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POLICIES TO PREVENT EROSION IN ATLANTA'S WATERSHEDS: Accelerating the Transition to Performance

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Ken Jones, Ph.D., *Senior Consultant*
Executive Director, Green Mountain Institute for Environmental Democracy
Michele Witten, *Consultant*
Susan Thomas, *Consultant*
Green Mountain Institute for Environmental Democracy

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26 State Street, Suite 12, Montpelier VT 05602 — www.gmied.org

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1. Progress

The Chattahoochee River and its tributaries flow through the heart of the booming Atlanta metropolitan area, creating a unique environmental and political challenge: ensuring that the ongoing construction of roads, houses, schools, and commercial centers does not accelerate erosion of Georgia's soils and the consequent sedimentation of lakes, ponds, streams, and the Chattahoochee itself. This white paper examines the economic and ecological rationale for reducing erosion and sedimentation; describes the changing technical, legal, and financial tools available in the region to do so; and offers a policy framework for evaluating options for further action.

The paper will develop four key points:

- Developers, regulators, and the general public in the metropolitan Atlanta area are just beginning to take seriously the impacts of sloppy development practices. For many years, sedimentation and erosion have imposed significant costs on the people and ecosystems downstream of development sites; this paper will describe those costs and link them to the policy decisions necessary for changing construction practices.
- Recently developed regulatory tools may create the legal and financial incentives needed to motivate project-owners and developers to more effectively control erosion and reduce sedimentation.
- Experience in the metropolitan Atlanta region with new approaches to designing and developing sites shows that by integrating erosion-control systems into developments, project-owners and contractors can significantly reduce erosion at nominal additional expense—usually less than 1 percent of the cost of construction. The marginal costs of designing and implementing controls that actually work—as opposed to steps that satisfy a permit requirement but fail to protect water quality—are small compared to the benefits they are likely to bring to the broader community.
- Changing the way sites are developed in the Chattahoochee watershed around Atlanta will require new approaches not just by developers and state and local regulators but also by landowners, business leaders, community groups, environmental activists, and individuals. Progress will require both new levels of cooperation among those groups and new levels of inspection and enforcement activity by regulatory bodies.

The paper concludes that the region appears to have in place the tools it needs to meet its challenge, though it still lacks some of the institutional capacity, shared knowledge, and commitment required to deploy those tools effectively.

The paper focuses specifically on environmental impacts from residential, commercial, and linear development (e.g. road-building). The paper focuses on the geographical area around Metro Atlanta and the impact of development there on the ponds and tributaries of the Chattahoochee as it flows through the area and beyond. In many ways, however, the environmental, legal, and policy issues described in this paper have statewide significance and must be viewed in a statewide context.

This examination of the Chattahoochee as the primary watershed in the Metro Atlanta area has taken place during a time of rapid change in public attitudes and public requirements. The condition of Georgia reservoirs has become a focus of news coverage due to the combined effects of recent drought conditions and increased sedimentation.[1] The Clean Water Initiative issued a report in November 2000 on how best to make environmental progress.[2] In August 2000, the Georgia Department of Natural Resources adopted a new general permit[3] relating to construction activities that is designed to produce significant improvements in water quality over the coming years. In the fall, the department also amended its rules for construction within stream buffer zones for the purpose of erosion and sedimentation control.[4] Those legal instruments redefine the public's expectations of private landowners and developers and provide the state government with stronger leverage to require more careful development practices. This white paper takes the new permit and rules as the starting point for thinking about how the players in the Chattahoochee watershed may develop more effective approaches for erosion control and sediment reduction.

The authors of this white paper also take as a given that the people of Georgia and the Chattahoochee watershed in particular have adopted erosion control and sedimentation reduction as a legitimate public purpose. Likewise, the authors take as a given that continued economic development is a shared public goal. The white paper does not advocate more or less development or conservation. Rather, it attempts to illuminate for the benefit of the general public and policymakers in the Atlanta area and statewide how their governance of the Chattahoochee is changing and what additional steps would produce the broadest public benefits.

2. The Problem: The Causes, Costs, and Consequences of Sedimentation

Sedimentation and turbidity are problems anywhere people disturb the soil or disrupt the natural vegetation that holds the soil in place when it rains. Georgia's rivers ran red with mud and sediments when farmers tilled the soil and still run red when rains wash over construction sites where dirt is exposed. The resulting erosion and sedimentation take a toll on the plants and animals that live in those rivers. Sediments also reduce property values by filling in ponds, exacerbating flooding, and diminishing the aesthetic value of surface waters. Sediments raise the cost of hydroelectricity by scouring turbine blades and reducing the volume of impoundment areas. Sediments raise the cost of making public water supplies fit to drink. Turbidity reduces the quality and economic value of recreational opportunities that clearer rivers provide. Inadequate erosion prevention or sediment controls by one party inflict costs on those downstream and spawn lawsuits, social conflicts, and the need for government intervention. To many, erosion and sedimentation is a moral problem beyond quantification: a symptom of broader failure to protect the environment.

This section of the white paper characterizes the sedimentation and turbidity problems in sufficient detail to illuminate their causes, some of their direct costs—and who pays them—and some of the consequences that are not easily quantified. The latter include the ecological and aesthetic harms that flow from unnaturally high turbidity and concentrations of sediments and mud in surface waters. The section concludes with a table summarizing those costs, but it does not attempt to sum them. The available data would not support such a tally; they do, however, demonstrate that the region and the state government are fiscally prudent to be searching for cost-effective ways to prevent erosion and control sedimentation from construction sites.

a. Trends in sedimentation in the Chattahoochee 1800-2000

Erosion and sedimentation are natural processes in rivers. Indeed, they are among the forces that have shaped the landscape. Human activities can alter erosion and sedimentation and are the focus of this analysis.

Figure 1, from a 1995 report on scientific and regulatory issues of erosion and sedimentation in Georgia,[5] shows a history of sedimentation reflecting changes in land use. In the early part of the 20th Century, agriculture was a predominant land use in Georgia. Farmers at the time paid insufficient attention to soil conservation. As a result, huge

Figure 1. Annual mean total suspended solids concentrations in the Chattahoochee River (from Hewlett and Nutter, 1969).

Kundell & Rasmussen (1995) p. 9

Note: figure altered to exclude plot lines for two additional rivers.

soil losses resulted in extensive sedimentation in the Chattahoochee (as well as in many rivers throughout the Eastern United States). From the data reported by Kundell and Rasmussen,[6] we estimate that several millions of tons of sediment were displaced in the Chattahoochee basin during the first half of this century. The implementation of better agricultural practices and the conversion of agricultural lands to forest resulted in sharp decreases in sedimentation.[7]

Within the past 30 years, increased and intensive economic growth has resulted in increases in sedimentation and turbidity which, if shown on Figure 1, would send the dotted line sharply up again. The Atlanta area is one of the fastest growing parts of the country. Some 50 acres of trees are cleared for development each day, local experts assert. During heavy rains, tens of thousands of tons of sediment are added to the Chattahoochee basin.[8] Sedimentation downstream from urban and suburban areas is now more significant than sedimentation from agricultural lands or silviculture.[9] Development has exacerbated sedimentation in two ways:

- during construction, when disturbed soils are highly erodible, and
- after construction is complete, when larger areas of the landscape are covered with buildings, roads, and parking lots. Those surfaces are impervious to rain, so water runs off them faster than it would an area covered with plants or trees. The increased speed and volume of the runoff increases its capacity to erode soils. In addition, runoff from impervious surface carries with it the dusts and dirts from natural and human-caused activities. Areas that are converted from natural vegetation to impervious surface result in the migration of that sedimenting material to streams and rivers rather than adding to soils through the normal infiltration process.

This paper focuses on sedimentation caused by both factors resulting from development.

Erosion and sedimentation are dynamic processes, so their impacts are constantly changing at any given location. A storm may deposit a heavy load of sediment in a small pond or a stretch of stream. The sediment may stay there for a few days or a few years, until a storm of sufficient magnitude flushes it downstream. This paper notes that some of the consequences of erosion and sedimentation are felt locally and some basinwide. For this discussion, the local impacts are those that can be attributed to a particular source of the sediments; basinwide impacts are those that result from multiple sources. The importance of this difference is for considering the assignment of damages. Local impacts can be more directly assigned to a particular development while basinwide impacts cannot.

b. Defining and measuring the problem: turbidity and sediment

The physics of the erosion and sedimentation problem need to be considered by policymakers if they are to devise appropriate control strategies. When stormwater erodes Georgia's soils it may mobilize particles of very different sizes, from fine clays to sands, gravels, and even rocks. The finest of those particles tend to stay suspended in the water column, making the water cloudy or "turbid" and reducing the capacity of light to move through the water. (The degree to which light is scattered by these particles is measured in

"nephelometric turbidity units" or NTUs.) The heavier particles settle out faster as sediments. (Measures of "total suspended solids" are given in terms of mass per volume of water, such as "milligrams per liter" or mg/l.) The velocity of the water determines how long particles of different sizes stay suspended: the more energy there is in the system, the greater the mass it can mobilize and suspend. The particles cause different types of problems when they are suspended and when they settle out as deposits on land, in streams, ponds, or lakes.

