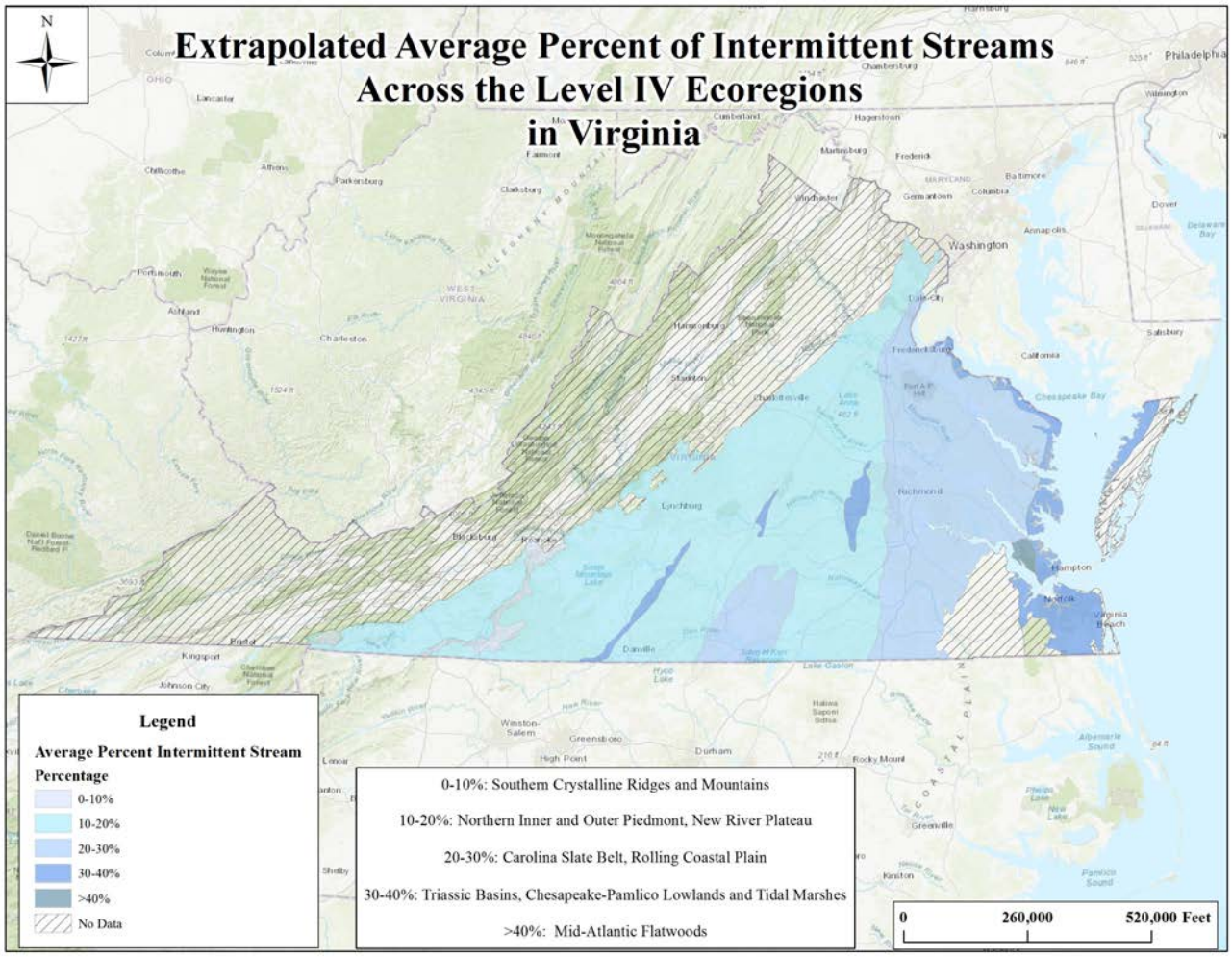


Figure 4: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in Virginia

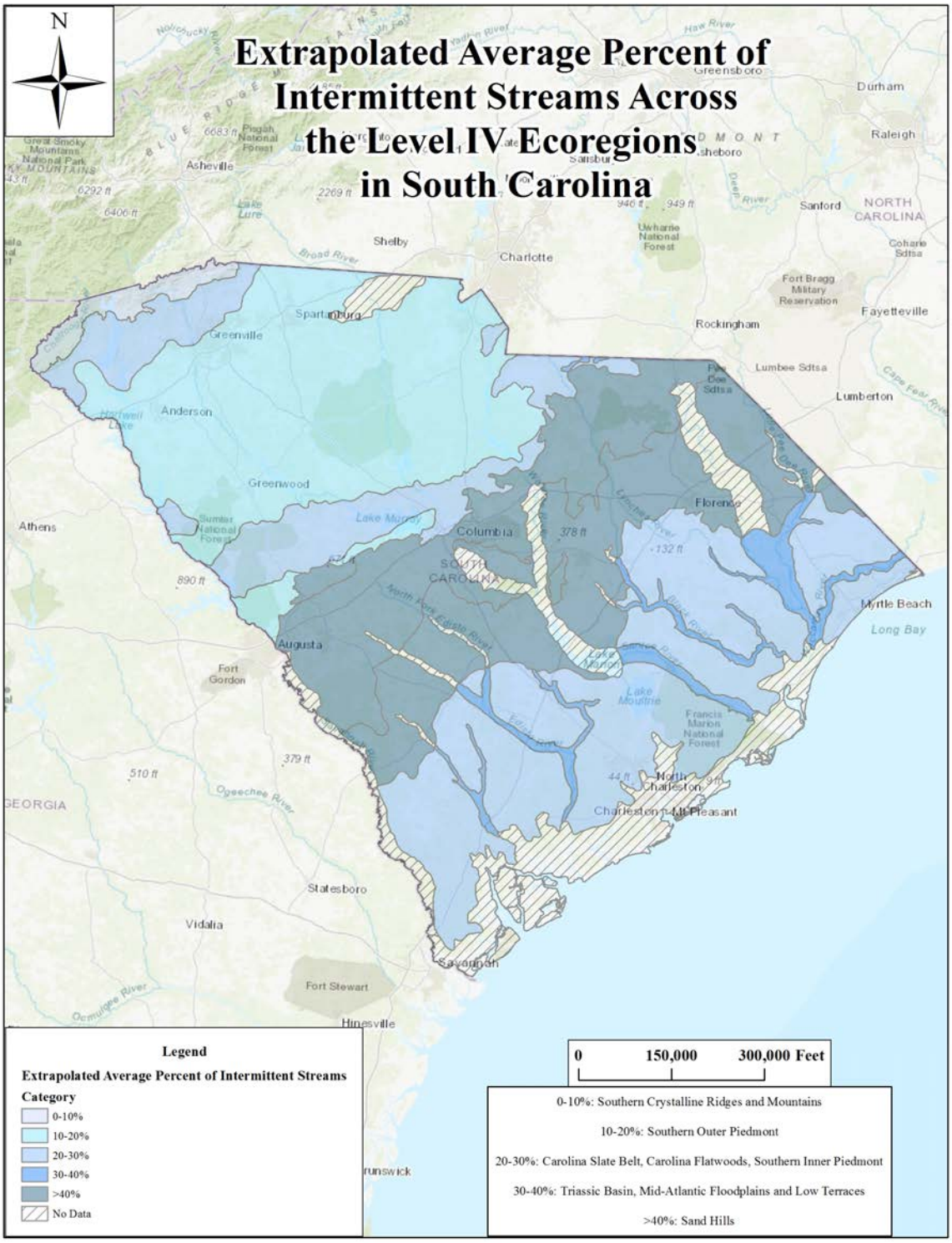


Figure 5: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in South Carolina

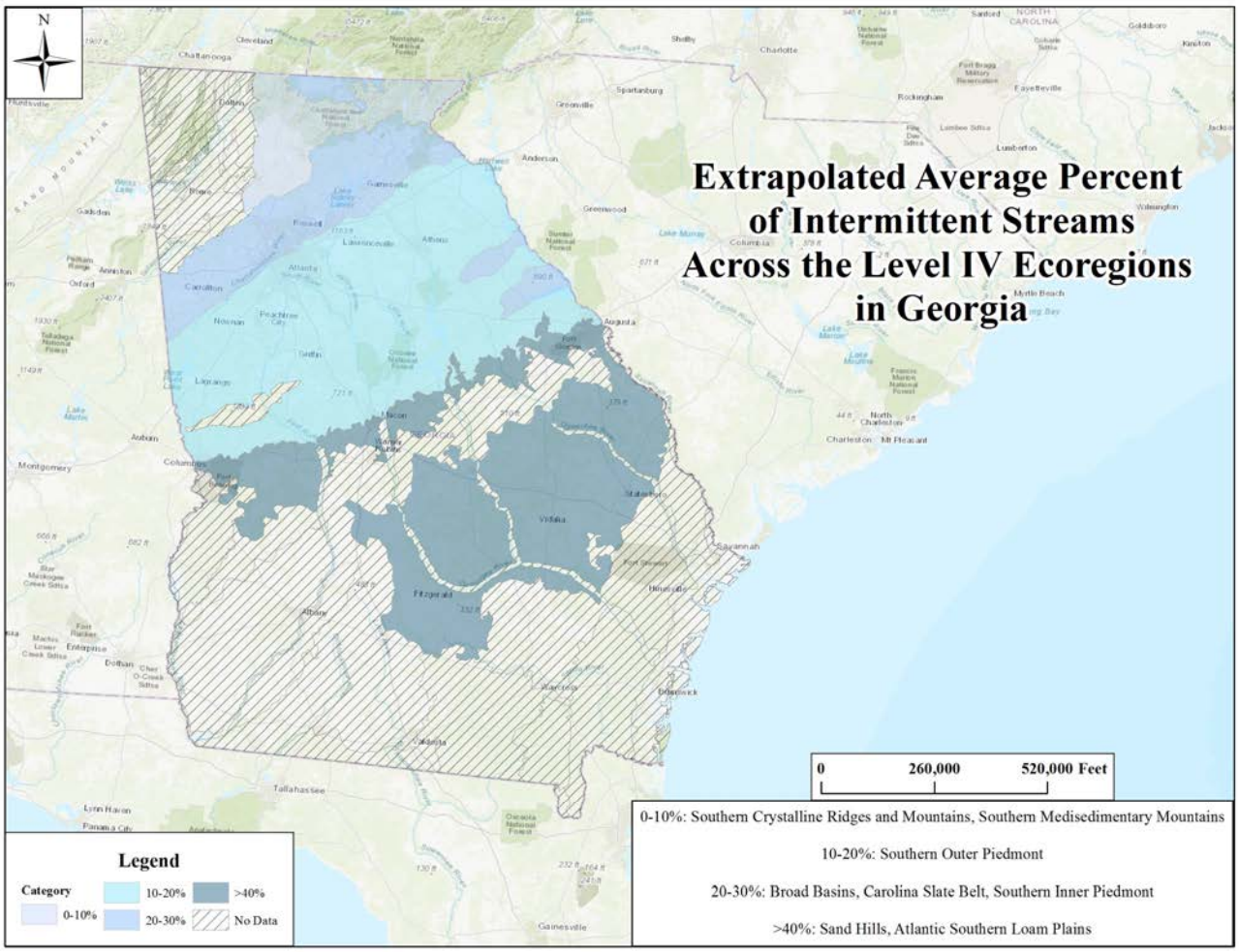


Figure 6: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in Georgia

11. Conclusions

This information about the extent of intermittent and perennial stream length shows that the impact of any potential change in the definition of WOTUS with respect to streams will vary across the state and by Level IV ecoregion. The implications of the change in stream jurisdiction, which could greatly affect the jurisdictional status of ephemeral and intermittent systems, appears to be greatest in the Atlantic Southern Loam Plains, Mid-Atlantic Flatwoods, Sand Hills, Chesapeake – Pamlico Lowlands and Tidal Marshes (data from the PCS Phosphate study – NC DWQ 2006), and Triassic Basin (Russell, et al. 2015) ecoregions and less in the steeper mountainous terrain. Since the NC data do not include ephemeral stream length, this estimate of the extent of streams no longer jurisdictional is a conservative estimate. Based on a weighted average of the percentage of intermittent streams by the area of each Level IV ecoregion, an approximate statewide estimate of 27% was calculated for intermittent streams statewide.

12. References/Citations

Caruso, B.S. 2014. GIS-based stream classification in a mountain watershed for jurisdictional evaluation. Journal of the American Water Resources Association 50(5):1304-1324.

Colson, T., J. Gregory, J. Dorney, and P. Russell. 2008. Topographic and soil maps do not accurately depict headwater streams. National Wetlands Newsletter 30(3):25-29.

DeBerry, D.A. and T.W. Crayosky. 2018. Qualitative Indicators for Perennial Stream Determinations in Virginia. Publication pending in "Wetland and Stream Rapid Assessments: Development, Validation, and Application. Edited by John Dorney, Rick Savage, Ralph Tiner, and Paul Adamus". Elsevier Publishing. London, England.

Federal Register. 2015. Clean Water Rule: Definition of "Waters of the U.S."; Final Rule. Federal Register 80(124): 37054-37126.

