TOWN of KILL DEVIL HILLS
STORMWATER MANAGEMENT PLAN
2010

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Executive Summary

Since the development of the last Stormwater Management Plan for the Town of Kill Devil Hills (Town) in 2001, many studies and initiatives regarding stormwater management have been undertaken in academia and by Federal and State environmental agencies. The State of North Carolina has implemented revised stormwater regulations that incorporate new standards for engineering stormwater measures and the use of Best Management Practices (BMPs) for enhanced management. The Town has also experienced an increase of development that has resulted in an increased demand on Town conveyance systems for stormwater control. This Plan supports the Town's vision of being in the forefront of stormwater management and utilizing the best resources available to enhance the functionality of their conveyance systems while also promoting less reliance on the Town's conveyance system to manage stormwater generated by development.

The intent of the 2010 Stormwater Management Plan (Plan) is to provide an overview of the existing condition of the stormwater conveyance systems within the Town and to incorporate new information and design standards regarding stormwater management. This update resulted in recommendations for design standards, regulations, policies and funding sources that may be implemented within the next five years to further improve the effectiveness of stormwater management in the Town. The Plan's recommendations consider potential impacts to private property, reduction of stormwater runoff, promotion of higher quality runoff entering the Town's conveyance system and adjoining waters, proposed improvements to the conveyance system and how to defray the cost of those improvements.

A stakeholder group was established composed of Town citizens, business owners, representatives of not for profit organizations, and representatives of Federal, State, and local agencies to provide a voice on the development of the Plan. Meetings were conducted to discuss current issues/concerns, rate the concerns as a priority for improvement and offer potential recommendations regarding solutions. This input was considered and compared to existing studies. An additional advantage of this approach was to determine if the public perceptions were consistent with scientific literature so that public educational needs could be identified. In addition, potential partnerships were identified between the Town, its citizens, agencies, and organizations to help implement stormwater strategies identified in the Plan.

The update is comprised of several sections which include: a review of existing conditions; current policies, programs and regulations; and computer simulations. Analysis of the information allowed for the creation of a Plan of Action that can be implemented in the next five years.

Existing conditions of the Town's conveyance systems and physical conditions of the landscape were reviewed and included changes since the last Stormwater Management Plan. Drainage patterns in the Town were reviewed through engineering studies and fourteen major watersheds were delineated. These major watersheds were broken into smaller catchments and subcatchments. Three of the major watersheds are served by ocean outfalls and eleven are served by outfalls flowing to Kitty Hawk Bay. Analysis of each watershed was performed and each conveyance system within the watershed was ranked to assess its current condition and effectiveness. A physical survey was conducted of the existing culvert networks, drainage

ditches, and canals. The type of material and physical condition of each culvert was recorded. Other parameters such as capacity, appearance and maintenance status of the public culverts, drainage ditches, and swales were noted. Results of the survey indicated that the Town's conveyance systems varied in conditions from newly constructed drainage systems implemented as part of the street improvement projects to areas which are in poor condition and are no longer functioning as designed. The topography and soil type were reviewed for each watershed. The type of soils and topography of a property can influence how stormwater is managed on a site, particularly if fill material is brought onto a property altering its composition. The Plan addresses the importance of topography and soil type in the consideration of stormwater management.

The Plan also includes a review of existing Federal, State, and Local policies, programs, and regulations that address stormwater. Pertinent State and Federal stormwater policies and regulations were reviewed and summarized. Coastal communities have been examined over the past several years by State and Federal agencies due to their unique characteristics such as high groundwater tables and policies have been implemented on the State and Federal levels to help mitigate for stormwater impacts. These policies/regulations provide guidelines for the use of Best Management Practices (BMPs) and emerging technologies that can be implemented to help manage stormwater onsite and reduce the amount of stormwater entering into public systems. The Plan identifies these BMPs, recommending their inclusion into plans for proposed projects as a way to help manage stormwater. Zoning districts, streets, sidewalks, and existing subdivision regulations were compiled for each watershed. Existing Town plans, including the Street Improvement Master Plan Update, Land Use Plan, Hazard Mitigation Plan, and the Flood Damage Prevention Ordinance were incorporated in the analysis.

