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An Assessment of Impediments to Low-Impact Development in the Virginia Portion of the Chesapeake Bay Watershed

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An Assessment of Impediments to Low-Impact Development in the Virginia Portion of the Chesapeake Bay Watershed

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Environmental Science at Virginia Commonwealth University.

by

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ABSTRACT

AN ASSESSMENT OF IMPEDIMENTS TO LOW-IMPACT DEVELOPMENT IN THE VIRGINIA PORTION OF THE CHESAPEAKE BAY WATERSHED

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Environmental Science at Virginia Commonwealth University.

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Stormwater runoff from urban and urbanizing areas poses a serious threat to water quality, and unless managed properly will impede efforts to restore the Chesapeake Bay. Water quantity, as well as quality, must be considered, and Low Impact Development (LID) is an innovative stormwater management approach that addresses both. LID seeks to mimic a site's predevelopment hydrologic regime by retaining and treating stormwater at the lot level using small, cost-effective landscape features.

The purpose for this study was to identify and rank impediments to the implementation of LID in the Virginia portion of the Chesapeake Bay watershed. This was accomplished by going to LID workshops and distributing a survey to stakeholders in attendance. The survey asked respondents to rank the following impediments to the implementation of LID: site-specific & non-structural, property owner acceptance, pollutant removal benefit, development rules, lack of education, maintenance considerations, flooding problems, and cost. Lack of education was ranked as the most important impediment, with development rules following close behind.

Pollutant removal benefit was ranked the least important impediment.

A second purpose was to assess whether there is a relationship between a county's growth rate and adoption of Better Site Design principles (BSD) and LID. A Code and Ordinance Worksheet was used to evaluate the development rules of 13 counties (6 high growth, 3 medium growth and 4 low growth) within Virginia's portion of the Chesapeake Bay Watershed. The scores from the worksheets were used to determine if the amount of growth pressure experienced by a county influenced the degree to which they incorporated BSD and LID in their local development codes. Statistical testing revealed that the relationship between growth pressure and score on the Code and Ordinance Worksheet was moderate, at best.

Introduction

In 1983 and 1987, the states of Virginia, Maryland, and Pennsylvania, the District of Columbia, the Chesapeake Bay Commission and the U.S. Environmental Protection Agency, representing the federal government, signed historic agreements that established the Chesapeake Bay Program partnership to protect and restore the Chesapeake Bay's ecosystem. In the year 2000, these commitments were renewed in the Chesapeake Bay 2000 Agreement (C2K), which unlike the 1983 and 1987 agreements, relies more heavily upon local jurisdictions for its implementation. The Chesapeake Bay 2000 Agreement targets 5 areas for improvement: Living Resource Protection and Restoration, Vital Habitat Protection and Restoration, Water Quality Protection and Restoration, Sound Land Use, and Stewardship and Community Involvement. The agreement then lists specific goals within each respective area. This study will focus on the Sound Land Use component within the Chesapeake Bay 2000 Agreement. The Chesapeake 2000 Agreement reads:

> "(i)n 1987, the signatories agreed that 'there is a clear correlation between population growth and associated development and environmental degradation in the Chesapeake Bay system.' An additional three million people are expected to settle in the watershed by 2020. This growth could potentially eclipse the nutrient reduction and habitat protection gains of the past. Therefore it is critical that we consider our approaches to land use in order to ensure progress in protecting the Bay and its local watersheds. Enhancing, or even maintaining, the quality of the Bay while accommodating growth will frequently involve difficult choices. It will require a renewed commitment to appropriate development standards. The signatories will assert the full measure of their authority to limit and mitigate the

> potential adverse effects of continued growth; each however, will pursue this objective within the framework of its own historic, existing or future land use practices or processes. Local jurisdictions have been delegated authority over many decisions regarding growth and development, which have both direct and indirect effects on the Chesapeake Bay system and its living resources. The role of local governments in the Bay's restoration and protection effort will be given proper recognition and support through state and federal resources. States will also engage in active partnerships with local governments in managing growth and development in ways that support the following goal.
>
> We acknowledge that future development will be sustainable only if we protect our natural and rural resource land, limit impervious surfaces and concentrate new growth in existing population centers or suitable areas served by appropriate infrastructure. We will work to integrate environmental, community and economic goals by promoting more environmentally sensitive forms of development. We will also strive to coordinate land-use, transportation, water and sewer and other infrastructure planning so that funding and policies at all levels of government do not contribute to poorly planned growth and development or degrade local water quality and habitat. We will advance these policies by creating partnerships with local governments to protect our communities and to discharge our duties as trustees in the stewardship of the Chesapeake Bay" (Chesapeake Bay Program, 2000).

One of the specific goals given in the agreement to fulfill the objectives stated above is "(b)y 2005, in cooperation with local government, identify and remove state and local impediments to low impact development designs to encourage the use of such approaches and minimize water quality impacts" (Chesapeake Bay Program, 2000). The intention of this study is to gain knowledge about the impediments to low impact development that will ultimately aid the Commonwealth of Virginia in meeting land use goals set forth in the Chesapeake 2000 Agreement.

Problem Description

Stormwater runoff from urban and urbanizing areas poses a serious threat to water quality. There is evidence to indicate that polluted urban runoff may be more harmful to water quality than municipal sewage or industrial waste discharges in many areas. The problem is not limited to water quality. Urbanization also has a profound impact upon the hydrologic characteristics of watersheds affecting the volume and rate of stormwater runoff. Adverse impacts include combined sewer overflows, more frequent and severe flooding, stream channel degradation, and increased sedimentation in reservoirs and estuaries (VA DCR, 1990).

The art of controlling nonpoint source pollution and managing stormwater in urban areas is still in the formative stages. There seems to be an increasing understanding of the problems involved but so far there is little agreement as to the best way to deal with them. A number of innovative techniques and practices have been developed to solve specific problems but as of yet no overall system has been proven to be clearly the best or most effective way of accomplishing all of the desired goals of urban stormwater management. Perhaps there is no clear-cut "best" solution because there is no standard problem. Each urban community has its own unique set of problems, conditions and circumstances. A stormwater management program that may solve one jurisdiction's problems may be totally unsuited for another. There is one basic principle for managing stormwater, however, that is applicable to all urban areas: the principle of basin-wide planning and management. Urban stormwater must be dealt with on an area-

wide basis. Control measures by individual landowners on a site-by-site basis will likely be ineffectual unless they are coordinated within the framework of an overall basin-wide management plan (VA DCR, 1990).

Low impact development is one tool that can be used by localities as part of their stormwater management program; however, localities are sometimes reluctant to try innovative techniques. The purpose of this research is to identify and rank impediments to the implementation of low impact development in the Virginia portion of the Chesapeake Bay Watershed, and to reveal if different categories of stakeholders (including local and state government employees, developers/realtors, consultants, and representatives of environmental organizations), and stakeholders from areas experiencing varying levels of growth pressure (low, medium and high) rank these impediments similarly. Another goal is to assess whether there is a relationship between a county's growth rate and adoption of better site design and low impact development principles.

Literature Review

Low impact development (LID) is a relatively new concept in stormwater management. LID is a site design strategy with the goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape. Hydrologic functions of storage, infiltration, and ground water recharge, as well as the volume and frequency of discharges, are maintained through the use of integrated and distributed micro-scale stormwater retention and detention areas, reduction in the amount of impervious surfaces, and the lengthening of flow paths and runoff time. Other strategies include the preservation/protection of environmentally sensitive site features such as riparian buffers, wetlands, steep slopes, mature trees, floodplains, woodlands and highly permeable soils (USEPA (a), 2000).

LID principles are based on controlling stormwater at the source by the use of micro-scale controls that are distributed throughout the site. This is unlike conventional approaches to stormwater management that typically convey and manage runoff in large facilities located at the base of drainage areas. LID measures provide a means to address both pollutant removal and the protection of predevelopment hydrological functions. LID practices such as bioretention facilities or rain gardens, grass swales and channels, vegetated rooftops, rain barrels, cisterns, vegetated filter strips and permeable pavements perform both runoff volume reduction and pollutant filtering functions (USEPA (a), 2000).

Definitions: Low Impact Development vs. Better Site Design

The term "Low Impact Development" is often used interchangeably with the term "Better Site Design (BSD)" and while the two are closely related, LID is distinctly more technical, focusing on retaining natural hydrology, while BSD is a planning tool used to reduce the harmful effects of development. LID is an ecosystem-based approach that seeks to design the built environment to remain a functioning part of an ecosystem rather than exist apart from it (Low Impact Development Center, 2005).

LID goes beyond the goals of BSD by providing many more tools to plan and engineer a site in a manner that maintains or restores the hydrologic and ecological functions necessary to support the integrity of receiving waters. LID requires strategic and customized use of conservation measures, multifunctional small-scale controls, and pollution prevention to address site-specific stormwater pollutant load, timing, flow rate and volume issues. This is not the same as a broad-brushed set of generic site design or conservation tools that only reduce impacts (Coffman, 2001). However, it can be said that both terms fall under the broader umbrella of eco-sensitive development, and localities can use bits and pieces of each depending on needs and site-specific conditions. Growth management strategies, such as Smart Growth, that emphasize the saving of green space and the redevelopment of existing urban regions, can utilize this retrofit capability of LID in order to promote ecologically restorative infill and brownfields development in impaired stream areas (Low Impact Development Center, 2005).

Development of BSD Principles

In 1996, the Center for Watershed Protection in Maryland convened the Site Planning Roundtable to examine impediments to better development at the local level and to develop model principles to promote environmentally sensitive and economically viable development. The Site Planning Roundtable represented a diverse and wide cross-section of interests involved in planning, designing, and building new communities. Nearly two years later, the Site Planning Roundtable agreed on a set of twenty-two model development principles (Appendix A). Their work was crafted into a document called "Better Site Design: A Handbook for Changing Development Rules in Your Community" (Center for Watershed Protection, 1998). This document explains each model development principle in depth, and explores current and recommended practices as well as perceptions and realities about the site planning topic. Furthermore, case studies are presented, and references and resources are provided for more information.

The model development principles incorporate elements of both low impact development and better site design, and from these principles a Code and Ordinance Worksheet (COW) was created that communities can use as a starting point for assessing how their current regulations stack up within the context of the principles (Appendix B). The model development principles generally fall into one of three areas:

- Residential Streets and Parking Lots
- Lot Development
- Conservation of Natural Areas

In many ways, the suburban landscape is a mix of these three habitats. The first habitat is devoted to the automobile, and includes roads, driveways, and parking lots. The second is the habitat where we live and work, including our yards and homes. The third habitat includes the open spaces and natural areas that are relatively undeveloped. The size, appearance, location, and design of all three areas are determined in large part by local subdivision codes and zoning ordinances (Center for Watershed Protection, 1998).

It should be recognized that the principles must be adapted to reflect the unique characteristics of each community. The percent of the three habitats mentioned above varies community by community, and therefore impacts to hydrology will vary as well. Furthermore, not all principles will apply to every development or community, and in some cases the principles may not fully complement each other (Center for Watershed Protection, 1998).

Impediments to Implementation of LID

Site Specific

Low impact development practices are site specific, and not all better site design and low impact development principles will complement each other at all times. The unique characteristics of any site proposed for development must be considered before the application of LID techniques can be effectively used. Some view this as an impediment to the utility of low-impact development. Because LID practices are site-specific and often non-structural in nature, some question the consistency of the LID vision. However, what some see as an impediment may actually be a benefit. Suitable

not only for expanding suburbs, different LID technologies can fit different landscapes. Many LID technologies excel when retrofitted to urban development, which was often built without any thought to stormwater management and pollution control (Zink, 2002).

Property Owner Acceptance

Consumer desire can be another impediment to the implementation of LID. Some say the suburbs are growing because that's where the majority of people want to live. For most first-time owners, the outlying suburbs, where land is cheapest, is about the only place they can afford to buy. And for many repeat buyers, the farther out the better. Furthermore, that's where the work is. Labor Department statistics show that three out of every four new jobs created in urban markets are located outside the central city (Sichelman, 1999).

Apologists for sprawl argue that reform means interfering with free markets. What's more, they say, "we just build what people want." In fact, sprawl is the result of numerous free-market warping policies. Highway construction, mortgage policies, flood plain insurance, fragmented property tax systems, and favorable tax treatment of house sales and mortgage interest all shape the "market" to encourage sprawl. In Maryland, an analysis of state policies and programs found that the state was directly subsidizing growth on the exurban fringe while discouraging investment in existing cities and towns. Despite ample opportunities for high quality in-fill development in desirable neighborhoods, developers focus their efforts on the fringe. As far as building what people want . . . people buy what is available (McMahon, 1997).

One study conducted in New England sought to prove that market appreciation rates for clustered housing with associated open space (a common BSD technique), can be equal to those for conventionally developed suburban housing types. Appreciation was measured as the percent change (as compared to absolute dollars) in the selling price of a unit of housing. Changes for cluster/open space housing were compared against those for conventional housing over the same time period. Two communities in Massachusetts were selected as the study areas and in both cases an open-space development was compared and contrasted to housing developed along more conventional lines in the same municipality. (Due to possible regional variations, direct comparisons were only made between housing types in the same municipality.) In both municipalities, the cluster developments exceeded their conventional counterparts in open market, sale-price appreciation. This indicates that the home-buyer, speaking in dollar-terms through the marketplace, appears to have demonstrated a greater desire for a home with access and proximity to permanently-protected land, than for one located on a bigger lot without the open-space amenity (Lacy, 1990).

Pollutant Removal Benefit

Since low impact development practices are commonly applied together, quantifying the nutrient removal benefit of LID can be difficult, leading some to question the point of implementing a new, unproven method of development. This is further complicated by the fact that the pollutant removal performance of many stormwater BMPs (best management practices) is undocumented for the most part. In addition, there is no widely accepted definition of "efficiency" or "pollutant removal" for stormwater

BMPs, and those that are non-structural do not have discrete inflow or outflow points and are difficult to monitor (USEPA, 1999).

The benefits of individual BMPs are site-specific and depend on a number of factors. These include the number, intensity and duration of wet weather events; the pollutant removal efficiency of the BMP; the water quality and physical condition of the receiving waters; the current and potential use of the receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Because these factors will vary substantially from site to site, data are not readily available with which to develop estimates of benefits for individual BMP types (USEPA, 1999). However, it is generally accepted that the highest nutrient removal efficiencies are exhibited by techniques such as peat-sand filters (similar to bioretention in that each combine physical filtering and adsorption with biological processes) and infiltration trenches, both of which are widely used in low impact development (NVPDC, 1994).

LID principles and practices are based on what has been learned over the years about stormwater management and the transfer of technology from other fields of engineering and science, such as sanitary engineering, agriculture, forestry, soil science, phytoremediation, bioremediation, and ecology. Add to this the existing and growing body of data on the performance of bioswales, bioretention, filter strips, and turf from universities, Federal Highway Administration, EPA and others. When you look at the entire body of related scientific data and engineering/environmental technologies, you begin to see the advantages and benefits of LID's multiple systems (treatment train) approach (Coffman, 2001). In any case, decreased impervious cover results in less

stormwater runoff and consequently less nutrient export (Center for Watershed Protection, n.d.).

Development Rules: Codes and Ordinances

Many communities have long struggled to achieve eco-sensitive development but some have found that their own development codes and standards can actually work against their efforts to achieve it. For example, local codes and ordinances often promulgate inflexible standards that result in highway-wide residential streets, expansive parking lots, and mass clearing and grading of forested areas. At the same time, local codes often give developers little or no incentive to conserve natural areas (Center for Watershed Protection, Aug. 1998).