Fritz, K.M., W.R. Wenerick, and M.S. Kostich. 2013. A Validation Study of a Rapid Field-Based Rating System for Discriminating Among Flow Permanence Classes of Headwater Streams in South Carolina. Environmental Management 52(5): 1286-1298.

Fritz, K.M., E. Hagenbuch, E. D'Amico, M. Reif, P. J. Wigington Jr., S.G. Leibowitz, R.L. Commeleo, J.L. Ebersole, and T-L. Nadeau. 2013. Comparing the extent and permanence of headwater streams from two field surveys to values from hydrographic databases and maps. Journal of the American Water Resources Association 49(4):867-882.

Gallen, S.F., Webmann, K.W, Frankel, K.L. Hughes, S., Lewis, R.Q., Lyons, N, Paris, P., Ross, K., Bauer, J.B., and Witt, A.C. 2011. Hillslope response to knickpoint migration for the Southern Appalachians: implications for the evolution of post-orogenic landscapes. Earth Surface Processes and Landforms 36: 1254-1267.

Griffith, G.E., Omernick, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D. R., and MacPherson, T.F. 2002. Ecoregions of North Carolina. US Environmental Protection Agency. Corvallis, OR (map scale 1:1,500,000).

Kerrow, A.J., Williams, D.G., and Collazo, J.A. 2006. The North Carolina Gap Analysis Project. Final Report. Biodiversity and Spatial Information Center, North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, Raleigh, NC. Page 21 of 788. Available at http://www.basic.ncsu.edu/ncgap/NCFinal%20Report.pdf. Accessed on November 21, 2017.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046, 116 pp. Available at https://www.epa.gov/sites/production/files/2015-03/documents/ephemeral_streams_report_final_508-kepner.pdf. Accessed on February 27, 2018.

National Land Cover Database (NLCD). 2011. NLCD 2011 Product Data Downloads. Available at: https://www.mrlc.gov/nlcd11_data.php. Accessed November 8, 2017.

N.C. Division of Water Quality. 2006. Stream Origin Assessment: South Creek, NC (PCS Phosphate Company). December 7, 2016 report. Available at https://files.nc.gov/ncdeq/Water%20Quality/Surface%20Water%20Protection/401/Policies_Guides_Manuals/StreamOriginAssessmentforSouthCreek.pdf. Accessed on January 9, 2018.

NC Division of Water Quality. 2010. Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Version 4.11, September 1, 2010. Raleigh, NC. Available at http://portal.ncdenr.org/web/wq/swp/ws/401/waterresources/streamdeterminations, Accessed on January 26, 2016.

NC Division of Water Resources. 2017. Data from the NC Stream Mapping Program, provided in response to a Public Records request. Andrew Kiley and Ernest Hahn. October 25, 2017 and November 7, 2017.

N.C. Environmental Management Commission. 2007. Neuse River Basin Protection and Maintenance of Existing Riparian Buffers. 15A NCAC 02B.0233. Available at: http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/15a%20ncac%2002b%20.0233.pdf. Accessed November 1, 2017.

RAPANOS et ux., et al. v. UNITED STATES. 2006. US Supreme Court. 547 U.S. 715. No. 04–1034.

Roy, A.H., Dybas, A.L., Fritz, K.M. and Lubbers, H.R. 2009. Urbanization affects the extent and hydrologic permanence of headwater streams in a midwestern US metropolitan area. Journal of the North American Benthological Society, 2009, 28(4):911–928.

Russell, P.P., Gale, S.M., Muñoz, B., Dorney, J. R. and Rubino, M.J. 2015. A Spatially Explicit Model for Mapping Headwater Streams. Journal of the American Water Resources Association. 51(1): 226-239.

US Army Corps of Engineers. 2005. Regulatory Guidance Letter Number 05-05. Subject: Ordinary High-Water Mark. Dated December 7, 2005. Available at http://www.nap.usace.army.mil/Portals/39/docs/regulatory/rgls/rgl05-05.pdf. Accessed on November 2, 2017.

Williams, N. B. 2005. Relationship between flow regime and aquatic macroinvertebrate abundance in headwater streams in the Piedmont Region of North Carolina. M. S. Thesis. North Carolina State University College of Natural Resources and the Department of Forestry and Environmental Resources. Raleigh, NC.

Williamson, T.N., C.T. Agouridis, C.D. Barton, J.A. Villines, and J.G. Lant. 2015. Classification of ephemeral, intermittent, and perennial steam reaches using a TOPMODEL-Based approach. Journal of the American Water Resources Association 51(6):1739-1759.

13. Appendix 1

General technical issues with the use of these data to predict the extent of jurisdictional streams and WOTUS – There are several issues to consider when comparing these data to the jurisdictional extent of streams for the 404 Permit Program of the USACE:

13.1.1. The State methodology employed in this study would not include ephemeral stream segments that have Ordinary High-Water Marks (OHWM) and are therefore jurisdictional streams for the 404 Permit Program. These ephemeral stream lengths are normally short and probably a very small percentage of the total stream length in any particular watershed. The change in 404 jurisdiction to the use of a "relatively permanent" definition would certainly exclude these ephemeral channels. Therefore, the reduction in jurisdiction predicted from the data on intermittent streams is a conservative estimate since these ephemeral channels also would no longer be regulated.

13.1.2. These stream data are gathered (with few exceptions) from rural (often dominated by agricultural land use or forested areas with active silviculture in some locations in the coastal plain) rather than urban watersheds. These watersheds were chosen by the State for data collection and model development since they are less disturbed for these Level IV ecoregions. The effect of urbanization on stream type in North Carolina and/or the Southeastern U.S. has not been documented. However, in an urban watershed in Cincinnati, Ohio ephemeral and intermittent streams were lost due to culverting of these channels as the area developed while the length of perennial streams increased due to higher base flows which probably converted some of the intermittent streams to perennial flow (Roy et al., 2009). Assuming similar changes may occur with urbanization in North Carolina, we believe that the impact of such stream changes in the context of this analysis is relatively minor since urban areas (urban, industrial and low density residential) make up only 3% of the North Carolina land use/land cover categories statewide (Kerrow, et al. 2006).

13.1.3. Results of the NC Stream Identification Method as compared to stream delineation by the USACE for 404 Permits. The USACE uses the presence of an OHWM to determine if a channel is jurisdictional for the 404 Permit program (US Army Corps of Engineers, 2005). Although the NC Stream Identification Method does not explicitly use this criterion, extensive field experience across the state has shown that intermittent and perennial streams in North Carolina always have OHWMs. Therefore, the intermittent and perennial streams identified by the NC Stream Identification Method are always jurisdictional streams for the USACE under the Section 404 Permit program under the 2005 guidance described above. In addition, there may be relatively short lengths of ephemeral streams upslope of the intermittent origin that have OHWMs that may be subject to permitting under Section 404 of the Clean Water Act. However, this assessment has relied on State stream definitions and ephemeral segments would not be included in the following analysis.