To further understand the physical conditions of the Town's conveyance systems, a hydrological model was utilized to model two watersheds to help determine how specific precipitation rates impact the conveyance systems. Two watersheds were selected for hydrologic/hydraulic modeling using the EPA SWMM modeling software. To further enhance the Town's understanding of the relationship between the hydrology and precipitation events, the two watersheds were selected primarily because they are representative of the Town's prevalent types of stormwater systems: "roadside ditches and swales" and "culverted drainage systems." Results of the hydrological modeling supported that many of the conveyance systems function as designed; however, maintenance of some systems are needed. The hydrological model also supported the acknowledgement that certain rain events such as long duration or intense events with large volumes of water in short periods of time can exceed the functionality of the conveyance systems and flooding may impact areas of the Town. In addition to a hydrological model, a second modeling program was incorporated in the Plan. This model was developed using Geographic Information System (GIS) and Community Viz and is a decision support model (DSS Model). The DSS Model provides assistance to the Town when reviewing potential new uses and/or modifications to a parcel of property and how this development will impact the stormwater conveyance systems. The DSS Model can be used to review projects as a quick visual tool to determine whether the project adheres to current regulations and how it may impact Town owned conveyance systems.

The Plan makes recommendations regarding design standards, regulatory practices, policies, and funding options that can be implemented within the next five years. If implemented, recommendations within the Plan should improve the effectiveness of the Town's Stormwater Management Program. The purpose of this Plan is to address stormwater runoff to the highest extent possible while acknowledging that our location and physical conditions limit the effectiveness of even the most well designed system. The recommendations within the Plan will minimize the quantity of stormwater entering the Town's conveyance systems and improve the quality of the stormwater entering the adjacent waters while minimizing the costs to the Town for maintenance and improvements to these systems.

I. Introduction

A. Statement of Intent

The intent of the Stormwater Management Plan (Plan) is to report the status of the existing condition of the stormwater measures of the Town of Kill Devil Hills (Town) and to incorporate new strategies regarding stormwater management. The analysis and assessment of the existing condition of the Town's stormwater measures and pertinent information regarding stormwater management will result in recommendations for design standards, regulations, and policies that may be implemented within the next five years to further improve the effectiveness of the Town's stormwater management in the Town.

B. Goals and Objectives of Stormwater Plan

Since the development of the Town's last Stormwater Management Plan in 2001, many studies and initiatives regarding stormwater management have been undertaken. The North Carolina Division of Water Quality (DWQ) has implemented revised stormwater regulations that incorporate new engineered stormwater design standards and the use of Best Management Practices (BMPs) for enhanced management. In this report these will be collectively called design standards. The Town has also seen an increase of development which resulted in an increased demand on Town conveyance systems for stormwater control.

In an effort to provide higher quality, more cost-efficient, and sustainable strategies for the protection and conservation of our coastal community, the Town is updating its Stormwater Management Plan (Plan) to consider new research and information. Development of the Plan will give the Town the ability to better understand past and existing conditions of their stormwater infrastructure, management practices and policies to help make informed decisions that will further develop the vision for a healthy, sustainable and thriving community.

C. Stormwater Plan Process

Stakeholder group meetings needed to occur early in the process so that the Stakeholders' guidance could assist in the development of the Plan. Discussions with Stakeholders and review of literature resulted in watershed specific recommendations. This process allowed for the identification of perceptions regarding stormwater management which were then compared to literature. This comparison revealed areas where education could benefit the public's understanding of stormwater management. The early coordination also promoted understanding of the Plan within the community. Generally, with understanding comes ownership of the Plan which enhances support for implementation of the

recommendations. Copies of the handouts, PowerPoint slides, and homework assignments completed by the stakeholder group can be found in Appendix A.

An important component of the study involved an analysis and summation of the existing conditions of the Town's stormwater drainage system by watershed. The Town's drainage patterns have been divided into watersheds that are composed of a varying number of catchments and subcatchments. A ranking of each watershed and corresponding conveyance systems was performed to provide guidance on potential opportunities for improvement in each watershed. In order to manage the Town's conveyance systems, BMPs are included in the Plan to encourage infiltration techniques that reduce the amount of stormwater entering into the conveyance systems along with designs to modify the conveyance systems to promote infiltration prior to discharges into the ocean or sound. The recommendations are watershed specific due to the dynamics of each watershed and their specific characteristics in regards to stormwater. With this information, strategic projects could arise from the Plan.

The collection and analysis of Town design standards, regulations, ordinances, policies, and existing plans were necessary to assist in ensuring that the Plan did not duplicate any existing effective initiatives and allowed for recommendations to modify existing local, design practices, regulations, ordinances, and policies to result in a more effective stormwater control strategy for the Town.

Two watersheds were selected for hydrologic/hydraulic modeling to assist in the analysis of how these systems manage stormwater in a variety of single storm events and in a series of storm events. This information is essential for understanding if the recommendations are effective.