Most local ordinances allow or encourage standardized layouts of "wall-to-wall house lots." Over a period of decades this process produces a broader pattern of "wall-to-wall subdivisions." No community actively plans to become a bland suburb without open space. However, most zoning codes program exactly this outcome. Communities wishing to break the cycle of "wall-to-wall house lots" need to consider modifying their zoning to actively and legally encourage subdivisions that set aside at least 50 percent of the land as permanently protected open space and to incorporate substantial density *dis*incentives for developers who do not conserve any significant percentage of land. When municipalities require nothing more than "house lots and streets," that is all they receive. Designing subdivisions around the central organizing principle of land conservation is not difficult. However, it is essential that ordinances contain clear standards to guide the conservation design process (Natural Lands Trust, 2001).

Under the current process of administrative review, projects that deviate from standard submittals and challenge traditional Euclidian zoning almost always require additional time and expense for approval. If the approval for an alternative plan takes an extra year, that alone can eat up the profits of the entire job. Given that the profit from land development is always realized at the end of the project, the compounded interest on carrying the land can be particularly onerous. If a locality would like projects to follow a particular design pattern (such as low impact development), then it might have to amend its land use regulations accordingly. The message for regulators is that if eco-sensitive development is a desired goal, then the regulatory system should be configured to streamline the approval process and manage the risk associated with the approval of innovative land development techniques (Kaufman, 2003).

Education about LID Principles

The education of citizens and local officials on the issues is critical to the success of any local planning initiative (Arnold and Gibbons, 1996). One of the biggest challenges to the implementation of low-impact development is to convince people that the approaches and technologies really work. Larry Coffman, stormwater expert with Prince George's County in Maryland and one of the nation's leading advocates of LID, acknowledges that it will take years for developers and local government planners to become comfortable with such techniques. "It will take about 10 years for these techniques to become commonplace," he has predicted (Blankenship, 2002).

In order to speed the process up, the Chesapeake Bay Program's Executive Council agreed to ratchet up stormwater control efforts on lands owned by the federal,

state, and District of Columbia governments. Although more development has historically meant more pollution, Council members signed a directive aimed at using their land as laboratories for new stormwater management techniques to prove this doesn't have to be the case. The directive, agreed to in December of 2001, calls for the Bay jurisdictions to implement 60 demonstration projects using emerging innovative technologies, from rain gardens to pervious pavement, designed to yield no polluted runoff at all. However, local officials, who are on the front line when it comes to approving new projects, are often slow to adopt techniques they may consider unproved. "Local staff can barely keep up processing development plans, much less do innovative work," said Tom Schueler, director of the Center for Watershed Protection. "Sometimes policy makers in the Bay Program think they can snap their fingers and the world will change. But there's an enormous culture of people who need education (Blankenship, 2002)."

One of the ideas behind the stormwater directive is to provide a showcase so developers, local officials and the public can see first-hand how such innovative stormwater management techniques work. The directive calls for information about the design, cost, and performance of stormwater management techniques featured at the demonstration sites to be made public. "The more examples that people can see of how new approaches can work—and work better and be cost effective—the better the chance we will have in effecting a change in the way we think about stormwater," said Kelly Shenk, who oversees stormwater issues for the Bay Program (Blankenship, 2002).

Reaching even further into the educational realm, the directive calls for the Bay jurisdictions to work with universities to teach future engineers, landscape architects and others about alternative stormwater management approaches, and to develop demonstration sites on campuses. "These are new concepts to these students," Shenk said. "If engineering programs keep doing the same thing decade after decade, we are not going to get the changes in the way of thinking, and the innovation, that we are trying to push. And that takes a long time (Blankenship, 2002)."

Maintenance Considerations

Maintenance considerations are viewed by some as an impediment to low-impact development, and many have questioned the long-term viability of LID systems. Opponents of the residential use of LID have tried to simplify the approach by characterizing it as only relying on rain gardens and rain barrels that will not be maintained by the property owner. LID is much more than this. It is a comprehensive multi-systems approach that has built-in redundancy, which greatly reduces the possibility of failure (Low Impact Development Center, 2005).

Many LID techniques have nothing to do with nor can they be significantly influenced by the behavior of the property owner. These include basic subdivision and infrastructure design features such as reducing the use of pipes, ponds, curbs and gutters; maintaining recharge areas, buffer zones, and drainage courses; using infiltration swales, grading strategies, and open drainage systems; reducing impervious surfaces and disconnecting those that must be used; and conserving open space. Low impact development's long-term success has much more to do with the knowledge, skills, and

creativity of the site designers than what the property owner does or doesn't do (Low Impact Development Center, 2005).

Maintenance agreements can be used if a developer is uncomfortable about on-site landscaping features that also serve as stormwater controls. However, the key factor in the success of LID is to ensure that the landscape practices (such as rain gardens) are attractive and perceived by the property owner as adding value to the property. If these LID practices are viewed as assets, the primary motivation for their long-term maintenance is that of property owners protecting their vested economic interests. Additionally, experience has shown that educational efforts can successfully promote active public engagement in protecting our waters by the simple act of people maintaining their properties. In actuality, LID site source controls reduce maintenance burdens for property owners and local governments. The techniques are simple, need no special equipment or high costs to maintain, and encourage property owners to be responsible for the impacts associated with their land. (Low Impact Development Center, 2005). Furthermore, additional storage volume is added as a margin of safety to account for some losses over time (although we expect LID to work better over time) (Coffman, 2001).

Flooding Problems

Some have questioned the ability of LID to handle large storm events. Traditionally, stormwater management systems have been designed to function well under a single design condition, e.g. the 100 year flood, the 10 year storm, etc. Designing control systems for a single extreme event does not mean that they will perform

adequately under other scenarios. For example, designing major floodways for the 100-year event over-drains the system during more frequent storms, degrades the natural stream system, and causes downstream water quality problems by rapidly transporting pollutants through the urban area and into receiving waters. Flow control standards, which have their origin in ensuring public safety and reducing property damage, have very little to do with ecosystem protection (Low Impact Development Center, 2005).

For preserving stream integrity, experience has demonstrated the importance of a stormwater system that specifically addresses the frequent or micro-storms that occur on a regular basis. By using decentralized site-based source controls, LID uses the stormwater from these more frequent events as a resource and is an effective ecosystem approach. Additionally, if the full suite of LID controls and better site design practices is creatively used, LID is capable of automatically controlling the 10 and 100-year storms through its primary strategy of restoring the built area's natural rainfall-runoff relationship. The more techniques that are applied, the closer to natural hydrologic function one gets (Low Impact Development Center, 2005).

In cases where stormwater regulatory requirements cannot be satisfied solely with the use of LID design techniques, then a "hybrid design" may be employed. A hybrid design employs both LID/BSD and conventional BMP's or detention practices (e.g., centralized BMPs) to meet stormwater requirements. Such a design might conserve specific natural features and provide open space to the greatest extent possible, while detention measures or centralized BMP's are also implemented to provide peak rate or quantity control beyond the site-specific capabilities of the LID/BSD strategy. Another

example of a hybrid design is one that incorporates LID for both the attenuation and infiltration of small storm events, and centralized BMP's to provide storage for larger storm events (VA Low Impact Development Workgroup, 2005).

Cost

Another impediment to low impact development is the perception that innovative development techniques will be more expensive to implement than conventionally accepted methods; however the exact opposite is often true. Because of its emphasis on natural processes and micro-scale management practices, LID is often less costly than conventional stormwater controls. LID practices can be cheaper to construct and maintain and have a longer life cycle than centralized stormwater strategies (NRDC, 1999). Savings are achieved by eliminating the use of stormwater management ponds, reducing pipes, inlet structures, curbs and gutters, less roadway paving, and less grading and clearing (Coffman, et al., 1998). These infrastructure reduction savings enable builders to add value-enhancing features to the property, to be more flexible and competitive in pricing their products, or even to recover more developable space since there is no need to waste land for a stormwater pond (Low Impact Development Center, 2005).

A common concern is that LID-based projects will be more expensive because they could require a longer time to receive project approval. This may or may not be true, depending on the receptiveness of local government officials to innovative practices. This potential cost increase is not an indictment of the concept of LID but of inexperienced institutions, individuals, and bureaucracies that remain unaware of the

great necessity for and benefits of a new approach. Additional LID cost concerns include the potential for greater expenses due to the increased use of on-site landscaping material. Despite these issues, experience has shown that LID still saves money over conventional approaches through the reduced infrastructure and site preparation work. Case studies and pilot programs show at least a 25 to 30% reduction in costs associated with site development, stormwater fees, and maintenance for residential developments that use LID techniques (Low Impact Development Center, 2005).

LID can even reduce the costs of stormwater retrofits. In Largo, MD, one study showed the feasibility of retrofitting an existing parking facility. The bioretention retrofit cost approximately $4,500 to construct and treats approximately one-half acre of impervious surface. The retrofit was a more cost-effective way to filter pollutants than many proprietary devices designed to treat the same volume of runoff. These proprietary devices could cost $15,000 to $20,000, would be more expensive to maintain, and would not significantly decrease runoff volume and temperature (USEPA (b), October 2000). And in cases where LID techniques are initially more costly to install, the long-term savings quickly add up. For instance, the cost of a green roof is about 30% higher than a conventional roof, but will last 40 or more years, three times longer than the average life span of a conventional roof (NVSWCD, 2003).

The next section explains the methods used to gather data in order to evaluate the hypothesis for this project. The hypothesis for this project was that development rules imposed by local governments pose the most formidable barrier to the implementation of LID. Methods to address the hypothesis included the analysis of a short survey

distributed to various stakeholders in the LID arena to determine if stakeholders from differing affiliations and areas of the Commonwealth ranked impediments similarly. Another objective of the project was to assess whether there is a relationship between a county's growth rate and adoption of better site design and low impact development principles. This was accomplished using the Code and Ordinance Worksheet (COW) to evaluate a selected number of county's development rules for impediments to LID implementation.

Research Methods

Since this project seeks to answer two different questions, two separate means of collecting data were necessary. The first question, "are development rules imposed by local governments the biggest impediment to LID implementation?" was evaluated by attending LID workshops and distributing a survey to attendees. The second question, "is there a relationship between a county's growth rate and adoption of better site design and low impact development principles?" was measured using the Code and Ordinance Worksheet developed by the Center for Watershed Protection, and can be found in their document titled "Better Site Design: A Handbook for Changing Development Rules in Your Community" (Center for Watershed Protection, 1998). This section describes in detail the steps that were taken to answer each question.

Low Impact Development Survey

In late 2001 through early 2002, the researcher attended numerous meetings and workshops focusing on low impact development throughout the Chesapeake Bay Watershed in the Commonwealth of Virginia in order to gain a feel for the current perceptions and attitudes towards LID. Local and state government employees, developer/realtors, consultants, and representatives of environmental organizations were invited to attend these workshops, which were sponsored by various entities and organizations. The knowledge the researcher gained by attending these meetings and workshops assisted in the development of a short survey (Appendix C) that was distributed at subsequent meetings to various stakeholders involved with low impact

development. These meetings were held between July 2002 and December 2003, and were located throughout the Chesapeake Bay Watershed, from northern Virginia to southwestern Virginia. (See Appendix D for a complete list of meeting dates and locations.)

The survey collected basic demographic information and asked the participants to rank several impediments to low impact development. Two open-ended questions at the end of the survey provided an opportunity for them to make note of any others and suggest methods of removing impediments (see Appendix E). The impediments given on the survey form were: site specific and non-structural in nature, property owner acceptance, pollutant removal benefit, development rules, lack of knowledge/education, maintenance considerations, flooding problems, and cost. The ranking of these impediments (dependent variable) was compared to both the respondent's occupation/affiliation and residence (independent variables) to see if any relationship existed.

Survey Analysis

Analyzing the survey was very straightforward when looking at the relationship between occupation/affiliation and ranking of impediments. Five options were offered in response to the question, "(w)hich category below best describes your current occupation?" The options were: local, state or federal government employee, developer/realtor, consultant, environmental organization, or other. Frequency distributions and cross-tabulations were used to determine if there was an association between a respondent's occupation and ranking of impediments. Chi-square was used to

determine if statistical significance existed, and Cramer's V measured the strength of the association between the variables.

A similar analysis was undertaken to look at the relationship between residence and ranking of impediments. The residence question on the survey was open-ended ("What city or county do you reside in?"), with respondents filling in an answer. In order to perform a meaningful analysis, it was necessary to group localities in terms of growth pressure. Based on figures provided by the U.S. Census, the percent change in population between 1990 and 2000 was used to rank the counties in ascending order of population growth (Appendix F). There are 95 counties in Virginia, not including the Virginia Beach area, which is comprised of independent cities, but no counties. An additional "county", Virginia Beach & environs, was created in order to capture respondents from this important region of the State. (Other independent cities throughout the state were also lumped within the appropriate county in order to simplify the analysis.) This resulted in 96 counties, which was divided by 3 to create 3 equally-sized groups (low, medium, and high growth pressure) with 32 counties each. Since the counties were ranked in ascending order of growth, the first 32 counties were coded as 3, signifying low growth, the second 32 counties were coded as 2, signifying medium growth, and the third 32 counties (including VA Beach & environs) were coded as 1, signifying high growth. Once coding was complete, frequency distributions and cross-tabulations were used to determine if there was an association between a respondent's residence and ranking of impediments. Chi-square was used to determine if statistical

significance existed, and Cramer's V measured the strength of the association between the variables.