13.1.4. Mountain physiographic region – There are two technical issues relative to data on streams from the Mountain ecoregions as described below.

13.1.4.1. Seeps – Seeps are very common in the uppermost ends of small valleys in the mountains where groundwater comes to the surface. These features are often delineated

as small wetlands rather than streams but often have biota more characteristic of perennial streams such as presence of benthic macroinvertebrates (immature salamanders, larvae of stoneflies, caddis flies and mayflies). Since seeps are not normally delineated as streams, there may be additional small lengths of perennial or intermittent channels within these seeps that are not captured in the data for stream length in the mountains.

13.1.4.2. The effect of small, relict landslides – Many small valleys in the mountains still show signs of relict landslides and small slumps that occurred many decades ago when the North Carolina mountains were heavily logged; often resulting in local erosion and relict landslide deposits (Gallen, et al. 2011). Many of these localized slumps and landslides have stream flow above and below them with little or no evidence of surface flow in the buried stream segment even though flow does occur beneath these slumps and landslides. Jurisdictional determinations (by USACE or the State) usually ignore these areas. A mapping or delineation effort of finer detail might depict some of these non-stream segments.

13.1.5. Level IV ecoregions were selected as the primary sampling framework for the data collection described in this report with the assumption that these areas provide landscapes of fairly uniform characteristics which should result in consistent stream forming conditions. Indeed, through the analysis in this report, the watersheds within a particular Level IV ecoregion (except one ecoregion as described below) have similar percentages of intermittent and perennial streams which supports this assumption of uniformity. However, the Eastern Blue Ridge Foothills ecoregion is unusual because of the four watersheds that have been mapped, two have a percentage of intermittent streams less than 10% and two have a percentage of intermittent streams greater than 30% with an overall average of 20.5% After a desktop review of topography for these watersheds, this appears to reflect a rather wide diversity of topography and soils in this particular ecoregion.

13.1.6. The stream data show the origins of perennial streams based on the NC Stream Identification Method which has been calibrated using long term flow data from eight locations of long monitoring (18 months) from relatively undisturbed sites in the central piedmont of NC (Williams, 2005). Whether these locations are the start of "relatively permanent" flow in the meaning of the Scalia opinion is unclear. For this analysis, we assume that "relatively permanent" is synonymous with perennial flow.

Appendix 3: Analysis of selected large projects for analysis under the proposed WOTUS definition (February 26, 2019, Version 1.0)

A total of eight large development sites were selected by the SELC staff (Figure 1) for detailed study from a list of 35 preliminary sites in the three states prepared by Moffatt & Nichol staff (6 in NC, 16 in SC, and 13 in VA). Of the eight sites, only three sites (Table 3) could be analyzed to determine the likely extent of wetlands under the new proposed WOTUS definition since they included wetland and stream maps with the stream maps showing stream flow duration. The other five sites only had summary data from the permitting process available or maps that did not show stream flow duration. These sites are located in the mountains (Doe Branch Mine in Virginia), the Inner Coastal Plain (Global TransPark and rail spur) in North Carolina, and Outer Coastal Plain (PCS Phosphate) in North Carolina. Since maps depicting intermittent versus perennial streams were available for the two NC sites, an analysis was made of the extent of wetland jurisdiction when intermittent streams would no longer be jurisdictional. However due to the small size of the sample, it is impossible to determine if these sites are representative of these physiographic regions in the Southeast. The results of this analysis are summarized below.

6.1. Doe Branch Mine, Virginia

This project is a proposed mountain top removal coal mine in the Virginia mountains that would impact approximately 1,100 acres of land (USACE, Norfolk District, 2013). The USACE reported that 1,980 feet of perennial, 9,670 feet of intermittent, and 4,680 feet of ephemeral streams would be impacted, along with 2.42 acres of jurisdictional wetlands. A FOIA was completed and submitted to the Norfolk District to gather information to help determine which of these wetlands would be regulated under the “continuous surface connection” to “relatively permanent” waters definition. The Environmental Assessment (EA) for the project reported that there were 2.42 acres of wetlands to be impacted that were subject to 404 Permitting and an additional 5.89 acres of isolated wetlands subject to permitting only by the Virginia Department of Environmental Quality.

This analysis revealed that none of the 2.42 acres of jurisdictional wetlands would still be jurisdictional under the proposed WOTUS definition since these non-isolated wetlands are not connected by intermittent or perennial streams to downstream waters.

6.2. Global TransPark and Rail Spur, North Carolina

This site is located in Lenoir County near Kinston, in the Rolling Coastal Plain Level IV ecoregion (Griffith et al., 2002). This is a 5,775-acre site with an additional 730 acres for the associated rail spur extension project. Wetlands, streams, and ditches were delineated and approved by the USACE. Stream origins were available from the NC Division of Water Resources whose staff determined stream origins for the riparian buffer rules.

This analysis revealed that 482.86 acres of the total 1,972.21 acres of wetlands on the site would still be jurisdictional under the proposed WOTUS definition. The wetlands no longer

regulated are mostly hardwood and pine flats and are not connected by intermittent or perennial streams to downstream waters. Note that most of the wetlands associated with the rail spur are believed to still be connected by an intermittent stream to downstream waters, but no recent field verification was done to test this assumption.

