

3.0 CUMULATIVE ANALYSIS AND PRIORITIZATION

The purpose of this section of the report is to present a “cumulative analysis” of the sub-watershed characterization presented in Section 2. More specifically, this section of the report assimilates the various sources of sub-watershed characterization information to:

- ❖ Assess impacts on watershed functions (including water quality, habitat and hydrology)
- ❖ Hypothesize on major sources/causes and pollution
- ❖ Identify indicator parameters for the sub-watersheds (based on estimated sources and causes)
- ❖ Prioritize sub-watersheds based on various prioritization criteria

The cumulative analysis was limited to the Phase 1 tasks of this project (including review of available data and information as well as the cursory windshield survey). **Therefore, the analysis will be re-evaluated during following phases of the project as more data and information become available.**

3.1 Impacted Watershed Functions

As previously indicated in Section 2.2.2, stream segments within the Swift Creek Watershed are listed as impaired and on the 303(d) list since they are unable to support an acceptable community of aquatic organisms. This documentation of biological impairment in the Swift Creek Study Area is a good example of an impacted watershed function. The analysis presented in this section of the report includes analysis of impacts on the following three categories of watershed functions:

- ❖ Water quality (impacts may be represented by high sediments, toxicity, eutrophication, etc.)
- ❖ Habitat degradation (impacts may be represented by loss of aquatic or terrestrial habitat)
- ❖ Hydrology (impacts may be represented by flooding and drainage problems).

In addition, the analysis of impacted watershed functions was conducted on a sub-watershed basis to assist with prioritization of the sub-watersheds (discussed in more detail in a following section) as well as on an overall watershed basis.

3.1.1 Sub-watershed Impacted Watershed Functions

For the sub-watershed analysis, available data and visual assessment findings for each sub-watershed were utilized to assess impacts on watershed functions. The results of this analysis are presented for each sub-watershed on page 3 of the sub-watershed characterizations forms included in Appendix D.

Impacts on water quality were based on the documentation of watershed conditions (presented in Section 2.2.2) as well as any observed water quality problems during the visual assessment (presented in Section 2.3 and Appendix C). Therefore, sub-watersheds with documented problems based on chemical monitoring (such as nutrient enrichment and exceedances in metals standards as in Sub-watershed 4A2 or eutrophication in the lakes in Sub-watersheds 1AX, 3BX, and 4E1) were noted as having an impact on the water quality function.

Impacts on aquatic habitat were based on an analysis of buffer zone encroachment (presented in Section 2.2.1.5) as well as observations during the visual assessment (presented in Section 2.3 and Appendix C). Buffer encroachment of over 20% of the 300-foot buffer was utilized as a threshold for aquatic habitat impacts. For example, Sub-watershed 4E1 with 28% encroachment on the buffer (presented in Table 2-7), was marked for impacts on aquatic habitat. In addition, poor scores in the visual assessment of stream bed conditions (presented in Table 2-30) were utilized as an indicator of aquatic habitat impacts. For example, Sub-watershed 1BX that received poor scores during the visual assessment are noted as having impacts on aquatic habitat in the sub-watershed characterization forms.

Note that since specific data and information were not available to assess impacts on hydrology on a sub-watershed basis, this watershed function will be assessed after collection of additional data in later phases of the project. **Based on the available data and the analysis of impacted watershed**

functions on a sub-watershed basis, the watershed function most greatly impacted was aquatic habitat degradation.

3.1.2 Overall Watershed Impacted Watershed Functions

As indicated above, the analysis of watershed impacts included analysis of water quality, hydrology and habitat watershed functions. Although the available data indicated that the habitat watershed function was most impacted, the analysis of causes/sources and indicator parameters for the entire study area (discussed in more detail in following sections) supports the conclusion **that all three watershed functions are impacted in the Swift Creek study area.**

3.2 Hypothesis on Major Causes/Sources of Problems and Indicator Parameters

Similar to the analysis of the impacted watershed functions above, an analysis of the major causes and sources of problems and indicator parameters was conducted on a sub-watershed basis to assist with sub-watershed prioritization as well as on an overall watershed basis.