Analysis of County Development Rules

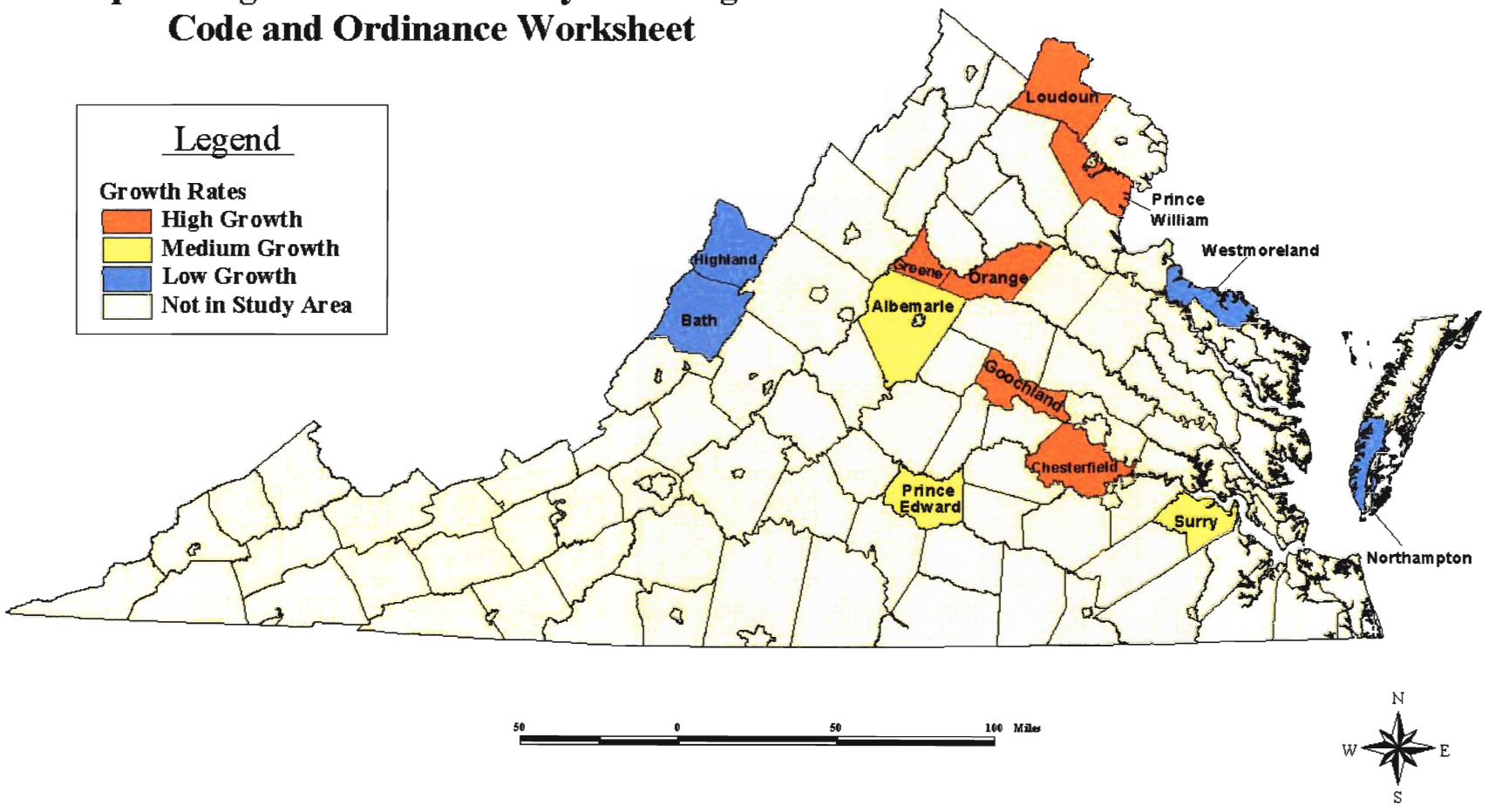
Sampling Technique

The second component of this project involved selecting a number of counties within the Chesapeake Bay Watershed in the Commonwealth of Virginia and comparing their development rules against the 22 Model Development Principles developed by the Center for Watershed Protection in order to assess the degree to which the counties encourage or discourage better site design and low impact development. The ranking of counties in ascending order of growth was used once again to select a systematic sample, however this time only counties within the Chesapeake Bay Watershed were listed (Appendix G). Since there are 66 counties in the VA portion of the Chesapeake Bay Watershed, the first 6 counties on the list were used as a starting point to create samples that were equal in size. From each of these 6 counties, or starting points, a count of 6 was taken, so that the 6^{th} county down the list from the original starting county was chosen as the first item in the sample, the 12^{th} county down the list from the original starting county was chosen as the second item in the sample, and so on until each of the 6 samples contained 11 counties each.

The sample that was most evenly distributed in terms of geographic representation resulted from the sample that began with Northampton County. This sample included the counties of Northampton, Bath, Westmoreland, Surry, Prince Edward, Albemarle, Goochland, Orange, Chesterfield, Prince William, and Greene.

Highland and Loudoun, the slowest and fastest growing counties respectively, were also added to reflect the extremes of population change and to help round out the geographic distribution of the selected counties (see Map 1).

Map 1: Virginia Counties Analyzed Using the Code and Ordinance Worksheet



Analysis of County Documents

Once the counties were selected, an extensive analysis of county documents was undertaken using the Code and Ordinance Worksheet (COW). The COW contains 22 questions that are designed to compare a locality's development rules to the Model Development Principles. Each question is assigned a specific number of points that add up to a total possible score of 100. If a development rule could be found that concurred with the Model Development Principle in question, points were awarded. In some cases, partial points were awarded when documentation could be found that the locality agreed somewhat, but not fully, with a Model Development Principle. Documents reviewed included Zoning and Subdivision Ordinances, Comprehensive Plans, and Design Standards Manuals. The Virginia Department of Transportation's Subdivision Street Requirements, The Virginia Stormwater Management Handbook, and Virginia's Septic Regulations were also consulted, as localities are required to follow the standards contained therein.

The results of these comparisons were made available to the counties to comment upon, and an additional assessment was carried out to see if there is a correlation between growth rate and the incorporation of BSD and LID principles within a county's development rules. This assessment consisted of a simple linear regression to determine if an association existed between a county's rate of population growth and total score on the COW.

Results

This section will summarize the findings of both the LID survey and the completion of the Code and Ordinance Worksheets. An analysis was performed to determine if a statistically significant relationship existed between a survey respondent's occupation and/or residence and the ranking of impediments to LID implementation. In addition, the COWs were examined to establish whether or not there is a relationship between a county's growth rate and its adoption of better site design and low impact development principles.

Low Impact Development Survey

Participants at nine meetings that focused on the implementation of LID between July 2002 and December 2003 were given a short survey that asked them to rank eight impediments to the implementation of LID. Basic demographic information was also collected, and two open-ended questions allowed respondents to identify other impediments and offer suggestions to remove them. Altogether, 211 surveys were completed correctly and used in the analysis. Survey data was compiled and entered into a statistical software package (SPSS 12.0, 2003). Analyses consisted of descriptive statistics that included frequencies and cross-tabulations.

Ranking of Impediments

Frequency tables and histograms counted and displayed the number of times an impediment was assigned a rank between 1 & 8. The most frequently assigned values and the percent of total number of responses for each impediment are as follows:

Table 1. Ranking of Impediments

Impediment	Most Frequent Rank	Percent of Total
Lack of Education	1	36.5
Development Rules	1	34.6
Flood Protection	4	18.5
Maintenance	4	17.1
Property Owner Acceptance	5	17.1
Site-Specific	3 & 6 tied	17.5
Pollutant Removal Benefit	8	30.8
Cost	8	18

This analysis indicates that lack of education and development rules are most frequently ranked as the number 1 impediment to low-impact development. However, since lack of education received a slightly higher percent of the total number of responses (77 out of 211 versus 73 out of 211 = 36.5% and 34.4% respectively), it can be reasoned that lack of education is perceived as the most important impediment to the use of LID. Pollutant removal benefit and cost are ranked as the least important impediments to LID, and since pollutant removal benefit received a much larger percent of the total number of responses (30.8% versus 18%), the pollutant removal benefit of LID is undoubtedly viewed as the least important impediment.

These conclusions are clearly supported when examining the frequency histograms of the impediments (Appendix H). When interpreting a frequency histogram it is important to note whether it is skewed or not. An even or symmetrical curve indicates a neutral response, meaning that most attendees ranked the impediment somewhere in the mid-range, while a histogram that is strongly skewed to the left (negatively skewed curve) indicates that the impediment is characterized as unimportant

and a histogram that is strongly skewed to the right (positively skewed curve) indicates that the impediment is characterized as important.

Most of the histograms are symmetrical in shape (site-specific, property owner acceptance, maintenance, flood protection, cost). However, the frequency histograms for lack of education and development rules are strongly skewed to the right, indicating that many respondents were in agreement that these impediments are very important, while the frequency histogram for pollutant removal benefit is strongly skewed to the left, indicating that many respondents did not view that impediment as important. Once again, it is clear that respondents thought that the pollutant removal benefit of LID was the least important impediment, as the histogram for the pollutant removal benefit was strongly skewed to the left, while the histogram for cost was more normal in shape.

Occupation and Ranking of Impediments

Cross tabulations were used to determine if there was an association between a respondent's occupation and ranking of impediments (Appendix I). These tests were first run using all 5 categories offered in response to the "Which category best describes your occupation?" question. Possible responses were represented by codes as follows: 10 = local, state, or federal government employee, 20 = developer/realtor, 30 = consultant, 40 = environmental organization or 50 = other. However, there were only 6 developer/realtor attendees in the sample, 9 environmental organization representatives and 10 who classified themselves as "others", compared with 120 local, state or federal government employees and 66 consultants. As a result, all cross tabulation tables had at

least 60% expected cell counts less than 5, making it difficult to have confidence in the results.

In order to make the test more meaningful, the categories developer/realtor, environmental organization, and other were collapsed into one. Nevertheless, this still produced cross tabulation tables with at least 33.3% expected cell counts less than 5. While 33.3% is rather high, by collapsing from 5 categories to 3, the number of expected cell counts less than 5 dropped from greater than 60% to 33%, a much smaller percentage. It was decided that in order to retain as much nuance as possible, no further collapsing (i.e. collapsing codes 20, 30, 40 and 50 into one category, creating just two categories for analysis: government employee and other) would take place.

Chi-square was used to determine if statistical significance existed between the independent (occupation) and dependent (ranking of impediments) variables, and Cramer's V measured the strength of any association found. In SPSS, the significance value (Asymp. Sig.) is evaluated to test independence when using the Chi-square statistic, as well as the usual chi-square value found in a chi-square table. The lower the significance value, the less likely it is that the two variables are independent (unrelated). Cramer's V may range from 0 to 1, one indicating a strong relationship between variables and zero indicating none. Results of comparing occupation/affiliation and ranking of impediments are as follows:

(Impediments are arranged in the same order as on the survey.)

Table 2. Occupation/Affiliation and Ranking of Impediments

Impediment	Chi-Square		Cramer's V
	value	Asymp. Sig.	value
Site-Specific	18.21	.198	.208
Property Owner Acceptance	9.42	.804	.149
Pollutant Removal Benefit	15.22	.363	.190
Development Rules	26.06	.025	.248
Lack of Education	20.24	.123	.219
Maintenance	9.85	.773	.153
Flood Protection	23.85	.048	.238
Cost	22.28	.073	.230

95% confidence level, $\chi^2 = 23.68$

At a 95% confidence level with 14 degrees of freedom, chi-square is 23.68. Test statistics indicate that the only statistically significant relationships that exist are between occupation and development rules, and occupation and flood protection.

The strongest association is between occupation and development rules, with a chi-square value of 26.06, an Asymp. Sig. value of .025, and Cramer's V suggesting that 24.8% of the variation is explained by occupation. Cross tabulation tables reveal that consultants ranked development rules as the number-one impediment to low impact development, with 48.5% of consultants ranking this impediment highest. However, government employees and others ranked lack of education as the principle impediment to the implementation of LID (40.8% and 44% respectively). (See Appendix H).

Occupation and flood protection displayed a relationship, although not as strong as the one seen between occupation and development rules. Chi-square is 23.85 with an Asymp. Sig. value of .048, and Cramer's V suggests that 23.8% of the variation is explained by occupation. Examination of cross tabulation tables reveals that consultants

rank the potential of flooding problems much higher than government employees or others. Government employees ranked this impediment most often as 8 (19.2%), while others ranked it most often as 7 (32%). Consultants, on the other hand, most frequently assigned flooding problems a rank of 4 (24.2%). (See Appendix H).

Residence and Ranking of Impediments

Cross tabulations were used to determine if there was an association between a respondent's residence and ranking of impediments (Appendix J). These tests were first run using all 4 categories created in response to the "What city or county do you reside in?" question. Possible responses were represented by codes as follows: 0 = no response, 1 = high growth, 2 = medium growth and 3 = low growth. The sample was dominated by residents of high and medium growth areas, with 102 indicating that they lived in areas of high growth, 80 in areas of medium growth, 14 in areas of low growth, while 15 attendees failed to indicate where they lived. As a result, all cross tabulation tables had at least 50% expected cell counts less than 5, making it difficult to have confidence in the results.

In order to make the test more meaningful, the "no response" category was eliminated, leaving 196 observations out of 211 total. Nevertheless, this still produced cross tabulation tables with at least 33.3% expected cell counts less than 5. While 33.3% is still rather high, by eliminating the "no response" category, the number of expected cell counts less than 5 dropped from 50% to 33%, a much smaller percentage.

Chi-square was used to determine if statistical significance existed between the independent (residence) and dependent (ranking of impediments) variables, and Cramer's

V measured the strength of any association found. In SPSS, the significance value (Asymp. Sig.) is evaluated to test independence when using the Chi-Square statistic, as well as the usual chi-square value found in a chi-square table. Cramer's V may range from 0 to 1, one indicating a strong relationship between variables and zero indicating none. Results of comparing residence and ranking of impediments are as follows: (Impediments are arranged in the same order as on the survey.)

Table 3. Residence and Ranking of Impediments

Impediment	Chi-Square		Cramer's V
	value	Asymp. Sig.	value
Site-Specific	15.94	.317	.202
Property Owner Acceptance	7.35	.920	.137
Pollutant Removal Benefit	9.17	.820	.153
Development Rules	19.97	.137	.225
Lack of Education	10.86	.697	.166
Maintenance	9.68	.785	.157
Flood Protection	7.55	.912	.139
Cost	9.09	.825	.152

95% confidence level, $\chi^2 = 23.68$

At a 95% confidence level with 14 degrees of freedom, chi-square is 23.68. Test statistics indicate that no statistically significant relationship exists between residence and ranking of impediments.

Analysis of Code and Ordinance Worksheets (COWs)

Thirteen counties in VA's portion of the Chesapeake Bay Watershed were analyzed using the Code and Ordinance Worksheet (COW) developed by the Center for Watershed Protection. Once scores were obtained for all thirteen counties, each county was assigned a residence code as described previously (1 = high growth, 2 = medium growth, 3 = low growth). Results are given in the table below:

Table 4. County Score on COW and Residence Code

	County	Score on COW	Residence Code
1	Prince William	71	1
2	Albemarle	68.5	2
3	Loudoun	68	1
4	Chesterfield	58	1
5	Northampton	52.5	3
6	Westmoreland	52	3
7	Goochland	45	1
8	Orange	42.5	1
9	Greene	37.5	1
10	Prince Edward	31	2
11	Bath	27	3
12	Surry	27	2
13	Highland	25	3

Both scores and residence codes for each county were entered into SPSS, and a simple linear regression was performed to determine if a relationship existed between a county's rate of population growth and total score on the COW. Before performing the linear regression analysis, a scatterplot was drawn to see if the variables were linearly related. Results are displayed below:

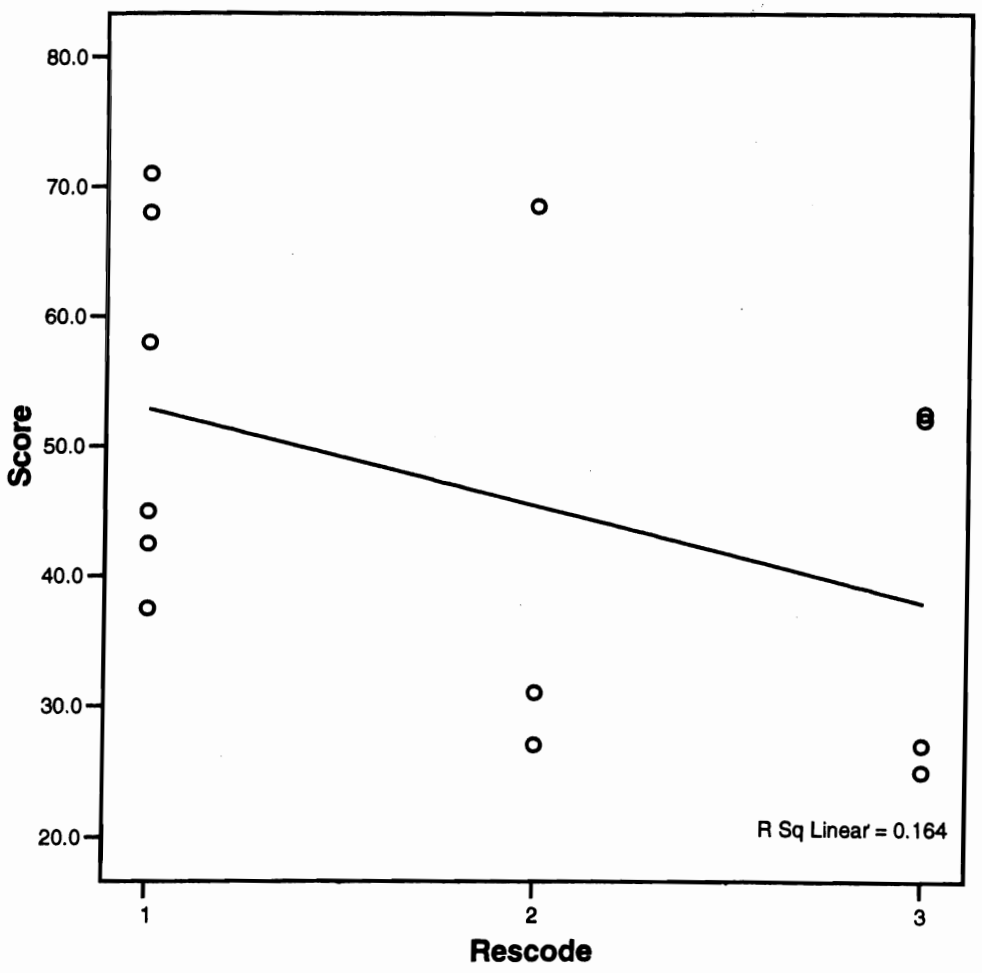


Figure 1. Scatterplot of County's Rate of Population Growth and Score on the COW

The scatterplot indicates that a negative relationship exists between a county's score on the COW and population growth. However, this is due to the way growth pressure was coded. High growth counties were coded as 1, medium growth counties as 2, and low growth counties as 3. If the coding had been reversed, that is high growth counties were coded as 3, medium growth counties remained as 2, and low growth counties as 1, a positive trend would have been observed.