6.3. PCS Phosphate, North Carolina

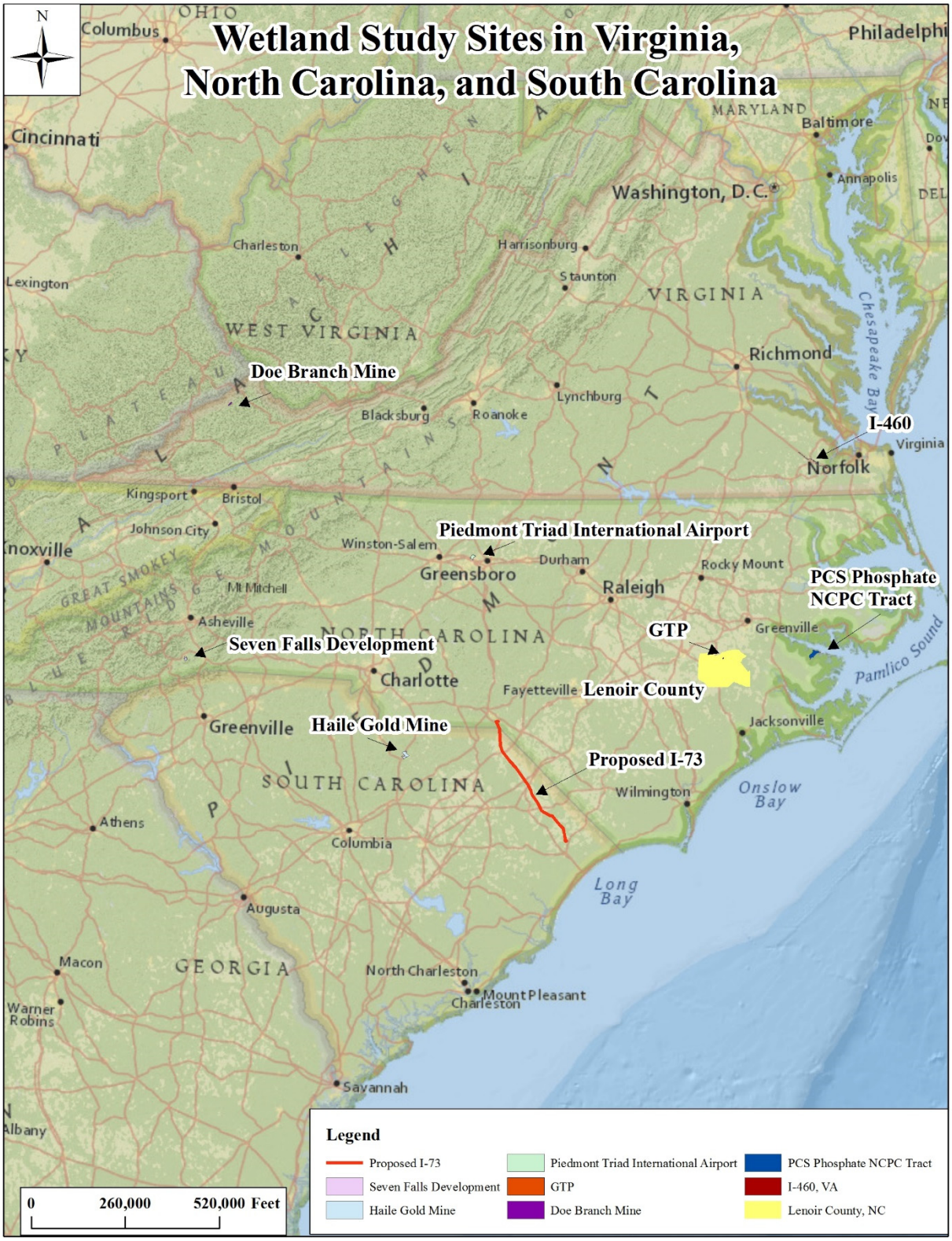
The PCS Phosphate mine is located in the Outer Coastal Plain (mostly in the Chesapeake-Pamlico Lowlands and Tidal Marshes and the Nonriverine Swamps and Peatlands, Level IV ecoregions) near Aurora. The NCPC tract is one of three large areas proposed for expansion of the mine. PCS Phosphate is a large, open pit phosphate mine that applied for an expanded mining permit with a Public Notice in 2008. This analysis focused on the NCPC tract which is bordered by the then existing mine, South Creek, and Pamlico River. The USACE confirmed the wetland and stream delineations in 2008 and this wetland analysis is based on the information contained in the final EIS (USACE, 2008). Stream lengths were derived after georeferencing the map of intermittent and perennial stream origins as prepared by consultants to PCS Phosphate and then field-verified by staff from the NC Division of Water Quality in 2006 (NC Division of Water Quality, 2006).

This analysis revealed that 2,346.57 acres of the total 2,544.74 acres of wetlands on the site would still be jurisdictional under the proposed WOTUS definition since these wetlands are connected by intermittent or perennial streams to downstream waters. Most of the no longer regulated wetlands are hardwood or pine flats with no direct connection to intermittent or perennial steams or with connections disrupted by roads with culverts (when present) only carrying ephemeral flow.

Table 3: Summary of selected large projects for analysis under the proposed WOTUS definition

Project	Wetlands under Pre-2015 Rule (acres)	Wetlands under Obama Rule (acres)	Wetlands under Proposed Rule (acres)	Wetlands Lost (percentage)
Doe Branch Mine, VA	2.42	2.42	0.00	100%
Global TransPark and Rail Spur, NC – intermittent and perennial streams jurisdictional	1972.21	1972.21	482.86	75.5%
Global TransPark and Rail Spur, NC- only perennial streams jurisdictional	1972.21	1972.21	463.24	76.5%
PCS Phosphate, NC — intermittent and perennial streams jurisdictional	2544.74	2544.74	2346.57	7.8%
PCS Phosphate, NC - only perennial streams jurisdictional	2544.74	2544.74	2246.31	11.7%

Figure 1: Selected large projects for analysis



Appendix 4: An Analysis of Federally Threatened (T) and Endangered Species (E) Presence in North Carolina Wetlands Types with Predicted Large Rates of Loss from the Proposed WOTUS Rule

Bog	Pine Savanna	Floodplain Pool	Basin Wetland	Seep	Headwater Forests
Bog Turtle (T(S/A), Green Pitcher Plant (E), Mountain Sweet Pitcher Plant (E)	Red-Cockaded Woodpecker (E), Canby's Dropwort (E), Cooley's Meadowrue (E), Golden Sedge (E)	Canby's Dropwort(E), Cooley's Meadowrue (E), Golden Sedge (E), Pondberry (E)	Canby's Dropwort(E), Pondberry	Bunched Arrowhead (E), Green Pitcher Plant €, Small-Anthered Bittercress (E)	Dwarf-Flowered Heartleaf (T), Small-Anthered Bittercress (E)

Bogs are typically the appropriate habitat for Bog Turtles *(Glyptemys muhlenbergii)* (Federally Threatened) in Western North Carolina. Bog turtles live in the mud, grass, and sphagnum moss of bogs, swamps, and marshy meadows. These wetlands are usually fed by cool springs flowing slowly over the land, creating the wet, muddy soil needed by the turtles. Throughout their range they are known to occur to nearly 4,500 feet in elevation in North Carolina. There are two major threats to its continued existence – habitat loss due to the draining and filling of wetlands for farming and development; and the illegal collection of bog turtles for the pet trade. The species is considered threatened due to similarity of appearance. The southern population in Western North Carolina has not experienced the same level of habitat loss as the northern population in New York to Maryland.

The Green Pitcher Plant *(Sarracenia oreophila)* (Federally Endangered) is found in Clay County, North Carolina, and typical habitat includes mountain bogs, seeps, as well as boggy stream side areas. The Green Pitcher Plant also can be found in some upland habitats that have been maintained by fire.