In addition, a component of the Plan uses Geographic Information Systems (GIS) technology. Existing physical data and current regulations and policies have been incorporated into a decision support system model (DSS model) which is a visual tool to aid the Town's staff, Planning Board, Commissioners, and designers of projects within the Town in making informed decisions. The DSS model does not make the decision for the user, however, provides visual analysis of proposed stormwater impacts and assists with the determination whether a course of action is compliant with current regulations and policies. The DSS model also provides information concerning potential stormwater impacts and ways to help mitigate their effects. Proposed projects, such as new development, redevelopment and/or stormwater projects can be viewed in a GIS platform by providing input about the proposed project into the DSS model. The DSS model will then evaluate the proposed project and provide information on whether the project adheres to current stormwater regulations or whether the project requires additional planning steps, such as a permit, and/or stormwater design features. A suite of potential solutions is then provided so the proposed project is more capable to meet the current goals and objectives outlined in the Plan. The DSS model also links the recommendations to the literature or studies to support the effectiveness of each

measure, and the literature citation is identified in the model. This coupling of information is intended to provide a comprehensive analysis.

All of these discrete efforts resulted in recommendations for design standards, regulations, and policies that when implemented will improve the effectiveness of the Town's stormwater management. Collectively, this information is the Town of Kill Devil Hills' Stormwater Management Plan 2010.

D. Definitions

Best Management Practices (BMPs) - any land or stormwater management practice or structure used to address flooding, reduce erosion and sedimentation, or otherwise control water pollution from runoff; includes urban stormwater management BMPs and agriculture/forestry BMPs.

Bioretention – the use of plants and soils for removal of pollutants from stormwater runoff and provides landscaping and habitat enhancement benefits.

Box Ditch - steep-sided trapezoidal ditches.

Conveyance System – a system which has been designed to transport stormwater runoff from roadways towards either an ocean, sound or holding pond.

CommunityViz (CV) – extension of ArcGIS software designed to model "what if" scenarios utilizing various types of data.

Catchment – the area which drains naturally to a particular point on a waterbody, thus contributing to its natural discharge.

Canal – large, typically wide ditch which may either have a dry bottom or retain water for extended periods of time.

Channel - a man-made ditch for conveyance of stormwater runoff, with at least some portion of its banks being 2:1 (horizontal: vertical) or steeper, and usually with a flat bottom.

Cistern/Rainwater Harvesting System – an above ground or buried tank or series of barrels that holds rainwater until it is used.

Culvert - a pipe which allows runoff to pass beneath a road, driveway or similar feature.

Corrugated Metal Pipe (CMP) – a type of culvert which is made of steel and used in conveyance systems.

Constructed Wetland - engineered systems designed to simulate natural wetlands to exploit the water purification functional value for human use and benefits.

Curb and Gutter - concrete structure and underground collection system; with low-flow runoff carried in the concrete gutter to curb inlet structures at fairly close intervals (300' intervals are typical in flat areas). The inlets may be connected to form a culverted drainage system, or they may discharged via short sections of pipe into an open roadside ditch.

Ditch - a man-made channel for conveyance of stormwater runoff.

Detention – storage of stormwater to help trap suspended pollutants and reduce peak discharge.

Dry Extended Detention Basin – a feature which temporarily stores incoming stormwater, trapping suspended pollutants, and reducing the peak discharge from the site.

Filter Strip – a section of land capable of sustaining sheet flow, either forested or vegetated, with turf grasses or other plants, which provides pollutant removal as the stormwater passes through it.

Grassed Swale – a shallow open-channel drainageway stabilized with grass or other herbaceous vegetation that is designed to filter pollutants.

Groundwater Table - the water table at which the groundwater pressure is equal to atmospheric pressure.

High-Density Polyethylene (HDPE) – corrosion resistant culvert.

Infiltration Devices – trenches or basins that fill with stormwater and allow the water to exfiltrate, i.e., exit the device by infiltrating into the soil.

Outfall – discharge pipe which conveys stormwater to either the sound or ocean.

Permeable Pavement – an alternative to conventional concrete and asphalt paving materials that allows for infiltration of stormwater into void spaces that provide temporary storage.

Restored Riparian Buffer – natural or constructed low-maintenance ecosystems adjacent to surface water bodies, where trees, grasses, shrubs, and herbaceous plants function as a filter to remove pollutants from overland stormwater flow and shallow groundwater flow prior to discharge to receiving waters.

Retention - holding back of stormwater runoff from an area.

Stormwater Runoff – flow of water that result from precipitation and which occurs immediately following rainfall or snowmelt.

Swale - an open drainage channel with gentle side slopes (typically 4:1) and usually shallower than a ditch.

Sock Drain - permeable filter fabric which covers a perforated drainage culvert.