Next, a simple linear regression was performed to determine the strength of this relationship. The Pearson Correlation Coefficient (r) was used to characterize the linear correlation between observed and model predicted values of the dependent variable (score on COW). In this analysis, $r = .405$, signifying a moderate positive linear relationship between residence code and score. The coefficient of determination, r^2, offers further information about the strength of this relationship as it represents the percent of the data that is closest to the line of best fit. In this case, $r^2 = .164$, indicating that only about 16% of the variation in score is explained by the model.

An analysis of variance was performed as part of the regression statistics in order to further test the model's ability to explain variation in the dependent variable. With a value of 2.152 and an observed significance (p-value) of .170, the F statistic reveals that the slope of the regression line is not significantly different from zero. In other words, the three categories of residence code are statistically equivalent, i.e. the mean score of all three categories are close in value.

In summary, statistical testing reveals that the relationship between growth pressure and score on the Code and Ordinance Worksheet is moderate, at best. It appears

that the counties that are experiencing the most population pressure tend to score higher on the COW, while those that are growing slower scored lower, and that counties experiencing the greatest population increase between 1990 and 2000 are somewhat proactive in attempting to accommodate the increased demand upon their resources in an environmentally protective manner. This issue will be discussed further in the next chapter.

Discussion

Low impact development is a relatively new tool in a locality's box for controlling stormwater runoff. Like most new ideas, LID has encountered some resistance, and this study has attempted to identify and rank impediments to the implementation of LID. The research hypothesis for the study was "that development rules imposed by local governments pose the most formidable barrier to the implementation of LID." Was the hypothesis supported by the outcome of the survey? Furthermore, did analysis of county development rules using the COW reveal that counties experiencing high growth pressure were more likely to incorporate better site design and low impact development principles into their codes and ordinances?

Low Impact Development Survey

Two hundred eleven valid survey responses were collected. Out of 211 responses, 77 indicated that lack of education was the most significant impediment to the implementation of LID, while 73 ranked development rules as #1. So, it seems that lack of education, not development rules, is thought to be the biggest roadblock in the use of low impact development. However, the demographics of the sample may account for this observation. Government employees composed more than half of the sample (120 out of 211), and are not likely to view themselves and their work negatively. After all, development rules are determined primarily by local and state government entities. If a more balanced sample had been obtained, the results may have been different.

The next step was to determine if occupation or county of residence influenced how a respondent ranked the impediments.

Occupation

Ranking of each impediment was measured for a potential relationship with occupation. The only associations that were found to exist were between occupation and development rules, and occupation and flood protection.

As noted earlier in this study, the strongest association existed between occupation and development rules. Examination of Appendix I reveals the details of this association. Government employees ranked lack of education as the most important impediment to LID implementation (40.8%), with development rules coming in second (25.8%). Those who classified themselves as others also ranked lack of education as the most important impediment to LID implementation (44%), with development rules coming in second (40%). This contrasts with respondents who classified themselves as consultants, who ranked development rules as the #1 impediment (48.5%). It is clear that there is a very strong feeling among consultants that development rules are the major impediment to the implementation of LID, since almost half agreed that it ranked as #1. This is not surprising, given that among all categories of occupation, this group is most likely to have encountered difficulty with development rules of some type (not necessarily LID) imposed by localities.

It is also not surprising that government employees would rank development rules highly as an impediment (#2), but not as the most important impediment. Government employees ranked lack of education as the #1 impediment to LID, probably because there

would be a natural tendency not to view one's self or one's work as the biggest roadblock in the path of an innovative or beneficial idea. However, government employees are usually acutely aware of how slow the wheels of change sometimes turn, and so it is not unexpected that they would acknowledge some culpability in the institutional resistance to LID. Also, considering that low-impact development is a relatively new concept in stormwater management, the necessity for education is an obvious and correctly noted need.

Although not as strong as the relationship that existed between occupation and development rules, an association also existed between occupation and flood protection. Examination of Appendix I displays this relationship. Consultants rank concerns about flood protection much higher than government employees or others. Consultants most often ranked this impediment as 4, while government employees and others most often ranked it as 8 and 7 respectively. Consultants are more likely to have technical knowledge of stormwater management practices and their limitations, and so it is not surprising that they would rank this impediment higher than government employees and others.

Residence

No association was found to exist between residence and the ranking of impediments. However, it should be noted that individuals from high and medium growth areas dominated the sample. One hundred two respondents were from high growth areas, 80 were from medium growth areas, while 15 did not answer that particular question. In contrast, only 14 respondents were from low growth parts of the state, so

this segment of the population was under-represented in the sample. This may be a result in and of itself, although not the one we were initially looking for. Assuming that most attendees lived in or very close to the county in which they worked, attendance at the various workshops reveals that medium and high growth counties were much more likely to send a representative to learn more about LID. This is probably in response to heightened growth pressure and a desire to explore alternative means of handling this pressure.

Open Ended Survey Questions

The open-ended questions at the end of the LID survey (Appendix E) reflected the results of the ranking exercise. Lack of education and development rules were mentioned most often in response to the question "Would you like to mention other impediments that aren't given in the list?" Some of the more unique responses to the question include engineer's time to design, i.e., 100 small systems vs. one main system, the lack of contractors who specialize in LID, design liability for consultants, the reduction of soil stability due to rising water table in LID developments, property insurance issues, financial lender education and willingness to take a risk. One respondent questioned whether LID would work when the ground is frozen.

Recommendations for overcoming impediments to LID also focused on increased education and the acceptance of LID principles by both state and local governments. The need not only for education, but active salesmanship was noted. Incentives were mentioned frequently, such as reduced mitigation ratios and reduced proffers and fees. Demonstration projects to showcase the benefits of LID, including requiring state

projects to implement LID, were viewed as another means of popularizing LID. One excellent recommendation was "consolidation of all related requirements (erosion and sediment control, stormwater management, Chesapeake Bay Preservation Areas) into one set of rules/procedure." Another recommendation worth noting was "professional society endorsement: ASCE, ASLA, ALA". One respondent even suggested, "Develop a worksheet that will aid in the design and review process." While the COW is not technical enough to be used in that capacity, some of the principles that it puts forth could be used as the basis for a more sophisticated worksheet that could be used by a developer considering the use of LID. Not everyone who attended the LID meetings was supportive of the concept. One respondent answered the open-ended recommendation question with simply "abandon the idea."

Analysis of Code and Ordinance Worksheets (COWs)

Overview

The Code and Ordinance Worksheet proved to be a useful tool when analyzing the development rules of the 13 counties; however it was not without its limitations. In general, the COW was much more useful when analyzing the more developed counties than the rural ones. Many questions on the COW simply were not applicable to the rural counties of Virginia. For instance, question 9(a) "(a)re there any incentives to developers to provide parking within garages rather than surface parking lots?" is not a reliable indicator of a county's commitment to better site design in a locality such as Bath, with a population of only about 5,000 and not much need for structural parking.

In rural counties, a substantial amount of the points awarded often came from state-issued guidance manuals, such as the VDOT Subdivision Street Regulations, because the questions asked were not addressed in county documents. Furthermore, the COW often did not account for other unique environmental initiatives undertaken in rural counties. For example, Highland County has a comprehensive ordinance addressing poultry farming that is intended to protect water quality, however the benefits of this ordinance was not captured by the COW.

Even more rapidly developing counties sometimes had specialized ordinances addressing environmental issues particular to that county that were not accounted for by the COW. For example, Albemarle County has a land use plan that designates 95% of its land as rural area and has placed significant restrictions on how much development can occur on that land. The county is attempting to put all of its commercial land uses and over ½ of its people on 5% of the land, yet this effective tool for watershed protection was not fully captured by the COW.

Furthermore, there were a few questions on the COW that were not particularly useful to either developed or rural counties. For instance, question 2(a) "(d)o street standards promote the most efficient street layouts that reduce overall street length?" is so nebulous and entirely up to the interpretation of the reviewer that credit could not be awarded for any county in the sample. Others were so environmentally advanced that no county document ever addressed them. An example of this type of question is 22(c) "(c)an stormwater be directly discharged into a jurisdictional wetland without pretreatment?" (A point is awarded if the locality answers "no".) Another example is

question 16(b) "(d)o current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops?" While certainly sound environmentally, these ideas are not yet commonplace enough to be reflected in local development codes in Virginia. However, these types of questions on the COW are useful in the respect that they may cause localities to consider better site design techniques that they hadn't previously thought about.

Some of the questions on the COW underscore the need for changes to regulations at the State level. For instance, not one locality addressed question 22(a) "(i)s stormwater required to be treated for quality before it is discharged?" This is the type of issue that could (and should) be addressed by changes to VA's Stormwater Management Regulations, since most localities don't have well-developed stormwater management ordinances and it's a concern that isn't confined by county boundaries.

Score on the Code and Ordinance Worksheets

The Code and Ordinance Worksheet scores locality development rules as indicated on the table below:

Table 5. Code and Ordinance Worksheet Scoring

Score	
90 - 100	Community has above-average provisions that promote the protection of streams, lakes and estuaries.
80 - 89	Local development rules are good, but could use minor adjustments or revisions in some areas.
70 - 79	Opportunities exist to improve development rules. Consider creating a site planning roundtable.
60 - 69	Development rules are likely inadequate to protect local aquatic resources. A site planning roundtable would be very useful.
Less than 60	Development rules are definitely not environmentally friendly. Serious reform is needed.

None of the counties analyzed in this study scored above 71 (see table 4), and many scored much lower. This is alarming given that the sample was dominated by high growth counties, some of them the fastest growing in the Commonwealth, yet only three counties out of thirteen scored what would be deemed a passing grade (60 or greater) if considered on a scale typical to most American schools. So, while it can be said that the counties experiencing high growth pressure are more likely than those experiencing medium or low growth pressure to incorporate better site design principles within their codes, the actual scores show that there is much room for improvement.

Statistical Analysis of Code and Ordinance Worksheets

Statistical analysis revealed that the independent variable, residence code, was not a significant predictor of the dependent variable, score on the COW. The correlation coefficient (r) was only .405, which suggests a moderate positive linear relationship between residence code and score. However, even if it is statistically significant, whether a correlation of a given magnitude is substantively or practically significant depends greatly on the phenomenon being studied. Generally, correlations tend to be higher in the physical sciences, where relationships between variables often obey uniform laws, and lower in the social sciences, where relationships may be harder to predict. A correlation of .4 between a pair of sociological variables may be more meaningful than a correlation of .7 between two variables in physics (Voelker and Orton, 1993).

The composition of the sample may have had an effect on the outcome of the regression analysis. Only 13 counties were analyzed, which may have been too small of a sample to produce statistical significance. Furthermore, the sample was not evenly

balanced in terms of residence codes. Only counties that fell within the Chesapeake Bay watershed in VA were included in the study population; these also tend to be the most populated counties in the Commonwealth, as many are in the highly desirable piedmont and coastal plain regions. The final sample was composed of six counties that classified as high growth, while only 3 were in the medium and 4 in the low growth groups. Almost half of the sample was categorized within one group, high growth, and this may have distorted the outcome. However, this also reflects the need for counties within the Chesapeake Bay watershed to step-up efforts to improve development rules in order to prevent adverse effects to water quality. The composition of the sample reveals that the region is clearly experiencing a disproportionate amount of growth pressure relative to areas of the state that are not within the watershed.

Perhaps if a different means of measuring growth pressure were utilized, the sample would have been different. The percent change in population between 1990 and 2000 was used to rank the counties in ascending order of population growth. These figures were provided by the U.S. Census, and while they are a relatively accurate measure of the number of people within a county, they don't quantify the actual development of land. More urbanized localities may already have the infrastructure in place to accommodate increased population growth, and so new development may not be necessary. Or, an unusual circumstance may exist, such as the building of a new prison, which dramatically increases the number of county residents. A more accurate measure of growth pressure may have been obtained by using housing starts or the number of housing permits issued in each county during a given time period.

The Chesapeake Bay Preservation Act and Score on COW

Virginia has taken steps towards meeting the challenge of increasing growth pressure in the Chesapeake Bay watershed. The Commonwealth's Chesapeake Bay Preservation Act specifically requires localities to revise their codes and ordinances to meet the provisions of the Act, which is designed to improve water quality in the Chesapeake Bay and its tributaries by requiring wise resource management practices in the use and development of environmentally sensitive land features. At the heart of the Bay Act is the idea that land can be used and developed in ways that minimize impact on water quality (VA DCR, n.d.).

Under the Bay Act, each Tidewater locality must implement a program based on the regulations adopted by the Chesapeake Bay Local Assistance Board. Local Bay Act programs start by adopting or amending local land use plans and ordinances. Local governments must amend their zoning ordinances, subdivision ordinances and comprehensive plans to incorporate water quality protection measures consistent with the Bay Act Regulations (VA DCR n.d.).

Five counties in the sample fall under the provisions of the Chesapeake Bay Preservation Act. These counties are Chesterfield, Northampton, Prince William, Surry and Westmoreland. Four out of the five fell into the top half of the sample in terms of score on the COW (Chesterfield, Northampton, Prince William and Westmoreland). Two of these counties, Northampton and Westmoreland, were classified as low growth. This suggests that the Chesapeake Bay Preservation Act is indeed making a difference in Virginia. Most of the counties that are required to adopt the provisions of the Act scored

better than those who aren't, even if they aren't experiencing high growth pressure. Furthermore, out of 13 counties in the final sample, Prince William scored higher than any other county, although two other counties, Loudoun and Greene, experienced significantly more growth pressure between 1990 and 2000, based on figures provided by the U.S. census. Neither Loudoun nor Greene is required to follow the Chesapeake Bay Act Regulations.

