TOWN OF CHAPEL HILL
Stream Buffer/Resource Conservation District Report

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III-I. Statement of Purpose

The purpose of examining Resource Conservation District (RCD) stream buffering requirements is to review alternatives aimed at protecting the Town of Chapel Hill's citizens and their properties from the impacts of floods; reducing sediment from construction and upstream runoff that hampers regional water quality and obstructs stormwater infrastructure; maintaining wildlife habitat and corridors and plant life within an urbanized setting; and preserving the aesthetic qualities of Chapel Hill.

To provide a basis for the Town's evaluation of alternatives for buffer regulation, the University of North Carolina Department of City and Regional Planning (DCRP) conducted research on riparian buffers; in particular, DCRP focused on several aspects of riparian policy:

Definitions

Riparian *areas* are a "complex assemblage of plants and other organisms in an environment adjacent to water."

Riparian *buffers* are a policy tool and management practice for protecting these areas and the functions they provide.

Source: Triangle J Council of Governments

- The existing regulatory environment; Resource Conservation District; Chapel Hill Development Ordinance §5.1 - §5.13
- Developing a rational basis and policy guidance for selection of buffer width, extent and special features;
- The point of origin for buffer measurement;
- Stream definition;
- Monitoring and enforcement.

The method for this research will be a comparative evaluation of the RCD with other local buffer protection ordinances to determine if the RCD can be enhanced to achieve the Town's stated goals.

It must be noted that a robust finding of the research is that adequate buffered streams have positive direct benefits for flood impact reduction and water quality, as well as the indirect benefits of habitat conservation and aesthetic improvements. These benefits will be discussed in Section III of this report.

Besides the community goals enumerated in the statement of intent such as flood control and filtering urban pollutants (Chapel Hill Development Ordinance §5.1), buffers can be a source of support for other town goals. For example, maintaining the integrity of riparian areas is consistent with the Town's comprehensive environmental protection goal of the comprehensive plan, to "identify, protect, and preserve open spaces and critical natural areas and enhance the community's...water resources" (*Planning for the Future: Chapel Hill's Comprehensive Plan, p. 79, 2000*). The recently completed plan demonstrates the Town's resolve to "improve existing

stormwater management practices" (§9F-1). Part of improving the "quality of runoff" is allowing the land adjacent to the town's watercourses to filter out impurities during storm events.

Planning for the Future also sets a community objective for the application of conservation design principles (§8A-3), setting high standards for the quality of open space within the town. The Resource Conservation District regulation should be viewed as an opportunity to incorporate conservation design principles in the town, which would help meet *Planning for the Future's* benchmark of conservation design.

Definitions

This report will use the terms *stream buffer, protected stream corridor,* and *riparian buffer.* For our purposes, these terms are synonymous.

This report will examine Chapel Hill's stream buffers from three different topics:

1. A brief synopsis of stream conditions.
2. An examination of the multitude of benefits that accrue from buffering streams.
3. Finally, a policy option section based on Town objectives and examples of buffer strategies from other North Carolina Piedmont communities.

Morgan Creek, Fall, 2000

III-II. Emerging Trends

There are several convergent influences in Chapel Hill that make buffer protection a timely issue. First, water quality has declined and flooding problems worsened in recent years. Several mandates are anticipated or have recently been adopted, requiring that the Town manage stormwater runoff more extensively. Finally, there has been an increasing consciousness of the importance of stormwater management among residents, Town officials, and regional decision-makers. Stormwater and its impacts are at the forefront of the community's consciousness, so the time is ripe to examine existing buffer policy as part of a comprehensive management program.

Problems

The Chapel Hill Resource Conservation District has as a primary goal to reduce the risk of flooding within the town. Properly accounting for stormwater volumes and providing adequate mechanisms to control the rate of flow can mitigate the impacts of flooding events. Heavy volumes of rain are inevitable, but the risk of damages due to flooding events can be avoided with proper planning. Buffering the streams that carry rainwater reduces the volume and velocity of runoff. The flood risk reduction from buffers is correlated with the width of the buffer and whether or not development is steered away from the streamside areas by policy.

The lack of a factual basis for planning is another concern in Chapel Hill. FEMA floodplain maps are outdated and cannot account for the growth of the town since their creation. The RCD applies to streams based on these floodplain maps, so adequate buffering depends on their accuracy

Another issue in Chapel Hill is the steady decline in stream health, as shown by bioindicators of stream health. There are presently five streams in the town of Chapel Hill that exceed Total Maximum Daily Load (TMDL) standards. Each of these, Bolin Creek, Booker Creek, Little Creek, Meeting of the Waters, and Morgan Creek, need special attention. There has also been increased sediment and pollutants in Chapel Hill streams and lakes. Lake Ellen and Eastwood Lake are of particular concern since citizens in these areas have been vocal proponents of actions to limit sedimentation in the lakes. Stream health is also threatened by the increased volume and velocity of stormwater runoff. Buffers provide a filter that reduces the rate of stream bank erosion of and the amount of sedimentation in streams.

Mandates

There are several mandates that will impact the way that Chapel Hill deals with stormwater management and buffers. First, Chapel Hill will be required to start meeting National Pollutant Discharge Elimination System (NPDES) Phase II permitting requirements by March 2003. Among the objectives of NPDES Phase II are:

- Construction runoff control;
- Post-construction runoff control;
- Public non-point source pollution education;
- Municipal good housekeeping (e.g., street-sweeping).

Communities are becoming more explicit about construction runoff control requirements and inspecting performance during construction. Post-construction sites need to be slow runoff to allow the riparian vegetation to filter out pollutants. Best management practices that detain or slow the rate of runoff leaving a site are necessary for the preservation of buffer integrity.

Chapel Hill is located in the upper reaches of the Cape Fear River basin. Cape Fear Watershed Rules, which include requirements for buffering along streams, will likely be promulgated in the near future. It is anticipated that these rules will closely represent the rules prepared for the Neuse River Basin, developed by the North Carolina Department of Environment and Natural Resource (DENR) Division of Water Quality (DWQ) in December 1998.

III-III. Benefits of Buffers

Riparian buffers can play a valuable role in addressing many of the problems associated with streams in Chapel Hill, and in preventing potential problems in the future. Benefits of buffers include reduction of the risk and damage of flooding, maintenance of water quality, and the protection of stream and riparian ecosystems. Furthermore, riparian buffers can provide recreational and educational assets for the community[1].

Flood Protection

Impervious surfaces in Chapel Hill have contributed to increased runoff velocity and quantity. Riparian areas absorb storm water through interception by riparian vegetation and infiltration into the pervious soils[2]. Furthermore, by slowing movement of runoff into the streams, vegetated riparian buffers can reduce peak rates of stream flow[3]. Also, wetlands are frequently located in riparian areas. These wetlands have the capacity to store significant amounts of water, reducing the rate and volume of stormwater runoff[4].

