Upper Neuse River Basin Association

Technical Memorandum

To: Kimberly Nimmer, NC Division of Water Quality

From: Heather Saunders, Upper Neuse River Basin Association

Date: Revised February 13, 2009

Re: Lick Creek Watershed — Preliminary management recommendations.

The Center for Watershed Protection (CWP), Upper Neuse River Basin Association (UNRBA), City of Durham Stormwater Services (DSS), the North Carolina State University (NCSU) Water Quality Group, Durham County Stormwater and Erosion Control Division, and the N.C. Ecosystem Enhancement Program (NCEEP) are currently undertaking a joint effort to develop a comprehensive watershed restoration plan for the Lick Creek Watershed in North Carolina (a watershed restoration plan is one in which management strategies are identified to remove a body of water from the impaired streams list).

In addition, organizations including the City of Durham's Planning and Public Works Departments; Durham County's Utility Division; the Durham Soil and Water Conservation District (DSWCD); the N.C. Division of Water Quality (NCDWQ); the N.C. Wildlife Resources Commission (NCWRC); the U.S. Army Corps of Engineers (USACE); the Triangle Land Conservancy (TLC); the Triangle Greenways Council (TGC); the Conservation Trust for North Carolina (CTNC); the City of Raleigh Public Utilities Department; Wake County Environmental Services; and local watershed residents have all been participants and contributors to the comprehensive stakeholder effort that characterizes this plan's development. The objectives of this memorandum are to:

1. Briefly discuss how existing conditions in the Lick Creek watershed should guide management approaches;
2. Show how land use changes in the watershed are expected to affect water quality and aquatic habitat; and
3. Suggest preliminary management strategies that Lick Creek Partners and Stakeholders will develop and include in the Lick Creek Watershed Restoration Plan.

Restoration planning efforts in the watershed were prompted by the biological impairment (NCDWQ 2006), poor dissolved oxygen reported by DSS, and nutrient-sensitive waters status of Lick Creek's receiving waters (NCDWQ 2008), Falls Lake, which serves as a drinking water reservoir for 600,000 Wake County, NC residents, as well as the pending Falls Lake Nutrient Management Strategy (NMS). The causes of impairment in Lick Creek have not been specifically identified; and consequently, identification of the causes of biological impairment has become the first goal of the management plan ("Develop a hypothesis about the causes of biological impairment in Lick Creek and recommend approaches to addressing impairment status"). Aquatic habitat is largely a function of geomorphology, substrate composition, the

availability of large woody debris, and discharge (CWP 2007). Fieldwork efforts and on-going water quality monitoring (on-going water quality monitoring refers to both project specific monitoring efforts as well as those being conducted as a general practice by DSS) in the Lick Creek watershed have aimed to determine if degradation to one or any of these components has contributed to the biological impairment of Lick Creek.

While the data collected for this project does not conclusively identify specific sources of pollution in the Lick Creek watershed, fieldwork and monitoring efforts have enabled us to make inferences about possible sources (such as agricultural practices, on-site wastewater treatment, nutrient loading and increased stormwater runoff) and thus, suggest a possible range of management strategies. A summary of probable causes has been provided by the CWP (2007) in the "Lick Creek Fieldwork – Findings and Recommendations" technical memorandum available at ftp://ftp.tjcog.org/pub/unrba/lick/techmemo060707.pdf. In addition to field observations, on-going water quality monitoring being conducted by DSS at two locations, one each on Lick Creek and Rocky Branch, and North Carolina State University (NCSU) (2007) at six locations in the watershed suggest that while water quality within the watershed is relatively good ("Analysis of Existing Data and Short-term Monitoring Plan for Lick Creek" technical memorandum available at ftp://ftp.tjcog.org/pub/unrba/lick/stermmonplan.pdf), water quality in some portions of the watershed may be declining (Line and Penrose 2007).

Existing Conditions in the Lick Creek Watershed

At the moment, the Lick Creek watershed is relatively undeveloped, with percentages of impervious cover that range from two to fourteen percent, yet significant increases in impervious surface are allowable under current zoning regulations, and the watershed could see 40% impervious surface coverage in some subwatersheds if completely built out. Schueler (1994) has reported that water quality is typically generally good where impervious surface is between zero and ten percent. Despite the fact that the watershed is relatively undeveloped, water quality monitoring being conducted by both NCSU and DSS has indicated that current water quality in some subwatersheds is already degraded (Line and Penrose 2007). Furthermore, when applied to the Lick Creek Watershed, CWP's Watershed Treatment Model predicted future increases in in-stream erosion and total nitrogen loading under current zoning regulations and development standards and practices (Fraley-McNeal et al. 2007).

Water Quality Summary as provided by City of Durham Stormwater Services

Monitoring data were obtained from the NCSU Water Quality Group, with whom UNRBA contracted to conduct monitoring of the watershed. Data were provided in an MS Excel spreadsheet and included relevant information as follows: site number and description; date sampled; gage height; discharge (calculated); and concentrations of various pollutants, including turbidity, *Echerichia coli (E. coli)*, nutrients, metals, dissolved oxygen (DO), pH, turbidity, total suspended solids (TSS) and conductivity. Water temperature was also measured in-stream and rainfall was recorded as measured at the Falls Lake dam.

Although sites were visited monthly over a period of 21 months, drought conditions persisted through most of 2007 and into early 2008. Many streams were dry or not flowing when field teams visited monitoring

sites. When streams were dry or not flowing, water quality samples were not collected. Even when water was present and flowing, samples may not be representative of typical conditions in Lick Creek because of the drought. Although DSS has monitored this watershed for several years, additional comparisons of NCSU data to DSS data were not performed for this interim summary.

The interim results of water quality monitoring are provided in Tables 1 and 2. Table 1 provides a detailed summary of water quality data including the number of samples, the arithmetic or geometric mean of the parameter, the range of the parameter, and two columns used to compare the results to accepted levels. The column labeled "% > WQS" or "% > EPA criteria" indicates the number of samples that were greater than, or less than, the accepted levels. Where a state water quality standard exists, the NCDWQ evaluates the percent of samples that violate the standard in order to deem a water "Impaired" and justify placement on the state impaired waters list. Generally, this decision is based upon 10% of the samples indicating a violation of the standard. There is no such evaluation of the U.S. Environmental Protection Agency (EPA) criteria to deem a water impaired, although samples may violate the criteria. Problem parameters for Lick Creek monitoring sites were identified using the NCDWQ water quality standards and the EPA Ambient Water Quality Criteria (AWQC). Total nitrogen and total phosphorus (or nutrients) do not have water quality standards; therefore, they were compared to the recommended ambient water quality criteria published by EPA in 2000. However, EPA did not provide guidelines for implementing the recommended criteria. For example, should the criteria never be exceeded, or the average concentration not exceed the criteria, or another method of evaluation be used. As such, the interpretation in this interim memorandum should be considered best professional judgment until EPA or the State of North Carolina provide additional guidance.

Overall, water quality appeared to be the best at monitoring sites describing Subwatersheds 4 and 5. The worst water quality was observed in Subwatersheds 1 and 7. Subwatersheds 1 and 7 had water quality data indicating high nutrient levels (phosphorus and nitrogen) and violations of either state water quality standards or EPA recommended criteria for turbidity and *E. coli*. Subwatershed 5 also had violations of standards or criteria for turbidity and *E. coli*, while Subwatershed 2 had violations of the water quality standard for turbidity. An overall summary of problem parameters is presented in Table 2. A check mark indicates a parameter that exceeded state or EPA standards. In cases where a state or EPA standard was not available, best professional judgment was used to indicate problem parameters. Data was not collected for Subwatershed 3; therefore data cells for this subwatershed have been left blank and shaded gray.

Table 1. Lick Creek Water Quality Data Summary (a)

			Pollutant Summary (b)													
			Temperature, C					Conductivity, uS/cm					DO, mg/L				
Site No.	Sub-watershed	Description	n	Mean	Range	%>WQS (c)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%<WQS (e)	Compliance status
LC6	1	Lick Creek at Sherr	7	16.3	3.41 - 25.61	0%	NA	7	143	68 - 204	NA	NA	7	5.21	2.01 - 13.5	43%	(e)
LC5	2	UT on Randsell Pro	8	15.7	3.83 - 30.19	0%	NA	8	218	67 - 800	NA	NA	8	5.46	2.39 - 12.93	50%	(e)
None	3																
LC4	4	UT at Olive Branch	7	13.9	2.1 - 21.33	0%	NA	7	117	50 - 189	NA	NA	7	5.28	1.98 - 12.67	43%	(e)
LC2	5	Martin Creek at Ke	8	16.1	6.28 - 25.47	0%	NA	8	94	51 - 151	NA	NA	8	5.4	2.29 - 12.53	38%	(e)
LC1	6	Lick Creek at South	8	17.7	5.49 - 25.41	0%	NA	8	135	82 - 189	NA	NA	8	3.95	1.65 - 7.66	50%	(e)
LC3	7	Rocky Branch at Ke	2	11.5	5.7 - 17.34	0%	NA	2	121	73 - 169	NA	NA	2	7.41	2.37 - 12.46	50%	(e)

			Pollutant Summary													
			Total Kjeldahl nitrogen, mg/L					Nitrate+Nitrite Nitrogen, mg/L					Ammonia, mg/L			
Site No.	Sub-watershed	Description	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%> EPA criteria (g)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.678	0.39 - 0.901	NA	NA	12	0.048	0.003 - 0.131	NA	NA	12	0.082	0.016 - 0.513		
LC5	2	UT on Randsell Pro	13	0.411	0.249 - 0.700	NA	NA	13	0.057	0.001 - 0.156	NA	NA	13	0.048	0.016 - 0.129		
None	3																
LC4	4	UT at Olive Branch	11	0.548	0.298 - 1.167	NA	NA	11	0.041	0.007 - 0.214	NA	NA	11	0.057	0.022 - 0.22		
LC2	5	Martin Creek at Ke	12	0.0465	0.252 - 0.688	NA	NA	12	0.101	0.014 - 0.335	NA	NA	12	0.041	0.015 - 0.072		
LC1	6	Lick Creek at South	16	0.529	0.351 - 0.779	NA	NA	16	0.058	0.007 - 0.161	NA	NA	16	0.081	0.015 - 0.227		
LC3	7	Rocky Branch at Ke	6	1.59	0.07 - 2.8	NA	NA	6	0.127	0.05 - 0.20	NA	NA	6	0.39	0.025 - 1.42		