While this study has resolved some questions about the implementation of low impact development and better site design in the Chesapeake Bay Watershed in Virginia, many more remain unanswered. We know that lack of education and local development codes are the greatest impediment to LID. To what degree can education actually effect a change in the implementation of LID by local governments? Is education alone enough? If not, what are the other factors? How do we ensure that all local governments have equal access to technical LID training? Perhaps if a similar study were undertaken 5 – 10 years from now, clearer answers to these questions would emerge when compared to the results of this study.

Conclusions and Recommendations

Better site design, combined with low impact development practices, can help reduce the impact of development through limiting impervious surfaces, preserving natural habitats and mimicking pre-development hydrologic functions (VA DCR, 2004). The Chesapeake Bay 2000 agreement states that by 2005 the partner jurisdictions would, "in cooperation with local government, identify and remove state and local impediments to low impact development designs to encourage the use of such approaches and minimize water quality impacts" (Chesapeake Bay Program, 2000). To what extent has Virginia accomplished this goal? How widespread is the actual use of LID?

While LID has certainly gained increased acceptance, it has not yet become mainstream in practice. However, more and more people are talking about it, and it is increasingly working its way into the everyday vernacular among stormwater professionals of all types. One unforeseen benefit of this project spanning over so many years is that it has allowed the researcher to witness the growing momentum of interest in low-impact development in Virginia. When the project was first started in 2002, low-impact development was a term known primarily to a small, dedicated, progressive group of local and state officials, but by the close of the project in 2007, LID was being embraced on a much larger scale. Since 2002, Stafford County has incorporated LID principles into their comprehensive plan and zoning ordinance, and other counties are in the process of following suit. Low impact development has become a major initiative in state policies, as reflected by its use in VA's Tributary Strategies, the incorporation of

certain LID practices into the VA Stormwater Management Handbook, and the increase in grant funding earmarked for LID projects. This effect is even trickling down into the educational system. A prominent environmental group within the Chesapeake Bay Watershed, Friends of the Rappahannock (FOR), is currently working to partner with local school systems to develop a LID program for high school students.

The results of this study indicate that lack of education about LID principles, not local government development rules, is the most significant impediment to the implementation of low impact development. However, differences were observed among survey respondents depending upon their occupation/affiliation. Government employees and others ranked lack of education highest, while consultants ranked development rules as the most important impediment. The pollutant removal benefit of LID was ranked as the least important impediment. A respondent's county of residence did not influence ranking of impediments.

We also learned that counties within Virginia's portion of the Chesapeake Bay Watershed who are experiencing the most growth pressure are more likely to incorporate better site design and low impact development principles within their local codes and ordinances. However, when analyzed using the Code and Ordinance Worksheet, none of the counties scored above a 71 out of a possible score of 100 (and many scored much lower), indicating that in the Chesapeake Bay Watershed in Virginia, development rules are likely inadequate to protect local aquatic resources.

There is no single solution to reducing the impacts to water quality that will inevitably occur as more people move into the watershed and development pressures

continue to increase. Low impact development is just one tool that can be used by localities to reduce the additional runoff and resulting nonpoint source pollution that will occur as impervious surfaces grow. And while it has gained increased acceptance in recent years, more could be done to mainstream LID. The following is a summary of recommendations that reflect the findings of this study:

Recommendations:

1) The need for further education cannot be over-emphasized. Many stakeholders are familiar on a cursory level with LID, however if it is to be widely implemented, more in-depth training will be necessary. Every person at each level of local government must be reached, from the Board of Supervisors to planning department staff. Some will need a deeper level of expertise than others. For instance, those who are involved with the review of LID plans must understand the more technical aspects of the approach. Other professionals who need more advanced training would include engineers, land development consultants and the contractors actually installing the practices.
2) Coordination and consolidation of state regulations addressing erosion and sediment control, stormwater management and the Chesapeake Bay Preservation Act would reduce confusion among those trying to implement LID. Clear guidelines about the use of LID should be established within each program, and each program should actively promote the use of LID practices. These guidelines should be developed as a collaborative effort so that each program is aware of

what is being advocated by the others and to ensure conflicting requirements are not put into place.

3) Incentives should be provided to those in the development community willing to implement LID. Tax credits, density bonuses, mitigation credits, and reduced proffers or fees all could be used to make LID more attractive to developers and may make "taking a risk" on LID more acceptable. Understandably, many developers may not see the point in learning a new methodology that may involve more review (and thus delay) and in some cases, costs more. Many developers are environmentally conscious, and if a benefit is offered in exchange for implementing LID, they would be much more likely to try it out.
4) Guidance documents that specifically aid in the LID design process need to be developed. A standardized worksheet should be created that assists those interested in using LID in determining whether or not it is appropriate for the development in question. Similarly, another worksheet could be developed that walks the user through the initial design phase. Model development sites need to be identified and actively promoted so that land development professionals have something tangible to scrutinize and evaluate.
5) More research on the benefits of LID needs to be undertaken. The pollutant removal capability of LID needs to be documented so that land development professionals are more comfortable using LID as a mitigation tool. Also, credit could be claimed for the use of LID practices in meeting the goals of Virginia's Tributary Strategies if scientifically defensible pollutant reductions were assigned.

Model LID projects need to be publicized so that they are visible not only to those involved in land use planning, but also to the average homeowner. These projects should be monitored to establish the long-term benefits of implementing LID.

6) LID needs not only to be allowed by regulating authorities; it also needs to be endorsed. This is the final step in mainstreaming LID, and can only occur after recommendations 1 – 5 have taken place. In order for both the regulating and development community to fully accept LID, it has to be proven over the long-haul, and this takes time. There will be growing pains, successes and mistakes. Mind-sets must be changed. However, If BSD and LID proponents persevere, eventually a synthesis will occur in which traditional stormwater management techniques and LID co-exist, as each have a place in the protection of water quality.

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Appendix A

Model Development Principles

Residential Streets and Parking Lots

These principles focus on those codes, ordinances, and standards that determine the size, shape and construction of parking lots, roadways, and driveways in the suburban landscape.

1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.

2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

5. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

6. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.

7. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.

8. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.

9. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

10. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

Lot Development

Principles 11 through 16 focus on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods.

11. Advocate open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.

12. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

13. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

14. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

15. Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.

16. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.

Conservation of Natural Areas

The remaining principles address codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development.

17. Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.

18. The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the delineation, plan review, construction, and occupancy stages of development.

19. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

20. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas to promote natural vegetation.

21. Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.

22. New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.

Appendix B

Codes and Ordinances Worksheet

1. Street Width

a. What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)?

If the answer is between 18-22 feet, award 4 points _____

b. At higher densities are parking lanes allowed to also serve as traffic lanes (i.e., queuing streets)?

If the answer is YES, award 3 points _____

2. Street Length

a. Do street standards promote the most efficient street layouts that reduce overall street length?

If the answer is YES, award 1 point _____

3. Right-of-Way Width

a. What is the minimum right-of-way (ROW) width for a residential street?

If the answer is less than 45 feet, award 3 points _____

b. Does the code allow utilities to be placed under the paved section of the ROW?

If the answer is YES, award 1 point _____

4. Cul-de-Sacs

a. What is the minimum radius allowed for cul-de-sacs?

If the answer is less than 35 feet, award 3 points

If the answer is 36 feet to 45 feet, award 1 point _____

b. Can a landscaped island be created within the cul-de-sac?

If the answer is YES, award 1 point _____

c. Are alternative turn arounds such as "hammerheads" allowed on short streets in low density residential developments?

If the answer is YES, award 1 point _____

5. Vegetated Open Channels

a. Are curb and gutters required for most residential street sections?

If the answer is NO, award 2 points _____

b. Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)?

If the answer is YES, award 2 points _____

6. Parking Ratios

a. What is the minimum parking ratio for a professional office building (per 1,000 sq ft of gross floor area)?

If the answer is less than 3.0 spaces, award 1 point _____

b. What is the minimum required parking ratio for shopping centers (per 1,000 sq ft gross floor area)?

If the answer is 4.5 spaces or less, award 1 point _____

c. What is the minimum required parking ratio for single family homes (per home)?

If the answer is less than or equal to 2.0 spaces, award 1 point _____

d. Are the parking requirements set as maximum or median (rather than minimum) requirements?

If the answer is YES, award 2 points _____

7. Parking Codes

a. Is the use of shared parking arrangements promoted?

If the answer is YES, award 1 point _____

b. Are model shared parking agreements provided?

If the answer is YES, award 1 point _____

c. Are parking ratios reduced if shared parking arrangements are in place?

If the answer is YES, award 1 point _____

d. If mass transit is provided nearby, is the parking ratio reduced?

If the answer is YES, award 1 point _____

8. Parking Lots

a. What is the minimum stall width for a standard parking space?

If the answer is 9 feet or less, award 1 point _____

b. What is the minimum stall length for a standard parking space?

If the answer is 18 feet or less, award 1 point _____

c. Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars?

If the answer is YES, award 1 point _____

d. Can pervious materials be used for spillover parking areas?

If the answer is YES, award 2 points _____

9. Structured Parking

a. Are there any incentives to developers to provide parking within garages rather than surface parking lots?

If the answer is YES, award 1 point _____

10. Parking Lot Runoff

a. Is a minimum percentage of a parking lot required to be landscaped?

If the answer is YES, award 2 points _____

b. Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed?

If the answer is YES, award 2 points _____

11. Open Space Design

a. Are open space or cluster development designs allowed in the community?

If the answer is YES, award 3 points
If the answer is NO, skip to question No. 12 _____

b. Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance?

If the answer is YES, award 1 point _____

c. Are the submittal or review requirements for open space design greater than those for conventional development?

If the answer is NO, award 1 point _____

d. Is open space or cluster design a by-right form of development?

If the answer is YES, award 1 point _____

e. Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g, setbacks, road widths, lot sizes)

If the answer is YES, award 2 points _____

12. Setbacks and Frontages

a. Are irregular lot shapes (e.g., pie-shaped, flag lots) allowed in the community?

If the answer is YES, award 1 point _____

b. What is the minimum requirement for front setbacks for a one half (½) acre residential lot?

If the answer is 20 feet or less, award 1 point _____

c. What is the minimum requirement for rear setbacks for a one half (½) acre residential lot?

If the answer is 25 feet or less, award 1 point _____

d. What is the minimum requirement for side setbacks for a one half (½) acre residential lot?

If the answer is 8 feet or less, award 1 point _____

e. What is the minimum frontage distance for a one half (½) acre residential lot?

If the answer is less than 80 feet, award 2 points _____

13. Sidewalks

a. What is the minimum sidewalk width allowed in the community?

If the answer is 4 feet or less, award 2 points _____

b. Are sidewalks always required on both sides of residential streets?

If the answer is NO, award 2 points _____

c. Are sidewalks generally sloped so they drain to the front yard rather than the street?

If the answer is YES, award 1 point _____

d. Can alternate pedestrian networks be substituted for sidewalks (e.g., trails through common areas)?

If the answer is YES, award 1 point _____

14. Driveways

a. What is the minimum driveway width specified in the community?

If the answer is 9 feet or less (one lane) or 18 feet (two lanes), award 2 points _____

b. Can pervious materials be used for single family home driveways (e.g., grass, gravel, porous pavers, etc)?

If the answer is YES, award 2 points _____

c. Can a "two track" design be used at single family driveways?

If the answer is YES, award 1 point _____

d. Are shared driveways permitted in residential developments?

If the answer is YES, award 1 point _____

15. Open Space Management

a. Does the community have enforceable requirements to establish associations that can effectively manage open space?

If the answer is YES, award 2 points _____

b. Are open space areas required to be consolidated into larger units?

If the answer is YES, award 1 point _____

c. Does a minimum percentage of open space have to be managed in a natural condition?

If the answer is YES, award 1 point _____

d. Are allowable and unallowable uses for open space in residential developments defined?

If the answer is YES, award 1 point _____

e. Can open space be managed by a third party using land trusts or conservation easements?

If the answer is YES, award 1 point _____

16. Rooftop Runoff

a. Can rooftop runoff be discharged to yard areas?

If the answer is YES, award 2 points _____

b. Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops?

If the answer is YES, award 2 points _____

17. Buffer Systems

a. Is there a stream buffer ordinance in the community?

If the answer is YES, award 2 points _____

b. If so, what is the minimum buffer width?

If the answer is 75 feet or more, award 1 point _____

c. Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required?

If the answer is YES, award 1 point _____

18. Buffer Maintenance

a. Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegetation?

If the answer is YES, award 2 points _____

b. Does the stream buffer ordinance outline allowable uses?

If the answer is YES, award 1 point _____

c. Does the ordinance specify enforcement and education mechanisms?

If the answer is YES, award 1 point _____

19. Clearing and Grading

a. Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites?

If the answer is YES, award 2 points _____

b. Do reserve septic field areas need to be cleared of trees at the time of development?

If the answer is NO, award 1 point _____

20. Tree Conservation

a. If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved?

If the answer is YES, award 2 points _____

b. Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction?

If the answer is YES, award 1 point _____

21. Land Conservation Incentives

a. Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)?

If the answer is YES, award 2 points _____

b. Is flexibility to meet regulatory or conservation restrictions (density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers?

If the answer is YES, award 2 points _____

22. Stormwater Outfalls

a. Is stormwater required to be treated for quality before it is discharged?

If the answer is YES, award 2 points _____

b. Are there effective design criteria for stormwater best management practices (BMPs)?

If the answer is YES, award 1 point _____

c. Can stormwater be directly discharged into a jurisdictional wetland without pretreatment?

If the answer is NO, award 1 point _____

d. Does a floodplain management ordinance that restricts or prohibits development within the 100 year floodplain exist?

If the answer is YES, award 2 points _____

TOTAL _____

Scoring

90 - 100	Community has above-average provisions that promote the protection of streams, lakes and estuaries.
80 - 89	Local development rules are good, but could use minor adjustments or revisions in some areas.
70 - 79	Opportunities exist to improve development rules. Consider creating a site planning roundtable.
60 - 69	Development rules are likely inadequate to protect local aquatic resources. A site planning roundtable would be very useful.
less than 60	Development rules are definitely not environmentally friendly. Serious reform is needed.

Appendix C

Survey

IMPEDIMENTS TO LOW IMPACT DEVELOPMENT SURVEY

The purpose of this research study is to identify the impediments to the implementation of low impact development in Virginia. Your participation is voluntary. If you do participate you may freely chose not to answer all of the questions, and you may stop at any time. The survey will take about 5 minutes of your time. There are no foreseeable risks to this research. The benefits of this research are to gain knowledge about the impediments to low impact development that will eventually aid the Commonwealth of Virginia in meeting land use goals set forth in the Chesapeake 2000 agreement. You will not be asked for your name or address. Information gained from this survey will be statistically analyzed and general findings published, but individual participants will never be identified. By responding to this survey, I agree to these terms.

First, please tell me a little about yourself:

Which category below best describes your current occupation? Please provide additional detail or specialty in the space provided after the category you chose. For example, government employees, specify which locality/agency and department; consultants, specify type of consulting, (environmental engineer, political, etc.)