3.2.1 Sub-watershed Causes/Sources of Problems and Indicator Parameters

Available data for each sub-watershed was utilized to hypothesize on major causes and sources of problems and indicator parameters. Results of the analysis are presented on page 3 of the sub-watershed characterizations forms included in Appendix D.

3.2.1.1 Hypothesis on Major Causes/Sources of Problems

The sub-watershed forms included a wide range of typical causes of pollution including the following:

- ❖ Urban development
- ❖ Rural development
- ❖ Agricultural developments
- ❖ Silviculture development
- ❖ Hydrologic Alterations
- ❖ Point Source Discharges/Spills
- ❖ Other

The land use trends analysis including the analysis of associated imperviousness (presented in Section 2.2.3.2), the analysis of potential pollution sources (presented in Section 2.2.3.4) and information on hydrologic alterations were utilized to complete the assessment. For example, Sub-watersheds with over 25% overall imperviousness were indicated for having urban and rural development as causes of pollution. In addition, subwatersheds containing large impoundments or just downstream of large impoundments (such as Sub-watersheds 3BX and 3AX near Lake Wheeler) were indicated as having hydrologic alterations. Based on the available data and the analysis of causes and sources of problems on a sub-watershed basis, **the primary cause of problems was increased imperviousness associated with urban and rural development.**

3.2.1.2 Indicator Parameters

The sub-watershed forms included a wide range of typical indicator parameters including the following:

- ❖ Turbidity
- ❖ Flooding
- ❖ Increased temperature
- ❖ Toxicity
- ❖ Eutrophication
- ❖ Aquatic habitat
- ❖ Riparian buffer
- ❖ Upland buffer/habitat loss
- ❖ Wetland loss
- ❖ Floodplain loss
- ❖ Biological impacts
- ❖ Low dissolved oxygen

❖ Fecal coliform and/or bacteria

Available monitoring data (presented in Section 2.2.2) and the analysis of buffer zone encroachment (presented in Section 2.2.1.5) were utilized to document indicator parameters in the various sub-watersheds. For example, since data for Lake Benson located in Sub-watershed 1AX indicates nutrient enrichments, eutrophication is listed as an indicator parameter for this sub-watershed. Subwatershed 4A2 (which contains the monitoring station at Swift Creek and Holly Springs Road) is listed for many indicator parameters since data indicates that there are exceedances in metals criteria (toxicity), turbidity is elevated, and there is nutrient enrichment. Buffer encroachment of over 20% of the 300-foot buffer was utilized as a threshold for hypothesizing that there is riparian buffer loss and possibly aquatic habitat (stream bed loss). Based on the available data and the analysis of indicator parameters on a sub-watershed basis, **the primary indicator parameter was riparian buffer loss.**

3.2.2 Overall Watershed Causes/Sources of Problems and Indicator Parameters

A study conducted by the Planning Branch of DWQ in the Upper Swift Creek Area (upstream of Holly Springs Road) in 2003, referred to as the WARP study, included a detailed evaluation of the causes of impairment. The following paragraphs summarize the findings of that analysis.

The WARP study included the following primary tasks:

- ❖ Identification of the most plausible potential “candidate” causes of impairment in the watershed
- ❖ Collection of additional data
- ❖ Characterization of the causes of impairment using a “strength of evidence” approach

The strength of evidence approach involves a logical evaluation of several sources of “evidence” to determine which evidence supports or does not support the correspondence of the candidate stressor to the impairment. The evaluation also included analysis of whether candidate stressors were primary causes of impairment, secondary causes of impairment, part of the cumulative cause of impairment, a contributing stressor, a potential cause or contributor or an unlikely cause or contributor. An important piece of evidence for the Swift Creek Watershed is that although impairment has been documented since 1989, DWQ believes that the Swift Creek Watershed may not have been impaired as recently as 1980 (WARP, 2003). Other sources of evidence evaluated included benthic macroinvertebrate community data, habitat and riparian area assessment, chemistry, toxicity data, current watershed activities and land uses and pollutant sources.

