CHAPTER 5: MANAGEMENT AND RESTORATION MEASURES

5.1 OVERVIEW

Impairment in the Bolin Creek Watershed has been determined based on the poor condition of aquatic organism communities. As noted in the previous chapter, aquatic organism communities in urban settings are affected by a wide variety of stressors contributed by sources in a diffuse, distributed, "non-point-source" way. One of the goals of watershed restoration planning is to estimate the amounts of stressors contributing to impairment and the amount by which these stressors need to be reduced to restore ecological function. However, when stressors are as broad and difficult to measure as they are in cases of "urban stream syndrome," it is difficult to say exactly how much of any one stressor is to blame for impairment or how much any one stressor needs to be reduced to restore ecological function. This means it is at a minimum not practical and more pointedly and likely not possible to select or prescribe management measures based on the specific amount they control or reduce a specific stressor.

Therefore, the approach this plan takes is to look at urban stressors and sources, and the management measures needed to address them, in more general terms. We have identified broad categories of hydrologic impairment, geomorphic impairment, water chemistry impairment, and biological impairment. Further, we have identified stressors and characterized the ways they impair streams and waterbodies, as shown in Appendix 3. We understand that addressing the complex and interrelated stressor combination presented by "urban stream syndrome" will require a broad approach that addresses the multiple levels of stream ecosystem functions all at once.

Restoration of Bolin Creek's ecological functions will require a multi-pronged approach to counter the multiple stressors common to urban settings. This is because of the wide variety of sources. Appendix 4 presents management measures in terms of countering specific sources. Appendix 5 profiles specific methods used to address the various stressors identified in Appendix 3 and analyzed in the Watershed Analysis chapter. This chapter will review the aspects of stream ecosystem functions we have determined need to be addressed in order to effect changes in physical, chemical, and biological conditions to allow the biological community to improve.

Lastly, the portions and functions of the watershed that are still functioning well need to be protected to maintain that function. But simply making all of these few remaining areas off-limits to new development is not viewed favorably by the owners of these properties. Therefore, this chapter also reviews techniques to protect ecological functions, as well as methods to develop a property in a way that minimizes negative effects on ecological functions.

5.2 MANAGEMENT APPROACH BY LEVEL OF ECOSYSTEM FUNCTION

HYDROLOGIC FUNCTIONS – ADDRESSING "FLASHY" FLOWS AND LOW BASE FLOW

A large proportion of the developed areas in the Bolin Creek watershed have no structures or methods to control stormwater rate or volume. Increasingly "flashy" stream flows following rainfall are a hydrologic symptom of changes in the watershed that in turn lead to changes in stream geomorphology. High velocity flows put considerable stress on stream banks and stream beds, causing erosion and changes in the shape of the channel. Erosion can undermine riparian trees, remove all kinds of habitats, and generate large amounts of sediment that is carried downstream to be deposited in another stream segment. Heavy deposits of fine sediment in turn fill in and obliterate stream habitats, change the shape of the channel, and smother organisms and their food sources.

With regard to other direct ecological effects, "flashy" flows reduce the nutrient processing capabilities of streams by reducing the time that leaf litter stays in one place. When leaf litter stays and decomposes for a long time in one location, fungi have time to colonize the material, animals have time to graze on the colonizing fungi, and thus the nutrients in the leaves cycle slowly through the stream food chain.

Reducing erosive, "flashy" flow is best dealt with by controlling stormwater runoff, particularly its rate (discharge, or volume in a given amount of time) and its total volume. This is done through the use of structures or grading of land that slows down or retains runoff. These methods can be fully engineered structures such as wet ponds or simpler methods that increase surface roughness and topographic depressions to slow the movement of runoff to streams. However, engineered structures usually require regular maintenance for their continued proper functioning. This and other retrofitting challenges are addressed more directly later in this chapter.