Restricting development in riparian areas can also lessen the damage caused by flooding. These areas are obviously the most likely to be flooded during high flow events[5]. By not building in these high-risk areas, the community is buffered from the impacts of floods.

Water Quality

The greatest value of riparian buffers is perhaps their ability to protect water quality by removing pollutants, including sediment, nutrients, metals, and hydrocarbons[6]. Storm water runoff moving into a stream must first pass through a riparian zone, either through overland or groundwater flow. As water moves through this area there are multiple mechanisms for the removal of pollutants. Sediment (and with it the pollutants, such as phosphorous, that often binds to it) is filtered out as it moves through vegetation[7]. Vegetation and bacteria take up nitrogen and other nutrients[8]. In addition, the wetlands located in riparian areas trap many pollutants[9].

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[1] Malanson, G.P. 1993. *Riparian Landscapes*. Cambridge University Press, Cambridge, UK.

[2] Hopkinson, C.J., and J.J. Valino. 1995. The relationships among man's activities in watersheds and estuaries: A model of runoff effects on patterns of estuarine community metabolism. Estuaries 18(4): 598-621.

[3] A. Bloom 1998. *Geomorphology: A systematic analysis of late cenozoic landforms*. Prentice Hall. Englewood Cliffs, NJ.

[4] Luce, C.H. 1995. "Forests and Wetlands" in *Environmental Hydrology*; ed. A.D. Ward and W.J. Elliot. 253-284. Lewis Publishers, Boca Raton.

[5] Triangle J Council of Governments. (1997, January). An Introduction to Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 1.

[6] McCarty, G.W et al. 2000. Assessing riparian buffer function for improved water quality. Abstracts of Papers American Chemical Society 220(1).

[7] Cooper J.R. et al. 1987. Riparian areas as filters for agricultural sediment. Soil Science Society of America Journal 51 (2): 416-420.

[8] Pinay, G. et al. 1993. Spatial and temporal patterns of denitrification in a riparian forest. Journal of Applied Ecology. 30(4). 581-591.

[9] Luce, C.H. 1995. "Forests and Wetlands" in *Environmental Hydrology*; ed. A.D. Ward and W.J. Elliot. 253-284. Lewis Publishers, Boca Raton.

One study found, in general, buffers removed pollutants in the following amounts[10]:

Pollutant	Removal
Sediment	75%
Total Nitrogen	40%
Total Phosphorous	50%
Trace Metals	60-70%
Hydrocarbons	75%

The degree to which buffers can remove pollutants is a function of the dimensions of the buffer, the vegetation type and amount, the soil type, the slope characteristics, and the amount of pollution entering the buffer[11].

It is important to note that these properties of filtering are only effective to the extent that runoff flows evenly across the buffer. If water forms concentrated flows in temporary channels during storm events, these flows are able to bypass the filtering mechanism of the buffer. Therefore, it is advisable to prevent this channelization during stormwater events[12].

Vegetation in the riparian buffer further enhances water quality by decreasing the internal erosion in streams. By providing a root system to stabilize banks, riparian vegetation decreases the amount of bank erosion, which can be a major source of sediment. By protecting the banks, the natural channel of the stream is maintained. Without this vegetation, streams can incise and become more channelized. This change in channel formation can lead to a loss in habitat for aquatic species. Furthermore, it can increase the flow of water through the stream, which can lead to greater flooding downstream, increased hazard to humans, and the washout of aquatic organisms[13].

Finally, buffers can play a critical role in moderating water temperatures in streams. Vegetation provides shade that can keep streams cooler in the summer, and warmer in the winter. Temperature is inversely related to dissolved oxygen concentration, so high summer temperatures can lead to a drop in dissolved oxygen without the presence of riparian vegetation

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[10] Schueler, Tom. 1995. *Site Planning for Urban Stream Protection.* Metropolitan Washington Council of Governments and the Center for Watershed Protection.

[11] Triangle J Council of Governments. (1997, January). An Introduction to Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 1.

[12] Schueler, Tom. 1995. *Site Planning for Urban Stream Protection.* Metropolitan Washington Council of Governments and the Center for Watershed Protection.

[13] Luce, C.H. 1995. "Forests and Wetlands" in *Environmental Hydrology*; ed. A.D. Ward and W.J. Elliot. 253-284. Lewis Publishers, Boca Raton.

to moderate water temperatures[14]. Both extreme temperatures and low dissolved oxygen can be harmful to aquatic organisms[15]. By keeping temperatures low, riparian buffers also prevent the growth of excess algae, which often favor high temperature conditions[16].

Stream Ecosystems

Streams and riparian areas provide habitat for huge diversity of species. In addition, the wetlands found in riparian areas are also important habitat for many aquatic and terrestrial organisms[17]. One stream in Chapel Hill has an identified endangered species adjacent to the stream. These declines in species have been a result of degradation to stream water quality, particularly in the form of sediment and pesticides[18]. Protection of riparian buffer areas is vital to the protection of stream habitat and biota[19]. The water quality improvements associated with buffers would protect Chapel Hill stream organisms from declines such as those seen throughout North Carolina as a result of poor water quality. The decrease in stormwater flow from riparian buffers is also important to aquatic organisms because high velocity flows cause scour and makes a stream uninhabitable[20].

Riparian buffers also contribute to instream habitat by providing a source of woody debris and organic matter to the streams. Woody debris is essential in creating complex stream habitat and sheltered areas within the stream for fish and other aquatic organisms[21]. These shelters are important during the high flows associated with urban streams. Organic matter falling into the stream provides a source of food and energy to the stream[22].

The riparian area itself is also an important ecosystem to protect. The vegetation provides habitat for a wide variety of terrestrial organisms, particularly birds due to their natural vegetation. The narrowness of riparian buffer areas can limit their ability to provide habitat for many species. However, riparian buffers can act as corridors linking larger patches of habitat and allowing for the movement of organisms from one area to the next through the urban environment[23].

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[14] Cooter E.J.; and W.S. Cooter. 1990. Impacts of greenhouse warming on water temperature and water quality in the southern United States. Climate Research 1 (1). 1990. 1-12.

[15] Fitzgerald, D.G. et al. 1997. A quarter century of change in the fish communities of three small streams modified byanthropogenic activities. Journal of Aquatic Ecosystem Stress & Recovery. 6(2): 111-127.

[16] Pan Y. et al. 1999. Spatial patterns and ecological determinants of benthic algal assemblages in Mid-Atlantic streams, USA. Journal of Phycology. 35(3): 460-468.

[17] Malanson, G.P. 1993. *Riparian Landscapes*. Cambridge University Press, Cambridge, UK.