Suspended clays degrade the value of water for many human uses, including drinking and industrial purposes. Even if turbidity does not leave water undrinkable, the reduced aesthetic quality of "dirty" water imposes costs on those who must use it. In streams, rivers, and reservoirs, ecological damages from suspended clays are typically restricted to sensitive species, unless the turbidity exists for long periods of time, is frequent, or particularly heavy. In addition, suspended solids—particularly clays—are carriers for nutrients, toxic materials, and pathogens, each of which may create ecological problems or require additional treatment before the water is safe for human use.

The deposition of the heavier sands or silts as sediment can be problematic in stream channels, reservoirs, and floodplains. The primary economic impacts are constraints on human uses of rivers and reservoirs. Rivers laden with sediments are harder to navigate and function less effectively in transporting flood waters. Sediments result in reservoirs with reduced capacity to store water for recreation, flood control, or hydroelectric generation. A costly remedy for excess sediment buildup in waterways is to remove the sediment through dredging, which can create negative impacts. The damages from sediment accumulation are different from damages caused by suspended sediments. Aesthetically, sediment reduces the size of small ponds and may make the bottom of recreational waters less pleasant. Biologically, the deposition of sediment upsets the life cycle of aquatic species including fish, plants, and insects. Fine particles can flocculate in reservoirs, creating a layer of smothering mud on the bottom.

There are strong links between these two kinds of problems. Turbidity results from the mobilization of sediment materials and whenever turbid water slows, its suspended material—principally the sand and silt—settles to become the muck, sand, or gravel at the bottom of the river and reservoir. However, the differences are important when considering how to monitor and regulate erosion and sediment control practices. Evaluating turbidity requires in-stream monitoring, particularly during heavy rains, and evaluating sediment loads requires the modeling of soil loss from sites as it relates to its transport and deposition rates at different stream flows.

In both regards, the authors of this white paper could find few reliable data about the Chattahoochee. To our knowledge, there has been no reliable estimate of sediment loads in the river since the 1960s, nor the collection of consistent data about turbidity and water quality.[10] The lack of data reflects the lack of concern the region—and the state—has shown for the problem. Indeed, many residents accept turbid waters as a natural phenomenon and remain unaware of the causes and consequences of the problem.

c. Site-specific or local damages

Local damages from sedimentation resulting from construction practices are the types of occurrences that people can see, such as sediment filling culverts, or clay deposits on landscaped yards or along the side of streets. A walk in the woods near a construction site might reveal small streams running through clay deposits rather than through natural stream channels.

There are two important reasons to consider these local impacts separate from more general basinwide impacts. First, each local event provides fresh motivation for local residents to increase their scrutiny of construction practices and regulation. Second, the direct impacts from local damage provide evidence to enforce permit requirements on individual developments. In fact, local residents' and regulators' major concern related to the issue of sedimentation is the damage that results from identifiable construction sites.[11]

There are tens of thousands of ponds in the Metro Atlanta area (4,529 in Fulton County alone).[12] Although there is no formal census of those ponds, water-quality experts assert that nearly all have been affected to some degree by sediments flowing into them from disturbed soils. There are more than 1,000 miles of rivers and streams in the Atlanta metropolitan area that the Georgia Department of Natural Resources identifies as degraded[13]; many of those miles have been severely degraded by development. In extreme cases, sediments from upstream have filled people's ponds or stream channels. Such an event has an obvious economic impact on the pond's owner who must either get the pond dredged or get by without the aesthetic quality of the pond. In less extreme cases, the clear water and sandy bottoms of streams or ponds are left turbid and mucky.

Several studies compiled by the U.S. EPA show that property values in residential communities are increased 5 to 30 percent by the presence of ponds. Therefore, it is reasonable to assume that the filling of these ponds decreases the values of the adjacent properties. The remediation of damage by dredging costs thousands of dollars per event.[14] Sometimes these costs are borne by the developer, but in other cases, the downstream pond owner picks up the bill.

To get a sense of the order of magnitude of the damage caused by such sedimentation, consider that in the 18-county Atlanta metropolitan area, there were some 1.1 million housing units (850,000 of them were owner occupied), with a median value of $105,000 in 1996.[15] If approximately 5 percent of those units were close to ponds and 10 percent were close to streams or the Chattahoochee itself, the value of some 165,000 properties could be tied to the quality of those waters. At the median value of $105,000 per unit, the total value of those properties would exceed $17.3 billion. If degraded water quality reduced the value of those properties by just 1 percent—knocking down the value of a $105,000 home by $1,050—the total lost property value in the region would be on the order of $173 million. Using a geographic information system, a more detailed analysis could map water quality in the area and the value of nearby properties, then adjust for the severity and duration of the degradation. Even if there were water quality data available that tracked turbidity and sedimentation over space and time in the Chattahoochee area—

and there are not—such an analysis would beyond the scope of this paper. Whether the actual loss is closer to $100 million or $200 million, this admittedly crude estimate is a useful reminder that construction activities that degrade ponds and streams impose economic losses on those who have already invested in the area.

Inadequate erosion prevention on construction sites can send tons of mud across property lines, damaging not just waterways by lawns, landscaping, trees, and structures. Homeowners have reported that the cost of replacing sod and landscaping from such incidents can cost hundreds or even a thousand dollars[16]. Restoring stream banks can cost on the order of $10,000, and dredging a small pond from $10,000 to $30,000. Dozens of victims of such events sue contractors or development owners each year in the Atlanta area, generally on the basis of "trespass and nuisance." The typical victim sues for $10,000 to $30,000, though some settlements have been for several hundred-thousand dollars. When the plaintiffs collect, any of several parties responsible for the development may pay the award, resulting in lost profits or higher costs to those who ultimately purchase or rent property at the development. Property owners adjacent to construction sites may ask government agencies to stop work on the site it they feel threatened by inadequate practices; those delays and occasional fines also add to the developers' costs.

Ecological impacts can be very dramatic on a local scale. Small streams can be severely degraded, new channels formed, trees smothered, fish habitat eliminated, wetlands filled, and new wetlands formed. There have been no well-documented efforts to capture the kinds of local impacts that result from sedimentation. The wide range of local conditions with respect to slope, proximity to waterways, and in construction practices makes estimates for those damages very difficult to approximate. Many people place considerable economic value on natural resources even if they do not "use" them and no financial transactions ever indicate their price. This study could not attempt to estimate the non-use values of the area's ecosystems. It is worth noting, however, that the cost of stream restoration is high. There is a wide range of restoration costs but examples from the U.S. Fish and Wildlife Service include projects that cost $10 to $250 per linear foot or from $50,000 to more than $1 million per mile. As noted above, the Georgia Department of Natural Resources has reported to the U.S. EPA that more than 1,000 miles of streams and rivers in the metropolitan Atlanta area are degraded, suggesting a potential restoration cost in the hundreds of millions of dollars, should the community decide to make that investment.

d. Basinwide damages

Easier to evaluate are the impacts that result at the basin level. The transport of sediment from multiple sites can have the more dramatic impacts on the Chattahoochee or its reservoirs. In addition to construction site sediment sources, sediment in the basin is the result of overall development and expanded impervious surface. Surface water quality is seriously degraded whenever development results in impervious surface greater than 20 percent and in the metropolitan Atlanta area, development in the past 30 years has tripled

the area with extensive impervious surface.[16] By 1995, about 30 percent of Atlanta's 13-county metropolitan region was classified as urban by the U.S. Geological Survey. Basinwide impacts are evidenced within the main stem of the river and its reservoirs. Major water withdrawals and recreational activities are two of the focuses for these kinds of damages.

Water from the Chattahoochee basin is currently used at a rate of about 450 million gallons per day to meet the demand for public and private drinking water supplies, and other residential, commercial, governmental, institutional, and industrial uses.[18] Local water management authorities supply water to households for domestic uses. That water must meet federal standards, including standards on turbidity. A report in *The Atlanta Journal and Constitution* noted that the Cobb County Marietta Water Authority had to use $300,000 of its $4 million operating budget on increased chemical costs for treating mud and silt from its Lake Allatoona source in early 2000.[19] This single case is consistent with a general study of 12 water treatment facilities in Texas, where increases in turbidity were shown to raise chemical treatment costs $5,000 per ton of sediment in the source water.[20] In addition to the dollar costs, there is an increased chance for bacterial contamination when suspended solids are introduced into a drinking water supply. Well maintained public water supplies rarely allow biological contaminants to reach users, but incidents can happen, such as the 1993 cryptosporidium outbreak in Milwaukee which left several people dead and many more ill.

Impacts of turbidity and sedimentation on reservoirs and hydroelectric facilities impose significant costs on utilities and the public. The capacity of reservoirs can be reduced significantly, thereby decreasing their value in flood control, as recreational assets, and as water storage for electricity generation. Sedimentation rates in West Point Lake, downstream from Atlanta, are almost 1.5 inches per year.[21] The upper and middle Chattahoochee produced approximately 1.25 billion kilowatt hours of electricity in 1990.[22] The marginal costs for hydroelectric generation are typically less than one cent per kilowatt hour and as low as one-tenth cent, making the operating costs for generating this electricity between $1 million and $10 million per year.[23] The damages related to suspended solids in the intake waters are a part of those costs. More importantly, the wholesale cost for electricity is between 2 and 4 cents per kilowatt hour;[24] if sedimentation were to reduce the available capacity for generating electricity, the value lost could be as high as $25 million to $50 million per year. The impacts from reservoir sedimentation can be remedied through dredging, but dredging results in additional monetary costs, which in this case would be borne by the users of electricity rather than by those who produced the sedimentation.