Subcatchment - a term applied to the smaller catchments, which make up and channel water into a catchment.

Watershed - all the land area that contributes runoff to a particular point along a stream or river.

Wet Detention Basin – a stormwater management facility that includes a permanent pool of water for removing pollutants and provides additional capacity above the permanent pool for detaining stormwater runoff.

II. Existing Conditions

A. Existing Physical Conditions of Town Stormwater Drainage Systems

1. Topography

The Town is bounded by the Atlantic Ocean to the east and the Albemarle Sound to the west. The topography of the Town ranges from sea level at the beach and soundfront to elevated active and relic dunes. Recent topographic information from a new optical remote sensing technology was used in the hydrologic/hydraulic model and the decision support model. The Light Detection and Ranging (LiDAR) data provided greater precision compared with data previously available which allowed for more precise delineation of the watersheds. The topography within the watersheds can impact the way stormwater reacts such as its ability to infiltrate into the ground or be transported within a conveyance system.

2. Soils

Dare County and the Town are located within the northeastern portion of the Coastal Plain physiographic region of North Carolina. According to the Soil Survey of Dare County, issued March, 1992, the Outer Banks soils and corresponding vegetative zones are divided into four main categories; foredune-beach, scrub, maritime forest, and marsh.

The foredune-beach areas are located along the eastern portion of the Town adjacent to the Atlantic Ocean and consist mainly of sandy Newhan soil types which are dominated by salt tolerant vegetation such as American beachgrass and seaoats. The soils in this zone are generally well drained.

The scrub zone is primarily mapped in between the highways and is the transitional area of the dune-swale topography found on the Outer Banks. The scrub zone includes well drained sandy soils such as Newhan soils, Corolla sands which are moderately drained, and Duckston soils which are poorly drained and located at lower elevations and wet areas.

The maritime forest zone is located along the western portion of the Town. The soil types in this zone depend on elevation and range from the well-drained Fripp sands which are found at higher elevations to the moderately drained Ousley fine sands and the poorly drained Osier fine sands which are mapped in nearly level or gently sloping areas.

The marsh zone is mapped along the western sound side areas of the Town and includes soil types that are frequently flooded and contain high water tables such as Carteret, Currituck, and Hobonny soils.

The soil types play an important role in the ability and rate for some stormwater to infiltrate into the ground as opposed to entering the Town's conveyance system and adjoining waters. Although it is important to identify the native soils when considering stormwater management practices, modifications to the soil, such as the use of fill and compaction, can modify the stormwater infiltration rate. A soil map can be found in Appendix B.

The following table lists the various soil types found within the Town.

TABLE 1: DARE COUNTY SOIL SURVEY

Soil Name	Soil Map Symbol	USDA Texture	Hydrologic Soils Group	Depth to Seasonal High Water Table (ft)	Permeability	Location
Beaches	BnD				Rapid	Frontal Dunes
Conaby*	CnA	Muck	B/D	0 to 1.5	Moderate	Swales/Depressions
Corolla	CoB CrB	Fine Sand	D	1.5 to 3.0	Rapid	Bypass and western portions
Currituck*	CuA	Mucky/Peat	D	+1.0 to 1.0	Moderate	Marsh zone/Sound areas
Duckston	DtA	Fine Sand	A/D	0 to 1.0	Rapid	Flats/Slight Depressions in between Highways
Duneland	DuE DwE	Sand	A	> 6.0	Rapid	Frontal Dunes and Relic Dune areas
Fripp	FrD	Fine Sand	A	> 6.0	Rapid	Dune Ridges
Hobonny*	HoA	Muck	D	+1.0 to 0	Moderate	Soundside/Marsh areas
Newhan	NeC NhC NuC	Fine Sand	A	> 6.0	Very Rapid	Dune areas
Osier	OsA	Fine Sand	A/D	0 to 1.0	Very Rapid	Marshes/Depressions
Ousley	OuB	Fine Sand	C	1.5 to 3.0	Rapid	Low Dunes/Soundside
Psamments	PsB	*Typically fill material and non-native soils				Developed areas where filling has occurred

* Poorly Drained soils

3. Groundwater Table

The groundwater within the Town is water located below the ground surface in the interstitial spaces in the soil. The groundwater table is the level at which the groundwater pressure is equal to atmospheric pressure. In the water cycle, groundwater is an important component, serving as a reservoir which is recharged primarily by precipitation. The elevation of the groundwater surface varies continuously. Groundwater movement is generally much slower than that of surface water. While surface velocities are typically measured in feet per second, groundwater is feet per day.