			Pollutant Summary													
			Total phosphorus, mg/L					Total nitrogen, mg/L					Total suspended solids, mg/L			
Site No.	Sub-watershed	Description	n	Mean	Range	%> EPA criteria (i)	Compliance status	n	Mean	Range	%> EPA criteria (h)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.726	0.405 - 0.947	100%	(i #)	12	0.726	0.405 - 0.947	75%	(h #)	12	34.1	6.0 - 97.0	NA	NA
LC5	2	UT on Randsell Pro	13	0.08	0.051 - 0.159	100%	NA	13	0.467	0.250 - 0.816	23%	NA	13	7.21	1.0 - 22.0	NA	NA
None	3																
LC4	4	UT at Olive Branch	11	0.057	0.038 - 0.096	100%	NA	11	0.588	0.322 - 1.202	36%	NA	11	7.55	4.8 - 12.0	NA	NA
LC2	5	Martin Creek at Ke	12	0.052	0.031 - 0.084	100%	NA	12	0.567	0.295 - 0.876	25%	NA	12	13.6	1.0 - 45.0	NA	NA
LC1	6	Lick Creek at South	16	0.089	0.047 - 0.168	100%	NA	16	0.587	0.374 - 0.866	25%	NA	16	12.6	1.5 - 45.0	NA	NA
LC3	7	Rocky Branch at Ke	6	0.11	0.05 - 0.334	100%	(i #)	6	1.72	0.27 - 2.9	66%	(h #)	6	30.6	14.0 - 68.0	NA	NA

			pH					Turbidity					E. coli, mpn/100mL				
Site No.	Sub-watershed	Description	n	Mean	Range	%<WQS (k)	Compliance status	n	Mean	Range	%>WQS (f)	Compliance status	n	Geometric mean	Range	%> EPA criteria (j)	Compliance status
LC6	1	Lick Creek at Sherr	7	NA	4.84 - 7.53	43%	(k*)	13	74.7	30.0 - 119.0	76%	Non-compliant	13	215	9 - 2400	NA	Non-compliant
LC5	2	UT on Randsell Pro	8	NA	5.07 - 7.58	13%	(k*)	14	25.6	2.0 - 79.0	14%	Non-compliant	13	93	15 - 2400	NA	Compliant
None	3																
LC4	4	UT at Olive Branch	7	NA	3.5 - 7.98	14%	(k*)	12	21.2	7.4 - 39.0	0%	Compliant	12	72	3 - 460	NA	Compliant
LC2	5	Martin Creek at Ke	8	NA	5.86 - 7.93	13%	(k*)	13	19.2	7.4 - 30.0	0%	Compliant	13	84	1.5 - 1100	NA	Compliant
LC1	6	Lick Creek at South	8	NA	5.18 - 7.15	13%	(k*)	15	36.7	4 - 97	27%	Non-compliant	18	178	15 - 2400	NA	Non-compliant
LC3	7	Rocky Branch at Ke	2	NA	6.02 - 7.68	0%	NA	2	33.7	29 - 38.5	0%	NA	6	777	71 - 25000	NA	Non-compliant

n = Number of samples analyzed
mean = arithmetic mean concentration except as noted.
Range = Minimum to maximum of reported levels. Where the minimum was not detected at a specified quantitation limit, the quantitation limit is shown.
Compliance state = evaluate of the concentrations and/or percent of criteria exceeded to determine complaince with criteria. For simplicity, a result of Compliant or Non-complaint is reported.
WQS = NC Water Quality Standard, 15A NCAC 02B .0211
* = Generally indicates minimum sample sizes are not met. See specific letter footnote.
# = Generally associated with nutrients for which EPA has not provided sufficient guidance on applying recommended criteria. See specific letter footnote.

(a) All data summarized in this table were provided by the NCSU Water Quality Group in November 2008 and includes data collected and analyzed by NCSU and the City of Durham Stormwater Services. The period represented is from January 2007 through September 2008.
(b) All pollutants are included in this summary except metals (i.e., Copper, Lead and Zinc). Values reported as less than detected were used in calculations of means as the detection limit.
(c) Temperature levels were compared to the North Carolina water quality standard for Class C lower piedmont streams which states that temperature is "not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 29 degrees C (84.2 degrees F) for mountain and upper piedmont waters and **32 degrees C (**89.6 degrees F) for lower piedmont and coastal plain waters". 15A NCAC 02B .0211 (3)(j)
(d) Conductivity, total Kjeldahl nitrogen, nitrate+nitrite nitrogen and total suspended solids do not have water quality standards or recommended criteria for Class C streams.
(e) Dissolved oxygen levels were compared to the instantaneous North Carolina water quality standard for Class C streams which states that dissolved oxygen shall be "not less than a daily average of 5.0 mg/L with a minimum instantaneous value of not less than **4.0 mg/L**". 15A NCAC 02B .0211 (3)(b). When a minimum of 10 samplies is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of a standard before deeming the stream "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant dissolved oxygen concentrations.
(f) Turbidity levels were compared to the North Carolina water quality standard for Class C streams, which states "the turbidity in the receiving water shall not exceed **50 Nephelometric Turbidity Units (NTU)** in streams not designated as trout waters". 15A NCAC 02B .0211 (3)(k). When a minimum of 10 samples is available, the NCDWQ methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream non-complaint or "Impaired".
(g) to be completed

(h) Total nitrogen was determined as the sum of total Kjeldahl nitrogen and nitrate+nitrite nitrogen. North Carolina does not have water quality standards for total nitrogen, so the EPA AWQC recommendations for nutrients were used for comparison. For Region IX (which includes central North Carolina), Level III Ecoregion 45, the total nitrogen AWQC based on measured data is **0.615 mg/L** (EPA 2000). EPA has not provided guidance on the method for evaluating the AWQC, so the compliance status reflects those sites with an arithmetic mean concentration greater than 0.615 mg/L. These are noted with an (h #).
(i) North Carolina does not have water quality standards for total phosphorus. The EPA AWQC recommends the following total phosphorus criteria for Region IX, Level III, Ecoregion 45: **0.03 mg/L**. (EPA 2000). However, all of the data for the Lick Creek watershed exceed this recommended criteriona, possibly due to naturally elevated levels of phosphorus in soils. The Complaince status column highlights those sites with an arithmetic mean total phosphorus concentration greater than **0.10 mg/L** with an (i #).
(j) North Carolina does not have water quality standards for E. coli, so the EPA AWQC recommendations for E. coli were used to judge instream levels. For freshwaters, a geometric mean concentration of **126 cfu/100mL** is recommended (EPA 1986). EPA recommends applying this geometric mean to a minimum of 5 samples collected within a 30-day period. Since samples were collected monthly over a 21 month period, this cannot be regidly applied to the Lick Creek study. However, comparing the geometric mean of all the data collected to the 30-day criterion does provide an important indicator of sites that would most likely violate the citerion as written.
(k) pH levels were compared to the North Carolina water quality standard for Class C streams, which states that pH "shall be normal for the waters in the area, which generally shall range between **6.0 and 9.0**". 15A NCAC 02B .0211(3)(g) When a minimum of 10 samples is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream as noncompliant or "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant pH at levels lower than 6.0. These sites are noted with a (k *).

Table 2. Water quality problem indicators for Subwatersheds 1-7 in the Lick Creek Watershed.

Subwatershed	Dissolved Oxygen	*E. coli*	pH	Total Nitrogen	Total Phosphorous	Turbidity
1	√	√	√	√	√	√
2	√	--	√	--	--	√
3						
4	√	--	√	--	--	--
5	√	--	√	--	--	--
6	√	√	√	--	--	√
7	√	√	--	√	√	--

DO levels were depressed below the NC instantaneous water quality standard at all monitoring locations during summer months. It is difficult to determine the cause of low DO during the period monitored due to drought conditions. DO may have worsened during the drought due to stagnant or pooled water. Other potential causes, for example continuous sources of ammonia and other oxygen consuming wastes, may have become more pronounced during this period and may have contributed to the low DO values. Given the number of monitoring location visits where stagnant and/or dry conditions were recorded, drought conditions most certainly contributed to low DO, but this could not be separated from other sources of pollution. *E. coli* were evaluated using the EPA criteria for bacteria, published in 1986. Using this criteria, Subwatersheds 1, 6 and 7 each had a geometric mean concentration of *E. coli* greater than the EPA criteria. Subwatershed 7 had a geometric mean concentration more than five times worse than the EPA criteria, far worse than any other Lick Creek monitoring locations. It appears that a one-time low pH event occurred throughout the Lick Creek watershed, causing this parameter to be highlighted as a problem. What event or condition may have caused these widespread low pH levels is unknown. In general, all other samples indicated a pH within the range specified by the NCDWQ water quality standards. (see Table 2, footnote (k)). Although pH is presented as a problem parameter in Table 2, it may not be of significance to current water quality management goals because it appears to be a one-time event. Total nitrogen and total phosphorus were evaluated based on arithmetic mean concentrations. The arithmetic mean total nitrogen concentration was compared to the EPA AQWC to determine those sites that might be out of compliance. However, total phosphorus concentrations were worse than the EPA AWQC at all monitoring locations. In order to highlight those subwatersheds with significantly worse levels of total phosphorus, best professional judgment was used, as described in Table 2, footnote (i). Turbidity concentrations may be elevated whenever there is a significant amount of soil exposed on land or when stream flows are such that erosion of the stream banks occurs. Using the NC water quality standard as a benchmark, turbidity violations occurred at a high frequency in three subwatersheds, as noted in Table 1.

Future Conditions in the Lick Creek watershed

Subwatersheds 1, 4, 5, 6, and 7 are already showing signs of eutrophication ("eutrophication" is defined as elevated levels of nitrogen and phosphorous) and elevated concentrations of *E. coli* and TSS at some sites. Although water quality impacts in Subwatersheds 4, 5, 6, and 7 are likely caused by additional sources other than just urban development (e.g. agricultural uses), Lick Creek land use analyses (Fraley-McNeal et al. 2007 and UNRBA 2008) make a strong case that the greatest impacts are yet to come. A successful restoration effort aimed solely at addressing existing impacts might result in some immediate benefits in

Subwatersheds 4-7, and possibly on the main stem of Lick Creek. However, conditions in Subwatershed 1 (where urban land uses are already dominant but still expected to see significant increases) lead us to conclude that immediate bacteria, nutrient, and/or sediment reductions from traditional restoration or changes to agricultural practices would soon be eclipsed by the hydrologic, sediment, and nutrient impacts of urban development.