Related to reservoir management are the occasional catastrophic effects from dam failure that are sometimes linked to increased sediment loads. Dam failures can cause significant loss of life and millions of dollars of property loss. When the Kelly Barnes dam in Georgia failed in 1977, 39 lives were lost. Other increases in flooding damages take place when river channels are affected by sedimentation. Flooding is exacerbated by a related trend: the increase in impervious surface that occurs with urbanization, such as that taking place in the Metropolitan Atlanta area. Sedimentation reduces the capacity of rivers to move water even as extensive impervious surfaces cause a decrease in floodwater retention, moving more

water into the rivers. Impacts from increased flooding were reported from the July 1994 Tropical Storm Alberto.[25]

The 1999 drought exacerbated problems in the reservoirs of northern Georgia and reduced their value for recreational use. Five owners of residences on Lake Lanier paid $100,000 to dredge sediments from their lakeshore, sediments reported to have come from nearby development. The dredging was necessary for these landowners to maintain access to their boats as water levels fell.[26]

In 1998, the Roswell city council agreed to help pay up to $500,000 for the dredging of Stanford Lake, which had been degraded by sediments from development upstream. Residents were asking the county to match that sum. The total dredging project was expected to cost $2 million.[27] Property owners adjacent to the lake would pay a share of that cost, but much would be passed on to other taxpayers, rather than to those directly responsible for the sedimentation.

Other changes in recreational value are important. Officials from the National Park Service report that higher turbidity levels reduce the level of participation in canoeing and rafting. Park visitors write comments urging that someone "clean up the river!" the officials report. No studies have been completed to quantify those impacts.

e. Ecological impacts

Ecological impacts resulting from sedimentation and turbidity are significant but challenging to describe for the Chattahoochee basin. The long history of serious sedimentation eliminates the possibility of evaluating baseline conditions. Therefore, one can only estimate impacts to individual species based on studies in less impacted basins. However, even with this limitation, it has been reported that the ecological condition in the Chattahoochee below Lake Lanier is significantly altered from pre-settlement conditions.[28] Many residents living along tributaries to the Chattahoochee have seen the transformation from clear water to mud in their lifetimes, though there is no comprehensive record of that change.[29]

Certain sediment-sensitive species of fish are missing from the basin downstream from Atlanta that can be found in less sediment-impacted areas. Several of these species are listed as threatened and endangered. In contrast, some species of both warm-water and cold-water sport fishes still reside in plentiful numbers within the Chattahoochee and its tributaries.[30] It is also notable that the Apalachicola estuary, which the Chattahoochee feeds, is recognized as a high quality and highly productive source of diverse species and commercial shellfish beds.

f. Real costs; significant inequity

One of the characteristics shared by nearly all of the costs described above is that the landowner or developer who causes them rarely suffers from the damage or has to pay for their remediation. In economic terms, the developers are able to externalize the costs of

their actions: exporting the damage and cost to someone else downstream, whether an individual or all the potential users of the river below the point of discharge, public and private, now and in the future. Meanwhile, most of the financial rewards of the development accrue to those who caused the problem, rather than to the broader public. This is a classic example of market failure: a situation in which individual actions exploit and degrade a shared public resource. The classic response to such market failure is public regulation to force the costs of the damage back onto the person who would cause it. Internalizing the costs of development through regulation enables markets to work more efficiently and equitably, while also protecting the shared public resource.[31] Absent such regulation, landowners victimized by mud and sediments must resort to the courts and sue for damages. As noted above, dozens of people do so each year in the Atlanta area, but such approaches are generally inefficient and inherently inequitable: the victims with the least resources are the least likely to hire attorneys and win compensation for their losses.

Over the last 30 years, Americans have insisted on stricter environmental regulations to reduce a variety of pollution problems at the local, state, and national level. Over the last few years, public and private environmental organizations have begun to focus more attention on reducing problems associated with surface water runoff. Georgia has begun to move in this direction, as well, as evidenced by the Environmental Protection Division's new general permit requirements on stormwater discharges from construction activity and its addition of 34 new positions to address water quality this year.

This white paper does not purport to justify those regulations on the basis of the damage estimates presented here. It is possible that the regulations will impose greater costs on developers than are necessary or desirable in relation to the benefits that they will achieve. It is also possible that the implementation of the new regulations will prove insufficient to achieve the public's goals. A more rigorous cost-benefit analysis of sedimentation and water-quality degradation might shed a bit more light on that question, though it would probably never be able to prove up-front whether particular regulations or development requirements would be "worth it." In all efforts to estimate all the damages—including the non-use damages related to ecosystem values, aesthetic values, and social equity values—economists must resort to techniques that leave considerable uncertainty in their numbers.

Nonetheless, efforts to estimate costs can provide useful insights into the value of changing policies or practices. Accordingly, the International Erosion Control Association has created an Economic Research Committee to begin taking steps to characterize the economic impacts of erosion.[32] Of more direct utility to those in Metro Atlanta will be the actual experience gained over the next three years as developers and regulators work with the new erosion-prevention regulations.

The challenge in the Atlanta region to quantify the economic costs of sedimentation and turbidity goes beyond the usual problems with the methods used by economists. There is a fundamental lack of physical data upon which to draw. Sedimentation and turbidity in the Chattahoochee have not been a focus of state government monitoring or water-quality

research, leaving no useful maps or records of the extent, duration, or severity of the problems over recent time. That information void reduces the region's capacity to frame solutions and measure their impact. Many other natural resource protection projects across the country have demonstrated that the ability to measure and report resource quality enhances the programs that are designed to protect those resources. Places benefiting from more comprehensive measurement and management strategies include Chesapeake Bay, the Great Lakes, Long Island Sound, and the South Florida/Everglades systems.[33] Over the last few years, the U.S. EPA's New England office in Boston made cleaning up the Charles River a high priority. The regional administrator established an intensive water-quality-monitoring program and defined public goals for the river in terms of improving grades on a report card on water quality. By linking data to decision-making, the region mobilized considerable public action and saw the river's water improve as a result.[34]

Table 1, below, summarizes the available information about the costs of sedimentation and turbidity in the Metro Atlanta area. The costs may be viewed as costs avoided by developers or transferred by them to others. Each of the numbers in the table is intended to provide a sense of the order of magnitude of the problem, not an exact measure. Because of that imprecision it is impossible—and unwise—to sum the figures to produce a "bottom line."

Table 1: Some of the Costs of Sedimentation* —and Who Bears the Loss		
Impact	**Approximate costs**	**Who pays**
A. Local Damages		
Dredging small ponds and streams	$1 million to $10 million per year	downstream landowners
Replacing inundated turf and shrubbery, landscaping	probably less than $1 million per year	downstream landowners
Property-value loss from degraded streams & ponds	$100 million (see explanation)	downstream landowners
B. Basinwide damages		
Dredging large lakes and reservoirs	$1 million to $10 million per year	town & county taxpayers
Drinking-water treatment costs	$1 million to $5 million per year	water ratepayers
Maintenance at hydroelectric facilities	$1 million to $10 million per year	electricity ratepayers
Replacing lost-capacity at hydroelectric facilities	$25 million to $50 million per year	electricity ratepayers
Recreation losses	< $1 million per year	recreation businesses and users
Aesthetic loss/muddy water	unquantified "non-use" value	general population
Ecological damage: reduced or extirpated species	unquantified "non-use" value	ecosystem; general population
Ecological damage: potential remediation costs	>$50 million	taxpayers, private benefactors
C. Legal actions		
Damages awarded to downstream victims of sedimentation	$0.5 million to $1 million per year	developers (and subsequent owners)
Stop-work orders (lost productivity)	<$1 million per year	developers (and subsequent owners)
Construction delays caused by litigation/attempts to stop project	Unknown	developers (and subsequent owners)

* See text for an explanation of these estimates. It would inappropriate to sum the costs.

3. New Tools for Reducing Erosion and Sedimentation

This section of the white paper describes some of the strengths and weaknesses of three new tools available to control sedimentation in Georgia rivers:

a. new approaches to site design and construction management which greatly reduce erosion at relatively low costs, by integrating relatively conventional elements into a truly effective performance-oriented system;
b. new regulatory requirements in the state's NPDES permit for construction activities—one possibility from these new regulations is the movement to results-based regulation (replacing a reliance on "best management practices"); and
c. the use of the TMDL process to link sediment reduction to water quality standards.

These three tools augment the approach that has been in place for years: permits based on demonstrating that construction sites would employ so-called BMPs or best management practices: specific design and construction elements defined in the *Manual on Erosion and Sediment Control* (the so-called "Green Book") produced by the Georgia Soil and Water Conservation Commission.[35] Permit authorities considered it sufficient if developers used techniques described in the Green Book, even if the individual techniques employed at a site did not work effectively as a *system* to protect water quality. By failing to require such a systematic approach and higher performance, the Green Book has not kept up with the "best" erosion-prevention or sediment-management approaches the industry has to offer. The old approach focused primarily on what was happening on the site and did little to focus attention on the ultimate effectiveness of those actions in reducing erosion. The approach did little to focus on the results of the actions, the quality of water leaving construction sites. Demonstrably cleaner runoff was not a requirement.