[18] Personal Communication, Judy Johnson, biologist ,North Carolina Department of Non-Game and Endangered Species.

[19] Fitzgerald, D.G. et al. 1997. A quarter century of change in the fish communities of three small streams modified byanthropogenic activities. Journal of Aquatic Ecosystem Stress & Recovery. 6(2): 111-127.

[20] Grossman, G.D. et al. 1998. Assemblage organization in stream fishes: Effects of environmental variation and interspecific interactions. Ecological Monographs. 68(3): 395-420.

[21] Flebbe, P.A. and C.A. Doloff. 1995. Trout use of woody debris and habitat in Appalachian wilderness streams of North Carolina. North American Journal of Fisheries Management. 15(3): 579-590.

[22] Roth, N.E. et al. 1996. Landscape influences on stream biotic integrity assessed at multiple spatial scales. Landscape Ecology. 11(3): 141-156.

[23] Triangle J Council of Governments. (1997, January). An Introduction to Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 1.

Recreation, Education, and Aesthetics

Buffers can provide valuable recreational amenities. Because of their attractive nature, they are excellent resources for parks and trails. They can be used to link larger parks, creating a network of open space. As Chapel Hill continues to grow, these natural areas can maintain the character of the town and its natural beauty. The biotic life that buffers protect offer recreational value such as fishing and bird watching, as well as an educational resource for studying biology and ecology. The educational nature can be utilized for all ages, from young children to adults and university students[24]

[24] Malanson, G.P. 1993. *Riparian Landscapes*. Cambridge University Press, Cambridge, UK.

III-IV. Chapel Hill Buffer Options

Previous sections of this report have examined the flood impact control, pollutant reduction, ecological enhancement of buffers and relevant conditions in Chapel Hill.

The Town already has established objective criteria for buffer policy in the Statement of Intent of the Resource Conservation District (RCD)[25]:

- To preserve the water quality of the Town's actual or potential water supply sources;
- To minimize danger to lives and properties from flooding;
- To preserve the water-carrying capacity of the watercourses;
- To protect watercourses from erosion and sedimentation;
- To retain open spaces and greenways;
- To preserve urban wildlife and plant life habitats from the intrusions of urbanization;
- To provide air and noise buffers;
- To preserve and maintain the aesthetic qualities and appearance of the Town.

The Town of Chapel Hill has a long history of stream protection, being one of the first communities in the state to create a resource conservation district to preserve the benefits of the floodplain and the environmental quality of its streams (brief description of Chapel Hill's RCD at right). In the intervening years, communities around the state and nation have developed alternative methods for stream buffers to meet a diversity of local objectives.

The purpose of this section of the report is to more thoroughly describe Chapel Hill's existing regulatory framework and illustrate alternatives for riparian buffer regulation supportive of a Town stormwater management strategy. The policy options presented here are based upon ways that other cities have chosen to manage riparian areas and contemporary research. An expanded look at buffer case studies is included in Appendix 1.

Town of Chapel Hill
Resource Conservation District Policy Synopsis
(Chapel Hill Development Ordinance, July, 2000)

- Buffer incorporates FEMA regulated floodway
- 75' feet buffer for stream draining less than one square mile.
- 100' foot buffer for stream draining more than one square mile.
- Buffer measured from stream bank
- Applies to perennial steams determined by Town methodology, but not intermittent streams.
- Primarily ground-level uses allowed by right within the RCD.
- Impervious surface limitations.
- Wherever practicable, no direct stormwater discharge into watercourse.
- Variance procedures are established.
- Requirements for development applications and measures for the correction of violation are established.

[25] Chapel Hill Development Ordinance, Article 5.1, July 2000)

In this section of our report, we will present reasonable alternatives for enhancing stream protection in the town of Chapel Hill. Town staff and elected officials can then determine what option best suits the town. To evoke the spirit of Chapel Hill's comprehensive plan, we hope to demonstrate stream buffer initiatives that can 'enhance' a community that is already exceptional.

To demonstrate the range of options that are available to the Town of Chapel Hill, the following table presents several options for each buffer configuration. The benefits and shortcomings of these alternatives are explained in more detail below.

Various aspects of stream buffer management

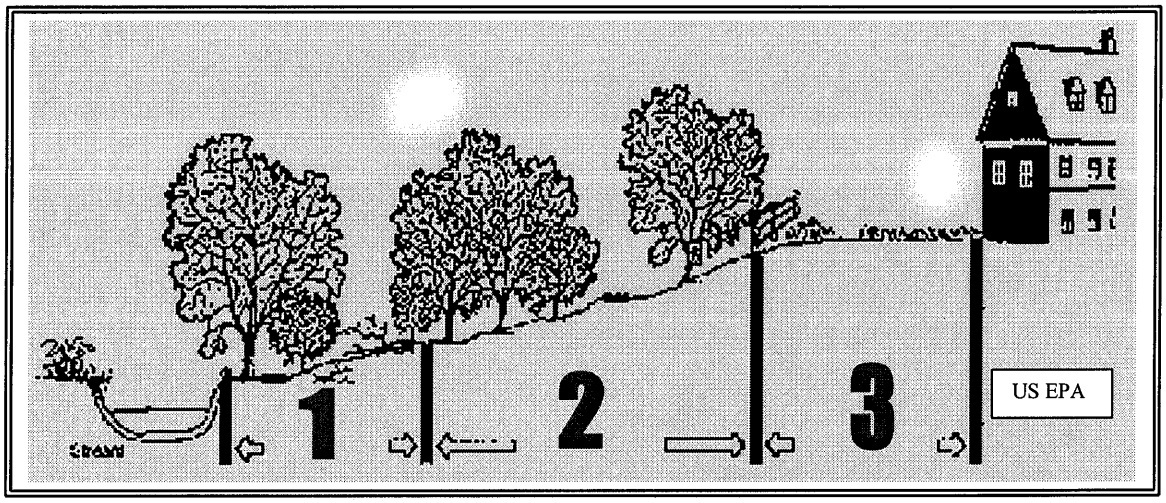
Buffer width	Multiple zones of varying widths	Fixed along all streams	Vary-slope	Vary-stream or land (CH)
Buffer measurement	From the edge of the stream (CH)	From the center of the stream	Extending from floodplain	
Permitted uses	Trails & passive recreation	Utility & water-dependent uses	Ground level uses (CH)	
Additional Performance Standards	e.g., impervious surface coverage, freeboard requirement (CH)			
Stream application	Perennial and intermittent streams	Perennial streams (CH)	Within the water supply watershed only	
Buffer enforcement	Buffer noted on site plans	Buffer signs placed on-site	Staff resources dedicated to inspections (CH)	

(CH) indicates Chapel Hill's current practices.