Some, but not all, of the factors which affect the groundwater table elevation are:

- The Elevation of the Ground. Generally, at lower elevations, the water table is shallow and close to the surface and when the water table intersects the surface, a waterbody is formed. As the elevation of the ground rises, the water table is not as close to the surface although at a flatter slope. The slope of the water table is what causes the groundwater to move slowly toward the receiving waterbody; the steeper the slope, the faster the flow rate.

- The Amount of Rain Received. Shortly after a rain (or snow melt) event water enters the interstitial spaces in the soil and the water table begins to rise. The more intense the rain rate, the faster and/or greater is the rise of the water table. Once the rain stops and water continues to infiltrate into the ground, the gradient of the water table causes groundwater movement toward the receiving waters and "draws down" the water table.

  Sometimes the water table can be raised greatly by a single very intense rain event, such as 7 or 8 inches in a 24-hour period (represents a 10-year, 24-hour rainfall event). Such a rain might well be associated with a tropical storm. A similar rise in groundwater may result from a series of smaller rain events, without sufficient time in between rain events for the water table to recover. For example, a 3" rain on Monday, a 2" rain on Wednesday, a 1.5" rain on Saturday, a 2.5" rain on the following Tuesday, totaling 9" can result in a response as that of a single 10-year, 24-hour rainfall event. Such a cumulative effect happened in the Town during August, 2004 resulting in flooding.

- Other Surface Water Recharge. Local "bumps" or mounding of the water table can occur in response to surface flow other than from precipitation. The relatively slow but steady inputs of irrigation, lawn watering, and septic system effluent can cause such effects.

- Soil Permeability. A soil's permeability is its ability to transmit water. Soils with high clay content have smaller flow paths for water and thus have slower permeability. Sandy soils, such as those which predominate in the Town generally have rapid permeabilities because of the larger interstitial spaces. In two identical settings, the same area with the same groundwater surface slope could transmit different amounts of groundwater. If the soils are coarse sands with a very rapid permeability, they would transmit more groundwater than would a silty clay with slow permeability.

- Seasonal Effects. In spring, summer and early fall, the uptake of moisture by plants tends to withdraw water from the groundwater "reservoir" and use it through photosynthesis for growth. In the colder months, these processes slow substantially, reducing the withdrawal from groundwater. Cold weather and shorter days also reduce the loss of surface water due to evapotranspiration, resulting in more water that must be infiltrated.

Areas within some watersheds have high groundwater tables, which can limit the amount of infiltration available during precipitation events and stormwater runoff can overwhelm the adjoining conveyance systems. Generally, such areas are found to satisfy two or three of the following characteristics:

- low elevation, typically elevations of 7 feet (NAVD '88) and lower;
- flat areas with prevalent ground slopes 0.5% or less; and
- areas distant from a deep waterbody or terrain feature capable of drawing down the water table.

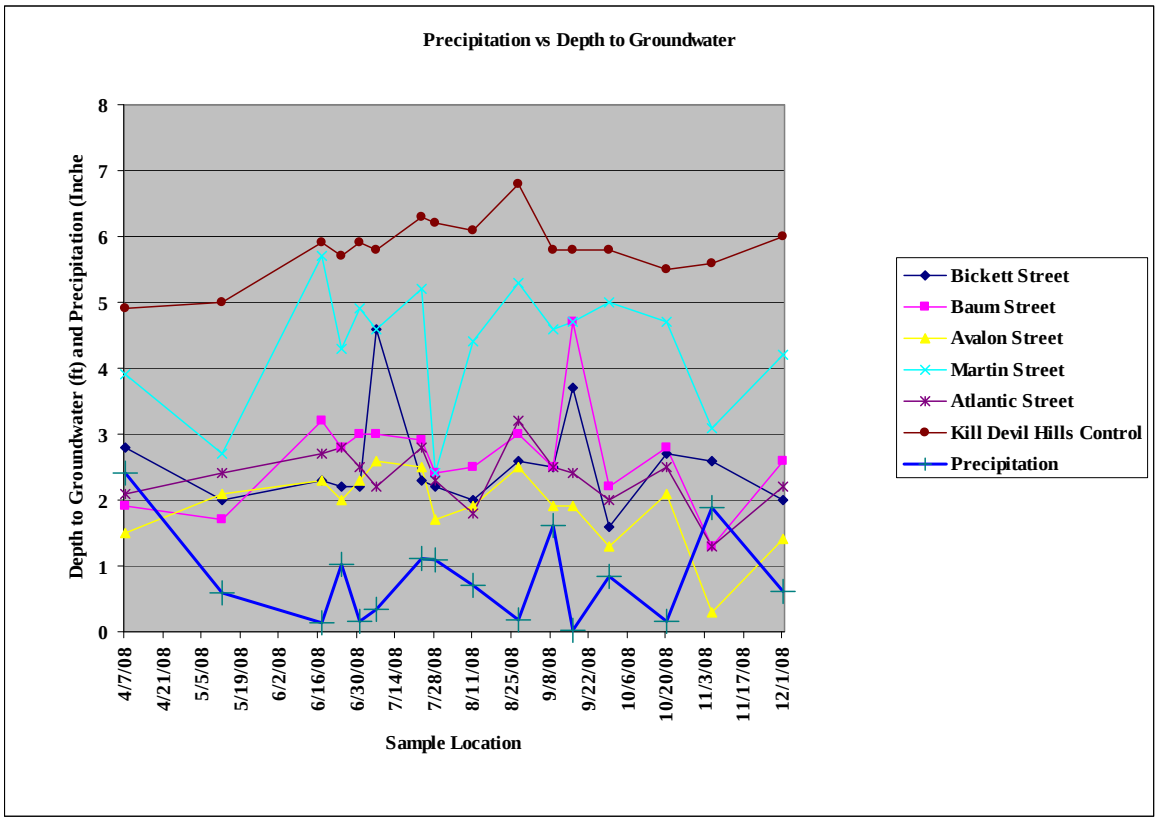
In general, these areas will have soil types having shallower "Depth to Seasonal High Water Table." Design of any proposed project should include consideration of groundwater effects. The larger and more intense the project, the more critical soil type becomes.