_____ Local, State, or Federal Gov't Employee_____
(including elected officials)
_____ Developer/Realtor_____
_____ Consultant_____
_____ Environmental Organization_____
_____ Other_____

What city or county do you reside in? _____

How did you first find out about Low Impact Development? (check all that apply)

_____ Workshop/Seminar
_____ Professional Organization
_____ Mass Media (TV, Radio, Newspaper)
_____ Word of Mouth
_____ Internet
_____ Letter of Invitation
_____ Don't Remember
_____ Other (please explain) _____

Please rank the following impediments to low-impact development, where 1=most significant impediment and 8=least significant impediment.

_____ Site-specific and non-structural in nature: Can't apply one set of principles universally; must consider unique characteristics of each site.

_____ Property owner acceptance: People prefer the typical American suburb (large-lot subdivisions) over clustered communities.

_____ Pollutant removal benefit: LID practices are commonly applied together, making it difficult to accurately quantify potential benefit.

_____ Development rules: Sub-division codes, zoning regulations and other local and State ordinances/laws that prohibit LID practices.

_____ Lack of knowledge/education about LID principles.

_____ Maintenance considerations: Property owners will not maintain on lot LID practices.

_____ Flooding problems: LID techniques cannot handle critical flooding problems as effectively as conventional development.

_____ Cost: LID practices increase the cost of development.

Would you like to mention other impediments that aren't given in the list?

_____

_____

_____

_____

Do you have any recommendations for overcoming impediments to LID?

_____

_____

_____

Thank you very much for participating in this survey. This survey will be used as one part of a thesis project that will identify the impediments to low impact development. If you have any questions or concerns about this survey, please contact V'lent Lassiter (804-786-6329 or rvlassiter@dcr.state.va.us) or Dr. Margot W. Garcia (804-828-2489 or mgarcia@hsc.vcu.edu). If you have any questions about your rights as a subject, you may call VCU's Office for Research Subjects Protection at 804-828-0868.

Appendix D

LID Meeting Dates and Locations

July 10, 2002. "Innovative Stormwater Management Workshop." Middletown, VA (Frederick County).

September 5, 2002. "Low Impact Development for Local Governments and Engineers." Fredericksburg, VA.

October 10, 2002. "Overcoming Impediments to Environmentally Sensitive and Low Impact Development and Design." Fredericksburg, VA.

March 12, 2003. "Low Impact Development Workshop." Harrisonburg, VA.

Workshop Series: "How to Best Consider Low Impact Development Practices and Other Innovative Stormwater Management Practices in the Review of Proposed Development Projects."

October 10, 2003: Charlottesville, VA

December 3, 2003: Richmond, VA

December 4, 2003: Fairfax, VA

December 8, 2003: Chesapeake, VA

December 11, 2003: Roanoke, VA

Appendix E

Responses to Open-Ended Questions

1. Would you like to mention other impediments that aren't given in the list?	
Category	**Comments and Responses**
Impediment already given on survey: cost	Cost of maintenance of streets with aggregate on grass shoulders in lieu of curb and gutter. Design costs for LID. Lack of usable soils in this area will raise cost. Additional design cost and soils investigation and cost. Most clients do not want to pay consultants to think for environmental benefit – only to provide cheapest, straightforward design. How will costs for perpetual maintenance be funded? Soils amendment cost to implement (valley soils don't promote good infiltration characteristics).
Impediment already given on survey: education	I don't know if these ideas are taught in college courses now but if they are not, that is an impediment. We need to infiltrate gov't/municipal agencies and design firms with people educated from the beginning in these areas.
Impediment already given on survey: flooding problems	Since large storms won't be addressed, conventional SWM will be necessary anyway at some sites. Reduces enticement to spend money, labor on LID – it's extra. Can I prove MS -19 in court for an owner with LID not in combination with conventional SWM?
Impediment already given on survey: local/state development rules	City and county governments, VDOT. Lack of latitude for innovative design due to code restrictions and overly burdensome review. VDOT and locality rules. The "land use" game itself and the proffer system mentality that is utilized in VA. The lack of will by local government to implement and stay with new/innovative approaches. The most significant impediment is engineers and designers are following "old" state regulations and standards. State needs to change its guidelines for stormwater runoff. Regulatory – especially state SWM & ESC reviewers, educate these people and have them develop/incorporate design standards in their manuals. Governmental – plan reviewers. Political acceptance. Program management (who is the guru/cheerleader that keeps LID out front?). Local Government Coordination. Ability of local municipalities to review/approve LID. No procedures are adopted by the county, we can not ask for the information to justify/prove the effectiveness of the LID design. The plan approval procedure. VDOT agreement, acceptance.

	Coordination with the Erosion & Sediment Control law. Coordination of agencies with conflicting goals: VDOT, Fire, DCR.
Impediment already given on survey: maintenance	"Low Impact Development" seems like it has potential to become a buzzword meaning "high maintenance & cost" and may discourage potential homebuyers. If systems are too complicated, people will not buy homes in LID developments. Maintenance – who? cost? perpetuity? Issues of public works vs. environment – public works focus on getting water out. Reverses 100 years of thinking on street/drainage regulations. Rain gardens, etc. look nice when new. Mature sites look sloppy if not maintained. Home owners associations, zoning, may not be able to enforce maintenance. County needs program to handle broken systems (i.e. home owner will not pay to fix cracked or failed underdrain.) Neighbor downstream may re-landscape and impede drainage from upstream. Some people flat out don't care about anything but their green lawns and don't see the need for these measures. Karst topography – snow removal, homeowners removing or damaging LID practices. Lack of understanding and providing maintenance by property owner.
Impediment already given on survey: property owner acceptance	Property owner acceptance can not be understated. Designers/developers respond to incentives from the county but more importantly, they respond to buyer demand. Given more options, many buyers of homes would probably embrace LID if they had that as an option. As it is, the developers/builders have disproportionate influence over what home designs are built. Find a way for buyers to have more of a voice in the process and we may find greater acceptance and demand for LID. Public perception of "quality development" – needing sidewalks, curb & gutter. Property owner acceptance is a huge factor, and overrides all others combined.
Approval Time/Risk	Time value of money! It takes too long to get LID approved and it is also too risky. Financial lender education and willingness to take a risk. Uncertainty to the developer. Market and financial institution concerns. Even if LID is not prohibited, it may not be easy to gain approval. It will be necessary to educate reviewers, etc. so they can adequately review LID plans. There could also be design liability for consultants. We design a LID site, there are problems, we get sued. There must be some way to demonstrate that the design professional followed standard practice. Must give consultant lee-way to avoid litigation.
Burden on Homeowner/ Developer	Burden to homeowner. More government intrusion to homeowner. Benefits accrue to the broader community, costs/burden is on developers and private property owners. How to transfer motivation from former to the latter.
Construction/ Engineering	Engineer's time to design, i.e., 100 small systems vs. one main system. VDOT minimum road standard requirements for maintenance. Availability of specialty materials/products associated with several structures; in rural areas deter consideration. Time factor and upfront leg work – paradigm change in mindset. Anti-traditional civil engineering. Not all development is the same – impediments vary too. Engineers are more likely to use proven off the shelf designs given the usual realities of fast turn-around with low cost. Current professional education and continuing education – reform that! Quality control of soil mixtures. Engineer acceptance (engineers design facilities they are most familiar with). Drainage – people desire conventional drainage systems. People prefer sidewalks, curb and gutter, etc.

	Secondary impacts – storing water around parking lots, roads and buildings raises water table reducing structural stability of soils. Roads and parking lots will fail, footings and sidewalks will crack, etc. 10% - 15% of land loss to LID causes sprawl. Conflicting site/development demands, pedestrian connectiveness, off-street parking in residential, maintaining drainage may limit unit yield, also eliminating curb eliminates a barrier between pedestrians and cars. Do LID practices work when ground is frozen? Who is going to maintain LID facilities? ADA requiring wider sidewalks. Emergency access – fire department does not want to make roadways narrower. Local zoning regulations – resist proposals for higher density while stating they are against sprawl. How to implement LID on existing properties (request/require homeowners to use rain barrels, for example)? More vehicles (parking) per household – on street parking more difficult with ditch section. Have to change developer's mindset – incorporate LID before designing layout. Construction oversight – local government fear that contractors will not install properly due to lack of understanding. Historic progression of stormwater control awareness, flood control, erosion & sediment control, water quality and stream restoration/protection: LID helps with pieces of each of these, but realize it doesn't address all 100%, but it is better for overall aesthetics to all stormwater controls. Contractor responsibility increased – can they be relied on? What happens if in 5 years we find LID is no longer working – what is done for SWM then? Even if the designers include LID – where is the excavator/contractor that will install these practices? Unproven technology; lots of potential failures and areas needing retrofit. Poor construction/inspection even if designed correctly. Frequency of shallow depth to bedrock. "Build-in" sites don't want to sacrifice the space. Concept for building location is programmed between architects and owners – not much flexibility remaining for LID. Additions to existing buildings. Sequence of construction and stormwater detention during construction. Difficult to apply on-site LID for residential uses. Construction crews need buy-in.
Incentives	Lack of incentive to developers, waivers needed for implementation. Protection needed once methods are in place (easements). Lack of incentives/impetus to developers. Incentives – why learn a new system and possibly spend time & money, when the old one gets us through the process? Who enforces? Who ultimately pays? No established incentives to encourage incorporation into development plans. No $ incentives to builder/developer. No incentives for developer.
LID Models	Few successful models to prove viability. Lack of accessible demonstration sites. Be able to define by examples. The lack of demonstrated cost savings and/or effectiveness sites. In other words, there are not many demonstration sites to provide incentive for LID. Lack of projects in Southwest VA or in different topography regions.

	No visible regional examples to help convince property owners and developers.
Public Health	Mosquito-vector related issues associated with LID and bioretention. West Nile virus.
Research/Guidance	No clear definition/goals of LID. Specific definition of LID. Lack of available information: techniques and benefits. No methodology/calculations to determine how LID works & whether it meets local/state water quality requirements. How much to push it. How much is practicable? Don't just give cookbook, as you effectively remove engineering judgment from the design. It will complicate the review if they are not educated to understand.
Resistance to change	Change! (Not wanting to.) Resistance to change. Property insurance issues. Engineers, developers and reviewers are too set in their ways and comfortable with the cookie cutter approach to design. LID requires a more imaginative process and greater difficulty in quantifying water quality and volume calculations to satisfy "red tape." Political inertia. Politics – conservative, anti-government region. "We've always done it this way" – the costs of learning something new. Inertia (people go with what they're familiar with rather than innovation). Resistance to change and apathy. The will to make it happen! Ignorance of developers, designers, reviewers to new ideas. Engineers that only focus on meeting minimum standards with methods that have been accepted, "proven"! Developer reluctance to try something that may involve more zoning review and delay. Education and changing mindset of many county planners and officials. Designer, engineer, and developer resistance to change; preference for the familiar; reluctance to make effort to try; fear of failure.
Stakeholder Cooperation	Lack of cooperation or initiative for stakeholders to work together. When (trying) to use LID no growth groups will use uncertainty to stop growth. Lack of coordination between federal, state and local government and related private sector individuals.
Training	Plan reviewer training. Lack of contractors specialized in LID. Unfamiliarity for developer, locality, contractors.
Other	Enforcement issues pertaining to LID on residential lots. Overall imperviousness of watershed is the most important factor in saving the Chesapeake Bay. LID is subfactor, a tool to help lessen impact of development. Changing business practices. The fact that when on-site wetland mitigation is performed, storm water flows are not permitted to be discharged into them. Conflict with density: the push for new urbanism (alleys, sidewalks, small lots, etc.) conflicts with some of the LID design principles.

2. Do you have any recommendations for overcoming impediments to LID?	
Category	**Comments and Responses**
Education	Showcasing successful implementations/education/awareness (public elected officials), model zoning/subdivision ordinances, etc. Incorporating LID training for local government staff. More educational opportunities. More workshops and other education aimed at county officials, more state guidance to emphasize LID approaches. Partnering/education between municipalities/engineers/VDOT to make use of LID more common. Typically industrial/commercial clients are much more receptive to using these techniques. Build on those uses and publicize to encourage residential developers to do the same. Workshops and education. Education, examples for the people to be impacted can see and relate to. Educate public officials and development community. Continued education – more specific regulatory guidelines to provide direction to designers and reviewers. More public awareness through news media. Begin education program in public school – environmental science, vocational-technical programs. Educate county officials first, then development/engineering community. Demonstration sites, clearinghouse to local ESC/SWM officials (i.e. list they can look at in their area). Greater education for local government Planning Commissions, Board of Supervisors. Educate Board of Supervisor members. Education! State policy/mandate. Education, incentives. Make it known and usable to developers and engineers. Better educational programs. Better understanding of financial institution impact. Public needs more education. Must show how LID will not be a huge cost increase to developer and local government. Education, education and more education. Education/Public Relations methods. Undertake concentrated public education campaign (like the "Know your Watershed" campaign) to bring stormwater management issues to public awareness. Community outreach programs and demonstrations. Get "key" developers on board. Continuing education, emphasizing water quality issues. Education at all levels. Education and training of all parties. Educating decision makers (legislators, developers) and public. Public education is the most important. People have to buy into the concept. Make it viewed as a benefit – self irrigating landscape system, create storage system and tap into sprinkler system. It has to be pretty and low maintenance for people to want it. Market it better. Educate all relevant parties.

	Major public awareness and acceptance by all localities. More education/seminars for stakeholders. Formal education as core curriculum. Lots of education opportunities for public and development. Education & agreement/coordination with all involved officials. Education! Encouragement by both federal and state agencies. Education – of localities, homebuilders associations, VDOT, civic groups, etc. Education is the key, including in colleges. Educate the public. Educational presentations and demonstrations to local officials and planners. Overcome regulatory obstacles and mindset. More education – get private, commercial sector involved. Provide more education about the facts that LID does not cost more, provides great environmental benefits, and can be very aesthetically pleasing. As people understand more about these practices, they will gain acceptance. A lot of education, both public and private. Spreading knowledge of LID – to local government and general population. Long-term education process – local government, developers, and population. Education sessions that are geared toward people from the private sector/public; pilot programs scattered around the state for education. Task forces/study groups = education. Organized effort to educate and implement principles and network with other environmental groups who would support and help to educate.
Flooding Problems	It appears that LID practices would be difficult to apply to an industrial park, for instance. It is desirable to use a regional SWM pond. This pond is usually designed and built with the park's infrastructure. Sites are typically developed later. Pond is built for worst-case impervious scenario. If a combination of LID and SWM pond(s) is used, then you can't know how large to make the pond. LID seems better suited to areas with less roof area as compared to total land area. On sites with very large buildings and relatively large building to land ratio, it seems LID would be difficult due to inadequate area to make pervious locations. Other methods such as underground detention would be necessary, or offsite (regional) SWM would be more suitable. It seems that many LID goals could be accomplished by simply requiring excess detention. Erosion in a stream channel does not vary linearly with the discharge. For this reason, it should be possible to release more water over a longer time period in order to replicate the original hydrology.
Incentives	State and local tax credits to property owners for maintenance. Incentives and tax benefits – top down approach. Local/state incentives – If this truly works then some $$ saved in regulatory costs could be reinvested in tailoring incentives, diminishing cost and increasing the critical mass of developer acceptance. Ordinance waivers or density bonus to allow for implementation of LID measures. Implement LID as an incentive rather than a requirement. If the private sector can profit from it, they will find a way to make it work. Change/consolidate regulations to give incentives to developers. Incentives – reduced mitigation ratios, reduced proffers or fees.