Table 3 summarizes indicators of both existing restoration need (current water quality monitoring and fieldwork indicators) and the need to prevent future degradation of the watershed (Watershed Treatment Model and future management need indicators). As has been described above, water quality monitoring in the Lick Creek watershed had indicated degraded water quality in some subwatersheds. Parameters such as FC, nitrogen, phosphorous, and TSS that exhibited elevated concentrations are indicated in Table 3 with a check mark (√), the assumption being that subwatersheds with already degraded water quality make good candidates for watershed restoration. Furthermore, subwatersheds with an abundance of potential restoration sites (evaluated and summarized in the "Lick Creek Watershed Restoration Priorities" memorandum [UNRBA 2007]) are also checked.

The Watershed Treatment Model (Fraley-McNeal et al. 2007) used parameters like expected changes in impervious cover and land use to predict increases in nitrogen, phosphorous, and TSS based on current zoning regulations and practices (subwatersheds that are expected to see significant increases in these parameters are indicated with check marks in Table 3). For example, Subwatersheds 1 through 8 are situated within the City of Durham's Urban Growth Area (UGA), and are therefore expected to receive more development than the other Lick Creek subwatersheds. Impervious cover percentages are estimated to be between 22 and 40% at buildout in Subwatersheds 1 through 8, as opposed to Subwatersheds 9 through 11, which are only expected to see as much as 12% impervious cover under current zoning regulations (Table 3). Consequently, Subwatersheds 1 through 8 are expected to see increases in total nitrogen, total phosphorous, and/or TSS. However, the Watershed Treatment Model (Fraley-McNeal et al. 2007) did not predict significant increases in these parameters for Subwatershed 9 and only indicated increases in total nitrogen for Subwatersheds 10 and 11. Subwatersheds that are expected to experience increased development make ideal candidates for preventative management strategies and inclusion in a comprehensive watershed management plan.

Table 3. Subwatershed indicators of restoration potential and future management needs in the Lick Creek watershed (switch WTM/Fieldwork columns)

				Current Water Quality Monitoring Indicators				Watershed Treatment Model Indicators			Fieldwork Indicators	Future Management Need Indicators	
Sub-watershed	Acres	Square Miles	Current Impervious Cover (%)	Fecal Coliforms	Nitrogen	Total Phosphorous	Sediment (TSS)	TN	TP	Sediment (TSS)	Abundance of Potential Restoration Projects	Impervious Cover at Buildout (%)	Increase in Impervious Cover from Current (%)
1	1079	1.69	10.7			√	√	√	√	√	√	36.3	25.6
2	1310	2.05	14.3					√		√	√	39.3	25
3	757	1.18	12.4					√	√	√	√	29.8	17.4
4	698	1.09	2.8	√	√			√	√	√		30.3	27.5
5	1600	2.50	3.0		√		√	√				30.1	27.1
6	1501	2.35	4.2	√	√			√			√	19.8	15.6
7	1551	2.42	4.8	√	√	√	√	√		√		25.7	20.9
8	1294	2.02	3.2	N/A*	N/A*	N/A*	N/A*	√				22.3	19.1
9	1959	3.06	4.0	N/A*	N/A*	N/A*	N/A*					6.3	2.3
10	1430	2.23	5.4	N/A*	N/A*	N/A*	N/A*	√				11.6	6.2
11	881	1.38	3.7	N/A*	N/A*	N/A*	N/A*	√				8.3	4.6
Total	14,060	22.0	5.9									22.6	N/A*

*N/A=Not applicable. These parameters were not measured in these subwatersheds.

Recommended Management Strategies

The Lick Creek watershed is already experiencing degraded water quality conditions (Line and Penrose 2007) and Lick Creek itself is listed as impaired on the State's 303(d) list of impaired water bodies list (NCDWQ 2008). Because of its proximity to Research Triangle Park and the rapidly developing Brier Creek area of Raleigh, the watershed is expected to experience significant development and increases in impervious cover (Fraley-McNeal et al. 2007). In light of this, the Lick Creek Partners are working together to develop a list of comprehensive management strategies that incorporate both restoration efforts as well as preventative management strategies that together will form a comprehensive Lick Creek Watershed Restoration Plan.

This memorandum lays out a preliminary set of management strategies to meet the objectives set by the Lick Creek Watershed Restoration Plan Partners and Stakeholders including: 1) restore water quality in subwatersheds that already show signs of degradation; 2) prevent degradation in the subwatersheds where urbanization is expected to occur; and 3) protect "critical" areas of high water quality and aquatic habitat from degradation. Furthermore, the suggested management strategies build upon a set of recommendations developed by CWP and Lick Creek Partners (CWP 2007); incorporate results from on-going water quality monitoring efforts, the critical lands analysis, and the subwatershed analysis; and aim to achieve the 4 driving goals of the Lick Creek Watershed Restoration Plan:

- **GOAL 1:** Develop a hypothesis about the causes of biological impairment in Lick Creek and recommend approaches to addressing impairment status.
- **GOAL 2:** Identify pollutants and their sources that may be impairing aquatic life and water quality in Lick Creek. Suspected pollutants include dissolved, fecal coliforms, and turbidity.
- **GOAL 3:** Develop strategies for reducing, and maintaining at levels meeting water quality standards, the pollutants identified in Goal 2.
- **GOAL 4:** Mitigate future changes to watershed hydrology and water quality.

Each recommended management strategy will be written and reviewed by key Lick Creek Partners and self-selected stakeholders during the summer of 2008. Once this and other strategies are developed and approved, they will become a part of the Lick Creek Watershed Restoration Plan. Under each suggested recommendation are a list of key questions that will help guide the development of the management strategy and a list of suggested reviewers (reviewers who have expressed interest in a particular recommendation are denoted with an asterisk). The Lick Creek Partners and Stakeholders are encouraged to review all the recommendations and participate in the development of as many recommendation strategies as possible.

1. Erosion and sediment control at construction sites:

Excessive sediment in streams can degrade aquatic habitat by smothering insect life and fish spawning habitat, reducing the water's available oxygen, and increasing nutrient levels. When forested land is disturbed to accommodate new construction, the loss of vegetation and addition of impervious cover (pavement and rooftops) significantly alters hydrology, increasing surface water runoff and changing the timing of water delivery to streams. Under natural conditions, stream size and shape is naturally formed to accommodate base flows and storm flows; however, when the hydrologic regime is altered and discharge is

increased, the size and shape of a stream changes to accommodate a new flow regime, often resulting in erosion of stream banks and incising. Sediment relocated from stream banks is deposited downstream where it may have negative impacts.

Indicators of the problem and current conditions

Stormwater flows and sediment levels in streams downstream of active construction or agricultural areas can be elevated, especially during storm events (when most sediment is moved). High stormwater flows can destroy habitat for aquatic invertebrates. The Lick Creek Partners are monitoring hydrology, sediments, and aquatic invertebrates in several key watershed locations.

Durham County Engineering Department is responsible for ensuring that all new developments follow state and local sediment and erosion control (SEC) regulations. Durham has relatively strong SEC regulations, requiring a significant level of plan review, regular inspections, and potentially high penalties for noncompliance. However, fieldwork carried out by the Lick Creek Partners concluded that extensive erosion and sediment control violations were occurring at active construction sites throughout the watershed (e.g. broken or bulging silt fences, poor inlet protection, and sediment-filled ponds), resulting in extensive sediment deposition in adjacent streams, wetlands, and lakes (CWP 2007). These violations are likely contributing to degraded water quality and aquatic habitat (CWP 2007). An objective of the erosion and sediment control strategy will be to gage the effectiveness of the current practices and recommend additional practices for reducing erosion and stream sedimentation.

Future threats

The majority of the southwestern portion of the Lick Creek watershed is expected to undergo a massive transformation in terms of development. In particular, Subwatersheds 1 through 8 are within the City of Durham's UGA and are therefore expected to undergo the most development of all the subwatersheds. With such high levels of development expected in a relatively undisturbed watershed that is characterized by soils already prone to erosion (Triassic Basin), implementation and maintenance of optimal erosion and sediment control measures will be nothing short of critical for preserving the aquatic integrity of Lick Creek.

Questions for the Review Process

1. What were the specific amendments to the SEC regulations made during 2007 and 2008?
2. What was the increase in SEC permit fees?
3. Has the increase in permit fees enabled more inspections to take place?
4. Have violators been getting assessed fines for non-compliance?
5. What have been the effects of these changes on compliance with the regulations (please provide specific statistical or practical evidence)? Have they resulted in more violations, better compliance, or both?
6. What other management strategies would reduce sedimentation and erosion problems in the Lick Creek watershed? Developers are required to provide post-construction peak flow control for the one-year, 24-hour storm to protect downstream channel stability. Should this requirement be applied during construction as well?

Suggested Review Committee Members

1. Joe Albiston, Sedimentation & Erosion Control Division, Durham County
2. Anne Kitchell, Center for Watershed Protection
3. Dean Naujoks, Neuse River Foundation
4. Joe Pearce, PE, Division Manager, Utility Division, Durham County
5. Chris Roberts, Sedimentation & Erosion Control Division, Durham County
6. Bobby Louque, City of Durham Stormwater Services

2. Uncontrolled Sediment and Discharge of Nutrients and Oxygen-Demanding Matter from Timber Harvesting and Sites Classified as "Agricultural"

Removal of perennial trees and shrubs that obstruct, diffuse, and evapotranspirate runoff more that other types of land cover increases the amount of runoff leaving the area. This additional runoff damages stream structure and helps carry sediment, pesticides, and fertilizers to waterways. Excessive sediment in streams can degrade aquatic habitat by smothering insect life and fish spawning habitat, reducing the water's available oxygen, and increasing nutrient levels. Because agricultural areas inherently provide less consistent vegetative cover than natural Piedmont forested conditions, the potential for deleterious stormwater runoff is higher. Pesticides and herbicides have been associated with agricultural runoff in several studies conducted by the US Geologic Survey (USGS).

Indicators of the problem and current conditions

Indicators of uncontrolled sediment include excessive turbidity, low dissolved oxygen content, excessive sedimentation on inside stream bends, the loss of porous substrate conditions, and the loss of visible pool and riffle sequences. Furthermore, sediment levels downstream of active construction or agricultural areas can be exacerbated during storm events (when most sediment is moved), further impairing conditions for aquatic life. The Lick Creek Partners are monitoring hydrology, turbidity, TSS, and aquatic invertebrates in several key watershed locations.

Fieldwork carried out by the Lick Creek Partners observed turbid conditions in streams draining from properties with large areas of exposed soil that are zoned agriculture and are not required to have grading permits from the County (CWP 2007). Properties deemed agricultural are not subject to local erosion and sediment control regulations, even if their current use does not include row crops or pastures. Furthermore, many mining operations are also not subject to local sediment and erosion requirements, and "dirt" farms (for the manufacturing of top soil) may possibly also qualify for mining exemptions if they are excavating soil to mix with soil amendments.