Buffer width

Chapel Hill RCD: 75 feet measured from the stream bank for watersheds draining less than one square mile. The buffer extends for 100 feet for watersheds draining more than one square mile. The District expands to incorporate the regulatory floodplain when that mapped distance is beyond the prescribed 75 or 100-foot distance.

Because of the Town's stated interest in flood impact reduction and preserving water quality, one option the Town should consider is a zoned buffer, as shown in the diagram below:



Communities within the **Neuse River Basin**, as shown in Table 1 in Appendix A, have incorporated a zoned approach. Inquiries with the staff of the North Carolina Division of Water Quality believe that any subsequent rules for the Cape Fear Watershed could be very similar to Neuse River buffer mandates.[27] Therefore, buffer policy for Chapel Hill should anticipate the potential of eventual state mandates.

Communities that take a multiple zoned buffer approach

- Cary
- Greensboro
- Charlotte-Mecklenburg
- Neuse River Basin (3 zones recommended)

The three-zoned approach includes an area of largely undisturbed native forest along the stream bank (#1 in above diagram) followed by an area of managed forest (#2 in diagram), followed by a grassy filter strip (#3 in diagram). There are two clear advantages for the Town in a zoned buffer approach:

[26] Gilliam, J.W., Osmond, D.L., & Evans, R.O. (1997). Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. North Carolina Agricultural Research Service Technical Bulletin 311, North Carolina State University, Raleigh, NC.

[27] Personal Communication, Cam McNutt, Cape Fear Basinwide Planner, North Carolina Division of Water Quality, March 3, 2001.

1. The fragile streamside zone (#1 in above diagram) may be more strictly managed. Many zoned buffer ordinances do not allow variances to be granted in these areas.

2. Disallowing land disturbance in the streamside zone maintains an overstory of trees above the stream, shading the water and regulating temperature. It also insures that the pollutant-filtering riparian vegetation nearest to the creeks remains intact.

The Chapel Hill RCD does not preclude variances in any area of the RCD.

The managed forest area (#2 in above diagram) may allow some activity, but within defined limits of deforestation and distance from the watercourse. The Orange County Water and Sewer Authority (OWASA) often creates utility easements near creeks and streams to drive vehicles into for maintenance purposes. A managed forest area would not inhibit OWASA's duties, but might cause the Authority to be more conservative in tree clearance near streams.

The outermost zone, containing grass only, remains conducive to landscaping. In the Piedmont, the grass filter strip in the outer zone has high potential for sediment reduction prior to silt reaching the most sensitive areas.[28]

Fixed Width Buffers

A commonly used standard in delineating buffers is *fixed widths along all buffered streams* (figure 2).

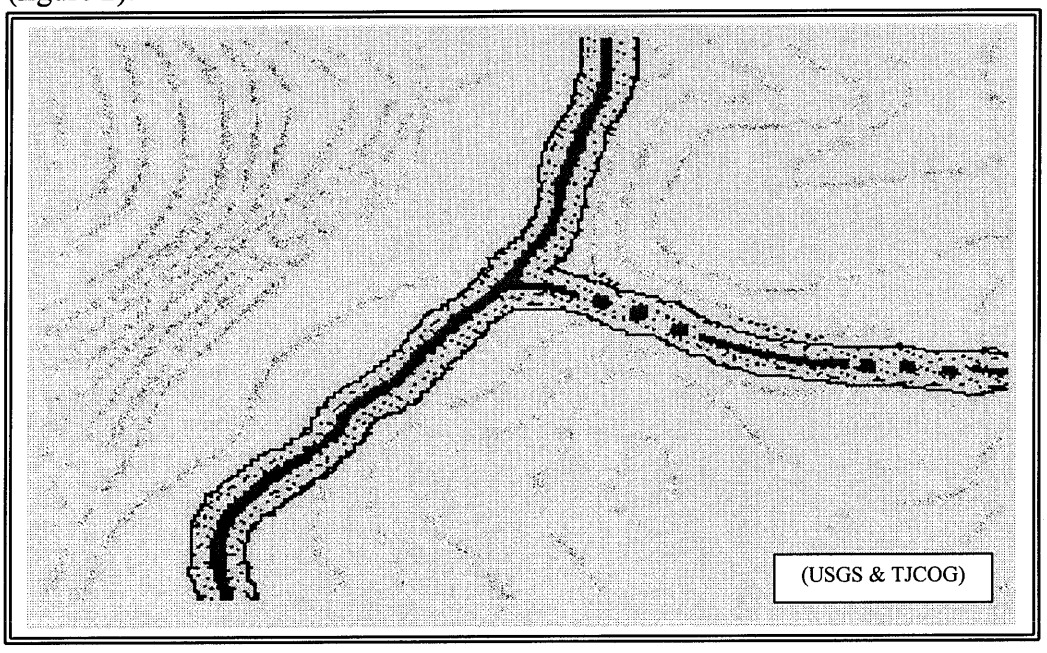


Figure 2: An illustration of a fixed width buffer along each side of perennial (solid line) and intermittent (dashed line) streams. The lighter lines are topographic contour lines.

[28] Triangle J Council of Governments. (1997, January). An Introduction to Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 1.

Typically, a width is selected based on scientific data and political feasibility and applied to mapped perennial and intermittent streams. One review of the literature on buffer width recommends width determination based on objectives. For effective sediment removal, widths from 10 to 289 feet have been successfully used.[29]

Communities that use a fixed width buffer approach
• *Chapel Hill* • Franklin County • Granville County • Person County • Wake County • Town of Wake Forest • Winston-Salem/Forsyth County

If the aim of the ordinance is to protect water quality, a buffer width of 50 to 100 feet is often appropriate. To address goals such as flood impact mitigation, protection of wildlife, or provide recreation opportunities, greater widths are often required.[30]

Buffers provide effective pollutant removal for runoff from land directly adjacent to them. Nearby lengthy stretches of pavement or grass allow rainfall to create a natural channel, effectively short-circuiting the buffer.[31]

While some municipalities chose to require the same buffer on all streams, it is more common to have a two –tiered buffer program where perennial streams, which flow throughout the year, are protected on either side of the banks by a broader buffer than intermittent streams, which flow only part of the year.

Fixed width buffers, like those in Chapel Hill, have the advantage of being more readily transferable to site plans and plats. However, they fail to account for many important variables (e.g., adjacent steep slopes, soil) that other buffer options address. For that reason, many communities have chosen to vary the width of their stream corridor in particularly sensitive areas.

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[29] Triangle J Council of Governments. (1997, January). An Introduction to Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 1.

[30] Triangle J Council of Governments. (1999, July). Local Ordinances for Protecting Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 4.

[31] Schueler, T. (1995). The Architecture of Stream Buffers. Watershed Protection Techniques Vol. 1, No. 4.