	Provide incentives through mitigation credits along with possible BMP credits by local governments. Support voluntary implementation of LID approach. Develop incentives in conjunction with Federal/State/Local governments to implement LID. Incentives for regulated community; education on cost/trade-offs (for example, implementing LID may cost more on a project, but not as much as wetland mitigation would cost on same project). Provide incentives for developers to implement. Unlikely to be utilized unless required or there is a tangible incentive. Give incentives (won't be utilized otherwise). Create incentives, reduce need for waivers, continue educating the public until this idea/concept becomes "the norm". Incentives to developers and localities. Use financial incentives such as reduction in stormwater fees. Provide mitigation credit for implementing LIDs. Incentives to contractors to try LID measures.
LID Certification/ Standardization	Workshops/certificates for developers/plan reviewers. Have a single set of LID standards for all localities/agencies promoting or requiring LID. Professional society endorsement, ASCE, ASLA, ALA. A Board should be created that uses private and public people (state & local) to make a good system that works and everyone can live with. Easier said than done. Need standards that are accepted by local governments. They should be very consistent from area to area. Need way to quantify SWM benefit to show compliance with laws.
LID Models	Incorporate into green developments, public education, example projects. Publicize working examples that people can visit and publish data on improvements to stream sedimentation or other tangible proof. If someone could develop a large green LID subdivision to serve as an example. An information kiosk with cost comparisons, explanations, benefits, etc. would be educational. Implement certain LID stormwater management techniques on small scale projects to make reviewing agencies aware of LID techniques. Arrange small-scale local demonstration sites. Conduct demonstration projects. Using partial LIDs in lieu of entire projects to facilitate installation and use. Demonstration projects & education. The more specifics people have to refer to – case studies – the better. Financial, effectiveness lessons learned. Case studies. Better education, demo sites in different regions. Site specific pilot projects in various localities with geographic/geologic constraints. More examples. Require all state projects to implement LID on construction. I think that we need design demonstrations. There are many biofilters in the ground now and some of the construction is almost "old hat".

	Continue to fund example sites/demonstration sites. Pilot program in southwest VA to show it can work in this area.
Local Gov't./State Action	Developing ordinances that are not as specific, leaving room to explore different low impact development techniques in different developments. Change the rules! All agencies be on the same page supporting LID and rules & regulations don't contradict each other or prohibit use. State code mandates for local adoption and state-sponsored training. Mandated – perhaps incentives can be used. Consolidation of all related requirements (ESC, SWM, CBPA) into one set of rules/procedure. Meet with state/local building code/planners, insurance chiefs. The VA Department of Transportation needs to get "on board" and allow BMPs within right-of-way, width requirements, shoulders (gravel). County piping requirements. A well defined state-level definition, guidance and agency contact (at the state level). Have state produce optional criteria in SWM Handbook. Change state regulations so more LID ideas can be incorporated into stormwater management practices. State government should promote LID, update ESC/SWM manuals. Continue to run LID workshops. Change VDOT policies and state laws. Make this seminar mandatory to all officials! Get the state government to accept and encourage principles at the design level. Local government is more accepting. Local Government Coordination. Uniform standards, incentives, demonstration projects. Require LID. Determine how LID will be inspected/enforced. Make water quality standards mandatory, methods to reach them elective, plus aggressive education, especially to development community. Work with the county on a number of test projects to speed the project through. Continue support through the development of changes to the public facilities manual and other codes including MS-19. Including LID in county ordinances. Coordination of regulations. Specific reference in State Code. Coordination between city/state/federal agencies along with developers and consultants. Make it mandatory. Require as-built inspection by design engineer. Provide incentives through county ordinances and VA ESC regulations. Add LID design guidelines to VA ESC Handbook and VA SW Manuals – try to win VDOT over. State standards/comp planning funding should be adjusted to encourage LID. Legislation requiring a percentage of LID implementation in development. Locality requires LID implementation for development approval.

	Require it by regulations! Long-term care of our natural resources is our responsibility, we must be accountable!
Maintenance	Maintenance protocol must be in place to assure proper function – difficult for subdivisions with multiple owners/resale of lots. LID be contained in common areas and the homeowner's association is charged with responsibility. State and locality are not going to go after a homeowner.
Marketing/ Promotion	Lots of communications at every level to sway public and professional opinions, in various media. Sell it, market the idea till we start to expect it as the new BMP. Show benefits and incentives. Get out the word about the need for these projects. Enlarge audience – take LID presentation to contractors/builders/developers associations meetings – and to VA Association of Counties meetings. Pitch directly to city councils and county supervisors. Continue workshops/task forces, committees, public outreach. Marketing to appeal to designers, developers, and homeowners. Localized outreach programs. There almost needs to be salesmen for this idea. Not just education but salesmanship. Everyone in this room is educated in stormwater management and at least a small bit in creative stormwater management and yet giggles and disbelieving sighs rippled through when roof gardens were mentioned.
Plan Review/ Development	More focus on LID in plan development and review. Providing guidelines for localities to mimic in what to require during plan review to ensure successful implementation. Have to get people (developers & localities) on board in initial design phase. Too difficult for state and feds to make them go back to the drawing board.
Research/Guidance	A partnership of research and development. "Wire" a project and do a longitudinal project at least 5 – 10 years. Performance of two more-or-less matched projects, LID & conventional. Measure results – environmental quality, cost, revenue, maintenance, performance in high & low flows, etc. Report this widely. More research, more case studies and more cost/benefit analyses. Cost-Benefit analysis to get developer buy-in. (Do studies exist?) Continue to develop technical documents and criteria for LID. Sponsor more workshops/demonstration sites for people to see. Publish pollutant removal benefit so localities can claim for Tributary Strategies. Comprehensive computational support of LID measures that can be universally integrated into the manuals of all agencies for the guidance of designers. Guidance/support to localities by state and federal agencies – will make LID approaches more acceptable to localities and developers. Research/study. Engineering publications/tools (tabular listing of applicability of methods in certain situations would be helpful!). Provide some research data that gives some comparison of effectiveness of each of the types of techniques. Develop a worksheet that will aid in the design and review process. Proven history of cost and benefits.

	Increased design aids from research. Regulator accepted calculation procedures.
Training	Very few private or public sector staff have really done LID calculations and site design. We need someone to come help us through the first real LID design or two. Site planner trainings (engineering training). Zoning administrator education. More seminars (and CD presentations) such as this one for municipalities to attend. Training and education for contractors, local governments, and land owners.
Other	Keep talking and implement in small steps. When briefing LID, make sure it is placed in the proper context. Public policy, citizen advocacy, industry education. Abandon the idea. Allow on-site created wetlands built as wetland mitigation to receive storm water flows. Stressing future benefits to better stormwater retention and design. Incorporate into movement to incorporate smart growth, cluster development, greenways-blueways.

Appendix F

Population Change in VA Counties

Population Change in VA Counties (1990 - 2000)*
(in Ascending Order)

	% Change 1990 - 2000*
Buchanan	-13.9%
Dickenson	-7.0%
Highland	-3.8%
Lee	-3.7%
Tazewell	-3.0%
Northampton	0.2%
Alleghany	0.9%
Scott	0.9%
Wise	1.4%
Henry	1.7%
Giles	1.8%
Pulaski	1.8%
Smyth	2.2%
Southampton	2.7%
Halifax	3.7%
Clarke	4.6%
Madison	4.8%
Nottoway	4.9%
Bath	5.2%
King and Queen	5.4%
Bland	5.5%
Rappahannock	5.5%
Russell	5.7%
Lancaster	6.2%
Charlotte	6.7%
Page	6.9%
Campbell	7.5%
Westmoreland	8.0%
Roanoke	8.2%
Wythe	8.4%
Dinwiddie	10.1%
Grayson	10.1%
Carroll	10.3%
Charles City	10.3%
Mathews	10.3%
Mecklenburg	10.7%
Arlington	10.9%

Pittsylvania	10.9%
Shenandoah	10.9%
Patrick	11.1%
Surry	11.1%
Appomattox	11.4%
Washington	11.4%
Amherst	11.6%
Nelson	13.0%
Montgomery	13.1%
Fauquier	13.2%
Rockbridge	13.4%
Prince Edward	13.9%
Middlesex	14.8%
Essex	15.0%
Caroline	15.1%
Lunenburg	15.1%
Brunswick	15.2%
Cumberland	15.2%
Gloucester	15.4%
Floyd	16.0%
Albemarle	16.2%
Craig	16.4%
Northumberland	16.5%
Rockingham	17.8%
Fairfax	18.5%
Isle of Wight	18.7%
Goochland	19.1%
Franklin	19.6%
Augusta	20.3%
Henrico	20.4%
King William	20.5%
Prince George	20.7%
Accomack	20.8%
Orange	20.8%
Warren	20.8%
Richmond	21.1%
Buckingham	21.4%
Botetourt	22.0%
Sussex	22.0%
Culpeper	23.3%
Chesterfield	24.0%
King George	24.2%
Louisa	26.1%
New Kent	28.6%
Frederick	29.5%
Amelia	29.7%
Prince William	30.6%
Bedford	32.5%

York	32.7%
Greensville	35.2%
Hanover	36.4%
James City	38.3%
Powhatan	46.0%
Greene	48.0%
Stafford	48.5%
Spotsylvania	57.5%
Fluvanna	61.3%
Loudoun	96.8%
VA Beach Area	

*provided by U.S. Census Bureau. "State and County Quickfacts" http://quickfacts.census.gov/qfd/

Appendix G

Population Change in Counties within Chesapeake Bay Watershed

Population Change in VA Chesapeake Bay Counties (1990 - 2000)*
(in Ascending Order)

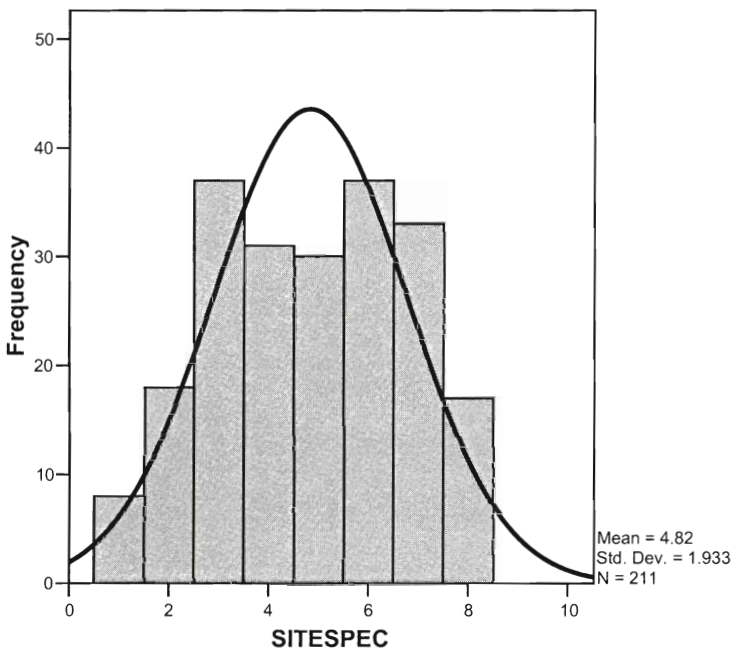
	% Change 1990 - 2000*
Highland	-3.8%
Northampton	0.2%
Alleghany	0.9%
Giles	1.8%
Clarke	4.6%
Madison	4.8%
Nottoway	4.9%
Bath	5.2%
King and Queen	5.4%
Rappahannock	5.5%
Lancaster	6.2%
Page	6.9%
Campbell	7.5%
Westmoreland	8.0%
Roanoke	8.2%
Dinwiddie	10.1%
Charles City	10.3%
Arlington	10.9%
Shenandoah	10.9%
Surry	11.1%
Appomattox	11.4%
Amherst	11.6%
Montgomery	13.1%
Fauquier	13.2%
Rockbridge	13.4%
Prince Edward	13.9%
Middlesex	14.8%
Essex	15.0%
Caroline	15.1%
Cumberland	15.2%
Gloucester	15.4%
Albemarle	16.2%
Craig	16.4%
Northumberland	16.5%
Rockingham	17.8%
Fairfax	18.5%

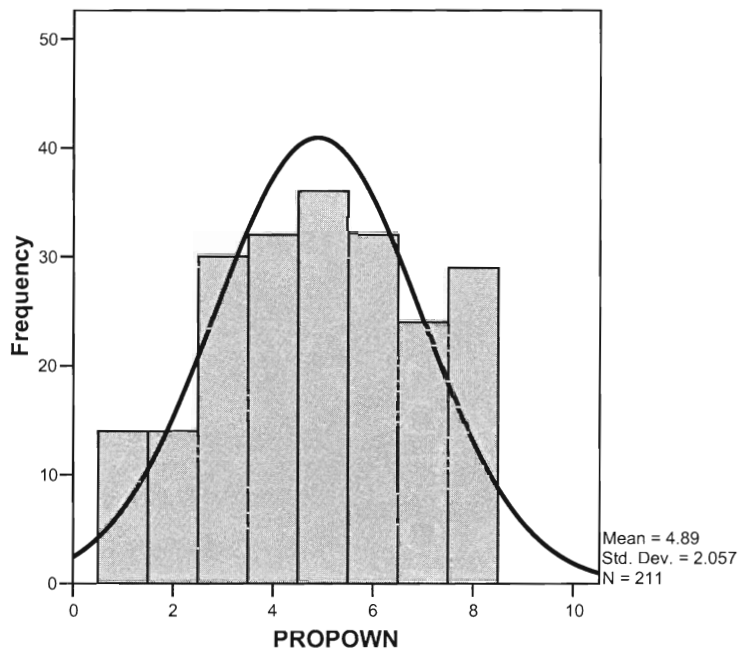
Isle of Wight	18.7%
Goochland	19.1%
Augusta	20.3%
Henrico	20.4%
King William	20.5%
Prince George	20.7%
Accomack	20.8%
Orange	20.8%
Warren	20.8%
Richmond	21.1%
Buckingham	21.4%
Botetourt	22.0%
Culpeper	23.3%
Chesterfield	24.0%
King George	24.2%
Louisa	26.1%
New Kent	28.6%
Frederick	29.5%
Amelia	29.7%
Prince William	30.6%
Bedford	32.5%
York	32.7%
Hanover	36.4%
James City	38.3%
Powhatan	46.0%
Greene	48.0%
Stafford	48.5%
Spotsylvania	57.5%
Fluvanna	61.3%
Loudoun	96.8%

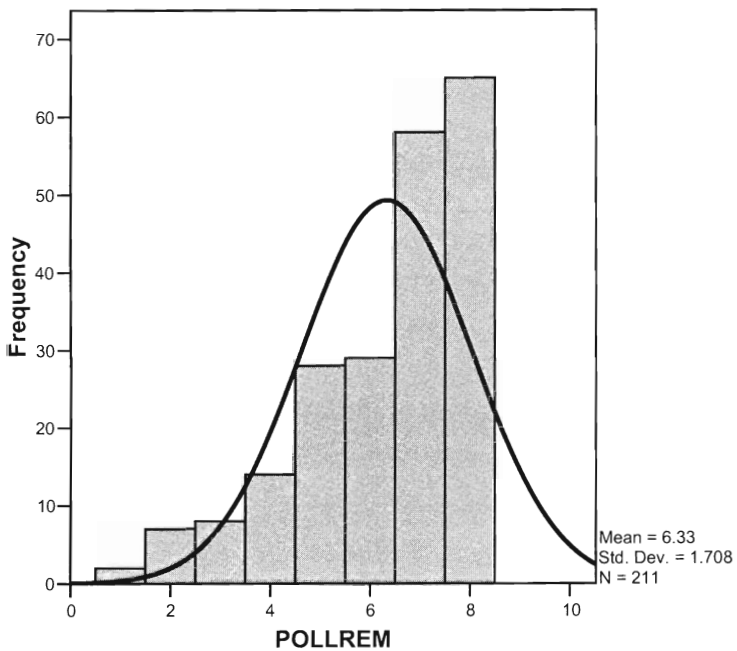
*provided by U.S. Census Bureau. "State and County Quickfacts": http://quickfacts.census.gov/qfd/