With the adoption of the NPDES permit in August 2000, Georgia took a step toward that kind of results-based system. This section begins to describe that transition. Section 4 examines the institutional capacity required to make the transition work, and Section 5 outlines a structure to implement change and additional policy considerations that will help guide the transition.

a. Success at Big Creek: attending to details as a new school is built

For a real-world, full-scale example of how construction can be done in Georgia to greatly reduce erosion without greatly inflating costs, regulators and contractors need look no further than the town of Alpharetta in suburban Atlanta where the Dirt II project organized a team to design and implement a comprehensive erosion-control plan for a new elementary school. The Dirt II project hired the team to make the Big Creek school project a demonstration site. The project demonstrated ways that construction processes can be carried out to minimize soil loss and maintain pre-construction hydrology. The project also described the sequence of steps necessary to implement appropriate technologies. One of the key members of that team, Dr. Richard Warner of Kentucky, describes the approach and results in detail in a separate report to Dirt II.

The Big Creek school presented a fairly typical set of challenges for a developer in the Atlanta area. Building the school would require disturbing the soil on 22.5 acres of a 50-acre lot in an affluent suburban area abutted by residential properties. The owners of those properties were vocal opponents of construction that might diminish their quality of life. They would be vigilant guards against muddy runoff. The developer, the Fulton County School Board, wanted to maintain its status as a good public citizen and manage a serious business risk: the possibility of intervention, litigation, delay, and damaged reputation. The school board was also constrained to keep design and construction costs as low as possible while still achieving the project's environmental goals. The site was fairly steep and wooded; clearing and grading the land for development would pose the risk of sending tons of mud downhill toward the neighbors and adjacent streams.

From the outset, the site preparation at Big Creek was innovative in its attention to erosion prevention and sediment controls. Warner, working with landscape architect Mike Breedlove of Breedlove Land Planning, designed sedimentation-control and stormwater-retention strategies using a recognized state-of-practice computer-aided design technique that helped model flows across the site and test the impact of various control options in different combinations. The computer helped the team plan a sequence of installations that would fit the site and the construction schedule. Some of the technologies could be found in the Green Book, others were newer (if not exactly high-tech); nothing in the Green Book, however, would have guided a more traditional designer to deploy the strategies in the combinations Warner planned.

The foundation for implementing better soil-conservation strategies is an integrated approach to site design and construction practice.[36]

The team's selection of sediment-reduction practices at the Big Creek school grew from a holistic approach to the site intended to ensure that the hydrology of the site would replicate pre-development conditions. In this way, rather than determining the volume of water that needs to be managed and designing structures to manage that volume, an evaluation of the overall flows and capacity of the site to allow infiltration is combined with energy-reduction devices and materials management. Most of those techniques are listed in the Green Book, but the proper combination of the techniques is not. Nor has the regulatory structure in the Atlanta area insisted that users of the Green Book achieve any particular results. The team working on the Big Creek school started with a commitment to produce a system that would actually achieve results and then demonstrated that doing so is relatively straightforward.

Among the newer technologies or system components, for example, was the installation of a slightly raised seep berm that served not only to direct stormwater to settling ponds, but also allowed for the more gradual process of directing water down gradient over a large area. The berm slowed runoff and trapped sediments more effectively than typical sediment basins. Consistent with the thorough consideration of erosion prevention and sediment control at the site, plans required the graveling of the access road early in the construction, so that construction vehicles would shed the mud from their wheels on the site and not while driving on public roads off site. Perforated plastic tubing was used on

site to move water down gradient to sediment basins, avoiding erosion on steep slopes and reducing further erosion. During the construction, drains at the top of the site were equipped with "beaver dams"—simple fabric sacks that could collect mud and debris before it could even enter the main drainage systems. After a rain, the mud could be emptied out of the sacks and the "dams" replaced. The project also included a sediment basin with perforated risers, a traditional technology, which functioned as a kind of experimental "control" by demonstrating the superior performance of the more innovative system components and design.

The team's first task was to design the drainage system and erosion controls; its second task was to help the site's general contractor install the controls in accordance with the plan. Contractors have their own way of doing things, and this site's contractor— Beers-Moody Inc.—had to ensure that its employees understood both how and why they had to do their work differently at Big Creek. Warner made a dozen visits to the site during the six months of site work, and developed a strong rapport with the contractors. Because some of the work was experimental, the team occasionally had to adjust the design. The contractor, sensing that the techniques being used at the site would become recognized as the state of practice in Georgia, brought in managers and workers from throughout its operation to observe the work and to begin raising the firm's capacity to offer equally high-quality work on other jobs.

One of the most important features at the Big Creek site was its extensive use of performance monitoring. Monitors were placed in several locations on the site to measure the volume, sediment concentration, and turbidity of stormwater. A series of monitors tracked the progression of stormwater flow through a series of system components or controls. Those efforts allowed the team to draw conclusions about the relative effectiveness of the specific control techniques on site and their interactions in the system.

The efforts of Warner and Beers-Moody Inc. yielded impressive results:

d. monitors showed runoff of no more than 340 NTU after a 3-inch rainfall
e. neighbors saw few problems to complain about
f. the monitoring technologies provided useful performance feed-back information throughout the construction work
g. the much higher performance was achieved at relatively little additional cost, and
h. from the owner's point of view, the project managed an important class of business risk in a technically effective, cost-effective, and socially responsible manner that produced substantial tangible value to the owner, its contractor, and the owner's external stakeholders.

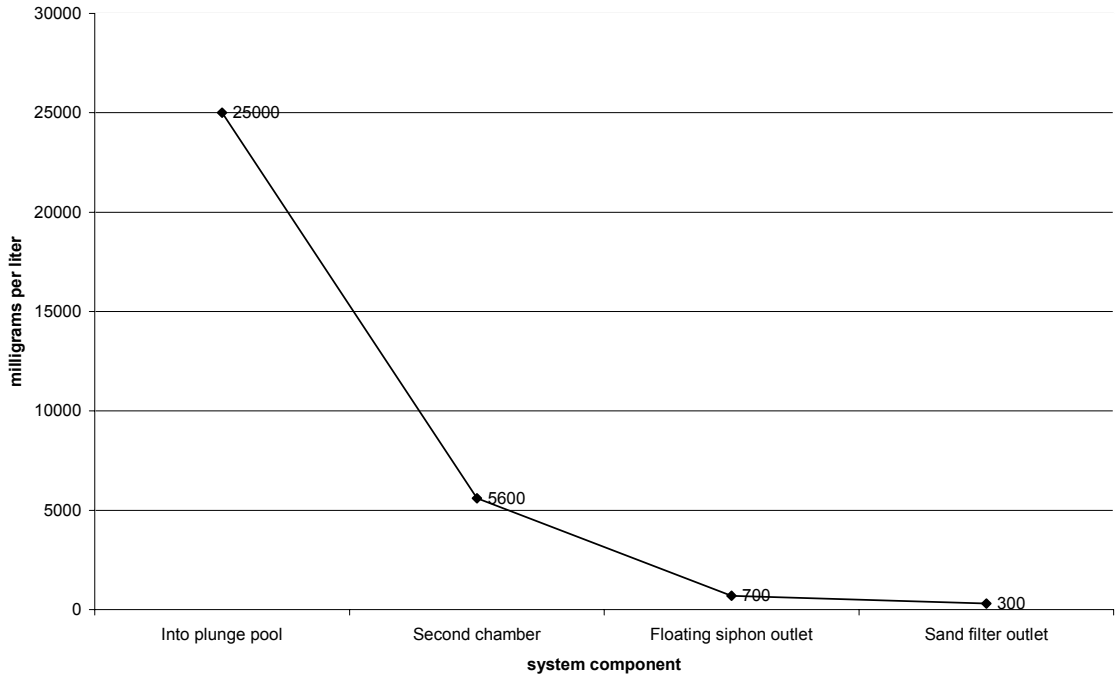
Sediment reduction

The summer of 2000 was very dry in the Southeast, so construction at most sites produced far less erosion and sedimentation than usual. At the Big Creek school site, results were particularly good; and there was sufficient rain to demonstrate the effectiveness of the newer technologies, system components and overall system approach. Several storms yielding more than one inch of rain, and a single storm from

August 31 to September 1 producing 3.36 inches, tested the sediment-control technologies. Nevertheless, there was little soil loss from the site and the overall hydrology of the site seems to have been minimally altered. This resulted in small offsite water flows; by design, most of the precipitation infiltrated on-site. The silt fences that ring the construction site showed no signs of sediment mobilization at the end of the demonstration period. The same retention ponds built to control runoff during construction will handle stormwater flows from the school's roof and parking lot drainage after construction is complete.

Warner measured sediment concentrations at different points in the system during and after the storms. In a brief but intense storm producing 0.9 inches of rain, water flowed into the main retention pond with a sediment load of 160,000 mg/l (16 percent by weight). Much of the sediment settled out in that pond as it filled. Water siphoned off the top of the pond then flowed through the sand filter. By the time the stormwater reached the bottom of the system—and well before any flow left the site—the system had removed all but 168 mg/l of sediments. All of the resulting flow was captured by infiltration in the functioning riparian zone; none of the sediment reached the river. During a storm that produced 3 inches of rain, the system produced similar reductions in total suspended sediments, as shown in Figure 2, and turbidity.