Durham County officials have no regulatory authority to require sediment and erosion controls (SEC) controls at these sites regardless of sediment discharges from the site or downstream water quality complaints. Complaints on sites classified as agricultural must be directed to the NC Division of Water Quality (NCDWQ) Raleigh Regional Office at (919) 571-4718. (The local Soil and Water Conservation District [SWCD] office should also be notified.)

Future threats

According to NCDWQ's 2006 Integrated 305(b) and 303(d) Report (NCDWQ 2006), agriculture is a significant cause of stream use impacts in the state; however, in general, local governments cannot apply restrictions other than lot size to agriculturally zoned districts (UNRBA 2007b). Within agricultural zones, USDA-Natural Resources Conservation Service (NRCS) standards and guidance may affect where facilities are sited and Voluntary Agricultural District designations help ensure that rezoning decisions factor in existing agricultural operations (UNRBA 2007b).

Nontraditional agricultural operations (e.g., horse boarding, nurseries, dirt stockpiling, community-supported agriculture, etc.) are on the rise and present management challenges because even though they are considered agriculture (and therefore cannot be regulated by the local government other than to protect public health), they may have significant amounts of impervious cover, fertilizer or pesticide use, and land disturbance and also because local SWCDs may not have been made aware of them.

Questions for the Review Process

1. Consider the incentives cited by the UNRBA for landowners with agricultural or animal operations to put effective watershed protection practices in place (Implementation Recommendation Sheet#15 (Agricultural Best Management Practices Education and Outreach); http://www.unrba.org/downloads.htm)? Do you believe these incentives to be sufficient and how do you think landowners should be educated about available programs?
2. UNRBA and CWP's fieldwork and NCSU and DSS's stream monitoring have both identified significant water quality degradation likely caused by industrial agricultural practices, particularly in Subwatershed 7 (Rocky Branch). Further monitoring along this reach is needed to determine if this is true. What level of monitoring should we recommend and what steps should be taken at agricultural sites that are identified as polluters?
3. Do you believe that the following types activities should receive <u>agricultural</u> exemptions from watershed protection laws (yes or no, with reasoning explained)?
    a) landfills for construction debris,
    b) sites providing fill dirt for construction of nearby housing developments,
    c) sites creating concrete blocks for the building industry,
    d) sites receiving dirt and debris from nearby grubbing operations(grubbing is preparing sites for building by clearing small shrubs, limbs, and roots from recently deforested lands), or
    e) sites with large buildings where breeding animals are housed?
4. For any of the above activities that you believe should receive exemptions, are there ways to meet the goals of the Lick Creek plan (protecting water quality, restoring water quality, protecting aquatic life) while still providing these exemptions?
5. How effective do you believe ongoing programs such as those being carried out by Durham County Soil and Water Conservation District or Natural Resource Conservation Service to be in changing public behavior (Implementation Recommendation Sheet #15 (Agricultural Best Management Practices Education and Outreach); http://www.unrba.org/downloads.htm)?

6. What will be required to effectively implement the strategies recommended in the Lick Creek Watershed Restoration Plan (e.g. talking with agricultural landowners about the recommendations, seeking grants, monitoring water quality, etc.)?

Suggested Review Committee Members

1. Jennifer Brooks, Durham Soil and Water Conservation District
2. Shari Bryant, N.C. Wildlife Resources Commission
3. Eddie Culberson, Durham Soil and Water Conservation District
4. Nora Deamer, N.C. Division of Water Quality
5. Julie Elmore, Piedmont Resource Conservation & Development, Inc.
6. Jim Fyfe, Stakeholder and Watershed Resident
7. Jeff Kilpatrick, Stakeholder and Watershed Resident
8. Dan Line, NCSU University Water Quality Group
9. Joe Pearce, PE, Division Manager, Utility Division, Durham County
10. Chris Roberts, Sedimentation & Erosion Control Division, Durham County
11. Helen Youngblood, Planning Department, City of Durham
12. Bobby Louque, City of Durham Stormwater Services

3. Water quality requirement for post-construction stormwater management:

Water column conditions such as dissolved oxygen levels, nutrients (nitrogen and phosphorus), turbidity, and fecal coliforms can be used to monitor the water quality of reaches that occur adjacent to and downstream of new development(s). High nutrient levels, excessive turbidity, and low dissolved oxygen levels can degrade water quality and aquatic habitat. Furthermore, increased nutrient levels require more intensive drinking water treatment methods. Excessive sediment in streams can smother insect life and fish spawning habitat, cause oxygen lags, may alter the in-stream light regime, and may induce algal growth.

Indicators of the problem and current conditions

Stormwater flows and sediment levels in streams downstream of construction sites can be elevated, especially during storm events when most of the sediment is moved. Such levels can destroy habitat for aquatic invertebrates, another indicator of stream health. The Lick Creek Partners are monitoring hydrology, sediments, and aquatic invertebrates in several key watershed locations. Setting limitations for dissolved oxygen, nutrients, turbidity, and other water quality parameters will help gage the effectiveness of post-construction Best Management Practices (BMPs) and will help standardize efforts to maintain good water quality throughout the watershed.

Fieldwork carried out by the Lick Creek Partners (CWP 2007) observed that new developments in the watershed did not incorporate sensitive site and stormwater design that would minimize impervious cover and increase the use of natural vegetation to maintain a pre-construction hydrologic regime. Furthermore, the Lick Creek partners noted that even in subdivisions that claim to be “environmentally friendly” (e.g. Brightleaf, the “Triangle’s Environmental Community”), there has been a failure to reduce unneeded impervious surface and preserve natural channels. The tendency has been to use 1-year detention dry ponds

for post-construction stormwater treatment in order to meet the 1-year detention requirements, which do not address water quality.

Future threats

Under current regulations, local and state agencies do not require new developments with less than 23% impervious cover to design post-construction stormwater controls to treat runoff water quality. However, research shows that water quality, hydrology, physical stream quality, and biological integrity all begin to show signs of degradation at around 10% impervious cover (CWP 2003), and that this threshold can be lower in sensitive areas. Many of the new developments in Lick Creek are designed to be just under the impervious cover threshold at which Neuse rules require water quality treatment (23%). Subsequently, water quality will likely suffer as a result of these developments.

In the future, retrofitting will be necessary to provide water quality treatment to meet requirements of the National Pollutant Discharge Elimination System (NPDES) Phase II program, and to address the 303(d) – listed status of Lick Creek and Falls Lake. Funding this responsibility will fall to the local government and the taxpayers, possibly with some assistance from scarce and limited grants. Furthermore, water quality trends and modeling show that the current program will not prevent additional degradation to receiving water bodies (Fraley-McNeal et al. 2007).

Questions for the Review Process

1. As stated in CWP's "Lick Creek Fieldwork – Findings and Recommendations" technical memorandum (2007), "Local and state regulations (for the Lick Creek watershed) do not require new developments with less than 23% impervious cover to design post-construction stormwater controls to treat water quality. New developments such as Brightleaf and Brightwood Trails have only 1-year detention dry ponds for post-construction stormwater treatment. Extensive research shows that water quality, hydrology, physical stream quality, and biological integrity all begin to show signs of degradation around 10% impervious cover (CWP 2003). The new developments in Lick Creek are designed to be just under the impervious cover threshold (23%) at which Neuse rules require water quality treatment (UNRBA 2008)". Based on initial findings from water quality monitoring and fieldwork, is a subwatershed in Lick Creek with 23% and only dry detention ponds capturing the 1-year storm flow likely to meet the goals of the Lick Creek Plan (protect from degradation or restore water quality and aquatic habitat)?
2. If you answered no to Question 1, what are the greatest water quality and aquatic habitat concerns in Lick Creek from new development?
3. Which subwatersheds are of greatest concern to you, and why?
4. Do the Lick Creek Watershed's Triassic Basin Geology and Soils require any special consideration in designing BMPs for post-construction stormwater management (see memorandum 1 on www.unrba.org/lick/downloads for a description of Triassic Basin in Lick Creek)?
5. If you answered "yes" to Question 4, please explain which types of practices you believe are necessary to achieve the Lick Creek management goals in managing impacts of new development over the long term.

6. Considering the recent designation of portions of Falls Lake as "Impaired" for nutrients and sediment, what level of post-construction stormwater management will be needed to meet the future requirements of the Falls Lake NMS?
7. If you answered "no" to Question 6, do you think the State (and ultimately the City and County of Durham and Wake County) will be required to ameliorate any stormwater management deficiencies on housing developments currently being approved (e.g. retrofit the watershed with stormwater management practices) in the future?
8. If you think that retrofits will be necessary, do you think stormwater retrofits will perform as well or as cost-effectively as stronger stormwater management requirements on new development would?
9. Do you agree with the following CWP recommended strategies?
    - Requiring post-construction water quality treatment for all new developments
    - In addition to the 1-year detention requirement, which provides some channel protection storage, consider discharge volume criteria. A performance criteria which limits the increase in volume, rather than peak discharge, could spur the use of environmentally sensitive design (e.g. Low Impact Development [LID]/Better Site Design [BSD]).
    - Increase nutrient offset fee to push the economic incentive towards managing stormwater onsite rather than paying the fee in-lieu.
10. Are current design standards within the watershed sufficient enough to meet the goal of improving water quality to protect water quality and aquatic habitat? If not, what design standards would you like to see employed?

Suggested Review Committee Members

1. Joe Albiston, Sedimentation & Erosion Control Division, Durham County
2. Heather Boyette, NC Division of Water Quality
3. Dave Brown, City of Durham Stormwater Services
4. Jacob Chandler, City of Durham Stormwater Services
5. John Cox, City of Durham Stormwater Services
6. Nora Deamer, N.C. Division of Water Quality
7. Steve Kroeger, NC Division of Water Quality
8. Dan Line, NCSU University Water Quality Group
9. Keith Luck, City of Durham, Durham County
10. Dean Naujoks, Neuse River Foundation
11. Joe Pearce, PE, Division Manager, Utility Division, Durham County
12. Chris Roberts, Sedimentation & Erosion Control Division, Durham County
13. Helen Youngblood, City of Durham, Durham County

4. Impacts from infrastructure crossing the stream corridor:

The installation of utility crossings may alter stream hydrology and cause incision that may inhibit streams from over-banking during high rainfall events, a key component to maintaining an active floodplain. An active floodplain can serve as a water storage facility during storm and flood events and riparian vegetation along floodplains helps prevent erosion and may provide aquatic habitat.