Since the last update to the Town's Stormwater Plan, the Outer Banks has experienced not only the unusually wet years such as 2004 and 2009, with several flooding events due to heavy precipitation combined with high groundwater levels, but also unusually dry years such as 2006/2007 with drought conditions present throughout North Carolina. These periods of wet and dry conditions influence the efficiency of the existing stormwater conveyance systems and corresponding water quality of the runoff. In drier times, less runoff is produced and has more opportunity to soak into the ground, become groundwater and be naturally treated before reaching a water body. In wetter times, runoff is higher, and more stormwater rushes to the receiving waters with less natural treatment of the runoff.

Precipitation and fluctuations in the depth to groundwater may also limit the types of BMPs that may be effective in a given area. Section III.C.1 below discusses the Town's water quality monitoring program. That program gathered valuable data on the relationship between precipitation and depth to water table. Figure 1 illustrates the 2007/2008 precipitation amounts recorded during water quality sampling and the depth to groundwater at the current monitoring locations. Four monitoring locations consistently record groundwater tables ranging from 3.0 feet

below the ground surface to as high as 1.0 foot below the ground surface. Although these areas illustrate a natural high water table, heavy precipitation events contributed to the high groundwater tables during several sampling events. These conditions may warrant a limitation on the types of BMPs that can effectively implemented to reduce the impacts from stormwater.

Figure 1: Precipitation Versus Depth to Groundwater – KDH Water Quality Program



B. Conveyance System Ratings

1. Types of Systems

The various areas of the Town of Kill Devil Hills have a wide variety of "systems" for handling surface runoff of stormwater. Before describing the process of rating these systems, the following listing and description of the various types of systems is provided.

a. No System

Many natural areas in Town, and some developed areas, have no defined, man-made drainage system. Most stormwater runoff infiltrates into the ground, and when it rains too hard

and overwhelms the capacity for infiltration, flooding (usually shallow) occurs until the water finds its way along roads, property lines or any path of lower topography toward a defined system or receiving waterbody. Areas with no system may function rather satisfactorily if they have soils with rapid permeabilities and a deep water table. In such cases, all but the heaviest rains may produce little or no runoff, and if there is some ponding of runoff after the rain stops, it will infiltrate typically in a few hours. Unfortunately, some older neighborhoods were built in soils without these natural advantages, and they have been identified over the years as areas with drainage problems. Such areas will typically require reworking with a defined drainage system of the types.

b. Roadside Ditches and Culverts

For purposes of this document, a ditch is defined as a man-made channel for conveyance of stormwater runoff, with at least some portion of its banks being 2:1 (horizontal: vertical) or steeper, and usually with a flat bottom. A culvert is a pipe which allows runoff to pass beneath a road, driveway or similar feature. Typically, in a roadside ditch and culvert system, the ditches make up 75% or more of the length of the system, so these are typically considered “open” systems. The advantage of an “open” drainage element such as a ditch is that it can carry a greatly increased amount of water with only a small increase in water depth. By contrast, a “closed” system such as a culvert, once flowing at full depth, can only carry a small amount of additional water by the building of pressure or “head” at its upstream end, which usually associates with some flooding.