In contrast to "flashy" storm flows, low base flows (stream flow in between storms) are a different kind of hydrologic symptom of change in the watershed. Low base flows have not been definitively linked to increased impervious surface, or to any one particular cause. However, as described in Appendix 3, there are a variety of identified watershed and land use changes that can have baseflow effects. Increasing soil infiltration of rainfall, and eventual groundwater recharge, throughout the watershed holds the potential to improve base flows in the most straightforward way. Fortunately, increased groundwater recharge does not have to take place in the context of formal, engineered stormwater management, making it highly accessible to the average property owner. Furthermore, once begun, it requires little maintenance beyond ensuring the general health of the vegetation and soil in the area.

The simplest way to increase soil infiltration is correct soil compaction (via soil restoration), and where present, remove impervious surfaces. Without rebuilding the soil it takes many years (or even decades) for natural processes to improve permeability, depending on how heavily compacted the soil is. Rebuilding, or restoring, the soil usually involves deep plowing to break up compacted layers and the addition of organic material to encourage the growth and activity of soil organisms, including healthy plant roots. In areas where soil has been compacted, an 18 inch plow is used to break up deep soil layers. In places where the forest leaf litter or topsoil has been removed, the soil is amended in place by adding compost and rototilling it in. This can be achieved using a pre-approved amendment rate of 2.5 inches or through a custom amendment rate calculated specifically for the site. For soil that is too rocky, compacted, or poorly drained to amend effectively, a topsoil mix with 8% to 13% soil organic matter can be imported and placed on the surface. For all these sites, soil inoculants add critical microorganisms back into the soil. Microorganisms digest the organic materials, producing compounds that "glue" the soil together into larger blocks. Even earthworms are available for amending soils. Larger organisms burrow through the soil, and plants push roots through, opening up tunnels of many sizes. The blocks and the tunnels vastly increase the ability of the soil to absorb rainfall.

Even where plants are currently growing, such as lawns, the soil may not be as healthy as it was prior to development. The development process usually involves the removal of topsoil down to a clayey, rocky subsoil in order to smooth the surface for building ("grading"). Heavy equipment compacts the entire area during grading and construction. Topsoil may, or may not, be laid back down after construction is complete; it is not required in practice or regulation. Plants, even grass, growing on this material often struggle to survive since the soil cannot absorb very much rainfall. It can take decades for the soil to loosen by weathering and plant and soil organism action, and that requires that a healthy soil ecosystem be allowed to develop. Removal of organic matter and use of herbicides and pesticides can very effectively prevent the reestablishment of a healthy soil community. Forests can very effectively restore soil condition given time. Grass lawns have a poorer record in this regard, mostly because of the intense management, and potential compaction involved during management, and shallow root zone.. Reforestation of available area not covered by rooftops, pavement, or gravel is generally considered to be a highly effective method to slow and absorb runoff, providing benefits for both groundwater recharge and control of stormwater runoff.

GEOMORPHIC FUNCTIONS – ADDRESSING STREAM INSTABILITY

As noted in the Watershed Impairment chapter, "flashy" storm flows can lead directly to changes in a stream's shape (geomorphology), which can in turn cascade to further changes in shape and effects on water chemistry and ecological conditions. But other direct stream impacts can also destabilize stream channels, as noted in the stressors table (Appendix 3). Beyond repairing geomorphic changes when hydrologic problems are addressed, management methods also include repairing direct or deliberate changes to the stream channel from straightening, armoring, and stream crossings such as culverts and fords.

Direct rebuilding of natural geomorphology is not advised in the absence of moderation of flashy hydrology. Thus stream restoration projects that have a stream channel reshaping component should not be undertaken without accompanying stormwater volume and velocity control upstream of the restoration area. Direct rebuilding of natural geomorphology has also been found to be highly disruptive of any existing biological community in the restoration zone, as should be expected when the entire streambed and banks are moved around with heavy equipment. Furthermore, in these cases it has been found that it can take several years for the biological community to return merely to the pre-construction state. Therefore, the best geomorphic rebuilding tools in stream restoration use a "light touch", attempting to disturb as little of the stream channel bed as possible, focusing more on reduction of erosive water energy at high flows through reconnection with the floodplain and reduction of bank erosion through bank reshaping and stabilization. The idea behind the "light touch" is to reduce the most stressful physical impacts and restore stabilizing natural features such as woody bank vegetation to start a natural process of reestablishment of geomorphic features. However, in some cases rebuilding of pool-riffle pattern and reestablishing hyporheic flow (flow under the surface of the stream bed) may be necessary where the geomorphic structure has been greatly simplified and natural processes cannot be easily "jump-started". Therefore, the need for rebuilding of natural shapes and features is one that should be individually addressed for each stream segment.