Variable width buffers

Another tool to for Chapel Hill to consider is modifying the buffer to incorporate sensitive areas around the creeks, like in this diagram of a variable width buffer that incorporates steep slopes (Figure 3).

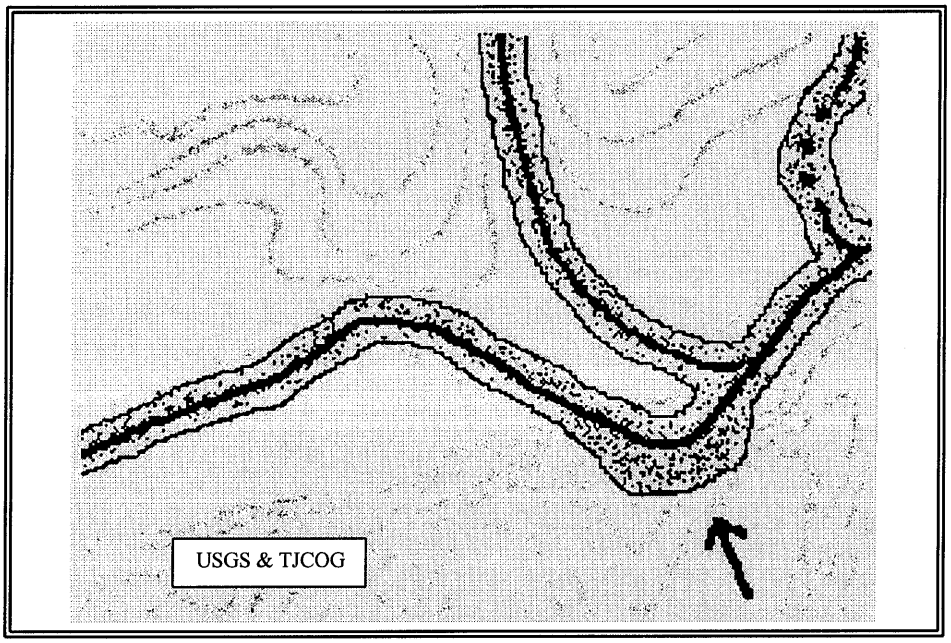

Figure 3: Variable-width buffer that expands (at arrowed point) to incorporate a steep slope area near the stream.

The North Carolina State Department of Environment and Natural Resources (DENR) promotes variable widths for buffers. NC DENR recommend calculating buffer width as follows:

Buffer (in feet) = 50' + (4 x slope)

For example, if the slope of the land adjacent to a stream is 10%, the buffer in that area should be 90 feet [50 + (4 x 10) = 90].

The advantage for Chapel Hill to incorporate slopes within buffer protection areas is that sloped areas, if allowed to change from an unvegetated state, can increase the rate and velocity of runoff. **Durham City/County** adopted new stream buffer requirements that include development restrictions on 25% slopes within 200 feet of perennial streams, or 100 feet of intermittent streams.

Some buffers are *variable based on the character of the stream or adjacent land.* Although these buffers are uncommon, they warrant consideration since they offer significant flexibility and assure that the most critical riparian areas are protected. Examples of stream conditions that might be incorporated within a variable-width buffer can include the following:

- Wetlands;
- Floodplains;
- Steep slopes, as discussed above;

- Erosive soils;
- Sensitive wildlife habitats.

Wake County uses an expanded definition of its floodplains by using both the base flood elevation provided by FEMA, and flood hazard soils from the soil survey based on their permeability.

Buffer measurement

Chapel Hill RCD: Buffer measurement begins at the stream bank.

The origin of buffer measurement typically falls in two categories, either from the center of the stream or from the edge of the stream bank. Although streams frequently vary in rate of flow, the stream bank is much more stable. Although streams sometimes flood over their banks, this usually only happens during extreme events. Therefore, measuring buffers from the edge of the stream bank has become a much more common practice to achieve some level of flood impact prevention.

An exception to these concepts is **Orange County**; who begins measuring its buffers from the edge of the 100-year floodplain, so the entire floodplain is part of the stream buffer. Chapel Hill also considers the entire regulatory floodplain as within its RCD.

Including the floodplain as part of the buffered area provides a defensible buffer width.

In addition to the buffer, some communities also regulate uses outside of the buffer by requiring setbacks for adjacent development. The **Wake County** and **Durham City/County** ordinances require a 10- or 20-foot building and grading setback from all drainageways or watershed buffers to minimize the impact of construction activity on the buffer's integrity.

As noted in the previous section of this report, in addition to providing extra flood protection in case of a stream flooding its banks, the buffer setback from the stream bank also offers structural protection against stream bank erosion.

Permitted uses

Chapel Hill RCD:

- Agricultural and related uses;
- Ground level loading and parking areas;
- Lawns, gardens and play areas;
- Golf courses, archery ranges, parks, hiking/horseback trails and other public/private recreational uses;
- Public utilities;
- Transportation infrastructure;
- Accessory activities to support residential structures (e.g., driveways, gardens);
- Public maintenance of transportation facilities and public utilities and storm drainages;
- Lakes, ponds, and associated infrastructure (e.g., Lakes Eastwood and Ellen).

The degree of protection that a buffer provides is correlated to the uses allowed in or near to it[32]. The **Durham City/County** and **Town of Wake Forest** buffer ordinances allow trails and other structures associated with passive recreation. **Winston-Salem/Forsyth County** allows water dependent uses, transportation infrastructure, and utilities.

Several of Chapel Hill's allowed uses within the RCD, (e.g., golf courses, nurseries, horseback trails) have the potential for contributing non-point source pollution to the stream. Although these uses may have been written into the ordinance to "grandfather" present uses, the language of the RCD allows future uses such as these to locate within the buffer, threatening water quality.

Additional performance standards

The RCD has standards for impervious surface limitation within its extent; in sewered areas: 20% of land; in unsewered areas: 12% of land; In Town-designated Water Critical Areas: 6% of land. The District includes an 18-inch freeboard requirement above the RCD flood elevation.

Chapel Hill is one of the few communities that has impervious surface limitations within its stream buffers.

[32] Triangle J Council of Governments. (1999, July). Local Ordinances for Protecting Riparian Buffers. TJCOG Technical Memo: Riparian Buffers Series, No. 4.

Other standards for development within the stream corridor area can include a freeboard requirement (i.e., an elevation of the lowest habitable floor above the FEMA base flood elevation). The freeboard requirement improves the confidence level that property will be protected from flooding based on the available data, and because filling of the floodplain area creates higher flood levels downstream as shown in figure 4.