Mountain Sweet Pitcher Plant *(Sarracenia rubra ssp. Jonesii)* (Federally Endangered) is a species that is more specifically dependent upon bogs for suitable habitat. Mountain Sweet Pitcher Plant is typically limited to wetlands and is not found in upland areas. The most serious threat to mountain sweet pitcher plant is the destruction or degradation of its small wetland habitat in Western North Carolina.

Red-cockaded woodpeckers (Federally Endangered) are typically found in mature pine forests – specifically those with longleaf pines averaging from 80 to 120 years old and loblolly pines averaging 70 to 100 years old. Although many woodpeckers are usually found in more upland pine savannas, it is possible that cavity trees could be located in or near wet pine savannas. The primary threat to red-cockaded woodpeckers is loss of suitable mature pine savanna habitat.

Canby's dropwort *(Oxypolis canbyi)* (Federally Endangered) has been found in a variety of coastal plain habitats, including natural ponds dominated by pond cypress, grass-sedge dominated Carolina bays, wet pine savannas, floodplain pools, shallow pineland ponds, basin wetlands, and cypress-pine swamps or sloughs. The largest and healthiest populations have been found in open bays or ponds that are wet throughout most of the year, but which have little or no canopy cover. Soils where

Canby's dropwort are found typically are sandy loams or acidic peat mucks underlain by clay layers which, along with the slight gradient of the areas, result in the retention of water. The primary threat to Canby's dropwort is the loss or degradation of wetland habitat in which it occurs. Extensive ditching and draining of wetlands for agricultural and silvicultural purposes has altered the groundwater table in many areas of the mid-Atlantic coastal plain where Canby's dropwort historically occurred.

Cooley's meadowrue *(Thalictrum cooleyi)* (Federally Endangered) occurs on circumneutral soils in grass-sedge bogs, floodplain pools, wet pine savannahs, and savannah-like areas. It may also grow along fire plow lines, in roadside ditches, woodland clearings, and powerline rights-of-way, and needs some type of disturbance such as fire or mowing to maintain suitable habitat. Plants often found growing with Cooley's meadowrue include tulip poplar growing with bald cypress and/or Atlantic white cedar. Cooley's meadowrue is threatened by loss of habitat, ecological succession, clearing for agriculture, forestry, herbicide application to power line corridors, development and road maintenance, and construction projects.

Golden sedge (Carex lutea) (Federally Endangered) grows in floodplain pools and partially shaded savannas/swamps where occasional to frequent fires favor an herbaceous ground layer and suppressed shrub dominance. The species is found in sandy soils overlying coquina limestone deposits, where the soil pH is unusually high for this region, typically between 5.5 and 7.2. Soils supporting the species are very wet to periodically shallowly inundated. The species prefers the ecotone (narrow transition zone between two diverse ecological communities) between the pine savanna and adjacent wet hardwood or hardwood/conifer forest. In eastern North Carolina, this habitat can often include floodplain pools. At most sites, Golden sedge shares its habitat with Cooley's meadowrue (Thalictrum cooleyi), another federally endangered plant species, and with Thorne's beakrush (Rhynchospora thornei), a species of concern. The remaining populations of Golden sedge are currently threatened by habitat alteration including fire suppression, conversion of its limited habitat for residential, commercial, or industrial development, highway and utility expansion, herbicidal applications to rights-of-way, and drainage activities associated with silviculture, agriculture and development projects.

Pondberry *(Lindera melissifolia)* (Federally Endangered) is associated with wetland habitats such as bottomland and hardwoods in the interior areas, and the margins of sinks, ponds, and other depressions in the more coastal sites. Pondberry can be found in floodplain pools as well as basin wetlands in North Carolina. The plants generally grow in shaded areas but may also be found in full sun. In North Carolina, one population exists in Sampson County and one in Cumberland County. In addition, one collection was recently made in Onslow County, but plants haven't been found again since the original collection. The most significant threats are drainage ditching and subsequent conversion of its habitat to other uses. Even ditching without later conversion of land use can alter the water regime in a manner that reduces the plant's vigor or eliminates it from the site.

Bunched arrowhead *(Sagittaria fasciculata)* (Federally Endangered) is usually found in undisturbed sites that are typically located just below the origin of slow, clean, continuous seeps on gently sloping terrain in deciduous woodlands. In North Carolina, bunched arrowhead is only known to occur in

Henderson County, though it was historically known from Buncombe County as well. The primary factor determining the rarity of bunched arrowhead is the current rarity of its required habitat. The seepage habitat in which bunched arrowhead occurs is extremely threatened and remaining bunched arrowhead populations are threatened by residential and industrial development, conversion to pasture, and invasive exotic species.

Small-anthered bittercress *(Cardamine micranthera)* (Federally Endangered) is found in seepages, headwater forests, wet rock crevices, stream banks, sandbars, and wet woods along small streams, in fully to partially-shaded areas. It is known only from the Dan River basin in north-central North Carolina (Stokes County) and south-central Virginia (Patrick County). With a very limited range, and found in close association with water, the plant is threatened by stream impoundments, channelization, water contamination, as well increased stormwater runoff which can abnormally increase the volume and velocity of stream flows, eroding stream banks and beds.

Dwarf-flowered heartleaf *(Hexastylis naniflora)* (Federally Threatened) grows in acidic soils along bluffs and adjacent slopes, in boggy areas next to streams and creek heads, in headwater forests, and along the slopes of nearby hillsides and ravines. It is found in the upper piedmont region of Western North Carolina and upstate South Carolina. The greatest threat to dwarf-flowered heartleaf is conversion of habitat to agricultural, residential, commercial, and industrial uses. Habitat may also be eliminated through the construction of reservoirs, which floods habitat.

References

https://www.fws.gov/asheville/htmls/listed_species/Green_pitcher_plant.html

https://www.fws.gov/raleigh/species/es_mtn_sweet_pitcher_plant.html

https://www.fws.gov/endangered/esa-library/pdf/woodpecker.pdf

https://www.fws.gov/raleigh/species/es_canbys_dropwort.html

https://www.fws.gov/raleigh/species/es_cooleys_meadowrue.html

https://www.fws.gov/raleigh/species/es_golden_sedge.html

https://www.fws.gov/raleigh/species/es_pondberry.html

https://www.fws.gov/asheville/htmls/listed_species/Bunched_arrowhead.html

https://www.fws.gov/asheville/htmls/listed_species/Small_anthered_bittercress.html

https://www.fws.gov/raleigh/species/es_dwarf-flowered_heartleaf.html

Appendix 5: NC WAM Wetland Functions

The following descriptions of the general functions provided by wetland according to the 16 NC WAM types used in this report. This information was drawn from the NC WAM User Manual Version 5 (NC Wetland Functional Assessment Team. 2016 and. additional information was also provided by Carolina Wetlands Association available at: (http://carolinawetlands.org/index.php/other-resources/wetlands-101/types-of-wetlands/)

6.4. Salt/Brackish Marsh

6.4.1. Hydrology – Salt/Brackish marshes provide an area that can be subjected to regular or occasional flooding by tides, with some reduction of wave heights. These help to alleviate tidal flooding and protect coastal shoreline from erosional forces. These marshes also store floodwaters during storms such as hurricanes or northeasters.