WATER CHEMISTRY FUNCTIONS – ADDRESSING POLLUTANTS AND CONTAMINANTS

Low water flow conditions and lack of geomorphic complexity can lead to changes in water chemistry, notably dissolved oxygen, and high flows can transport huge amounts of sediment that are stressful to aquatic organisms. However, in urban areas direct pollutant and contaminant sources are abundant, and may be significant enough that the biological community cannot recover even if the hydrology and geomorphology are restored.

The most direct methods of addressing water chemistry problems are the identification and correction of direct discharge sources, most of which are likely to be illicit or unpermitted, and the treatment of runoff that has washed over paved surfaces, carrying numerous contaminants. For direct discharges, it may be difficult to identify the contaminants involved and their source location, but the prevention of discharge is a fairly direct and inexpensive process (unless an extensive legal process is required for enforcement). In comparison, the latter sources typically require stormwater treatment structures (BMPs) to use natural processes of settling, filtration, adsorption, absorption, chemical reactions, and biological metabolism to reduce or convert contaminants to less toxic or disruptive forms. This requires engineering to design them, area for them to be located, and construction effort and materials to install them.

Another significant source of pollutants may be soil water (interflow) or ground water that has been contaminated through dumping of liquids or solids, or leakage from storage areas. However, such contamination requires much more expensive remediation methods, usually involving excavation of contaminated soil or landfill, and pumping and treatment of contaminated groundwater.

ECOLOGICAL FUNCTIONS – ADDRESSING POOR INSTREAM HABITAT AND CLEARED RIPARIAN ZONES

Ecological conditions are ultimately the combination of the aforementioned aspects of stream ecosystems: the hydrology, geomorphology, and water chemistry, and the effects of these factors on organisms. Poor hydrologic, geomorphic, and water chemistry conditions have considerable effects on stream communities. But stream communities may be affected in very directly biological or ecological ways, such as: removal of the riparian forest that disrupts physical conditions in addition to the carbon sources available at the base of the food chain; introduction of invasive aquatic species that disrupt predator-prey relationships or interspecies competition; introduction of invasive terrestrial plant species that take down riparian forest or contribute leaf matter that has different nutrient qualities; and other changes in interactions between plants, fungi, and animals of the stream and the forest.

Stream restoration is rarely carried out through direct restoration of ecological functions, with the exception of riparian reforestation and invasive species eradication. Oftentimes, these methods are used as part of the “light touch” in restoring geomorphic condition, through restoration of the stabilizing functions of the riparian forest.

PRIORITIZATION OF MANAGEMENT MEASURES

As described in the previous chapter, the hydrologic, geomorphic, water chemistry, and biological functions of stream ecosystems are highly interdependent. Disruption of one function will cascade through the other functions, making it difficult to decide where to start restoring stream ecosystem functions. However, we can generally view stream ecosystem functions as a kind of pyramid, where functions above are more affected by those below, but there is less effect in the opposite direction. In terms of direction of effect, for the most part hydrologic conditions dominate all other stream ecosystem functions, geomorphic conditions mostly dictate water chemistry and biological conditions, and so forth. It should be understood these "directions of effect" are not absolute, but used more to identify the aspects of the system that are least affected by the others.