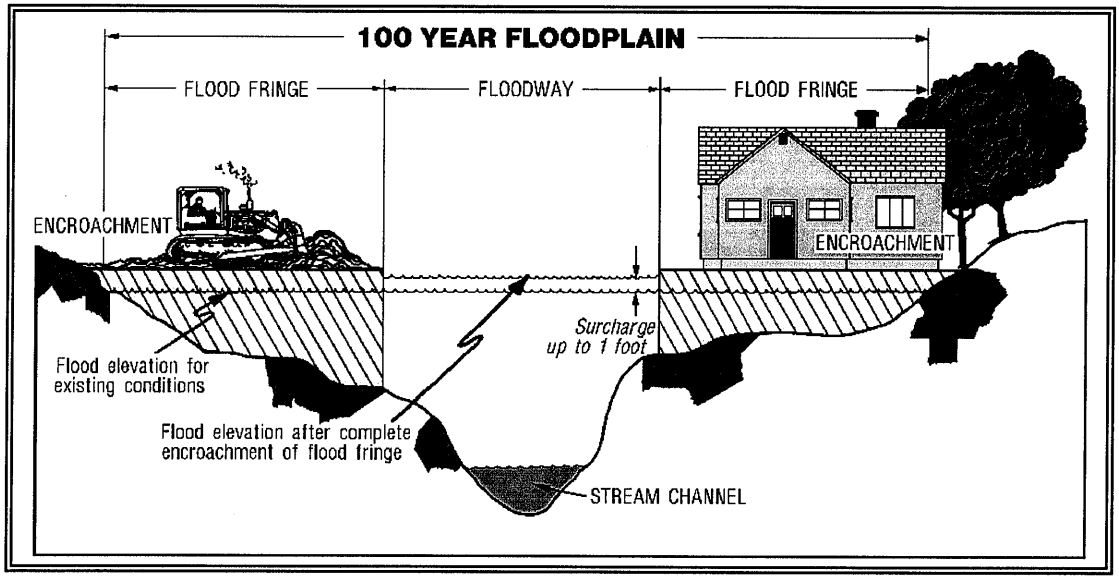

Figure 4: Schematic of floodplain showing that filling of floodplain leads to elevated flood levels, the so-called surcharge area; this effect on downstream properties can be offset to a degree by a freeboard requirement. (Nebraska Dept. of Natural Resources)

Streams incorporated in buffer

Chapel Hill requires buffers along perennial streams. The Town designates a perennial stream by its appearance on Aerial Topographic Maps and field verification for aquatic vegetation, fish, and aquatic arthropods (Chapel Hill Development Ordinance §2.90.1.

Although the Town Development Ordinance states that the RCD buffers only perennial streams, this methodology is inclusive for some of the smaller, more fragile headwater streams. Most non-point pollution enters waterways through first order streams. First order streams tend to flow intermittently, so it is important to buffer the intermittent sections of streams in order to achieve

Definitions

Perennial stream-flows throughout the year, except in extreme droughts.

Intermittent stream-flows at least part of the year.

Ephemeral stream-may only flow during rain events.

optimal results.[33] Some guides advise buffering ephemeral streams, although analyzing what constitutes an ephemeral stream is problematic.[34] The Town should consider updating the protected stream classification to better represent actual practice.

A possible way to do this would be to change the protected stream definition to incorporating all mapped streams using USGS topo mails or Soil Survey maps as a basis. Communities generally establish perennial and intermittent streams based on USGS topographic quads, but the **City of Durham** found that USDA soil survey maps were more accurate in mapping intermittent streams. Using the maps provides a tangible definition of streams.

Examples of methods for stream determination

Chapel Hill: aerial topos & field determination

USGS topographic sheets:
- Cary
- Greensboro

USDA soil survey maps:
- Durham City/County

Buffer notification and enforcement

Chapel Hill is fortunate to have in place a mechanism to enforce RCD violations through the Senior Code Enforcement Officer staff position in the Inspections Department. As with any regulation, improved enforcement procedures through staff resource increases and stiffer penalties would help minimize violations.

To be granted a permit, Chapel Hill requires the following submissions within each application:

- A utilities plan;
- A grading plan showing existing and final contours;
- A sedimentation and erosion control plan;
- A stormwater management plan;
- A soil analysis.

(Chapel Hill Development Ordinance §5.8)

The RCD is not directly delineated in the Development Ordinance. The Ordinance guides permit applications (§18.4.1, "Application Submittal Requirements" and §19.1, "Zoning Compliance Permit Required"), ensuring that the RCD is noted on site plans.

[33] Gilliam, J.W., Osmond, D.L., & Evans, R.O. (1997). Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. North Carolina Agricultural Research Service Technical Bulletin 311, North Carolina State University, Raleigh, NC.

[34] Wenger, S.J. & Fowler, L. (2000). Protecting Stream and River Corridors: Creating Effective Local Riparian Buffer Ordinances. Carl Vinson Institute of Government, University of Georgia.

Land disturbing activities within Chapel Hill's RCD "shall be kept to the minimum feasible; the smallest practical area of land shall be exposed at any one time during development and kept to the shortest time necessary; temporary vegetation shall be used as required; native plants and vegetation shall be retained and protected to the maximum degree possible; and re-vegetation is required as needed."

The Development Ordinance required the preparation of a Resource Conservation District Guide (§5.13). This guidance provides more detailed information about the RCD, criteria for interpretation of the Town's buffer requirements, a discussion of the evaluation of applications, and design and construction standards.

Pre-Construction stream buffer notation & protection

Charlotte-Mecklenburg County
(Fixed width – zoned approach)

- Prohibits temporary sediment basins within its buffers.
- All temporary basins must be noted on plans.
- Fill material is prohibited in buffer zones.
- All stormwater outfalls must be shown on plans as ending within the outermost zone.
- Outer buffer boundary must be clearly marked by orange fabric fencing prior to land disturbance as well as noted on plans.
- Measurable thresholds of re-vegetation in the event of buffer disturbance.

The **Mecklenburg County Department of Environmental Protection** has an effective education program. The Department requires the land developer distribute provided materials concerning the buffer to builders (prior to construction), who in turn notifies each homeowner of the buffer (prior to occupancy). The buffers are included on an online GIS overlay that is downloadable from a FTP site for site plan purposes (http://www.co.mecklenburg.nc.us/coeng/Storm/floodinfo/floodinfo.htm).

III-V. Conclusions

Chapel Hill's RCD has many exemplary features, but opportunities remain for the Town to improve. The intent of the Chapel Hill Resource Conservation District is to meet several goals related to public health, safety and general welfare or the town's character:

- To preserve the water quality of the Town's actual or potential water supply sources;
- To minimize danger to lives and properties from flooding;
- To preserve the water-carrying capacity of the watercourses;
- To protect watercourses from erosion and sedimentation;
- To retain open spaces and greenways;
- To preserve urban wildlife and plant life habitats from the intrusions of urbanization;
- To provide air and noise buffers;
- To preserve and maintain the aesthetic qualities and appearance of the Town.