Figure 2: Containing Sediments on Site: Each Component Reduces the Load



Monitors also measured the decline in turbidity during the storm graphed in Figure 2. Turbidity levels were very high in the plunge pool and second chamber, but had fallen to

1050 NTU at the outlet of the floating siphon and to 330 at the outlet of the sand filter. The reduction of sediment and turbidity is one part of the calculation of downstream impacts; the other information (not shown in Figure 2) is the reduction in the volume of water that is managed as stormwater. The Big Creek school's water-management system enhances on-site infiltration and thus reduces the overall impact of sediment and turbidity.

Monitoring systems

Warner installed a series of monitors at the start of site work. The monitors were commercially available and operated throughout the site preparation, providing reliable and useful information about flow rates at various points on the site. Samples were captured by the monitors—and manually—and analyzed. The array enabled the construction team to track events at the site. The team removed the monitors at the end of October 2000 as site work was being wrapped up and the builders were beginning to put the roof and walls on the new school.

Construction costs

Beers-Moody Inc. estimated the cost of each of the design elements in the erosion-prevention system. Those estimates suggest that the innovations added relatively little cost or delay to the project. Beers-Moody priced the erosion-control work at $290,000, or about 9.7 percent of the $3 million cost of preparing the site or about 2.3 percent of the $12.5 million total construction budget for the school. Developers typically expect erosion-control work to account for about 2 percent of total construction costs, so the increase of just three-tenths of a percentage point appears to be a relatively small sum, given the superior results of the system at Big Creek school. The total value of construction in the Metro Atlanta area is estimated at $1 billion to $2 billion per year[37]; if as much as an additional 1 percent of that cost is used to prevent erosion during the construction, the total cost of protecting the region's waters from runoff at new construction sites would be between $10 million and $20 million.

Over time, as other contractors install similar systems, they should find the least costly ways to install them and their bid-prices should more accurately reflect the true costs. In most pilot projects, testing an innovation costs much more than the same work does once it becomes routine.

Thus, it is fair to conclude that using techniques like those tested at Big Creek will add relatively little if anything to the developers' total *out-of-pocket* costs and are unlikely to impose a significant damper on the construction industry or the growth of the Metro Atlanta area. Indeed, the superior performance of a state-of-practice system may save the owner or the contractor significant sums in avoided restoration work or bad publicity. Most significantly, practices like those used at Big Creek school that reduce erosion and sedimentation reduce the *total* costs of the project by reducing the substantial social, economic, and ecological costs imposed on people and places downstream.

b. The NPDES permit requirements

It is quite possible that many site owners, developers, and contractors would choose to employ recognized state-of-practice techniques such as those demonstrated at Big Creek, simply as a way of reducing the potential of an erosion disaster at their site and the consequent expenses, delays, litigation, and embarrassment. Experience in Georgia and elsewhere suggests otherwise, however. As documented earlier in this paper, developers have tended to transfer the costs of erosion downstream to others rather than internalizing the cost of prevention. It is worth recalling that among all the costs listed in Table 1, above, all of the big-ticket ones were borne by the general public, including downstream homeowners. Of the costs borne directly by developers, damage awards for lawsuits cost are probably less than $1 million per year[38], substantially less than the $10 million to $20 million developers might have to invest in erosion prevention to minimize their liability and their damage to water quality. Rational self-interest alone would not compel Atlanta-area developers to reduce their environmental impacts, at least not in the short term.

In the broad sense, that market failure is one reason why the Georgia Environmental Protection Department revised its regulatory approach to construction sites in June 2000 with the adoption of its new permit requirements for large construction sites under the federal National Pollution Discharge Elimination System (NPDES). The requirements of the federal Clean Water Act and a court case provided the state with a more direct incentive to adopt the new permit. During the early 1990s a criminal case against a contractor worked its way up to the Georgia Supreme Court. The court ruled that in the absence of a specific permit for reducing erosion and sedimentation, the state had to evaluate the developer's actions against four somewhat ambiguous criteria. The statewide requirements of the NPDES permit are intended to reduce the ambiguity in applying the court's criteria. The requirements could significantly reduce sedimentation from construction sites. They could also be the impetus for the start of results-based management of construction sites.

Prior to the new NPDES permit system, Georgia law required most developments to obtain a permit before disturbing the soils on a site. Counties and municipalities granted those Land Disturbing Activity Permits in most cases. The Environmental Protection Division of the Georgia Department of Natural Resources (EPD) gave the authority to county and municipal governments to grant those permits if they could show they had the resources and evaluation standards necessary to ensure compliance with the law. To get a permit, developers needed to file an Erosion and Sediment Control Plan. The basis of the plan was a published guidance document, the Manual on Erosion and Sediment Control—the Green Book—produced by the Georgia Soil and Water Conservation Commission. The Green Book specifies the capacity of certain erosion-control technologies under certain soil, slope and vegetation conditions. The permit process did not require applicants to demonstrate that their plans would achieve a specific performance result, however, merely that the project would use techniques included in the Green Book.

Contractors and landscape architects interviewed for this study identified three problems with the old permit approach:

a. adherence to the Green Book in site planning was not uniform
b. adherence to the Green Book was not sufficient to ensure adequate erosion control, and
c. adherence to the plan by individual contractors, on a day-to-day basis, was uneven at best.

As a result, erosion and sedimentation continued, with resulting muddy water and filling ponds. The pressures of the marketplace encouraged designers and contractors to use techniques that would minimize their direct out-of-pocket site-preparation costs. The marketplace did nothing to require those parties to internalize the full costs of their projects. Although the regulations adopted in 1975 were probably more effective than what had gone before, they were insufficient to reduce sedimentation or protect the water quality of the state. The regulations were also inadequately enforced.

EPD's new permit requirements became effective on August 1, 2000. The new NPDES permit differs from the Land Disturbing Activity Permit in three significant ways.

First, the NPDES permit is granted by the state (and it is ultimately enforceable by the federal EPA). There is no condition in the permit for the state to delegate permit authority to local jurisdictions. EPD review may ensure a more consistent evaluation of the required erosion-control plans and more consistent implementation of the erosion-prevention and sedimentation-control practices statewide. If the disturbed area is to be greater than 5 acres, permit applicants must submit to the EPD a comprehensive erosion-control plan signed by a licensed professional who attests that it will meet the state's requirements.

Second, the permit requires the developer to monitor water quality related to sedimentation. Each permit proposal must include a plan for a comprehensive monitoring program signed by a licensed professional. The programs must provide for in-stream monitors to measure turbidity levels during rain events. The developers must report the results of those measurements to EPD at least once a month during construction.

The third significant innovation in the permit could eventually lead to a fundamental change in Georgia's policy of sediment control and related water-quality protection. The new permits are still based on the applicant's use of the practices specified in the Green Book, but developers will have an option of adopting a performance-based approach instead. Rather than justifying the permit solely on the basis of the technologies that will be in place on the site (regardless of their likely effectiveness in protecting water quality), the permit applicant could propose being held accountable for the quality of the water flowing from the site. Although there appear to be few incentives in the system to encourage developers to choose that option, some may choose it and demonstrate its value over the three-year life of the NPDES permit.

Those changes in the permit requirements will demand that development owners and contractors pay much more attention to sediment control. It is too early to determine, however, whether that attention will translate into better on-site practices and reductions in soil loss from construction sites. At the time this report was being written, some four

months after the permit requirements went into effect, there was still considerable uncertainty in Georgia as to how EPD will interpret those requirements.

One of the key sections of the requirements describes acceptable "management practices and permit violations."[39] Two of the four items in the section describe quantitative limits in the amount of sediments sites may discharge without being deemed in violation of the permits. One of those sections stipulates:

> "A discharge of storm water runoff from disturbed areas where best management practices have not been properly designed, installed, and maintained shall constitute a separate violation for each day on which such discharge results in the turbidity of receiving water(s) being increased by more than 10 nephelometric turbidty units for waters classified as trout streams or more than 25 nephelometric turbidity units for waters supporting warm water fisheries…"

"Proper design, installation, and maintenance of best management practices shall constitute a complete defense," the regulations say, against any activities that might result in raising turbidity levels above those described above. A design is to be considered "proper" if it is "designed to control" soil erosion in the most severe 24-hour storm likely to occur in a 25-year-period. "'Designed to control' means the selection and the location of a system of BMPs appropriate for all rainfall events up to and including a 25 year 24-hour rainfall event." Thus, it is up to the EPD staff to determine what is "appropriate"; the permit appears to set a high standard by specifying that an appropriate system should perform well even under extreme conditions. A working definition of "appropriate" will probably emerge fairly quickly as EPD—and possibly the courts—reviews permit applications. By making best management practices a "complete defense," however, the EPD rules step back from letting the monitoring results speak for themselves in determining whether a developer has installed an adequate system.

c. EPA's Interest in "Total Maximum Daily Loads"

Throughout America, most rivers and lakes are much cleaner today than they were a generation ago, largely because EPA and the states have effectively regulated point source dischargers through the NPDES program. Thousands of rivers and lakes still do not meet the water-quality standards America has set for them, however, largely because of nonpoint sources of nutrients and sediments. EPA has recently expanded the use of a tool authorized in the Clean Water Act to make progress in reducing nonpoint pollution, and that tool—the "Total Maximum Daily Load" requirement or TMDL process—is relevant to progress in restoring the quality of the Chattahoochee River and its tributaries.