Appendix H

Frequency Histograms of Impediments



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8
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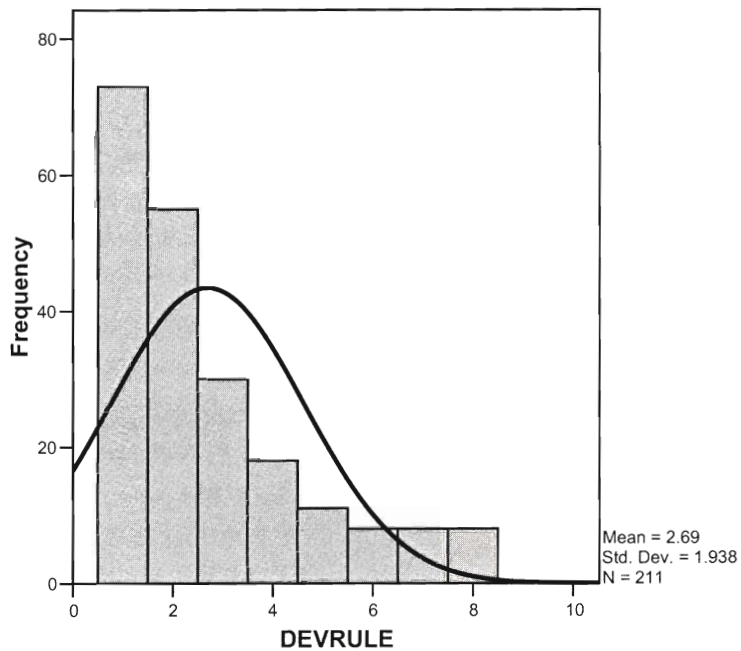
POLLREM
Mean = 6.33
Std. Dev. = 1.708
N = 211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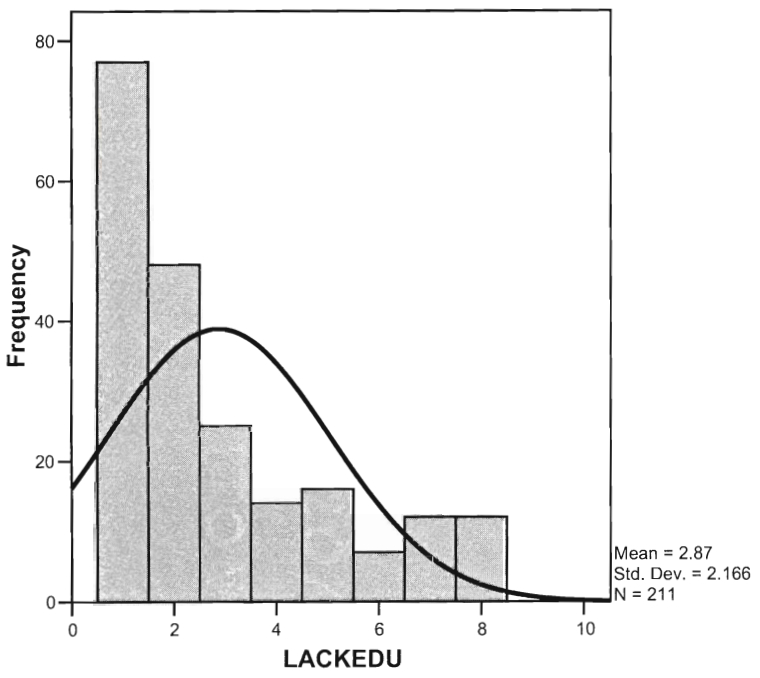
Std. Dev. = 1.938
N = 211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2
4
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LACKEDU
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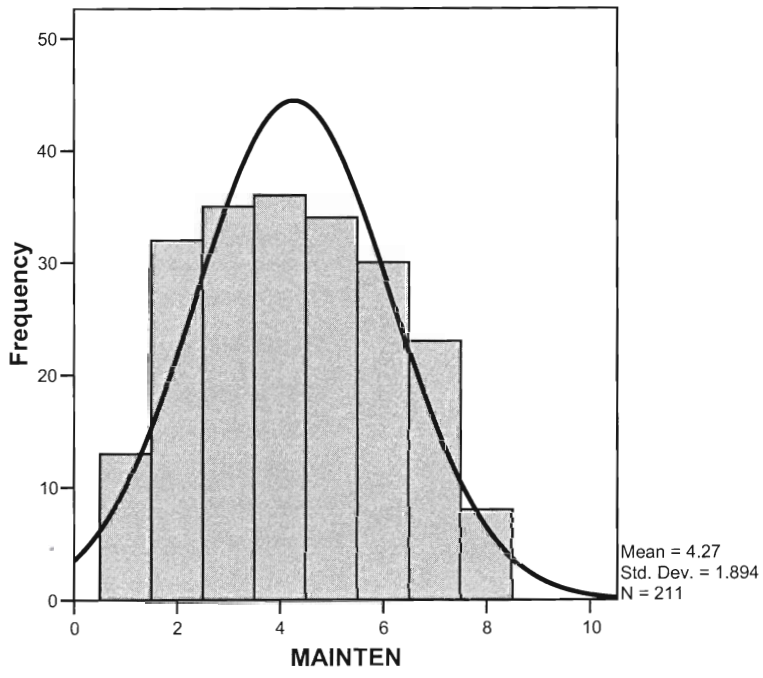
Std. Dev. = 2.166
N = 211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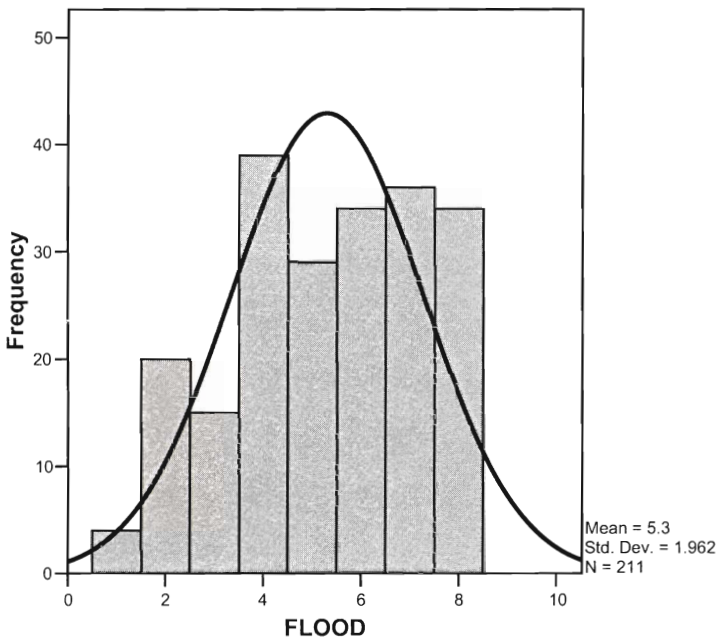
N = 211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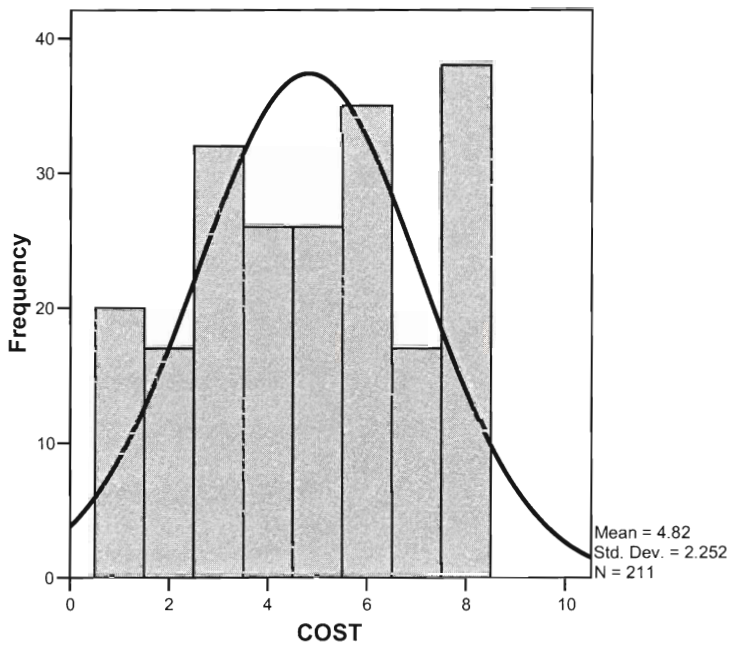
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20
10
0
0
2
4
6
8
10
COST
Mean = 4.82
Std. Dev. = 2.252
N = 211

Appendix I: Respondent's Occupation and Ranking of Impediments Cross Tabulation

Gov't Employees (Code = 10)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	4	3.3	11	9.2	2	1.7	31	25.8	49	40.8	9	7.5	4	3.3	10	8.3
2	5	4.2	7	5.8	2	1.7	39	32.5	25	20.8	19	15.8	14	11.7	9	7.5
3	24	20	17	14.2	5	4.2	12	10	17	14.2	17	14.2	7	5.8	22	18.3
4	17	14.2	15	12.5	10	8.3	13	10.8	11	9.2	22	18.3	21	17.5	10	8.3
5	16	13.3	23	19.2	15	12.5	10	8.3	7	5.8	22	18.3	16	13.3	10	8.3
6	21	17.5	18	15	15	12.5	5	4.2	3	2.5	17	14.2	15	12.5	27	22.5
7	20	16.7	13	10.8	39	32.5	5	4.2	4	3.3	10	8.3	20	16.7	9	7.5
8	13	10.8	16	13.3	32	26.7	5	4.2	4	3.3	4	3.3	23	19.2	23	19.2

Others (Code =20)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	2	8	0	0	0	0	10	40	11	44	0	0	0	0	2	8
2	4	16	3	12	0	0	5	20	8	32	2	8	0	0	3	12
3	5	20	5	20	0	0	5	20	2	8	4	16	1	4	3	12
4	5	20	6	24	2	8	3	12	0	0	5	20	2	8	2	8
5	3	12	3	12	3	12	1	4	1	4	3	12	7	28	4	16
6	4	16	3	12	4	16	1	4	1	4	4	16	4	16	4	16
7	0	0	3	12	7	28	0	0	1	4	5	20	8	32	1	4
8	2	8	2	8	9	36	0	0	1	4	2	8	3	12	6	24

Consultants (Code =30)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	2	3	3	4.5	0	0	32	48.5	17	25.8	4	6.1	0	0	8	12.1
2	9	13.6	4	6.1	5	7.6	11	16.7	15	22.7	11	16.7	6	9.1	5	7.6
3	8	12.1	8	12.1	3	4.5	13	19.7	6	9.1	14	21.2	7	10.6	7	10.6
4	9	13.6	11	16.7	2	3	2	3	3	4.5	9	13.6	16	24.2	14	21.2
5	11	16.7	10	15.2	10	15.2	0	0	8	12.1	9	13.6	6	9.1	12	18.2
6	12	18.2	11	16.7	10	15.2	2	3	3	4.5	9	13.6	15	22.7	4	6.1
7	13	19.7	8	12.1	12	18.2	3	4.5	7	10.6	8	12.1	8	12.1	7	10.6
8	2	3	11	16.7	24	36.4	3	4.5	7	10.6	2	3	8	12.1	9	13.6

Appendix J: Respondent's Residence and Ranking of Impediments Cross Tabulation

Gov't Employees (Code = 10)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	4	3.9	6	5.9	1	1	37	36.3	34	33.3	6	5.9	3	2.9	11	10.8
2	9	8.8	9	8.8	5	4.9	24	23.5	21	20.6	17	16.7	10	9.8	7	6.9
3	15	14.7	16	15.7	5	4.9	13	12.7	12	11.8	18	17.6	9	8.8	14	13.7
4	16	15.7	17	16.7	6	5.9	12	11.8	9	8.8	14	13.7	16	15.7	12	11.8
5	12	11.8	16	15.7	16	15.7	4	3.9	9	8.8	18	17.6	14	13.7	12	11.8
6	14	13.7	15	14.7	15	14.7	5	4.9	4	3.9	16	15.7	18	17.6	16	15.7
7	19	18.6	10	9.8	25	24.5	5	4.9	7	6.9	9	8.8	16	15.7	11	10.8
8	13	12.7	13	12.7	29	28.4	2	2	6	5.9	4	3.9	16	15.7	19	18.6

Others (Code =20)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	4	5	7	8.8	1	1.3	22	27.5	34	42.5	4	5	1	1.3	7	8.8
2	6	7.5	3	3.8	2	2.5	26	32.5	16	20	10	12.5	8	10	9	11.3
3	15	18.8	11	13.8	1	1.3	12	15	11	13.8	14	17.5	4	5	13	16.3
4	13	16.3	11	13.8	7	8.8	5	6.3	4	5	16	20	15	18.8	8	10
5	13	16.3	14	17.5	10	12.5	7	8.8	4	5	10	12.5	11	13.8	11	13.8
6	17	21.3	13	16.3	7	8.8	1	1.3	3	3.8	11	13.8	12	15	16	20
7	9	11.3	9	11.3	24	30	3	3.8	4	5	11	13.8	15	18.8	5	6.3
8	3	3.8	12	15	28	35	4	5	4	5	4	5	14	17.5	11	13.8

Consultants (Code =30)

Rank	SiteSpec		PropOwn		PollRem		DevRule		LackEdu		Mainten		Flood		Cost	
	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %	Freq	Valid %
1	0	0	1	7.1	0	0	7	50	3	21.4	1	7.1	0	0	2	14.3
2	1	7.1	0	0	0	0	1	7.1	6	42.9	5	35.7	1	7.1	0	0
3	3	21.4	1	7.1	0	0	3	21.4	1	7.1	1	7.1	2	14.3	3	21.4
4	0	0	3	21.4	1	7.1	0	0	0	0	2	14.3	5	35.7	3	21.4
5	4	28.6	1	7.1	1	7.1	0	0	1	7.1	3	21.4	2	14.3	2	14.3
6	4	28.6	3	21.4	1	7.1	1	7.1	0	0	1	7.1	1	7.1	3	21.4
7	2	14.3	3	21.4	6	42.9	0	0	1	7.1	1	7.1	1	7.1	0	0
8	0	0	2	14.3	5	35.7	2	14.3	2	14.3	0	0	2	14.3	1	7.1

VITA

Rebecca V'lent Lassiter was born on November 24, 1964 in Richmond, Virginia. She graduated from Washingtonville High School in Washingtonville, NY in 1982 and received her Bachelor of Science in Sociology with a Certificate in Environmental Studies from Virginia Commonwealth University in 1990. V'lent currently resides in Richmond and is employed by the Virginia Department of Conservation and Recreation, Division of Chesapeake Bay Local Assistance, as a Senior Environmental Planner.