The following presents the analysis of the various candidate causes of impairment in Swift Creek that were determined to **not be significant causes of impairment or not primary causes of impairment:**

Habitat degradation – sedimentation. As indicated in Section 2.2.2, the Neuse River Basinwide Water Quality Plan (2002) listed sediment as the cause for impairment based on biological data. This hypothesis was tested using the weight of evidence approach using available data (benthic macroinvertebrate community data, habitat and geomorphic evaluation, and watershed history and characteristics). Results of the analysis indicated that substantial sediment accumulation and resulting habitat degradation in Swift Creek and tributaries (upstream of Holly Springs Road) is not evident based on stream surveys and habitat assessments conducted in conjunction with biological sampling. Therefore, **there is little evidence that sedimentation alone is severe enough to be considered a cause of impairment overall for Swift Creek** (although there are some localized areas of exception).

Habitat degradation – lack of key microhabitat. Benthic macroinvertebrate community data, habitat and geomorphic evaluation and watershed history and characteristics were utilized in this evaluation of causes of impairment. Although there are areas with poor habitat (including deep uniform stream channels, little habitat diversity, no riffles and very low baseflow velocities), **the lack of key microhabitat is not viewed as a primary limiting factor for benthos.**

The following presents the analysis of the various candidate causes of impairment in Swift Creek that were determined **to be significant causes of impairment:**

Hydromodification and associated scour due to storm flows (resulting from high density development). Habitat and riparian area assessments, stream observation during storms and watershed characteristics were reviewed to assess stormflow scour as a source of impairment in the watershed. Associated with the removal of organisms and microhabitat during storms, **stormflow scour was determined as a likely contributor to habitat degradation and dislodging of organisms.**

Toxicity (resulting from residential and commercial development). Water chemistry data, instream bioassay data, sediment chemistry and bioassay data, watershed characteristics and benthic community data were utilized in the evaluation of toxicity as a cause of impairment. Although toxic impacts are very episodic and difficult to identify, data on benthic community composition, midge deformities and one acute bioassay failure during a storm suggest that **toxicity is evident at least periodically in the watershed.**

Hydromodification (resulting from dams). Impacts from dams include the following:

- ❖ Prevention of downstream colonization of aquatic populations
- ❖ Lower water levels below dams
- ❖ Change in temperature and dissolved oxygen
- ❖ Change in food type

Although it is difficult to isolate these impacts from those of lower baseflows associated with urbanization and organic enrichment, **there is evidence that the lowered water levels below dams are an important stressor to the biological communities in Swift Creek.**

Organic and nutrient enrichment. Benthic community data and water quality monitoring data was utilized to evaluate organic and nutrient enrichment as a potential cause of impairment. Although it was difficult to distinguish between the impacts of lower base flows (associated with urbanization) and organic and nutrient enrichment based on dissolved oxygen, **there is evidence that enrichment is associated with intermittent and localized impacts in the watershed.**

Summary of Overall Watershed Causes/Sources of Problems and Indicator Parameters

Based on the “weight of evidence” analysis presented in the WARP study for Swift Creek upstream of Holly Springs Road, **the two most important factors (in order of importance) include scour and toxicity since the impacts of enrichment and habitat degradation are more localized.** The limitation of macroinvertebrate recolonization from the blockage of drift by impoundments (hydromodification) is also of concern. Although habitat degradation due to limited microhabitat was not viewed as a primary cause of impairment, combined with other causes of impairment, the cumulative effect can result in impairment. **All of the stressors and indicator parameters discussed above are associated with the high levels of development in the Swift Creek Watershed upstream of Holly Springs Road.** The findings of this analysis are most likely applicable to the remainder of the Swift Creek Watershed (to downstream of Lake Benson) as these areas are also experiencing rapid development.