The Clean Water Act requires each state to designate appropriate "uses" for each water body. Such uses include providing drinking water and opportunities for swimming, fishing, and boating and industrial purposes—such as shipping—which allow people no direct contact with the water. Each state must establish water quality standards that would allow its water bodies to support the state-designated uses. Standards must be higher for uses involving human consumption of the water, for example. States are supposed to monitor streams and lakes to see if their designated uses are impaired, though few states

have adequate monitoring programs. For those river segments that are impaired, states must design a pollution-reduction strategy to decrease the release of the relevant pollutant(s).

Georgia's experience with sediment and "designated uses" is a good example of the challenge of the Clean Water Act. One of the classes of designated use for rivers and lakes is the ability to support aquatic life. The water-quality parameters for supporting aquatic life are not easily determined and are complicated by being interdependent. Georgia does not have a water-quality standard for turbidity or for sedimentation and none of its water bodies are listed as failing to meet their designated uses based on sediment. This is the case despite a general agreement among environmental experts in Georgia that sediment is probably the most important cause of impaired water quality and the alteration of river basin ecology in Georgia.[40]

The U.S. EPA concluded that the Georgia EPD had paid insufficient attention to sediment because the state's water-quality reports in 1998 and 2000 did not include sediments as a pollutant. As a result, EPA has stepped in and is attempting to determine appropriate loads of sediment for some of Georgia's rivers that do not support sufficient aquatic life. Those studies and the recommended strategies to reduce the pollutant loads are called "TMDLs" (Total Maximum Daily Loads) and they are one of the more technically and politically challenging tasks facing state agencies and EPA around the country.

EPA's initial attempt to determine TMDLs for eight Georgia rivers (the Chattahoochee was not one of them) faced criticism from several interested parties, including the watershed associations and university-based researchers. EPA and others continue to work on the challenge, however.[41] Their efforts may ultimately link a suite of sediment-control strategies to water quality and the status of aquatic habitat. The TMDL process may shift the focus on individual pollution-control activities (including sedimentation from construction sites) to more comprehensive strategies designed to achieve measurable improvements in the health of watersheds. For example, strategies to reduce sedimentation may shift from BMP-based permits of construction activities to a basinwide allocation of sediment limits to all identifiable sources: construction sites, farms, forestry operations, and municipal governments.

The ultimate significance of the TMDL process is unknowable at this point because it could easily take several years for EPA and Georgia to establish a sediment-load limit in a watershed. The NPDES permit for construction sites is intended to stand for three years and be revised in the fall of 2003. The two processes could come together to frame a significant policy choice in the near future.

4. Institutional Capacity, Challenges, and Opportunities

Reducing erosion and controlling sedimentation in the Chattahoochee appears attainable but it is not yet self-sustaining. The management and regulatory tools described in Section 3, above, will work only if numerous institutions in Georgia develop the capacity to make them work. This section of the white paper identifies roles that various institutions and organizations might play in advancing the public purpose of improved water quality in the Chattahoochee River and its tributaries. The paper also identifies steps those institutions might take to enhance their capacity to achieve those roles. The overall framework informing this section is a pragmatic one based on the assumption that the most effective ways to make environmental improvements are through efforts to set specific, measurable goals, then manage programs to achieve those goals, measuring results along the way, and adapting strategies as experience indicates.

The Green Mountain Institute for Environmental Democracy has worked with a group of states on using that approach with a range of problems. The institute calls the approach an "environmental results management system" or ERMS.[42] Over the last six years, the National Academy of Public Administration has built a case for performance-based management of environmental problems. The Academy brought that work together in a major report to Congress in November 2000, accompanied by an array of 17 supporting research papers.[43]

a. EPD's challenge

The new NPDES rules place an enormous new responsibility on the Environmental Protection Division of the Georgia Department of Natural Resources. The rules require the department to review permit applications from those who would develop parcels over five acres in size or build a road of modest size. Reviewing the submittals is perhaps the easiest part of the challenge. The department must first articulate clearly what it will consider an "appropriate" erosion-prevention and sediment-control plan. Its definition could determine the extent to which site designers expand their use of integrated management strategies and/or focus on reducing sediment runoff.

One of the potential strengths of the new NPDES permit system is the responsibility it puts on licensed professionals to ensure the integrity of the permitted plans and their implementation at construction sites. Site designers must certify that their plans will do the job; contractors must certify that their work will be in compliance with the plans. One week after BMPs are installed, a licensed professional must inspect them and determine that they were installed and are being maintained as designed; if they are not, the appropriate permit holder must correct any flaws. A licensed professional must also certify that monitoring results are accurate and complete. In practice those requirements essentially privatize the inspection and enforcement functions of the regulations. The system has the potential to work well, provided all of those licensed professionals are well trained in the standards and their professions, and fulfill their responsibilities honestly. EPD will have to enforce the system vigorously to make it clear from the start

that the professionals will lose money, reputation, and possibly their license if they certify work that fails to perform as promised.

Maintaining the integrity of that extended enforcement system will require a sufficient number of EPD personnel who can review plans, inspect construction sites, and monitor stormwater runoff. If EPD does not devote the personnel to "checking the checkers," the entire system will probably fail. The licensed professionals who certify the work must have confidence that their colleagues at other sites are adhering to the same high standards as they are. Otherwise, contractors or developers will push them to compromise on their standards in order save the developers a few out-of-pocket dollars. If the public loses confidence in the network of professionals, EPD will have to bear all of the responsibility of inspecting the projects and enforcing the permits, and that would take significantly more people than checking the checkers.

The EPD is a respected institution with a demonstrated capacity to make regulatory programs work. Neither the state nor county governments has devoted sufficient resources to erosion prevention and sediment control in the past, however. Prior to the NPDES permit, EPD faced challenges in handling the volume of cases related to water-quality impacts at construction sites. In several instances, private landowners had to initiate legal action to stop construction and EPD was unable to provide the inspections or oversight necessary to control practices. The new NPDES permit will increase the department's workload. The recent addition of 34 employees to work on water quality will help EPD meet its responsibilities, but building this capacity remains a technical and financial challenge.

b. Developers, contractors, and design professionals

The Big Creek school project demonstrated that many actors in the system need to catch up with the state of practice in site design and erosion prevention in order to maximize the potential environmental gains while minimizing their costs. Developers and project owners need to better understand the potential of their site; site designers and contractors need to learn new ways to design and sequence construction; workers need experience installing new systems and a keener understanding of their personal responsibility in keeping sedimentation to a minimum. A vigorous enforcement stance from EPD can provide incentives for all of those people to perform, but EPD cannot teach everyone how best to deploy the newer tools.

Market pressures on designers and contractors will motivate considerable learning at a fast pace, provided the market punishes bad actors and rewards good ones. (Enforcement sets that virtuous cycle in motion.) Even within a competitive market, design professionals have an interest in helping each other keep up with the state of practice so that the profession as a whole maintains its reputation. Trade associations, often working with regulators and environmental activists, can provide courses to get essential information out to their members. Larger or more sophisticated firms can mentor their business partners and even some of their competitors. Environmental activists can reward leaders in the field, thereby enhancing their reputations and their standing among the competitors.

There are a relatively few large earth-moving and grading contractors operating in Georgia. Those firms will often compete for public contracts and have very high incentives for maintaining a clean reputation and a well-trained workforce. There are thousands of small contractors and earth movers in the state, however. All it takes is a backhoe or a Bobcat to get started on a small site. Those workers may have no training in erosion control and no clear incentive to learn. Building their individual and collective skills may be the responsibility of the contractors' trade associations. Because local builders often work close to home, local civic groups and watershed associations may also encourage them to adopt better building practices.

Not all construction jobs are driven by private-sector forces, however. School districts oversee school construction; counties and the Georgia Department of Transportation oversee highway construction; and municipalities contract for buildings of all kinds. Those public institutions can help jump-start the transition to better building practices throughout Georgia by emulating the approaches used by the school board at Big Creek. As developers, the institutions should insist on environmentally sound site designs and build high performance standards into their requests for bids. They should evaluate bidders not just on price but on their experience—and success—with new design and construction techniques. Public institutions can create a market for well-trained builders with good records. The public officials have a secondary role to play here as well: explaining to their constituents why they have made erosion prevention a specific feature of their project and how they will measure success. That kind of dialogue helps build the larger public's capacity to make better-informed decisions about environmental protection. It is an essential step in raising the public's expectations of the development community.

c. Environmental organizations

Local and statewide public-interest, conservation, and environmental organizations and activists have several important roles to play in making the new NPDES permit system work. Often, it is an environmental group or a watershed organization—such as the Upper Chattahoochee Riverkeeper—that will know the most about the dynamics of a stream system and be able to spot problems or progress. That capacity enables environmental organizations to extend the EPD's enforcement capacity merely by being vigilant. Members can be watchful at nearby construction sites, reminding the owners and contractors that their performance will be noticed. The larger organizations with an interest in water quality can help bring together citizens, developers, contractors, and regulators to collaborate on problem solving, policy-making, and information sharing. Such watershed-based coalitions may be able to achieve sufficient improvement in water quality to avoid the expense and conflict that may accompany the imposition of a TMDL.[44]

d. Monitoring and reporting

Of all the requirements built into the new NDPES rules, the one that may have the most profound impact over time is the requirement that developers monitor their stormwater runoff during construction. The rules currently require reporting to EPD once a month, but they authorize EPD to request more frequent reports and to specify the format of the reports.[45] That requirement could work in Georgia much as EPA's toxics release inventory has worked nationwide. TRI requires firms to report publicly on their emissions of toxic chemicals. As a result, firms have a constant incentive to reduce their toxic emissions and thereby avoid the bad publicity that high emission rates can bring.