Indicators of the problem and current conditions

A build-up of debris at culvert mouths or evidence of erosion around headwalls and/or embankments may indicate poor flow alignment and the build-up of sediment at the mouth of culverts may indicate hydrologic modification. Reduced velocity at the mouth of culverts, and scouring at the base of culverts may also be used as indicators of hydrologic modification. These changes can impact macroinvertebrate communities and may inhibit the passage of fish and/or the suitability of spawning habitat.

During their fieldwork, the Lick Creek Partners observed that extensive riprap was present at most new infrastructure crossings, accompanied by steep side slopes (CWP 2007). The partners also noted that many of the new developments in the watershed had gravity sewers that run parallel to the main stem of Lick Creek and cross it and its tributaries frequently in relatively short distances. Furthermore, it appears that the utility easements associated with the utility lines are encroaching into forested buffers.

Future threats

As development in the watershed continues (up to approximately 40% impervious cover in possible in some subwatersheds), and more land areas are incorporated into the city, it is inevitable that public utilities will be expected to service new communities. This means that the stream reaches in Lick Creek are likely to see many additional public utility crossings in the coming decades.

Questions for the Review Process

1. The UNRBA and CWP's fieldwork and NCSU and DSS's stream monitoring have both identified habitat and water quality degradation likely associated with newly cleared and developed sites. Field observations, especially in Subwatershed 1 ("Lick Creek Fieldwork – Findings and Recommendations" technical memorandum [2007]) found that "the design and placement of new sewer lines and road crossings associated with development in Lick Creek does not minimize impacts to streams and wetlands." Do you agree with this finding?
2. The NCDWQ reviews and approves buffer impacts and stream corridor crossings. Do you believe that the state's review and approval process is sufficient enough to minimize stream and riparian area impacts?
3. Are the mitigation requirements for stream crossings and buffer impacts sufficient to encourage the use of environmentally protective designs wherever feasible?
4. Do you believe that design criteria changes could reduce the impacts to streams and stream buffers? If so, which of the following should be changed and how?
    - Location of sewer lines
    - Location and number of buffer impacts
    - Design and/or location of permitted stream crossings
    - Local design review process
    - State design review process

Suggested Review Committee Members

1. Joe Albiston, Sedimentation & Erosion Control Division, Durham County
2. Eric Alsmeyer*, U.S. Army Corps of Engineers, Wilmington District

3. Dave Brown, City of Durham Stormwater Services
4. Jacob Chandler, City of Durham Stormwater Services
5. John Cox, City of Durham Stormwater Services
6. Nora Deamer, N.C. Division of Water Quality
7. Anne Kitchell, Center for Watershed Protection
8. Dean Naujoks, Neuse River Foundation
9. Joe Pearce, PE, Division Manager, Utility Division, Durham County
10. Chris Roberts, Sedimentation & Erosion Control Division, Durham County

5. Buffer and floodplain encroachment:

The removal of riparian vegetation along stream corridors can have severe impacts on stream stability and flooding. Riparian vegetation helps slow water velocities during flood events when a stream overtops its banks and also helps keep soil in place through root structures. Removal of this vegetation may cause more extensive and destructive flooding because there is no control on discharge, which contributes to in-stream erosion and bank-cutting. Furthermore, riparian areas help with nutrient removal when streams overtop their banks. Riparian buffers and floodplains also provide aquatic habitat in the form of backwater sloughs, intermittent water storage areas, root structures and masses, and so forth. These habitat types provide spawning areas for fish and aquatic invertebrates and play a critical role in maintaining the stability of the aquatic food chain, by providing a diversity of habitats.

Indicators of the problem and current conditions

The most obvious indicator of floodplain and buffer encroachment is the lack of riparian vegetation adjacent to streams and waterways. Other indicators include severe bank erosion, channelization, and sedimentation. Developments, parking lots, and other impervious surfaces close to streams also pose a significant threat to water quality and stream stability. The lack of pervious cover can result in even greater discharge and sedimentation, further exacerbating the problems described above.

Fieldwork carried out by the Lick Creek Partners observed a multitude of impacts to stream and wetland buffers at recently-constructed and active development sites, as well as in timber harvesting areas (CWP 2007). Observed impacts included the clearing of riparian vegetation, sedimentation, stream degradation, encroachment, and the deposition of fill materials adjacent to waterways. Furthermore, the Lick Creek Partners noted that many of these impacts were permitted by the NCDWQ as variances from the Neuse River Basin buffer rules (CWP 2007).

Future threats

A good portion of the Lick Creek watershed is expected reach anywhere between 20 to 40% at buildout (Subwatersheds 1, 2, 3, 4, 5, 6, 7, and 8). This means that more riparian vegetation and stream buffers will be threatened by encroachment and development as new land is needed for new subdivisions and infrastructure. A continued policy of permitting riparian buffer impacts threatens riparian corridors that would otherwise be protected and compromises the integrity of the Neuse NMS and modeling that assumes that these buffers are in place. Increased erosion, flooding, sedimentation, and aquatic habitat degradation are all likely consequences of further buffer and floodplain encroachment.

Questions for the Review Process

1. Fieldwork and NCSU and DSS's stream monitoring both found that newly cleared and developed sites are often associated with habitat and water quality degradation in the receiving water body. Field observations, especially in Subwatershed 1, found that "clearing of riparian vegetation, encroachment of infrastructure, deposition of fill materials, discharge of sediment, and changing of the natural hydrology" on new development sites are encroaching on stream riparian areas and wetlands (CWP 2007). Do you agree with this finding? Why or why not?
2. An example of the observations in Question 1 is that several acres of impacts to the 50-foot Neuse buffer were approved in the new Brightleaf development (Subwatershed 1). The NCDWQ reviews and approves buffer impacts and stream corridor crossings. Do you believe that the state's review and approval process is effective in minimizing stream and riparian area impacts to the extent that it is practical and feasible to do so? Why or why not?
3. CWP's primary recommendation is, "Stop approving buffer impacts. The 50-foot buffer required by the Neuse rules is minimal. NCDWQ should hold the line here and not approve impacts or exceptions." Do you agree with this recommendation? Of the exceptions that are currently allowable, which should be revised or excluded specifically?
4. Do you believe that the mitigation requirements required in exchange for impacts to wetlands and riparian buffer encourage the most environmentally protective designs feasible? Why or why not?
5. The East Durham Open Space Plan recommends adopting wider riparian buffer requirements (100-foot buffers) in Lick Creek. The CWP "Lick Creek Fieldwork – Findings and Recommendations" technical memorandum (2007) recommends adopting these and strengthening wetlands buffer requirements and preservation tactics. Do you believe that changes should be made to the following:
    - Minimum buffer width requirements (increase from 50-foot to 100-foot minimum)?
    - Minimum wetland width requirements (increase to 50-foot minimum)? As it stands now, Durham requires a wetland buffer of 25 feet (in some cases, this width may be reduced to 10 feet).

Suggested Review Committee Members

1. Joe Albiston, Sedimentation & Erosion Control Division, Durham County
2. Dave Brown, City of Durham Stormwater Services
3. John Cox, City of Durham Stormwater Services
4. Rob Breeding, N.C. Ecosystem Enhancement Program
5. Shari Bryant, N.C. Wildlife Resources Commission
6. Jacob Chandler, City of Durham Stormwater Services
7. Nora Deamer, N.C. Division of Water Quality
8. Michele Droszcz, N.C. Ecosystem Enhancement Program
9. Anne Kitchell, Center for Watershed Protection
10. Robert Louque, City of Durham Stormwater Services
11. Dean Naujoks, Neuse River Foundation
12. Chris Outlaw, City of Durham Stormwater Services
13. Chris Roberts, Sedimentation & Erosion Control Division, Durham County

14. Joe Pearce, PE, Division Manager, Utility Division, Durham County
15. Helen Youngblood, City of Durham, Durham County

6. Protection of high-quality streams and wetlands:

High quality streams and wetlands provide irreplaceable water quality and aquatic habitat benefits such as water storage, pollutant removal, both aquatic and terrestrial habitat, erosion control, and recreation. In addition, the protection of these systems can be used to teach citizens about natural resource systems and can provide invaluable conservation benefits in terms of breeding and foraging areas for fish and birds.

Indicators of the problem and current conditions

An excess of degraded stream and wetland systems, a decline in macroinvertebrate community diversity, loss of riparian buffers and streamside vegetation, and a disappearance in fish species all suggest a loss of high-quality streams and wetlands. Furthermore, a lack of pristine stream and wetland areas is an obvious indicator that conservation measures within the watershed are lacking.

The Lick Creek watershed is already experiencing degraded water quality conditions (Line and Penrose 2007) and Lick Creek itself is listed as impaired on the State's 303(d) list of impaired water bodies list (NCDWQ 2008). In addition, the watershed is also expected to experience significant development and increases in impervious cover (UNRBA 2008). Given the combination of declining water quality and expected increases in impervious cover, it seems fair to assume that stream and wetlands are under threat from both pollutant loading and development. As it stands now, Subwatersheds 1 through 8 have lower levels of open green space and protected land areas (between 0 to 17%) than Subwatersheds 9, 10, and 11, which have the greatest amount of green space and protected land area with 39, 12, and 53% cover, respectively.

Future threats

A good portion of the land that is directly adjacent to Falls Lake (mostly in Subwatersheds 9, 10, and 11) is owned and protected by the U.S. Army Corps of Engineers (USACE) and is preserved as open space in perpetuity. However, more than half of the Lick Creek watershed falls within the City of Durham's UGA, which suggests that high-quality streams or wetlands in this zone are at risk of being altered, removed, impaired, and/or degraded as a result of development. Most of the subwatersheds in the Lick Creek Watersheds are expected to see increases in the amount of open space and protected land area; however, percentage increases do not reflect the current levels of protected area in the watershed and cannot be used to evaluate whether sufficient green spaces and critical lands are protected in terms of protecting water quality. Every effort should be made to preserve as many existing high-quality aquatic and riparian systems as possible, starting with areas identified in the Upper Neuse Clean Water Initiative (UNCWI) Conservation Plan (Trust for Public Land 2006). Land preservation and conservation opportunities become scarcer and more expensive as development proceeds and urban services are extended. Long-term planning and a coordinated acquisition approach are critical for this strategy to be successful.