Strengths

Based on our research and the capacities of other communities, Chapel Hill's RCD has several definable strengths. It is important to recognize what Chapel Hill is doing well to ensure that these practices continue. Chapel Hill has a well-deserved reputation for being on the forefront of environmental planning. Several features of the buffer ordinance demonstrate the strength of Chapel Hill's commitment to environmental quality.

- The restriction of impervious surface within the RCD (6%-20%, depending on conditions);
- The limitation of the disturbance of vegetation with the RCD (this could be enhanced by more measurable standards for development, such as the tree-cutting standards of Charlotte-Mecklenburg);
- The freeboard requirement for structures within the floodway fringe being elevated 18 inches above the RCD flood elevation;
- The buffer expands to incorporate the regulatory floodplain;
- Citizen participation in stream restoration has been successful in the Town
- The perennial stream definition is more inclusive than the name might indicate;
- Buffer width is comparable to most contemporary ordinances.

Opportunities for improvement

Analysis of the buffer protection ordinances of other North Carolina communities reveals some options for buffer regulation that the Town could incorporate into a comprehensive stormwater management program. These opportunities for improvement are presented in the following section as recommendations for the Town of Chapel Hill to consider implementing.

III-VI. Recommendations

Incorporate Zoned Buffer in Resource Conservation District
The Town should follow the model of the zoned buffer design for optimal flood management and stream protection. In following this design, the Town would develop a reserve area near its streams to filter pollutants and provide flood storage. The streamside zone in an updated Chapel Hill RCD should be a zone without development potential and as such would provide a small reserve of streamside land. In addition, future state buffer mandates, similar to the Neuse River basin rules, will likely require this design.

Re-evaluate buffer width based on updated floodplain map information
The state of North Carolina is a cooperative technical state with the Federal Emergency Management Agency. In performance, the state will remap all floodplains in the near future. These maps may show a different picture of flood risk in Chapel Hill, and these updates should be incorporated into buffer protection.

Clarify terminology in the Resource Conservation District

- Perennial and intermittent streams

Since the Resource Conservation District is not mapped and the definition of a protected stream is limited to perennials, development must rely on an ad hoc determination of RCD requirements prior to permit approval. The definition should be clarified. For example, a new RCD stream definition could include mapped (USGS and/or USDA Soil Survey) perennial and intermittent streams and those defined by aerial photography and field evaluation. This would give developers and redevelopers a more tangible description of the Town's RCD. It would also better explain the Town's methodology of stream delineation.

- Land disturbance

Communities like Charlotte/Mecklenburg are specific pertaining to the amount of tree cutting and land disturbance that are allowed within stream buffered areas. Chapel Hill does not currently provide measurable standards of minimum land disturbance activity. Standards that require on-site signs and markers to cordon off the sensitive streamside areas could be established. Developing these standards for permitted land disturbances could improve the Town's ability to enforce and developers' to comply with regulations.

Make enforcement of buffer regulations a priority

- Allocate additional staff resources to enforcement

The Town is encouraged to increase its capacity to monitor performance during construction and on a general basis through an increase in staff resources to allow for continuous monitoring and inspections.

- Update the RCD Guide as an educational tool

Updating the RCD guide to include any alterations of the RCD could be demonstrated as consistent to the NPDES Phase II Requirement related to public education and outreach.

- Add to the RCD the explicit requirements of plan approval for construction within its boundaries

For example, include a provision requiring developers to provide buffer notation on plats and plans within the RCD Development Ordinance section.

Use water quality monitoring data as a policy guide and a measure of buffer impact
In order to determine the effects of buffers on water quality and stream conditions, monitoring of the stream will be necessary. Several physical characteristics can be measured easily, including

- Temperature
- Dissolved oxygen
- Flow rate
- Discharge
- Turbidity

Measurements of turbidity and flow are particularly important during peak flow events. Bio-indices of macroinvertebrates are commonly used in analysis of stream water quality. Two recommended indices are

- EPT index
- BIBI

Comparing these findings with recommended standards as well as with historical data of Chapel Hill can provide a measurement of the degree to which the buffer regulations (and other water management programs) are reaching the desired goals, and can be used to guide policy future policy decisions.

Update the RCD to eliminate permitted uses that are inconsistent with Town water quality goals.
Several permitted uses have the potential to contribute non-point sources like Nitrogen, fecal coliform, metals, and sediment that are harmful to stream health:

- Ground level impervious surfaces
- Golf courses
- Horseback trails
- Outdoor plant nurseries
- Horticulture
- Parks

Fully incorporate stream buffers in community design goals
The Town's goals of an integrated greenway system and conservation design can be greatly augmented by the aesthetic quality of its watercourses, and the Town should pursue design guidelines that preserve Chapel Hill's unique character.

Foster citizen participation in stream restoration and monitoring
As an extension of the Town's successful Big Sweep program, the town should sponsor citizen stream restorers for non-supporting sections of the town's streams. As part of this program, presentations about watershed health, stream monitoring, and re-vegetation could be developed pursuant to NPDES Phase II Objectives for public education and

participation. The potential for community monitoring programs, as have been used in many other streams throughout the country, should be examined. A potential model for a stream-walking/bio-monitoring document from the Texas Natural Resources Conservation Commission, "Watershed Owner's Streamwalk Guide" is available online: http://www.tnrcc.state.tx.us/admin/topdoc/gi/218.pdf.

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Appendix 1

Buffer Practice and Policy in Chapel Hill and other Locations

Communities across North Carolina determine riparian buffer extent using a variety of criteria.

Various aspects of stream buffer management

Buffer width	Multiple zones of varying widths	Fixed along all streams	Vary-slope	Vary-stream or and (CH)
Buffer measurement	From the edge of the stream (CH)	From the center of the stream	Extending from floodplain	
Permitted uses	Trails & passive recreation	Utility & water-dependent uses	Ground level uses (CH)	
Additional Performance Standards	e.g., impervious surface coverage, freeboard requirement (CH)			
Stream application	Perennial and intermittent streams	Perennial streams (CH)	Within the water supply watershed only	
Buffer enforcement	Buffer noted on site plans	Buffer signs placed on-site	Staff resources dedicated to inspections (CH)	

The following is a brief synopsis of how selected communities strive for a variety of stormwater management goals (e.g., flood damage prevention, water quality, habitat conservation, recreational amenities and community aesthetics) through stream buffering. Because of similar topographic conditions and soil type to the town of Chapel Hill, the majority of the communities included are in the Piedmont Region of the state. The first

set of buffer requirements is for area communities, with the Chapel Hill Resource Conservation District noted under the Cities and Towns section for comparison purposes.