If EPD simply stores the monitoring reports in a file, they will have no such impact. If EPD were to post the reports on a web site, or better yet, require all permit holders to post them there within 24 hours after a storm, the monitoring reports could become an effective driver for improvements in erosion prevention, sediment control, and water quality. Information technologies would make it simple for all larger developers to post their results on a web site and have them available to public inspection in a variety of formats—including maps showing areas where sediment levels would be rising rapidly. Reporting—either voluntary or required—might even take the form of on-site web-cameras which would show any viewer anywhere what was happening at particularly sensitive construction sites around the clock.

A single NTU reading from any given site may do little to advance the public's understanding of erosion or how to manage it. That reading may reveal more about the day's precipitation than it does about the quality of the erosion prevention and sediment control work on site. Over time, however, the results of site-based monitors may provide researchers and site designers with the information they will need to gauge the relative effectiveness of various designs and combinations at different types of sites and under different weather conditions. They should also make possible the complete transformation of the regulatory system from one based on BMPs to one based on—and delivering—results.

Information will not become a driver in the NDPES system as framed in the 2000 permit, however, unless EPD and or environmental groups make a strategic effort to assemble it, interpret it, learn from it, publicize it, and—above all—actually use it in decisionmaking.

And, as rich as the data from construction monitors may be, they will become truly valuable only when related to more detailed monitoring of basinwide sediment flows.

e. A leading indicator

The authors of this white paper cannot claim to know the extent of the impact of the new NPDES rules to date. Our modest research effort turned up some anecdotal evidence that the rules are changing behavior. Landowners and contractors are signing documents acknowledging their legal responsibility for erosion from their sites; this is new. Water quality monitoring is being conducted; most contractors have never done this before. To reduce their development teams' exposure to legal liability, site designers are making

their plans more specific. One firm we interviewed now includes a "Land Disturbance Construction Activities Sequence" with all of its plans, in accordance with the requirements in the NPDES permit. The sequence follows the general line of:

1. Meeting to review sequence
2. Install exit and entrance
3. Flag site boundaries and buffers
4. Clear a path for perimeter controls (such as silt fences, berms, etc)
5. Install retention ponds
6. Complete construction of all perimeter controls
7. Grass or pave all of site except for building footprint
8. Build.

5. A Framework for Continued Progress

At the core of all of the capacity building described above is a single goal: improving the result, the quality of water leaving the construction site and thereby, improving the quality of the waters of the state. By focusing the attention of owners, designers, contractors, workers, public-interest groups, environmental activists, and the general public on that water-quality goal—decreasing the quantity of runoff, its turbidity, and its sediment load—the actions described above could help attain that public purpose.

Results-based management assumes that participants will constantly seek better and cheaper ways to achieve any given result. This could certainly happen in the Metro Atlanta area if local, regional, and state institutions choose to make it so over time.

a. "Plan, Do, Check, Adapt"

Managing for results—focusing on environmental outcomes rather than bureaucratic inputs—is slowly emerging as the preferred paradigm across the nation. A recent report by the Environmental Results Management System initiative provides a summary of the efforts of several state environmental agencies in implementing results management.[46] The basic structure of this approach is captured in four steps: plan, do, check, and adapt. That system can be applied to work for sediment control in Georgia.

Plan: For a given environmental problem, the "plan" step requires the determination of *measurable* objectives for solving the problem. For the case of sedimentation, a long-term objective will be the reduction of sedimentation in Georgia river basins and improved water quality. Such an objective is currently not measurable because of a lack of a baseline and a comprehensive measurement system. Therefore, the state and other affected parties need to design some interim objectives that *are* measurable and will show progress toward the implementation of sedimentation control practices at construction sites. Currently, people are anxious about how the NPDES permit system will unfold; they have widely varying expectations with respect to how that erosion prevention and sediment control will take place. Establishing clear programmatic objectives with respect to implementing strategies for sediment control will be important in developing a common understanding of expectations for site design and contractor practice at construction sites.

Do: Given a set of measurable objectives, contractors, regulators, and other affected stakeholders have a responsibility to make substantive progress toward those objectives. The current regulatory structure, while emphasizing the use of the Green Book in implementing land disturbance practices, allows considerable flexibility in the work of design professionals or contractors. Absent objectives for preventing erosion, that flexibility has simply fostered carelessness. Coupled with sound performance goals, however, that flexibility provides an opportunity for planners and contractors to innovate, to exploit their creative energy. The regulatory and management system can focus on the environmental ends, rather than attempting to prescribe the means. This is the essence performance management.

Check: A significant change from past practices will be required to develop a system to check the progress towards the measurable objectives. As noted above, the requirement to monitor water quality downstream from construction sites will provide some data to a measurement system. However, this information alone will not be sufficient without additional reporting on the progress in changing construction practices, and plan reviews.

Adapt: The most challenging part of a results management system is using the results of the measurement system to change decisions. The EPD has initiated a review process for the NPDES permit, and TMDLs developed for Georgia by EPA have been reviewed recently in a process convened by the Georgia Conservancy and the Institute of Ecology at the University of Georgia. Tying those efforts to specific measurable objectives will close the loop, ensure consistent policy development, and add value to the measurements currently required under the new permit program.

Success with the Plan-Do-Check-Adapt model is possible for most contractors and managers in this system, though implementing the approach requires strong leadership and sustained attention.

The timing is appropriate to initiate a results-management system. The development community is focused on ensuring compliance with the new permit requirements, whatever they may be. That intense focus and willingness to try new approaches will probably be short lived. Soon, new permits will be granted, a new set of practices will be established providing comfort to the development community. Establishing clear objectives soon is necessary to ensure that the new practices produce the intended results.

However, another important consideration is the role of county and municipal officials. Not only do local officials have the experience and historical authority for considering erosion and sedimentation control actions on construction sites, but as we note in this paper, the local impacts from sedimentation are important drivers for ensuring action. Maintaining a strong and effective local presence in reviewing and overseeing construction practices may be useful to maintain the strength of associating site-specific activities with local effects.

b. Synergistic policies

The policy framework described above is intended to maximize the flexibility of individual landowners, site designers, and contractors while providing strong incentives for each of those parties to exercise that flexibility in ways that produce socially responsible results. The key to the ongoing success of the policies—the NPDES permit system in particular—is the strength of the incentives. If there are no negative financial or legal consequences to sloppy construction and the resulting degradation of the waters of the state, that is what the system will produce. If, however, the system rewards ever-more-effective erosion controls with ever-greater flexibility and financial gains, healthier rivers will result.

Several types of policies could create incentives for better performance. The three approaches summarized below would build on—and strengthen—the emergent results-based approach included in the NPDES permit. The full achievement of the policies would require—and reward—a flowering of water-quality monitoring technologies. Thus, the three policies described below could either be the logical extensions of the NPDES permit or, in three years, its replacement, if the NPDES permit process has done little to improve performance.

Maximizing the impact of information

If EPD is successful in implementing the monitoring requirements at major construction sites, the department will create a tool that could generate considerable leverage. EPD or a private organization could gather all of the monitoring results from comparable projects and then compare the relative success of the site designers and contractors in terms of the sediments they allowed to flow off site. If sufficient leeway can be found in the state's statutes governing public contracts, public entities such as school boards, municipal governments, or state agencies, could choose to contract only with those who have demonstrated top-quality work. Professionals would have a strong incentive to compete on the basis of their environmental performance if public contracts were available only to those firms ranking in the top third of an erosion-prevention performance ranking, for example. Moreover, that kind of pressure would encourage firms to seek the least expensive ways to reduce erosion and sedimentation and thus compete not only on quality but also cost. The incentives would reward innovation in site design and construction techniques and that would help reduce the long-term costs of achieving a healthier environment.

An alternative to that approach would hinge on building performance incentives into the contract rather than into the selection process. Contracts could stipulate that designers and contractors who achieve specific water-quality goals during construction will receive cash bonuses. Those rewards would be similar to the incentives offered to contractors for completing projects on or ahead of schedule.

Pollution taxes or credits

A somewhat more direct approach to achieve the same end would require additional regulatory or statutory authority as well as reliable comprehensive monitoring. Georgia could levy a tax on construction sites proportional to the amount of sediment they move into surface waters. A site like the Big Creek school that captures virtually all of its sediments would pay very little; a sloppy version with ineffective controls would pay a lot. Pollution taxes are not common in the United States, but Europe uses them extensively and to good results. The tax would provide a direct financial incentive to innovate, to reduce erosion, and improve water quality. The tax might even be structured in ways that provide additional financial rewards to those firms with the most comprehensive and reliable monitoring systems, making it immediately worthwhile to builders to create the information base for further policy development.

If taxing pollution—and raising the cost to the developer of poorly designed or managed sites—is politically unpalatable, a "positive" version of the approach could be tried. Sites

could become eligible for property-tax reductions or income-tax credits tied to their environmental performance.