6.4.1.1. Water quality – These wetlands can handle saline waters, providing a transitory zone between ocean and inlets, with roots of vegetation that help to trap sediments. Oysters commonly inhabit this wetland type and help improve water quality through their filtering capabilities. In addition, the wetland itself removes sedimentation through settling. These wetlands provide organic matter via tidal export for aquatic food chains in the adjacent estuary.

6.4.1.2. Habitat – These wetlands are made of predominantly herbaceous vegetation of varied plant species, which can inhabit a variety of animals. Growth of vegetation helps increase land elevation to alleviate flooding impacts. These wetlands also provide nursery habitat for many species of fish, crabs, shrimp and feeding grounds for tidal birds.

6.4.2. Estuarine Woody Wetland

6.4.2.1. Hydrology – Estuarine woody wetlands provide an area that can be subjected to regular or occasional flooding by tides and/or marshes, with some reduction of wave height.

6.4.2.2. Water quality – These wetlands can handle mildly saline waters, providing as escape for erratic tidal flood and saline levels from storm surges. In addition, the wetland itself removes sedimentation through settling.

6.4.2.3. Habitat – These wetlands are readily adapted to disturbance. Dominant organisms are mostly a subset of the salt/brackish marsh or adjacent uplands.

6.4.3. Tidal Freshwater Marsh

6.4.3.1. Hydrology – Tidal freshwater marshes provide an area that can be subjected to regular or occasional flooding by tides, with the majority of

the time being saturated as well by estuaries and lower reaches of streams and rivers. These wetlands also store floodwaters during storms such as hurricanes or northeasters.

6.4.3.2. Water quality – These wetlands can handle mildly saline water. The wetland itself also removes sedimentation and nutrients as well as other contaminants mainly through settling.

6.4.3.3. Habitat – These marshes support a large diversity of mostly herbaceous plant species, with many water-loving birds relying on these areas for critical habitat along with associated mammalian species.

6.4.4. Riverine Swamp Forest

6.4.4.1. Hydrology – Riverine swamp forests are characterized by seasonal to semi-permanent inundation, with overland and groundwater being important sources of water, as are over bank and tidal flooding. Beaver impact has an effect on water level; many riverine swamp forests especially in the mountains and piedmont are formed due to beaver activity. Storage of stormwater is an important function of these wetlands.

6.4.4.2. Water quality – These wetlands are important in reducing pollution from stormwater that comes from overland flow.

6.4.4.3. Habitat – These wetlands have large woody hydrophilic trees that inhabit most often like oaks, elms, ashes, etc. Present hollow trees provide space for animals like bats and swifts to inhabit as well. Nesting habitats are also provided for many bird species in these forests. Amphibians, reptiles, and fish also rely on these areas for habitat.

6.4.5. Seep

6.4.5.1. Hydrology – Groundwater is discharged to the surface on a slope, not in a geomorphic floodplain or a natural topographic crenulation, to form a seep, therefore making these wetlands semi-permanently to permanently saturated by groundwater. These do not typically have long term surface water. Seeps provide water during low flow periods to downstream waters though.

6.4.5.2. Water quality – moves water slowly on hillslopes down to the floodplain of streams. Some filtration of local stormwater runoff occurs as well.

6.4.5.3. Habitat – relatively open centers with herbaceous vegetation, may be surrounded by trees that could also shade the wetland if it is small enough. Many rare plant species exist in seeps due to their aspect and

saturation. Salamanders and other amphibians commonly inhabit this wetland type as well.

6.4.6. Hardwood Flat

6.4.6.1. Hydrology – Hardwood flats are found in poorly drained, interstream flats mostly in the Coastal Plain. These wetlands are usually seasonally saturated or intermittently to seasonally inundated by a high water table or by poor drainage. The primary source of water is a high water table from precipitation and overland runoff.

6.4.6.2. Water quality – Recharging groundwater is the main water quality-related function of wet flats. Filtration of local runoff can also occur in some flats.

6.4.6.3. Habitat – Mineral soils and vegetation is dominated by hardwood trees such as oaks, tulip poplar, sweetgum, etc. that drop their leaves in the fall providing habitat for a variety of mammals and birds.

6.4.7. Non-Riverine Swamp Forest

6.4.7.1. Hydrology – Non-riverine swamp forests occur primarily in the embayed region on poorly drained, interstream flats not contiguous with streams, rivers, or estuaries. They are seasonally to semi-permanently inundated with hydrology driven by groundwater discharge, overland runoff, and/or precipitation instead of flooding.

6.4.7.2. Water quality – These wetlands provide good water storage due to the hummocky ground present.

6.4.7.3. Habitat – These wetlands are dominated by forest vegetation like bald cypress, black gum, tulip poplar, etc. providing important habitat for amphibians as well as mammals and birds.

6.4.8. Pocosin/Carolina Bays

6.4.8.1. Hydrology – Pocosins and Carolina Bays occur primarily on poorly drained, interstream flats and other basins with peat or muck soils. These wetlands are seasonally saturated or inundated by a high or perched water table. The primary source of water is a high water table following precipitation and due to slow drainage. Occasionally these can be flooded with ground water. Pocosins and Carolina Bays provide recharge for downstream waters and help maintain low flow. They also store waters and reduce downstream flooding. Some intermittent or perennial stream origins occur at the edge of the pocosin or Bay.

6.4.8.2. Water quality – Filtration of local runoff occurs in some pocosins or Bay. Pocosins and Carolina Bays also store carbon in their organic soils.

6.4.8.3. Habitat – Dominated by waxy evergreen shrubs and woody vine vegetation makes these wetlands good provision of food for migrating birds and black bears. These wetlands also provide good wildlife habitat and protection due to their inaccessibility by people.

6.4.9. Pine Savanna

6.4.9.1. Hydrology – Pine savannas occur primarily on poorly drained, interstream flats in the Coastal Plains ecoregions. These wetlands are usually seasonally saturated by a high water table or by poor drainage. Little water surface storage due to the relatively flat ground surface is typical of these wetlands. Groundwater recharge is an important function of pine savannas.