Table 1: Area Buffer Width Requirements
(Source: Triangle J Council of Governments-As of July, 1999)

Jurisdiction	*Streams*	
	Perennial	**Intermittent**
Counties		
Orange	Variable: 50' – 150' measured from the edge of the 100 yr. floodplain	Variable: 50' – 150' measured from the edge of the 100 yr. floodplain
Durham	Variable: 50' – 150', plus limitations on development in 100-year floodplain	Variable: 30' – 150', plus limitations on development in 100-year floodplain
Wake	50'	50' for drainageways draining >25 ac.; 30' for drainageways draining >5 ac. and <25 ac.
Franklin	50'	
Granville	30'	
Person	30'	30' (Non-explicit requirement)
Cities & Towns		
Chapel Hill	*75' measured from the stream bank for a watershed area less than one square mile.* *100' measured from the stream bank for a watershed area of one square mile or more.*	
Durham	50' – 100', plus limitations on development in 100-year floodplain	30' – 100', plus limitations on development in 100-year floodplain
Raleigh	60' in watersheds >25 ac. 35' in watersheds < 25 ac. (100' for high density areas)	60' in watersheds >25 ac. 35' in watersheds >5 ac. and <25 ac.
Hillsborough	Variable: 30' – 100'+ (100'+ for high density)	30' (in protected water supply zones—PW and PWCA—only)
Cary	100' Zonated	100' for all USGS topo streams; 50' for all Wake Co. Soil Survey streams
Wake Forest	50'	25' for channels draining >5 ac.
Roxboro	30' (100' for high density)	
Butner	30' (100' for high density)	

Cary recently committed $12 million for the preservation and acquisition of open space, applicable to riparian areas.

Carrboro (for streams outside water supply watershed areas)

- For streams that drain at least 50 acres, but less than one square mile:

  50' or 5 times the average width of the stream as it flows through the property, which ever is larger.

- For streams with drainage areas less than 50 acres:
  15' or 5 times the average width of the stream, which ever is greater.

Charlotte-Mecklenburg County has adopted SWIM (Surface Water Improvement and Management) buffers in most of its cities and towns. The County and City of Charlotte SWIM requirements have three managed zones with escalating regulations on development. The *streamside* area is the most restrictive, then there is a *managed use* area, where development is permitted with conditions and buffer disturbance mitigation (such as BMPs and tree clearance restrictions) and an *upland* area, that discourages encroachment and aids in sheet flow of stormwater runoff. The watershed buffering requirements for the county and selected cities is summarized in the table below:

Table 2: Mecklenburg County & Municipal Jurisdiction Buffer Requirements

Jurisdiction	*Total Watershed Area*			
	≥ 640 ac.	≥ 300 ac.	≥ 100 ac.	≥ 50 ac.
County				
Mecklenburg	Total = 100' + 50% of floodfringe beyond 100' Streamside – 30' Managed Use – 45' Upland – 25' + 50% of area of floodfringe beyond 100'	Total=50' Streamside=20' Managed Use=20' Upland=10'	Total=35' Streamside=20' Managed Use=none Upland=15'	No Buffer Requirements
Cities & Towns				
Charlotte	Same as Mecklenburg County	Same as Mecklenburg County	Same as Mecklenburg County	Same as Mecklenburg County
Cornelius	Total=entire floodplain but no less than 100 feet	Total=50' No zones	Total=35' No zones	
Huntersville	Total=floodway +100% of floodfringe but not less than 100' Streamside=30' Managed Use=45' Upland=remainder	Total=50' Streamside=20' Managed Use=20' Upland=10'	Total=35' Streamside=20' Managed Use=None Upland=15'	
Matthews	Same as Huntersville	Same as Huntersville	Same as Huntersville	Same as Huntersville
Davidson	Total buffer width=a minimum of 100' for all streams within Davidson's jurisdiction. For all FEMA-regulated streams the width is 100' plus 50% of the areas of the floodfringe beyond 100'			

The City of **Greensboro** has four zonated buffer widths based on stream type and intensity of development:

Table 3: City of Greensboro Stream Buffer Cases 1 - 4

Case	Minimum Width (each side)	Undisturbed	No Built-Upon Surface (vegetated)	Built-Upon Limit of 50% (no occupied structures allowed)
1	50'	First 15'	N/A	Next 35'
2	50'	First 15'	N/A	Next 35'
3	30'	N/A	Entire 30'	N/A
4	100'	N/A	Entire 100'	N/A

Note:
Case 1: Drainageways draining an area equal to or larger than 50 acres. (Intermittent streams)
Case 2: Perennial streams (as defined by City methodology)
Case 3: Perennial streams (noted on Greensboro "watershed map" as adjacent to "low density" development)
Case 4: Perennial streams (noted on Greensboro "watershed map" as adjacent to "high density" development)

Through ordinances established in the 1980s and 1990s, the City of **Winston-Salem** and **Forsyth County**, North Carolina established a comprehensive watershed plan for Salem Lake, which provides close to half the drinking water for local residents. As part of the city/county collaboration, stream buffers were established:

- 100' stream corridor along all perennial streams in the watershed.
- Development permitted in the corridor is restricted to the following: water dependent uses, transportation infrastructure, utilities, and passive recreation structures. Land dependent uses are prohibited within 25' of the stream.

The **Portland, Oregon** region separates streams into Primary and Secondary Protected Water Features. Buffer width varies according to adjacent slope and incorporates wetlands.

Primary Protected Water Features include:

- All perennial streams
- All other streams draining more than 100 acres, wetlands, natural lakes, and springs.

Secondary Protected Water Features include:

- Intermittent streams draining 50-100 acres.

Table 4: Portland Metro Stream Buffer Requirements

Protected Water Feature Type	Slope adjacent to Protected Water Feature	Starting Point for Measurements from Water Feature	Width of vegetated buffer
Primary Protected Water Features	< 25%	• Edge of bankfull flow or 2-year storm event • Delineated edge of wetland	25'
Primary Protected Water Features	25% for 150 feet or more	• Edge of bankfull flow or 2-year storm event • Delineated edge of wetland	100'
Primary Protected Water Features	25% for less than 150 feet	• Edge of bankfull flow or 2-year storm event • Delineated edge of wetland	Distance from starting point of measurement to top of ravine (break in 25% slope), plus 25'
Secondary Protected Water Features (intermittent streams draining 50-100 acres)	< 25%	• Edge of bankfull flow or 2-year storm event • Delineated edge of wetland	15'
Secondary Protected Water Features (intermittent streams draining 50-100 acres)	25%	• Edge of bankfull flow or 2-year storm event • Delineated edge of wetland	25'