Studies have identified that watershed-wide hydrologic changes underlie a great deal of the impairment of Bolin Creek. As noted in the previous chapter, hydrologic function is impaired in two major ways: in the reduction of base flow and the increase in "flashy" flows. Based on the idea that the other stream ecosystems functions cannot begin to return to a "healthy" state without at least partial improvement of hydrologic function, it would make sense to make management measures that improve hydrologic function a greater priority in implementation. Indeed, many studies have shown that restoring a stream's hydrologic condition leads to the geomorphic, water chemistry, and biological functions restoring themselves through natural processes. This is only the case where more direct stressors to these other functions, such as direct pollution sources, riparian clearing, changes in the food web, or direct modifications to the stream channel are not present. Where these stressors are present, as is common in urban settings, management approaches must improve all of these functions to some degree.

5.3 RETROFITTING AND RESTORATION CHALLENGES

Approaches to controlling stormwater in existing development areas (also known as "retrofitting") range from large regional facilities treating stormwater from a large number of properties, to lot-level stormwater management structures. Retrofitting at any scale suffers from particular challenges that don't exist for new developments. Successful retrofitting requires several things:

1. Space available for the structure and access for maintenance
2. Permission from the owner of the space, or acquisition of the space
3. Funding for engineering design and initial construction
4. Regular maintenance and a funding source for maintenance and repairs
5. An entity responsible for maintenance and repairs
6. A way to guarantee or enforce maintenance and repairs after construction

Regional- and neighborhood-scale stormwater management is for the most part what is used in those areas developed after stormwater management ordinances were enacted. This method requires that stormwater structures are installed at the time of development, when land can be set aside. They provide a mechanism to ensure there is a dedicated location for the structure, that maintenance will be performed (through a bond or other means), and that funds are collected to cover maintenance costs (usually through a property owners association that is responsible for maintenance). Neighborhood-scale stormwater management may be regional for particularly large developments, although the trend currently is to have smaller structures distributed throughout a development. Regional-scale stormwater retrofits are most likely to treat runoff from many different developments. These will also have the benefits of a dedicated location and easement, and usually have funding for regular maintenance. On the other hand, acquisition of property or even stormwater easements after development is considerably more difficult and may be a significant limiting factor.

On the other hand, lot-level stormwater management has the benefit of a fully-distributed approach to stormwater management. Treating runoff as close to the source as possible has been found to be the most effective when installed and maintained properly. Distributed stormwater management mimics natural runoff processes. Increased groundwater recharge is best achieved in a highly distributed manner as well, and is supported by distributed stormwater management.

Lot-level stormwater management addresses the issue of space and responsible entity. There is a single property owner, so these requirements are rather simple. However, in the absence of significantly increased inspection capacity, there is no clear way to guarantee regular maintenance, or even that the structure will be left in place. Property owners generally view their property as under their complete control, and our culture reinforces this view. Even sympathetic or cooperative property owners may not fully grasp the required maintenance and funds required. Property owners associations may be able to enforce maintenance through neighborhood covenants, or at least that the structure stays in place and isn't removed. But there is no mechanism to add such responsibilities to existing associations and covenants.

Successful restoration will involve more than projects and programs. The long-term success of the restoration will also depend on how maintenance is approached. A program for maintenance of stormwater practices in neighborhoods developed in the past decade or so has been set up under NPDES stormwater permits. However, the Bolin Creek Watershed Restoration Team recognizes that a broader maintenance mechanism is needed to fully support watershed restoration efforts. Towards that goal, a request response system is recommended in which anyone can report maintenance needs that can then be provided to the most appropriate entities.

Types of maintenance required include:

- Regular inspection of stormwater devices
- Repair of stormwater devices
- Trash and debris removal
- Vegetation maintenance, including native species establishment, invasive species control, creating vegetated areas that promote infiltration and interception
- Recreational trail and utility corridor maintenance to reduce erosion

Volunteers may assist the BCWRT in maintenance. Maintenance programs can be further developed with local civic groups, scouts, schools, and. Adopt-a-trail programs can be developed to address trail maintenance.