6.4.9.2. Water quality – Filtration of local runoff can occur in some pine savannas.

6.4.9.3. Habitat – Long-leaf pine and pond pine are dominant in these wetlands with some low shrubs like wax-myrtle, creeping blueberry, etc. Typically, a more open canopy and shrub layer is present. The ground layer can be very diverse though. These wetlands are home to the Venus Fly Trap, a carnivorous plant endemic to North Carolina. Red-cockaded woodpeckers also are common due to the provision of mature pine trees where nests in cavities can occur.

6.4.10. Pine Flat

6.4.10.1. Hydrology – Pine flats occur primarily on poorly drained, interstream flats in the Coastal Plains ecoregions. These wetlands are usually seasonally saturated or intermittently to seasonally inundated by a high water table or due to poor drainage. The primary source of water is a high water table due to precipitation and overland runoff. Groundwater recharge is an important function of pine flats.

6.4.10.2. Water quality – Filtration of local runoff can occur in some flats.

6.4.10.3. Habitat – These wetlands are dominated by forest, early successional forest/shrub species, or can be found on managed pine plantations. Since this type is successional in nature, it is fairly open and has low species diversity and structural complexity. These areas provide habitat for a variety of birds and mammals mainly due to their relatively large size.

6.4.11. Basin Wetland

6.4.11.1. Hydrology – Basin wetlands are seasonally to semi-permanently inundated but may lose surface hydrology during later portions of the growing season. Sources of water are perched groundwater, groundwater discharge, overland runoff, and precipitation. These wetlands occur in

natural depressions that are surrounded by uplands or occur on the edges of small lakes/ponds. Typically, these are only wet for part of the year and experience dryness during warmer months. In addition, they can store significant amounts of stormwater and thereby reduce downstream flooding. Finally, they recharge groundwater and thereby provide low flow to nearby streams during drought periods.

6.4.11.2. Water quality – Basins provide treatment of stormwater from localized overland flow.

6.4.11.3. Habitat – Habitat of basin wetlands varies greatly from a dominant forest in mafic depressions and ephemeral pools, to primarily herbaceous or emergent vegetation in lime sinks, man-excavated depressions, and along shorelines of small open waters. These wetlands provide important breeding ground for many amphibian species like frogs and salamanders.

6.4.12. Bog

6.4.12.1. Hydrology – Bogs occur in geomorphic floodplains or natural topographic crenulations and are typically located on flat or gently sloping ground mainly in the mountains and foothills of NC. These are formed by a poorly understood combination of groundwater seepage and/or blocked overland runoff, making it at least semi-permanently saturated, but typically not inundated. When they are impacted by beaver activity, longer inundation periods can result. Release of water to adjacent streams during low flow conditions is an important function of bogs.

6.4.12.2. Water quality – Filtration of local stormwater and removal of pollutants is common as is water storage.

6.4.12.3. Habitat – Generally these wetlands are transitional in nature and may be found in a variety of forms such as supporting a closed canopy to lacking canopy trees, with sparse ground cover to dense mats of herbs and moss. These wetlands provide important habitat for rare animal and plant species like the Bog Turtle, Alder Flycatcher, Four-Toed Salamander and a variety of orchids.

6.4.13. Non-Tidal Freshwater Marsh

6.4.13.1. Hydrology – Non-tidal freshwater marshes are found in geomorphic floodplains, in natural topographic crenulations, or contiguous with open waters that are large. These wetlands are subject to semi-permanent inundation or saturation, but not typically subject to flooding by tides. Beaver activity is a common cause for the creation of these wetlands.

6.4.13.2. Water quality – These can also develop in areas of disturbance by humans and thus helps to reduce the impacts of erosion and sedimentation as

well as removal of other pollutants. Their water storage capacity can also reduce downstream flooding as well as provide water for low flow conditions in nearby streams.

6.4.13.3. Habitat – Habitat tends to be predominantly herbaceous vegetation in transition. Many species of wildlife, such as waterfowl and other birds, use this type of wetland for breeding, wintering and migrating.

6.4.14. Floodplain Pool

6.4.14.1. Hydrology – Floodplain pools are found in geomorphic floodplains. These wetlands occur due to abandoned stream or river channels, like oxbows that have been cut off, or in localized depressions near the toe of slopes. These pools are semi-permanently inundated. Sources of water are primarily groundwater, precipitation, and sometimes overbank flooding.

6.4.14.2. Water quality – Storage of floodwaters is an important function of floodplain pools as well as removal of pollutants from nearby, adjacent stormwater runoff.

6.4.14.3. Habitat – These wetlands are usually dry at some points of the year, thus providing important habitat for amphibians to breed. Vegetation typically is located on the fringe of these and lacking in the middle, being dominated by herbaceous vegetation like ferns, sedges, etc.

6.4.15. Headwater Forest

6.4.15.1. Hydrology – Headwater forests are found in geomorphic floodplains of first-order streams or smaller and in topographic crenulations without streams. Groundwater seepage and diffuse surface flow are important sources of waters. Typically, these have surface flow only due to precipitation. These wetlands have little water storage though because of the relatively flat ground surface. Headwater forests are intermittently inundated by surface water or seasonally saturated to semi-permanently saturated, thus providing flow to streams during droughts.

6.4.15.2. Water quality – Source of stormwater treatment (filtering pollutants) from overland flow that serve as natural drainage features in the landscape towards actual stream channels, most often reducing the flow of the water to downstream waters, especially in urban settings.

6.4.15.3. Habitat – These wetlands are dominated by hardwood tree and shrub species like oaks, sycamores, maples, etc. providing important habitat for many amphibian species like frogs and salamanders.

6.4.16. Bottomland Hardwood Forest

6.4.16.1. Hydrology – Bottomland hardwood forests are found in geomorphic floodplains of second-order or greater streams. Generally, these wetlands are intermittently to seasonally inundated. Overbank flooding is an important source of water as is groundwater and surface runoff. In addition, this wetland can store significant amounts of stormwater water during floods and thereby reduce downstream flooding.

6.4.16.2. Water quality – Stormwater treatment from overland flow is an important water quality function of this wetland type. These wetlands can receive sediments and nutrients from overbank flooding along brownwater streams and treat these reducing their potential harmful effects.

6.4.16.3. Habitat – Habitat within this wetland type is dominated by hardwood trees like oaks, ashes, maples, etc. providing important habitat for a variety of birds and mammals.

Appendix 6: History of Stream Dynamics in the Southeastern Piedmont (from Trimble 1974).

STANLEY W. TRIMBLE

MAN-INDUCED SOIL EROSION ON THE SOUTHERN PIEDMONT

1700–1970

ENHANCED EDITION

WITH A NEW FOREWORD BY ANDREW GOUDIE

SOIL AND WATER CONSERVATION SOCIETY

Soil and Water Conservation Society
Ankeny, Iowa

FIG. 29