Questions for the Review Process

Lick Creek fieldwork and the Lick Creek Critical Lands Analysis (summarized in the "Lick Creek Fieldwork – Findings and Recommendations" and "Lick Creek Watershed Critical Lands Protection Analysis" technical memoranda, available at www.unrba.org/lick/downloads) have identified large forested tracts of land with relatively excellent water quality and aquatic habitat conditions. The critical lands analysis, which is based on the UNCWI Conservation Plan (Trust for Public Land 2006), led CWP and UNRBA to recommend preservation of numerous significant areas, especially in Subwatersheds 6 – 10.

1. Of those parcels recommended by the UNCWI and Lick Creek Critical Lands Analysis, 1,016 acres area are also prioritized in the East Durham Open Space Plan. Do you believe that Durham City and County have sufficient funds to protect these critical lands?
2. Is there sufficient interest by the City of Raleigh to acquire high-value UNCWI lands in the Lick Creek Watershed?
3. If you said, "Yes," to Question 1 or 2, what percentage of the costs of acquiring these lands or how much cash do you believe that local governments would be willing to provide?
4. What role should local land trusts such as Triangle Greenways Council and Triangle Land Conservancy play in the protection of these critical lands (Triangle Greenways Council has placed a high priority on protection of lands in Lick Creek)? Should they have been the lead or should they be partnering with other organizations?
5. Of the high-value lands identified by the UNCWI Conservation Plan (Trust for Public Lands 2006) and Lick Creek Critical Lands Analysis (2007), 67% are on parcels that are developable under current zoning regulations. The total area of these parcels is 11,406 acres. Protecting all of these parcels by fee-simple acquisition is unlikely, even if landowners were willing. What other approaches, such as conservation subdivisions, should be used to protect the significant areas of these parcels that do undergo development?
6. Based on a visual map analysis and on GIS analysis done in Lick Creek, we estimate that most of the highest-value critical lands in Lick Creek could be protected by strict adherence to existing floodplain regulations and the riparian buffer protection recommendations in the East Durham Open Space Plan (100-foot buffers). Do you believe that this approach is a viable way to protect these high-value lands?
7. The NCDWQ lists Falls Lake as impaired for nutrients and partially for sediment, and preliminary water quality monitoring on this project hints at potential water quality impairment in addition to the current listing on Lick Creek. If a TMDL is developed for the Lick Creek Watershed, is it possible for Lick Creek and Falls Lake to meet their TMDLs if the critical lands identified in this project are developed as currently zoned?

Suggested Review Committee Members

1. Eric Alsmeyer*, U.S. Army Corps of Engineers, Wilmington District
2. Frank Thomas, Homebuilders Association of Durham, Orange, and Chatham Counties
3. Dean Naujoks, Neuse River Foundation
4. Anne Kitchell, Center for Watershed Protection
5. Jacob Chandler, City of Durham Stormwater Services
6. Dave Brown, City of Durham Stormwater Services

7. Nora Deamer, N.C. Division of Water Quality
8. Heather Boyette, N.C. Division of Water Quality
9. Rich Gannon, N.C. Division of Water Quality
10. John Cox, City of Durham Stormwater Services
11. Robert Louque, City of Durham Stormwater Services
12. Chris Outlaw, City of Durham Stormwater Services*
13. Eddie Culberson, Durham Soil and Water Conservation District
14. Joe Pearce, PE, Division Manager, Utility Division, Durham County
15. Rob Breeding, N.C. Ecosystem Enhancement Program
16. Michele Droszcz, N.C. Ecosystem Enhancement Program
17. Shari Bryant, N.C. Wildlife Resources Commission*
18. Paul Clark, N.C. Division of Water Quality
19. Jim Fyfe, Stakeholder and Watershed Resident*
20. Jeff Masten, Triangle Land Conservancy
21. Bev Norwood, Triangle Greenways Council
22. Helen Youngblood, Planning Department, City of Durham
23. Ed Buchan, City of Raleigh Public Utilities
24. Keith Luck, Planning Department, City of Durham
25. Lisa Creasman, Conservation Trust of North Carolina

7. Delineation of streams and wetlands:

Accurate stream and wetland delineation is a crucial aspect to protection. Section 401 and 404 of the Clean Water Act implicitly protect intermittent and perennial streams and wetlands from development and encroachment. State and federal agencies rely on local consultants to delineate these areas based on criteria established and monitored by the USACE. While all delineations are required to be visited and approved by a USACE representative, the Lick Creek partners expressed concern that delineations in the watershed under-represent the actual amount of stream and wetland in a given area.

Indicators of the problem and current conditions

The Lick Creek Partners (CWP 2007) used various stream and wetland layers from various sources during their fieldwork including U.S. Geologic Survey (USGS) 1:24,000 quadrangle maps, DSS Hydro-l and Hydro-p mapping, Digital Elevation Model (DEM)-generated streams, and National Wetlands Inventory (NWI) mapping. The Lick Creek Partners observed that many small, first-order DEM-generated streams were not captured by USGS or Durham mapping, however, were verified as flowing streams by ground crews. In addition, field crews noted significant differences between the NWI layer and wetland locations in the field. Furthermore, in many cases, wetland delineation flagging did not appear to fully cover the true wetland extent.

Future threats

Under current regulations, only streams that are depicted on an USGS 1:24,000 quadrangle maps or on U.S. Department of Agriculture Soil Survey maps are protected by the Neuse River Basin buffer rules. This means that any actual intermittent or perennial stream in the watershed that does not show up on these maps

does not have protected buffers and may be at risk as a result of development. Moreover, in practice, the Soil Survey maps may not be consulted because they are not always available in a digital format in Durham. This means that some streams, especially intermittent streams, might not be receiving adequate protection.

Questions for the Review Process

During Lick Creek fieldwork ("Lick Creek Fieldwork – Findings and Recommendations," 2007) staff used various sources of stream and wetland mapping: USGS 1:24,000 quadrangles and DSS mapping (both used for regulatory definitions of streams), DEM-generated streams (made by USGS for UNRBA), and NWI (regulatory wetlands maps). In general, regulatory maps were found to be deficient.

1. Field crews observed that the regulatory maps fail to capture many small, first-order streams shown in the UNRBA's DEM-generated mapping and verified as flowing streams by ground crews. Should the Lick Creek Watershed Restoration Plan recommend "a further comparison of the streams verified by field crews to the Durham County soil maps and Wake County mapping"?
2. If such a field comparison were undertaken, do you agree with CWP that, "If these streams are also missing from these additional regulatory resources, we recommend updating local stream maps referenced for regulatory purposes with the DEM *or some other* layer."
3. In addition, field crews noted significant differences between the NWI layer and wetland locations in the field. Do you believe that there should be an update to the wetlands mapping in Lick Creek?
4. If you said "Yes" to Question 2 or 3, which of the following mapping approaches do you think should be considered?
    - Locally developed and adopted stream maps based on Light Detection and Ranging (LIDAR) mapping and field verification
    - State-developed stream maps based on LIDAR mapping and some limited local field verification
    - Locally developed and adopted stream maps based on assessment of all streams using the NCDWQ method for delineating streams
    - Locally developed and adopted wetlands mapping
    - Digitization of soil survey stream maps (also legally binding, but not in a digital format that can be seen with development proposals, leading to possible confusion about stream location)
    - Some other mapping approach
5. Should the Lick Creek Watershed Restoration Plan recommend greater oversight of consultants' delineations by USACE and the State?
6. The official (Federal Emergency Management Agency [FEMA]) delineation of floodplains begins at a one square-mile drainage area, which means that all floodplains with less than one square-mile of drainage are not legally recognized as floodplains. Some local governments (including the City of Raleigh) are undertaking efforts to re-delineate 100-year floodplains upstream of current points, to a smaller designated catchment size. Do you agree with CWP that this should be done in the Lick Creek watershed? If so, what size catchment should be used?
7. Should the Lick Creek Watershed Restoration Plan recommend local government protection (e.g. riparian buffer protection) for ephemeral stream channels?

Suggested Review Committee Members

1. Eric Alsmeyer*, U.S. Army Corps of Engineers, Wilmington District
2. John Cox, City of Durham Stormwater Services
3. Jacob Chandler, City of Durham Stormwater Services
4. Dave Brown, City of Durham Stormwater Services
5. Nora Deamer, N.C. Division of Water Quality
6. Heather Boyette, N.C. Division of Water Quality,
7. Frank Thomas, Homebuilders Association of Durham, Orange, and Chatham Counties
8. Ed Buchan, City of Raleigh Public Utilities
9. Eddie Culberson, Durham Soil and Water Conservation District
10. Robert Louque, City of Durham Stormwater Services
11. Chris Outlaw, City of Durham Stormwater Services*
12. Helen Youngblood, Planning Department, City of Durham
13. Keith Luck, Planning Department, City of Durham
14. Jim Fyfe, Stakeholder and Watershed Resident*
15. Dean Naujoks, Neuse River Foundation
16. Anne Kitchell, Center for Watershed Protection

8. Major restoration projects:

Lick Creek has been listed as "impaired" by the State due to its inability to support aquatic life and low levels of dissolved oxygen (NCDWQ 2006). In addition, fieldwork conducted as part of this planning process has revealed that sedimentation is another major problem in terms of aquatic habitat and water quality. Furthermore, a large majority of the watershed falls within the Triassic Basin, which is represented by highly erodible soils. While stream restoration alone is not enough to recover water quality in the watershed, it is an important component to repairing water quality conditions. In many circumstances, because of massive stream incision, a stream will not be able to recover itself without assistance.

Repairing the many sections of stream that are actively eroding will significantly reduce the amount of sediment in these streams. In addition, stream restoration projects may enable a stream to carry sediment under varying flow conditions, reduce stream flow velocities, remove nutrients and sediment through flooding, stabilize stream banks, and prevent loss of soil.

Indicators of the problem and current conditions

Multiple major restoration opportunities have already been identified for the Lick Creek Watershed (UNRBA 2007). Almost 25 acres of drainage area could receive water quality treatment by stormwater retrofits and one linear mile of stream buffer could be reforested (CWP 2007). Major restoration projects such as stormwater retrofits, stream restoration, and large buffer planting projects require engineering design, construction by a contractor, long-term maintenance, and/or project management by a local government; however, these potential restoration projects could help restore ecosystem functions that have been lost to development pressure. Furthermore, the NCEEP and UNRBA are currently working on a project that will atlas all major restoration projects, such as those listed in the Lick Creek Watershed Restoration Priorities memorandum (UNRBA 2007), and will strive to see these projects implemented in the field.