A challenge that Carrboro and Chapel Hill staff (along with most local governments) are currently facing is the development of programs and capacity to inspect and maintain the increasing number of stormwater practices installed as required as lands develop. This applies to restoration and retrofit projects as well as those installed as part of development. Carrboro has committed to a goal of inspecting every private, permitted practice as part of the Town's recently issued NPDES stormwater permit. Chapel Hill has a stormwater utility that provides the support to perform inspections of private BMPs. Both Towns rely on private maintenance of systems, but neither Town has been able to either perform inspections or to reach out to landowners to educate them about their maintenance responsibilities. But for retrofits and restoration projects carried out by the Towns, who is responsible for maintenance and repairs becomes much less straightforward.

5.4 ESTIMATION OF IMPROVEMENT

Given the many types of stressors that impair ecological function, the incremental changes required to improve ecological function in the watershed, and the slow response of biological systems to such changes, it can be difficult to estimate how much improvement any given project will provide, even to estimate how long it would take to see such improvement. There is insufficient literature regarding the results of watershed-scale restoration efforts, especially how the stream biological community responds and how quickly, to be able to predict changes in Bolin Creek relative to any particular management method.

However, we can rate conceptualized projects (projects with enough specificity to be able to calculate treatment areas and estimated efficiency) well enough to compare projects of similar kinds, particularly those that have a well-established rating system for management of flow rate, volume, total suspended solids, nitrogen, phosphorus, fecal coliform, etc. At the present time, this method of rating benefits is largely confined to formally-engineered stormwater control structures, although there is better understanding about the effects of various ecosystem restoration methods and erosion control and soil protection methods. Where possible, calculations will be run to determine the hydrologic and chemical changes an engineered structure could be expected to provide and recorded in the "projects" part of the geodatabase.

In particular, we can describe the hydrologic and geomorphic improvements an engineered project is expected to provide by projected changes in streambank or streambed erosion based on estimates of changes in shear stress. The most commonly used method for estimating streambank erosion is the Bank Erosion Hazard Index (BEHI) combined with an estimate of Near-Bank Stress (NBS). NBS can be estimated from the kind of hydrologic modeling that is used to estimate pre- and post-construction runoff rate and volume.

We can describe the chemical improvements an engineered project is expected to provide for particular constituents that have crediting systems set up for them, such as total suspended solids, nitrogen compounds, and phosphorus compounds. In particular, the Jordan Lake Nutrient Accounting Tool would be most useful for these estimates. There are published removal efficiencies for other constituents that can be referenced if needed.

Estimating chemical source reduction (such as from detecting and eliminating illicit discharges) relies on being able to get a good estimate of the source discharge constituents, concentrations, and total volumes. This kind of information is usually more difficult to get than even detecting the discharge in the first place.

To our benefit, to meet the needs of Jordan Lake nutrient management, the State is creating a more extensive crediting policy for nutrient management measures, including methods for rating new ideas and technologies. These methods can be incorporated to rate projects as the methods are developed.

It is likely that addressing the hydrologic and chemical problems of the most heavily-developed (and incidentally, oldest) tributaries, Tanyard Branch, Mill Race Branch, and Tanbark Branch would address a significant proportion of the problems in the lower Bolin Creek watershed. These tributaries have consistently scored Poor on measures of macroinvertebrate community integrity, and are likely to comprise a significant proportion of stressor sources in the lower Bolin Creek watershed.

5.5 WATERSHED RESTORATION PROJECTS DATABASE

As part of this planning effort, a geographically-referenced database (a geodatabase) has been created as a centralized way to store information about known stressors (or "problems") and potential water quality improvement projects as a way to help coordinate the multiple organizations that would implement such projects and collect all in one place the many projects that have been recommended or suggested.

"Problems" and their locations have been collected from many sources, including past plans (such as the EEP Local Watershed Plan and the "WARP study"), stream walks, and information from citizens. "Projects" have been collected from even more sources, but include most of the past studies that were summarized in the previous chapter. For completeness even projects that have been rejected as "infeasible" have been recorded in this dataset to prevent futurestaff from having to investigate projects that have already been investigated but results not recorded anywhere. All these projects, and others that have been conceived in the intervening time, have been collected into this one geodatabase. Attributes and documentation for the projects portion of the geodatabase are described in Appendix 8.