Roadside ditch and culvert systems can be aesthetically unappealing and hard to maintain. In a residential setting, a property owner will likely maintain “his” lawn out to the edge of pavement, but if there is a ditch with near vertical sides, the property owner may allow it to grow up with weeds or tall grass.

c. Culverted Drainage Systems

Fully enclosed systems, with runoff entering only at inlet structures, have been the standard treatment in suburban areas for quite a few decades. In the Town, water may reach the inlets via surface flow along the edge of the streets, or by shallow roadside swales.

Culverted drainage systems avoid the aesthetics problems of the roadside ditch and culvert system, providing a neat, finished appearance, and have been used in a few newer areas of the Town. Their disadvantages include:

- will not handle runoff in excess of their design capacity as an open system might;
- will not provide a chance for the runoff to infiltrate into the ground, unless the culvert is perforated and wrapped with a permeable filter fabric (commonly called a "sock drain"); and
- the initial cost is higher.

Maintenance of a culverted drainage system is best accomplished with an expensive piece of equipment which flushes water to an endpoint of a culvert, and another which removes the sediments by a truck-mounted vacuum device

d. Roadside Swales

A swale is an open drainage channel with gentle side slopes (typically 4:1) and is usually shallower than a ditch.

When a swale encounters a driveway, a dip or depression is provided to allow flow from the grass portion of the swale to continue along at generally the same elevation and slope. As an enhancement to this approach, the grass areas between driveways are left 2 to 4 inches lower than the driveways, promoting beneficial infiltration of runoff into the soil. With careful planning, it is often possible to run a roadside swale system several hundred feet before the driveway dips get too deep and/or too steep. At this point, the system may transition to a culverted drainage system. Often, these types are blended, with a "sock drain" culvert system carrying flow collected from several smaller areas served by roadside swale systems

e. Curb and Gutter

Curb and gutter systems are on higher elevated streets or in more built-up areas. Roadside ditches and swales are replaced with a concrete curb and gutter, with low-flow runoff carried in the concrete gutter to curb inlet structures at fairly close intervals (300' is fairly typical in flat areas). The inlets may be

connected to form a culverted drainage system or they may dump via short sections of culvert into an open roadside ditch.

There are relatively few curb and gutter systems in the Town.

f. Outfall Ditches and Canals

Outfall ditches and canals are open water systems. In some cases, one or more roadside systems discharge into a system which transmits water to a receiving waterbody. Such a ditch may have a relatively dry bottom, or may be perennially wet. These often-large systems have large capacities that make them essential elements in the Town's system. The status of property rights varies (easements by plat, easements by deed, easements by prescription, public property owned in fee, etc.).

g. Detention/Retention Systems

Detention/Retention systems are typical stormwater controls historically used throughout the Town. Generally "detention" means holding back a portion of the stormwater runoff from an area to release it at a slower rate into the receiving drainage system, while "retention" means holding back all of the stormwater runoff from an area, or at least all of the runoff from a defined rainfall event. For many years, private commercial, industrial and multi-family residential sites have been required to retain all the runoff from the 10-year, 2-hour rainfall, declared to be 4.3 inches in volume. Most such retention occurs in open, grassed basins, with runoff entering via surface flow, flumes and/or culverts. Generally, no exit is provided, as the intent is for runoff to be stored until it is lost by evaporation or infiltration into the groundwater.

A few commercial sites have retention in the form of underground chambers. These expensive devices are cost-effective only where the value per square foot of land is very high.

Some large commercial areas have "wet ponds" for retention or detention. These may be interconnected to the public system of culverts or ditches.

2. Stormwater System Evaluation

Along with the Stormwater Inventory Map which can be found in Appendix C, a survey and rating of the Town's primary storm drainage culverts,

structures and related facilities has been prepared by Engineering Services of Virginia, Inc. (ESVI). The survey is entitled "Stormwater System Evaluation," July, 2008, which will be referred to as "the Evaluation" and a copy of which is attached as Appendix D. Relatively minor driveway culverts and similar facilities serving only a small area were not surveyed or evaluated because their consideration is not practical in the development of a master stormwater plan. The evaluation was conducted with consideration of four parameters: Physical and Structural Condition, Appearance, Capacity, and Maintenance Status. Each parameter was assigned a number of points out of 100 total to reflect the weight of each parameter with regards to the importance of that parameter to a functioning stormwater system.