Future threats

As the watershed becomes more developed, major restoration projects like stream re-alignments and floodplain developments and associated buffer plantings will likely become more difficult due to complications from encroaching urbanized land uses. In turn, restoration opportunities will become scarcer and projects such as retrofitting will become more and more expensive. It is therefore imperative to ensure that restoration opportunities already identified are factored into future planning efforts and implementation begins as soon as possible. Delaying implementation will result in higher costs.

Questions for the Review Process

During Lick Creek fieldwork ("Lick Creek Fieldwork – Findings and Recommendations," 2007) field crews identified very few major restoration opportunities (e.g. large stream repair projects, large stormwater retrofits, extensive buffer replacement), and even fewer that are eligible for state or federal funding.

1. Of the potential major restoration projects identified in the Lick Creek Watershed Restoration Priorities memorandum (UNRBA 2007), which types of projects do you see as most critical and how these fit into a broader watershed restoration strategy.
2. If you said, "No" to Question 1, please explain why you do not believe that major restoration projects should be a primary focus of the plan.
3. Several agencies are currently undertaking restoration efforts in the Lick Creek watershed and surrounding watersheds. In your opinion, are government agencies like the Soil and Water Conservation Districts (SWCD), NCEEP, or other agencies coordinating efficiently to ensure environmentally effective projects while making efficient use of public funding? If not, what could be done to improve coordination?
4. CWP has recommended, "Evaluate the geomorphic monitoring plan associated with the SWCD stream restoration project. If the monitoring plan has a short duration or spatial scale, work with project partners to identify someone interested in providing long term monitoring. This would be an interesting project about the response of a Triassic Basin channel to upstream development and the effectiveness of stream restoration in Triassic Basin streams." How much monitoring would be required to make this a useful study? What type of research will be required to determine the applicability of use-index ratings in the Triassic Basin portions of the watershed?

Suggested Review Committee Members

1. Eric Alsmeyer*, U.S. Army Corps of Engineers, Wilmington District
2. John Dorney, N.C. Division of Water Quality
3. John Cox, City of Durham Stormwater Services
4. Jacob Chandler, City of Durham Stormwater Services
5. Dave Brown, City of Durham Stormwater Services
6. Robert Louque, City of Durham Stormwater Services
7. Chris Outlaw, City of Durham Stormwater Services*
8. Eddie Culberson, Durham Soil and Water Conservation District
9. Jennifer Brooks, Durham Soil and Water Conservation District
10. Rob Breeding, N.C. Ecosystem Enhancement Program
11. Michele Droszcz, N.C. Ecosystem Enhancement Program

12. Nora Deamer, N.C. Division of Water Quality
13. Heather Boyette, N.C. Division of Water Quality
14. Dan Line, NCSU Water Quality Group
15. Dean Naujoks, Neuse River Foundation
16. Anne Kitchell, Center for Watershed Protection
17. Jeff Masten, Triangle Land Conservancy

9. Restoration projects to be implemented by volunteers:

Opportunities exist for small restoration projects that can serve as "quick wins" for on-the-ground implementation. These projects are fairly simple to design and relatively inexpensive compared to major restoration projects. Additionally, volunteers can often accomplish these projects with the technical assistance of local government staff or extension agents. Examples include trash cleanups, simple buffer plantings, and small stormwater retrofits.

Indicators of the problem and current conditions

Multiple volunteer restoration opportunities have already been identified for the Lick Creek Watershed (UNRBA 2007) and efforts are underway to see implementation of some of these projects on the ground through a Home Depot Foundation Grant that was awarded to UNRBA via CWP. Furthermore, NCEEP and UNRBA are currently working on a project that will atlas volunteer projects such as those listed in the Lick Creek Watershed Restoration Priorities memorandum (UNRBA 2007). However, more funding is needed to see all of the possible sites restored, and landowner outreach will play a significant role in the potential of volunteer riparian buffer plantings.

Future threats

As the watershed becomes more developed, volunteer restoration opportunities will likely multiply. However, a reliance on post-impact mitigation efforts should be avoided and every effort made to preserve existing aquatic systems as they provide a suite of environmental services such as water storage and pollutant removal that are lost or impeded as these systems are degraded. Furthermore, major restoration projects are expensive and difficult, and it should be noted that land acquisition will likely become more and more expensive as the watershed continues to develop. In addition, space for tree and buffer plantings will also likely become more limited.

Questions for the Review Process

During Lick Creek fieldwork (memoranda available at www.unrba.org/lick/downloads) field crews identified some volunteer restoration opportunities (e.g. buffer replanting that could be done by volunteers).

1. Do you believe that volunteer restoration projects should be a primary focus of the Lick Creek Watershed Restoration Plan?
2. If you said, "Yes" to Question 1, please explain why you see these projects as valuable.
3. If you said, "No" to Question 1, why?
4. Although volunteer restoration projects have relatively low costs compared to major restoration projects, they require lots of coordination to involve and manage volunteer groups, apply for and

receive funding, purchase trees and equipment, and get volunteer input from local governments and businesses. Who should coordinate such efforts in Lick Creek on an ongoing basis?

Suggested Review Committee Members

1. Jim Fyfe, Stakeholder and Watershed Resident*Tommy Esqueda, Wake County Environmental ServicesMark Bailey, Wake County Environmental Services Laura Webb Smith, City of Durham Stormwater ServicesTom Hill, Wake County Environmental ServicesRobert Louque, City of Durham Stormwater ServicesJohn Cox, City of Durham Stormwater ServicesChris Outlaw, City of Durham Stormwater Services*Eddie Culberson, Durham Soil and Water Conservation DistrictJacob Chandler, City of Durham Stormwater ServicesDave Brown, City of Durham Stormwater ServicesNora Deamer, N.C. Division of Water QualityHeather Boyette, N.C. Division of Water QualityJennifer Brooks, Durham Soil and Water Conservation DistrictRob Breeding, N.C. Ecosystem Enhancement ProgramMichele Droszcz, N.C. Ecosystem Enhancement ProgramJohn Dorney, N.C. Division of Water QualityDean Naujoks, Neuse River FoundationAnne Kitchell, Center for Watershed Protection
20. Jeff Masten, Triangle Land Conservancy

10. Suspicious discharges from onsite wastewater systems:

Onsite wastewater systems are prevalent throughout Lick Creek. Due to the geology, traditional onsite wastewater system designs are not possible in many locations, and there is a significant number of sand filter systems that discharge directly to streams. Because these are more complex than conventional onsite wastewater systems, they are more prone to failure and must be permitted and inspected by the state. Most of these systems are nearing 30 to 50 years old. Fieldwork from Little Lick Creek in 2005 and Lick Creek in 2007 confirm that these systems are failing and that they are frequently not sufficiently maintained or inspected.

Finding a solution to this problem is complex for many reasons:

- Many of these systems are aging systems owned by low-income households or on low-rent properties
- Many of these systems could be connected to the City's sewer system, but the hook-up fees and plumbing costs can be prohibitive
- Because these systems are permitted by the state, it is the state's responsibility to monitor and enforce regulations of their NPDES permits, not the responsibility of Durham County Environmental Health
- The City has a program for detecting and stopping illicit discharges, but it is unclear whether the County does?

The UNRBA suggests forming a temporary task group of the various responsible state, county, and city agencies, as well as elected officials, to address the problem of how to better manage or replace existing problem onsite wastewater systems.

Indicators of the problem and current conditions

Fecal coliform bacteria is the major indicator of untreated onsite wastewater system discharges. Failing onsite wastewater systems can cause high levels of fecal coliforms even during periods of low-flow because

these systems run all the time. Short-term monitoring done for the restoration plan includes nutrient and fecal coliform monitoring at Site 1, downstream of the major concentrations of sand filter-type onsite wastewater systems. Since this site is also downstream of other potential coliform bacteria contaminants (in subwatershed 7, Rocky Branch Creek, for example), it may be difficult to separate out one potential cause from another. However, if significantly higher fecal coliform bacteria levels are found at Site 1 than at sites upstream of concentrations of failing systems (monitoring sites 2, 4, 5, and 6), then there may be cause to investigate just upstream and downstream of the suspected failing onsite wastewater system sites. In addition, it is possible to monitor direct outfalls from sand filter type onsite wastewater systems.

Although sand filter and other problem systems are not as numerous in the Lick Creek Watershed as they are in Little Lick, pollution from these systems is a serious problem in small, concentrated areas with these systems. In particular, fieldwork teams found a concentrated number of onsite wastewater system discharges to the stream in a residential neighborhood near Olive Branch Rd., Bookman Rd., Hester Rd., and Rondelay Rd.

Future threats

The potential future threat from failing onsite wastewater systems does not seem to be increasing, as most systems at high risk of failure are already near the threshold. New housing developments in the watershed are annexed into the city and are served by the city's sewer system. However, experience from Little Lick Creek shows that many properties with such systems have not been incorporated into the city or hooked up to the City sewer, even when they are surrounded by other properties under city jurisdiction. This creates islands of homes with aging, substandard onsite wastewater systems on poorly drained soils.

Questions for the Review Process

1. Is it likely (or possible) that owners of sand filter or other problematic onsite wastewater systems can effectively treat wastewater and prevent waste discharges from occurring? If so, please explain how you think this could be accomplished.
2. If you said, "No" to Question 2, please explain what you think could be done to alleviate the impacts from such systems.
3. Are failing systems near the City sewer system being reported and managed? If not, what is preventing the failures from being addressed?
4. UNRBA believes that reducing the impacts from failing onsite wastewater systems in Lick and Little Lick Creeks is a complex problem that can only be addressed by local and state agencies working together. Should a temporary task force be formed to address this problem?
5. Are any of the following viable approaches to reducing the impacts from failing onsite wastewater systems:
    - Grants for rural homeowners to replace or repair failing systems
    - Relief from (e.g. waivers, no-interest loans) City connection fees for people with such systems to connect to the City sewer system
    - A monitoring program run by the state or local government to ensure that existing systems are monitored regularly

- An effort to educate onsite wastewater system owners about proper maintenance, with a special focus to inform the owners of sand filter systems that they are responsible for holding NPDES permits and to assist these landowners in obtaining the permits.