For the time being, this geodatabase is used only by the Towns of Carrboro and Chapel Hill, and it is expected that the geodatabase will be split and the Towns will maintain information relevant to their jurisdictions independently of each other. The Towns will apply their own prioritization schemes to their own set of "problems" and "projects" as they are developed. Where these methods of prioritization have been formalized they are presented in the Implementation, Monitoring, and Plan Revision chapter.

5.6 PROTECTION FROM FUTURE IMPACTS

Efforts to restore the aquatic health of Bolin Creek need to also insure that planned new development and redevelopment do not result in new stresses to the creek and its tributaries. Benthic monitoring sponsored by Carrboro in the upper watershed has indicated potential signs of more recent stress, and highlights the need for vigilance in planning for new development in the watershed. The discussion focuses on strategies for better management of erosion and stormwater on development sites to minimize impacts from construction and increased post-development stormwater volume and protection of critical lands and their watershed functions.

CONSTRUCTION PRACTICES

This chapter has described how development can impair soil function through compaction, removal of topsoil, and other kinds of degradation. Ideally, soil functions on a site will be preserved simply by leaving areas undisturbed: no removal of forest cover, no tracking heavy equipment across an area, and no grading or removal of topsoil. However, without completely limiting all development, some soils are going to be disturbed. Fortunately, the same methods that can be used to restore a poorly-functioning soil are even easier to use before an area has been seeded or planted with vegetation.

Other opportunities exist for improvements in protection during the construction phase of projects. One opportunity is to increase the frequency of inspections of construction sites. This could be pursued either via additional staff capacity and/or additional volunteer efforts. The Friends of Bolin Creek have led efforts to train volunteers via the statewide Muddy Water Watch program. Another consideration is that there are ongoing policy investigations at both the federal level and at the state level to adopt new erosion control legislation that would significantly increase the scope of regulations to not only address installation and maintenance of management measures, but require performance standards for turbidity leaving a site as well.

LOW IMPACT DEVELOPMENT

Prevention of further channel erosion and habitat degradation will require effective post-construction stormwater management for all new development in the watershed. Current (and proposed) development regulations for stormwater management have focused on two primary environmental concerns: flood management in the form of peak flow and total volume, and water quality in the form of total suspended solids (TSS) and nutrient concentrations and loads leaving a site. However, even with the best available stormwater management approach, the total volume and peak rate of flow from a developed site can not completely mimic the natural flow volume and peak rate from an undeveloped state. The explicit goal of Low Impact Development (LID) is to maintain a site's hydrology as close as possible to that undeveloped state.

Low Impact Development techniques combined with engineered storm water management practices can be used to achieve volume control that exceeds current regulatory requirements and provides additional protection. The goal of LID is to develop site design techniques, strategies, BMPs, and criteria to store, infiltrate, evaporate, retain, and detain runoff on the site to replicate pre-development runoff characteristics and mimic the natural and unique hydrology of the site thereby minimizing hydrologic alterations relative to pre-development conditions. With LID, storm water is managed in small, source control landscape features rather than in large structures located at the downstream extent of drainage areas. However, ponds may be required in addition to LID practices to create a "treatment train" designed to satisfy volume control performance criteria. Through LID, hydrologic functions such as infiltration, peak and volume of discharges, and ground water recharge can be maintained with the use of reduced impervious surfaces, functional grading, open channel sections, disconnection and utilization of runoff, and the use of landscaped bioretention/filtration areas. The net result will be to mimic the site's natural hydrologic functions or water balance between runoff, infiltration, storage, ground water recharge, and evapotranspiration. With the LID approach, receiving waters experience little change in the volume, frequency, or quality of runoff or in the base flows fed by ground water.