Both of the tax approaches have the advantage of operating dynamically over time. That is, they could provide continuing economic rewards to property owners who maintain and manage their stormwater systems at high levels of performance. A construction-permit process is essentially a one-time event with short-lasting economic consequences. An erosion tax or credit would have an impact on performance over the life of the project and could be assessed on properties that have already been developed, providing an incentive for them to refocus on their site design and management.

Public investment in erosion control

There are a number of steps that public institutions could take to strengthen the impact of the NPDES permit system and to encourage the transition to a results-based system. Among them, as noted above, is the leadership role public entities can play when they are building a public project. Government agencies could also invest directly in erosion prevention and sediment control in any of several ways. Governments could buy development rights along streams and rivers to maximize the impact of vegetative buffer strips. Governments could subsidize the installation of sand berms or drainage systems at sites that might not otherwise use them. Governments could finance the monitoring systems—including not just the instruments, but also the enforcement personnel, data-gathering teams, map-making staff, and web masters who would make the data useful.

6. Conclusions

Georgia's experience with its new NPDES permit for stormwater control at residential, commercial, and linear construction sites is still too limited to be much of an indicator of the future. It is possible that the permit will change little in Metro Atlanta or across the state. Developers, state regulators, and others who make decisions affecting the quality of the state's streams, may conclude that the easiest thing to do is to keep on using "best management practices," even when those practices are inconsistent with state-of-practice design and can no longer honestly be called "best."

The Big Creek school project set a new standard for design and construction in the Atlanta area. Its systems approach to erosion prevention, sediment control, and water monitoring redefined "best management" in the area. Indeed, the project demonstrated that the "alternative" approach included in the NPDES permit—the results-based approach—might well be a feasible policy tool in Georgia.

The results-based approach would ultimately require developers to demonstrate that their projects had only nominal impacts on the state's surface waters or else pay a fine. The approach depends on monitoring the actual outfall from construction sites. The approach would shift the focus of erosion control from abstract paper—maps and site plans—to reality: mud and water and the point at which they so often mix and affect people and the environment.

Making the leap to that results-based system is an enormous challenge for developers, contractors, regulators, environmentalists, and citizens alike. This white paper has suggested a number of steps that each of those players could take to make the system's success more likely. Those steps appear worth taking because the dynamic, information-rich, performance-based approaches described here are more likely than traditional tools to achieve the region's goals: cleaner waters at the lowest possible costs, a strong and growing economy, and practices that will more equitably distribute the costs and benefits of that economic vitality.

7. Endnotes

[1] The *Atlanta Journal and Constitution* has published several features on the threats to the Chattahoochee over the last three years, and particularly in September 1999 and February 2000.
[2]Final Report, Clean Water Initiative (Atlanta, GA: November 2000, on line at www.cleanwaterinitiative.com/recommendations.html).
[3] Georgia Department of Natural Resources, Environmental Protection Division, "Authorization to Discharge Under the National Pollutant Discharge Elimination System Storm Water Discharges Associated with Construction Activities," signed June 12, 2000, effective August 1, 2000 through July 31, 2003. (The permit is referred to as "the EPD NPDES permit" in subsequent references.)
[4] *Rules of Georgia Department of Natural Resources,* Chapter 391-3-7, Erosion and sediment control.
[5] James E. Kundell and Todd C. Rasmussen, *Erosion and Sedimentation: Scientific and Regulatory Issues* (Atlanta, GA: Georgia Board of Natural Resources, 1995).
[6] Ibid.
[7] This white paper has made no effort to evaluate the role of agriculture or silviculture in sedimentation today.
[8] W.R. Stokes III and R.D. McFarlane, *Water Resources Data for Georgia, Water Year 1998*. U.S. Geological Survey Water-Data Report GA-98-1, 1999.
[9] E.A. Frick, D.J. Hippe, G.R. Buell, C.A. Couch, E.H. Hopkins, D.J. Wangsness, and J.W. Garrett, *Water in the Appalachicola-Chattahoochee-Flint River Basin, Georgia, Alabama, and Florida, 1992-1995*. USGS Circular 1164, on line at http://pubs.water.usgs.gov/circ1164>, updated April 29, 1998.
[10] The authors discussed the issue of sediment as it relates to water quality with several individuals, both regulators and users. In no case, could anyone identify a systematic reporting of turbidity levels in surface waters in Georgia.
[11] A court case in the early 1990s (Hughey v. JMS Development corp. 78 F.3d 1523 (11th Cir. 1996)) was initiated in response to a developer's impacts on a local stream. Since that time, lawsuits and criminal cases have been directed at individual developers and received coverage in local newspapers.
[12] Fulton County Environmental and Community Development Department.
[13] Georgia Department of Natural Resources, *Rivers/Streams Partially Supporting Designated uses.* Report to U.S. EPA.
[14] Christopher Quinn*, Atlanta Journal and Constitution* (December 23, 1999): J1.
[15] United States Census of Construction and Housing, 1996, State of Georgia.
[16] Sophia Lezin, *Atlanta Journal and Constitution* (February 26, 1999): J1.
[16] Frick et al.
[18] United States Geological Survey, http://water.usgs.gov/cgi-bin/wuhuc?huc=0313000.
[19] Chris Reinolds, *Atlanta Journal and Constitution* (February 5, 2000).
[20] Bruce McCarl, *Impacts of Diminished Water Quality on Municipal Water Treatment Costs* (Water Resources Institute Digest, on line at www2.ncsu.edu/ncsu/CIL/WRRI/news/mj98digest.html. 1998).
[21] Frick et al.
[22] United States Geological Survey, http://water.usgs.gov/cgi-bin/wuhuc?huc0313000.
[23] National Energy Information Agency, U.S. Department of Energy*, AEO 98, National Energy Modeling System* (Washington, DC: 1999).
[24] ibid.
[25] Frick et al.
[26] Stacy Shelton, *Atlanta Journal and Constitution* (February 28, 2000).
[27] Brad Schrade, *The Atlanta Journal and Constitution* (Sept. 17, 1998).
[28] Georgia Department of Natural Resources, *Chattahoochee River Basin Management Plan* (Atlanta, GA: 1997).
[29] Personal interview, Helen Tapp, former director of the Gwinett Council for Quality Growth
[30] Kundell and Rasmussen.
[31] Stephen G. Breyer, *Regulation and Its Reform* (Cambridge MA: Harvard University Press, 1982).
[32] International Erosion Control Association. *Sizing Up Erosion and the EC Industry* (on line at www.ieca.org/resource).
[33] Chesapeake Bay Program*, Chesapeake 2000* (Annapolis, Maryland). U.S. EPA, Region 2*, Long Island*

Sound Study (New York, NY). U.S. EPA Great Lakes National Program Office, *Lakewide Management Plans* (for Lakes Michigan, Superior and Erie)(Chicago, IL). U.S. EPA Region 4, South Florida Initiative (Atlanta, GA).

[34] Jodi Perras, "Reinventing EPA New England: An EPA Regional Office Tests Innovative Approaches to Environmental Protection" (Washington, DC: National Academy of Public Administration, 2000).

[35] Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia,* Fifth Edition, (Atlanta, GA, 2000).

[36] A soil-loss computer model designed and implemented at several sites in over 40 states by Dr. Richard Warner (SEDCAD – Sediment, Erosion Discharge Computer Aided Design), Warner et al., Civil Software Design, Ames, IA, 1998.(ref.) provides the basic parameters to consider in the design of erosion, sediment, and stormwater control strategies. From the results of the model, an integrated set of flow modification, hydrodynamic energy damping, sediment retention and surface modification can be designed. The implementation of these strategies by construction site contractors requires site design detail with respect to scheduling and oversight. Programming advances will enable design professionals to generate automatic AutoCAD design drawings and easily overlay soils, land cover, and topography with alternative site development, sediment, and stormwater control scenarios.

[37] United States Census of Construction and Housing, 1996, State of Georgia.

[38] Estimated by multiplying the typical lawsuit settlement of $10,000 to $30,000 by the number of suits per year, which is about 20 to 40 (personal communication, Georgia Environmental Law Center).

[39] See Part III, Section C, items 1 through 4 of the EPD NPDES permit.

[40] Final Report, Clean Water Initiative (Atlanta, GA: November 2000, on line at www.cleanwaterinitiative.com/recommendations.html).

[41] The Georgia Conservancy cosponsored a forum on sediments with the Institute for Ecology at the University of Georgia. That forum resulted in the formation of a Technical Advisory Group, which is working on a protocol for establishing sediment TMDLs. This group has been meeting monthly since September 2000. For the purpose of Dirt II, these two regulatory processes are important considerations for designing or encouraging policies to reduce sediment. The Metro Atlanta Chamber of Commerce and the Regional Business Coalition sponsored a Clean Water Initiative beginning in April 2000 to study issues associated with wastewater and stormwater management. They held seven public meetings, and issued a final report in November 2000. The report includes several recommendations pertaining to stormwater management.

[42] Environmental Results Management Initiative Workgroup, *Environmental Results Management Systems: Moving from Planning to Action by Measuring what Counts* (Montpelier, VT: Green Mountain Institute for Environmental Democracy, August 2000).

[43] National Academy of Public Administration, *Environment.Gov: Transforming Environmental Protection for the 21st Century* (Washington, D.C.: National Academy of Public Administration, November 2000).

[44] Ibid.

[45] Section 5. B. 1, page 30 of the EPD NPDES permit.

[46] Environmental Results Management Initiative Workgroup.