6. For any of the ideas above, how should they be funded? Could any of the following ideas work?
    - Cost sharing
    - Capital improvements
    - Restoration/mitigation funding (e.g. NCEEP or N.C. Clean Water Management Trust Fund)
    - Waivers from sewer connection fees
    - Low-interest or no-interest loans
    - An onsite wastewater utility

Suggested Review Committee Members

1. John Cox, Durham Stormwater Services
2. Dan Line, NCSU Water Quality Group
3. Robert Brown, Durham County Environmental Health
4. Laura Webb Smith, City of Durham Stormwater Services
5. Nora Deamer, N.C. Division of Water Quality
6. Ted Lyon, N.C. Division of Environment and Natural Resources
7. Katie Kalb, City of Durham, Public Works Department
8. Anne Kitchell, Center for Watershed Protection

11. Outreach and education targets:

The Lick Creek fieldwork teams identified several locations where targeted education to watershed residents, businesses, and the development community is needed to educate site managers about illicit discharges and best management practices. Practices such as uncovered fuel storage, poor waste storage, and poor stream buffer management reveal opportunities for education staff to help landowners and business owners better understand regulations and best management practices.

In addition, fieldwork, subsequent site visits, and talks with local stakeholders underscores the recommendation to "educate local elected officials and the public on the impacts of impervious cover to aquatic systems, the susceptibility of the Lick Creek watershed to future impairment due to growth potential and Triassic conditions, and potential management techniques to minimize future impacts (i.e. buffers, better site design, post-construction stormwater quality treatment)" (CWP 2007). The UNRBA and other stakeholders should work together in an effort to raise general awareness of these pressing issues and stimulate support for initiatives to address them.

Indicators of the problem and current conditions

During field investigations, observations were made of management practices not meeting illicit discharge or trash dumping regulations. Furthermore, in many cases, land owners and businesses were observed to have mowed their vegetation to the edge or water bodies and have not left any riparian buffer along waterways

other than grasses. The Lick Creek watershed is one of the fastest-growing areas in Durham County, so the need for educating local elected officials and the public is important and timely.

Future threats

As Lick Creek becomes more densely developed, it will be critical for political leaders, planning staff and advisory groups, developers, and citizens to be aware of the vulnerable nature of Triassic Basin soils and streams. Without this awareness, the water quality of the creek and of this arm of Falls Lake is in greater jeopardy. Furthermore, landowners must be made aware of the importance of riparian buffers and the regulations governing them in the Neuse River Basin.

Questions for the Review Process

1. What is the most effective way to reach the following groups in terms of education and outreach, and what should the "messages" be for each group?
   - Land/business owners targeted for education in this plan
   - Citizens living in the watershed
   - Elected officials in Durham City, Durham County, and Wake County
   - The land development community
   - The agricultural community
   - The City of Raleigh and other Falls Lake advocates
2. Who should be responsible for conducting research into the effects of urbanization on Triassic Basin soils?

Suggested Review Committee Members

1. Laura Webb Smith, City of Durham Stormwater Services
2. Eddie Culberson, Durham Soil and Water Conservation District
3. Jennifer Brooks, Durham Soil and Water Conservation District
4. Chris Roberts, Sedimentation & Erosion Control Division, Durham County
5. Dean Naujoks, Neuse River Foundation
6. Sarah Bruce, Upper Neuse River Basin Association
7. Bobby Louque, City of Durham Stormwater Services

12. Long-term monitoring:

The goals of the Lick Creek Watershed Restoration Plan include; 1) forming an hypothesis about the potential cause of biological impairment, 2) identifying other pollutants that may be impairing the watershed, and 3) preventing future degradation or impairment. In order to continue reporting to meet goals 1 and 2, and in order to monitor progress on Goal 3, DSS has committed to continuing a long-term water quality monitoring effort at two existing Durham monitoring sites in Lick Creek. The Lick Creek Watershed Restoration Plan will recommend that these monitoring findings be regularly reported to the City of Durham, Durham County, Wake County, and the City of Raleigh. This plan will also recommend exploring options

(such as outside funding sources or partnerships) for expanding the long-term monitoring effort in the Lick Creek Watershed.

Indicators of the problem and current conditions

Both NCSU's current, two-year monitoring effort for this planning effort, and DSS's long-term monitoring are gathering data for various water quality and aquatic habitat parameters. DSS's long-term monitoring is expected to depict general water quality and aquatic habitat trends in the watershed. However, their long-term monitoring will not gage improvements achieved or degradation to specific subwatersheds. The long-term monitoring, as planned, will not tell us whether specific sites such as new developments or large sites with agricultural exemptions are complying with regulations. Furthermore, more monitoring is needed to determine where the highest sources of pollution are coming from. When specific sources of pollutants are identified, specific recommendations can be made to rectify those issues.

Current monitoring by NCSU has revealed water quality degradation in Subwatersheds 1, 4, and 7, in addition to water quality degradation on the main stem of Lick Creek just upstream of its confluence with Falls Lake. The parameters of concern include sediment (turbidity and TSS), fecal coliforms, and nutrients. Base flow turbidity data from Subwatershed 1 preliminarily indicate that mean turbidity levels are above the state's standard. Sediment and fecal coliform averages from Subwatershed 7 (Rocky Branch Creek) have consistently been among the highest in Durham County, and sediment, fecal coliforms, and nutrient levels in the main stem are elevated. These findings indicate that Lick Creek is contributing to nutrient and sediment problems in Falls Lake.

Future threats

In some cases, such as in Rocky Branch Creek, existing water quality problems may be due to one or two site-specific practices that are unlikely to be repeated in other areas throughout the watershed. If this is the case, working with landowners to change practices may result in improvements, and monitoring might reveal those improvements. However, the more widespread threat to Lick Creek's water quality is urban development of the watershed within Durham's UGA. Monitoring of Subwatersheds 1 and 2 hints that new development, especially active construction sites, are causing water quality degradation. If this is the case, some level of monitoring efforts should be continued in Lick Creek's urbanizing subwatersheds (1-8). Finally, Falls Lake's impairment status may lead local jurisdictions in Lick Creek to consider monitoring nutrient and sediment levels in developing portions of Lick Creek.

Questions for the Review Process

1. Do water quality monitoring data from NCSU's short-term monitoring sites point to degradation or impairment in Lick Creek and its tributaries beyond its current 303(d) listing for aquatic habitat? If so, which parameters are of concern?
2. Do you agree that existing water quality monitoring data from developing subwatersheds, particularly Subwatersheds 1 and 2, raise concerns about the impacts of upcoming development of the Lick Creek watershed to 23% impervious cover being the threshold for stormwater management requirements?

3. If you said, "yes" to Question 1, how could a long-term monitoring plan for Lick Creek inform decisions about how this development should be managed to protect water quality?
4. Can a "paired watershed" approach be used to compare parameters from the various subwatersheds being monitored in Lick Creek and make inferences about the baseline conditions in Lick Creek? If so, which subwatersheds should be paired?
5. Do you agree that there is value in continuing subwatershed-level monitoring in the Lick Creek Watershed? If so, could monitoring programs from local governments such as DSS continue monitoring at the subwatershed level (done currently by NCSU)?
6. Do you believe that the current level of monitoring is sufficient to inform a preventive effort to protect water quality in Lick Creek and in Falls Lake (ensuring that sites are meeting regulations, ensuring that developing subwatersheds are meeting water quality standards, etc.)?
7. Are there opportunities to use monitoring networks proactively in Lick Creek to prevent water quality degradation?

Suggested Review Committee Members

1. Dan Line, NCSU Water Quality Group
2. Chris Outlaw, City of Durham Stormwater Services
3. Robert Louque, City of Durham Stormwater Services
4. Steve Kroeger, N.C. Division of Water Quality
5. Nora Deamer, N.C. Division of Water Quality
6. Heather Boyette, N.C. Division of Water Quality
7. Laura Webb Smith, City of Durham Stormwater Services
8. John Cox, City of Durham Stormwater Services

References

15A North Carolina Administrative Code (NCAC) 2B .0200. Procedures for Assignment of Water Quality Standards

Center for Watershed Protection (CWP). 2003. *Impacts of Impervious Cover on Impervious Streams*. Center for Watershed Protection. Ellicott City, MD.

Center for Watershed Protection (CWP). 2007. *Lick Creek Fieldwork: Findings and Recommendations*. [online]. Available at: ftp://ftp.tjcog.org/pub/unrba/lick/techmemo060707.pdf [accessed May 15, 2008].

Fraley-McNeal, L., Hoyt, S., and Kitchell, A. (2007). *Lick Creek—Watershed Treatment Model Analysis*. [Online]. Available at: ftp://ftp.tjcog.org/pub/unrba/lick/techmemo062007.pdf [accessed May 15, 2008].

North Carolina Division of Water Quality (NCDWQ). 2007. *"Redbook" Surface Waters and Wetlands Standards*. [Online]. Available at: http://h2o.enr.state.nc.us/admin/rules/documents/redbook_1may07_full_with_cover.pdf [accessed May 15, 2008].

N.C. Division of Water Quality (NCDWQ). 2008. *North Carolina 303(d) List; Draft for Public Review*. [Online]. Available at: http://h2o.enr.state.nc.us/tmdl/documents/B.Draft2008303dList.pdf [accessed May 15, 2008].

Line, D. and Penrose, D., 2007, *Analysis of Existing Data and Short-term Monitoring Plan for Lick Creek*. [Online]. Available at: ftp://ftp.tjcog.org/pub/unrba/lick/stermmonplan.pdf [accessed May 15, 2008].

Schueler, T. 1994. Feature Article. Watershed Protection Techniques 1(3):104.

Trust for Public Land. 2006. *Upper Neuse Clean Water Initiative Conservation Plan*.

Upper Neuse River Basin Association (UNRBA). 2003. *Upper Neuse Watershed Management Plan*. [Online]. Available at: ftp://ftp.tjcog.org/pub/unrba/finlplan.pdf [accessed May 15, 2008].

Upper Neuse River Basin Association (UNRBA). 2007. *Lick Creek Watershed Restoration Priorities.* [Online]. Available at: ftp://ftp.tjcog.org/pub/unrba/lick/techmemo101507.pdf [accessed May 15, 2008].

Upper Neuse River Basin Association (UNRBA). 2007b. *Upper Neuse Watershed Management Implementation Recommendation #15*. [Online]. Available at: http://www.unrba.org/downloads.htm [accessed May 15, 2008].

Upper Neuse River Basin Association (UNRBA). 2008. *Lick Creek Watershed Critical Lands Protection Analysis*. [Online]. Available at: ftp://ftp.tjcog.org/pub/unrba/lick/techmemo012408.pdf [accessed May 15, 2008].

US Environmental Protection Agency (EPA). 1986. Quality Criteria for Water 1986. EPA 440/5-86-001. Office of Water Regulations and Standards, Washington DC. May

US Environmental Protection Agency (EPA). 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX. EPA 822-B-00-019. Office of Water. December

Wikipedia. 2008. *Thalweg*. [Online]. Available at: http://en.wikipedia.org/wiki/Thalweg [accessed July 2, 2008].