There is a wide array of impact reduction and site design techniques that allow the site designer to create storm water control mechanisms that function in a similar manner to natural control mechanisms (see Table 11). In technical terms, LID provides an added layer of protection by both increasing the time of concentration (T_c) and decreasing the runoff curve number (CN). Time of concentration is defined as the time required for runoff to flow from the most remote point of a drainage area to the outlet or downstream most point in a drainage area. The runoff curve number is an empirical parameter developed by the USDA Natural Resources Conservation Service and used in hydrology for predicting direct runoff and infiltration. It is widely used and is an efficient method for determining the approximate amount of direct runoff from a rainfall event in a particular area, based on based on the area's hydrologic soil group, land use and cover, treatment and hydrologic condition.

An example of a specific LID performance standard is that no one BMP shall receive runoff from an area greater than, for example, five (5) acres. LID can be a challenging standard to meet, and one that is most frequently implemented for lower-density development. The Pacifica development in Carrboro presents an example of a successful extremely thoroughly studied higher density LID project. In many cases, the LID approach will allow developers to save money by reducing infrastructure costs.

Table 11: Low Impact Design Techniques

Low Impact Design Goals	Flatten slope	Increase flow path	Increase sheet flow	Increase roughness	Minimize disturbance	Flatten slopes on swales	Infiltration swales	Vegetative filter strips	Constricted Pipes	Disconnected impervious areas	Reduce curb and gutter	Rain barrels	Rooftop storage	Bioretention	Revegetation	Vegetation preservation
Increase Infiltration					X		X	X		X	X			X	X	X
Increase Time of concentration	X	X	X	X		X		X	X	X	X	X	X	X	X	X
Retention							X	X				X	X	X	X	X
Detention						X			X			X	X			

CRITICAL LAND PROTECTION

The upper part of the watershed contains currently undeveloped or minimally developed lands with the most likelihood of future development, whereas the middle and lower watershed will see little new development but some redevelopment in the coming years. This low-density and rural land is almost exclusively all in Carrboro's Northern Transition Area. As new development that level increases, will there be sufficient regulatory methods to ensure that stream runoff and associated pollutants and stresses will not increase and cause further impact on the already stressed stream channels and biota?

High conservation value lands for a variety of ecological services have been identified in the past in multiple studies, including the EEP Local Watershed Plan, a study of land conservation for terrestrial wildlife (“Landscape for Wildlife in Orange County”), and a conservation study and newly adopted conservation requirements for Carolina North, 900+ acres of largely undeveloped university property in the middle of the two Towns. The North Carolina Wildlife Commission has also developed a “Green Growth Toolbox”, with specific recommendations presented to Orange County governmental staff, that provides conservation oriented recommendations for “greener” developments. Education and outreach to all stakeholders and ongoing consideration of approaches to better protect critical lands is a necessary component of watershed management efforts.

RECOMMENDATIONS FOR PROTECTION

The following steps are recommended to further extend watershed protection for developing and redeveloping lands.

Local governments can encourage and require where possible that stormwater management for new development use “Low-Impact Development” techniques. LID practices or a combination of LID and conventional storm water management practices can be used to control and treat the increase in storm water runoff volume associated with postconstruction conditions as compared with preconstruction (existing) conditions. This may be achieved by hydrologic abstraction, recycling and/or reuse, extended detention or other accepted management practices that increase the time of concentration and decrease runoff curve numbers, and address geomorphically relevant flows. One specific step that Carrboro can take is to add a provision like Chapel Hill’s in its Land Use Ordinance for stormwater volume control. A regulatory step that both local governments can take is to encourage LID by limiting the area that any one BMP can treat. Local governments can increase their capacity for inspection and enforcement of relevant local regulations, including erosion control, stormwater management, buffer protection and integrity, and other relevant ordinance provisions. Local governments can also review and amend ordinance provisions that provide additional steps to increase infiltration and interception through soil, vegetation, and runoff management and additional protection of watershed critical areas. Carrboro can specifically review and update its Land Use Ordinance for open space protection to include approaches to insure that required open space is composed of substantial areas that provide ecological services. As is, significant areas of open space can include recreational playfields, utility easements, and other areas that provide minimal ecological services, including maintenance of hydrologic functions.