3.3 Sub-watershed Prioritization

As a final component of the cumulative analysis, the 20 sub-watersheds were prioritized based on various criteria to assist in developing recommendations for Phase II of the project. Prioritization criteria for habitat and water quality improvement and community priorities included the following categories:

- ❖ Need for Characterization Data (based on availability of data presented in Section 2.2.2 and land uses presented in Section 2.2.3)
- ❖ Documentation of Existing Problems (based on documented watershed conditions presented in Section 2.2.2)
- ❖ Potential for future problems (based on land use/historic trends presented in Section 2.2.3)
- ❖ Critical resources (based on the natural resources presented in Section 2.2.1)

Scoring of the various sub-watersheds for the prioritization is described in more detail below:

Need for Characterization Data

- ❖ 1 pt if no data available

- ❖ 1 pt if no data available AND contains over 5% high density development

Documentation of Existing Problems

- ❖ 1 pt if overall impervious is > 15%
- ❖ 1 pt if > 20% buffer encroached
- ❖ 1 pt if > 6% impaired (303d) streams
- ❖ 1 pt if existing monitoring data indicates problems (Poor score)
- ❖ 1 pt if visual assessment observations indicate problems (Poor score)

Potential for Future Problems

- ❖ 1 pt if population increase from 90 to 99 is > 40%
- ❖ 1 pt if population increase from 99 to future is > 40%

Critical Resources

- ❖ 1 pt if > 40% of stream miles designated as water supply watershed
- ❖ 1 pt if > 20% floodplains
- ❖ 1 pt if >20% wetlands
- ❖ 1 pt if contains Natural Heritage Element Occurrence (s)
- ❖ 1 pt if contains Natural Heritage Area(s)
- ❖ 1 pt if contains historic site(s)
- ❖ 1 pt if contains archeological site(s)
- ❖ 1 pt if > 20% protected lands (parks, greenways, etc.)

Cost Sharing Opportunities

- ❖ 1 pt if located in an incorporated area interested in cost sharing opportunities

Results of the prioritization by the above listed criteria are presented in Table 3-1. Results of the prioritization by sub-watersheds sorted by score are presented in Table 3-2. **As indicated in the table, the top five sub-watersheds include:**

- ❖ **4BX** (located in a highly developing area within Cary)
- ❖ **4E1** (located in a highly developing area within Apex)
- ❖ **4A1** (located in a highly developing area within Cary)
- ❖ **4DX** (located in a highly developing area within Cary)
- ❖ **4E2** (located in a highly developing area within Cary)

The purpose of the Phase I prioritization was to identify target sub-watersheds for analysis in Phase II. It is recommended that the prioritization be continued through Phase II as additional data and information is collected. Two specific analyses that will be important for prioritizing sub-watersheds in Phase II involves the following modeling parameters:

- ❖ **Annual pollutant loading estimates** (derived from water quality modeling) to determine which sub-watersheds contribute the highest pollutant loads for select parameters as well as which sub-watersheds are anticipated to have the greatest increases in pollutant loads from current to future conditions. This analysis will be useful in addressing impacts on the water quality watershed function.
- ❖ **Erosive velocity estimates** (derived from hydrologic and hydraulic modeling) to determine which stream banks are most susceptible to erosion from scour based on an analysis of peak flows and associated instream velocities, soil type, and vegetation. This analysis will be useful in addressing impacts on the habitat watershed function. This analysis may be most important since scour was hypothesized to be the most pervasive stressor in the watershed.

Additional information on recommended modeling is presented in Section 4, Recommended Actions for Phase II. Prioritization in Phase II should also be expanded to address prioritization of traditional compensatory mitigation opportunities. For example, potential cost sharing opportunities within certain sub-watersheds may make one project or sub-watershed a higher priority than others. Cost sharing opportunity criteria for prioritizing mitigation opportunities should include the following:

- ❖ If within an incorporated area interested in cost sharing opportunities
- ❖ If contains an existing restoration project (opportunity to build on existing efforts)

- ❖ If there is a TMDL planned or underway (opportunity to partner with NCDWQ)