The following is a brief review of the highlights of the Evaluation:

a. Physical and Structural Condition

The physical and structural condition of the elements of the system was assigned 30 points of weight out of a total of 100. The better the physical and structural condition, the more points the system receives. Structural Condition was observed July, 2008, and a wide range of conditions was noted. Newer areas of the Town, along with areas with relatively new improvement projects, have culverts which are high-density polyethylene (HDPE) and other corrosion-resistant materials. These systems are performing well; however, observations show that they can be susceptible to damage at the end of the culverts by mowing equipment. On the other hand, corrugated metal pipe (CMP), the drainage culvert material of choice up until around the 1980s, is vulnerable to corrosion. In some cases, notably along Memorial Boulevard, CMPs can be found rusted through to complete perforation or even collapse. This situation will require an extensive, long term replacement program.

b. Appearance

The second evaluation parameter is Appearance or how well the stormwater feature fits its setting. The more appropriate the fit to the setting, the higher the points. Generally, open-ditch configurations, which might be appropriate in a light industrial setting, were down-rated where they occurred in residential areas. Appearance was assigned 15 points out of 100. Except for areas with

unpleasant, hard-to-maintain roadside ditches, most of Town received fairly good ratings on Appearance.

c. Capacity

The parameter assigned the highest weighting, 40 out of 100 points, was Capacity. Recognizing that it is not the Town's objective to route its stormwater to the ocean or sound as rapidly as possible, system elements were given relatively high marks if they could handle a significant portion of the estimated 10-year flow. For example, a culvert might carry as little as 40% of the 10-year runoff from its contributing area and still receive 25 out of 40 possible points. The intent was to focus attention on those systems where main "trunk" culverts had an extremely low percentage of the capacity needed to carry the 10-year runoff. Over 10% of the Catchments and Subcatchments evaluated (14 out of 130) had trunk culverts so severely undersized that they had 6% or less of their 10 year capacity. Trunk culverts with capacities this low present serious concerns about the ability to handle excess runoff from extreme rains or ocean overwash events.

d. Maintenance Status

Maintenance status receives the final 30 points of 100. Higher points were assigned for systems with the higher level of maintenance. Most of the culvert and ditch systems in Town are rather well maintained. One exception is that an efficient means needs to be developed to restore shallow, gentle-sided roadside swales to their proper flowline elevation. Ideally, such swales should be several inches lower than the driveway inverts or swales they connect, affording potential for infiltration. Instead, in many areas, the accumulation of fine soil has built up the elevation of these swales to the point where they hold water on the intervening driveways.

C. Watersheds

Through previous stormwater studies by prior consultants, the Town had been divided into a series of Watersheds which varies from 8 watersheds in an earlier study, to 13 (3 to ocean outfalls and 10 to sound outfalls) in the most recent study adopted in 2002.

In this effort to delineate watershed boundaries, the previous work of others was refined using existing topographic surveying to find terrain ridges, field-surveyed information on culvert systems, interviews with Public Services street maintenance staff, as well as direct field observation of apparent high points of roadside drainage systems.

The watersheds now reflect 14 watersheds. Three Watersheds (O01, O02 and O03) are served by ocean outfalls; thus, the prefix "O" indicating Ocean and eleven watersheds (S01 through S12, with S02 not used) served by outfalls flowing to Kitty Hawk Bay, a branch of the Albemarle Sound; thus, the prefix "S" indicating Sound. The location of the boundaries of these watersheds, as well as their components, was refined through the examination of topographic maps, consultations with Town maintenance personnel, examination of the culvert and ditch systems, and other field observations. It is believed that the precision of these boundaries has been improved.

- Each watershed was broken into two or more Catchments, each one reaching the outfall by a separate branch of ditch and/or culvert. A third digit identified the Catchment; for example S015 is the 5th Catchment in Watershed S01.
- Some or all of the Catchments were further defined as having Subcatchments. A fourth digit is used; S0152 is the 2nd Subcatchment in Catchment S015.

The delineation of these outfalls and their boundaries is shown on the "Stormwater Inventory Map of Kill Devil Hills, NC," prepared by ESVI, which will be referred to as "the Inventory" and is Appendix C.

Following is a foldout map of the **entire town** showing all Watersheds at a scale of 1" = 2,000'. Additional foldout maps at a scale 1" = 800' show more detail of each watershed, including its catchments. To see even more detail, including watersheds, catchments, subcatchments and a schematic layout of stormwater system components, the Stormwater Inventory Map is presented as Appendix C, at a scale of 1" = 400'. Maps of maximum detail, showing sizes, elevations, etc. of individual pipes and other components may be viewed at the Department of Public Services and the Department of Planning and Inspections.

On the foldout map of the entire town, several areas not shaded in color were not designated, analyzed or studied. Among these are:

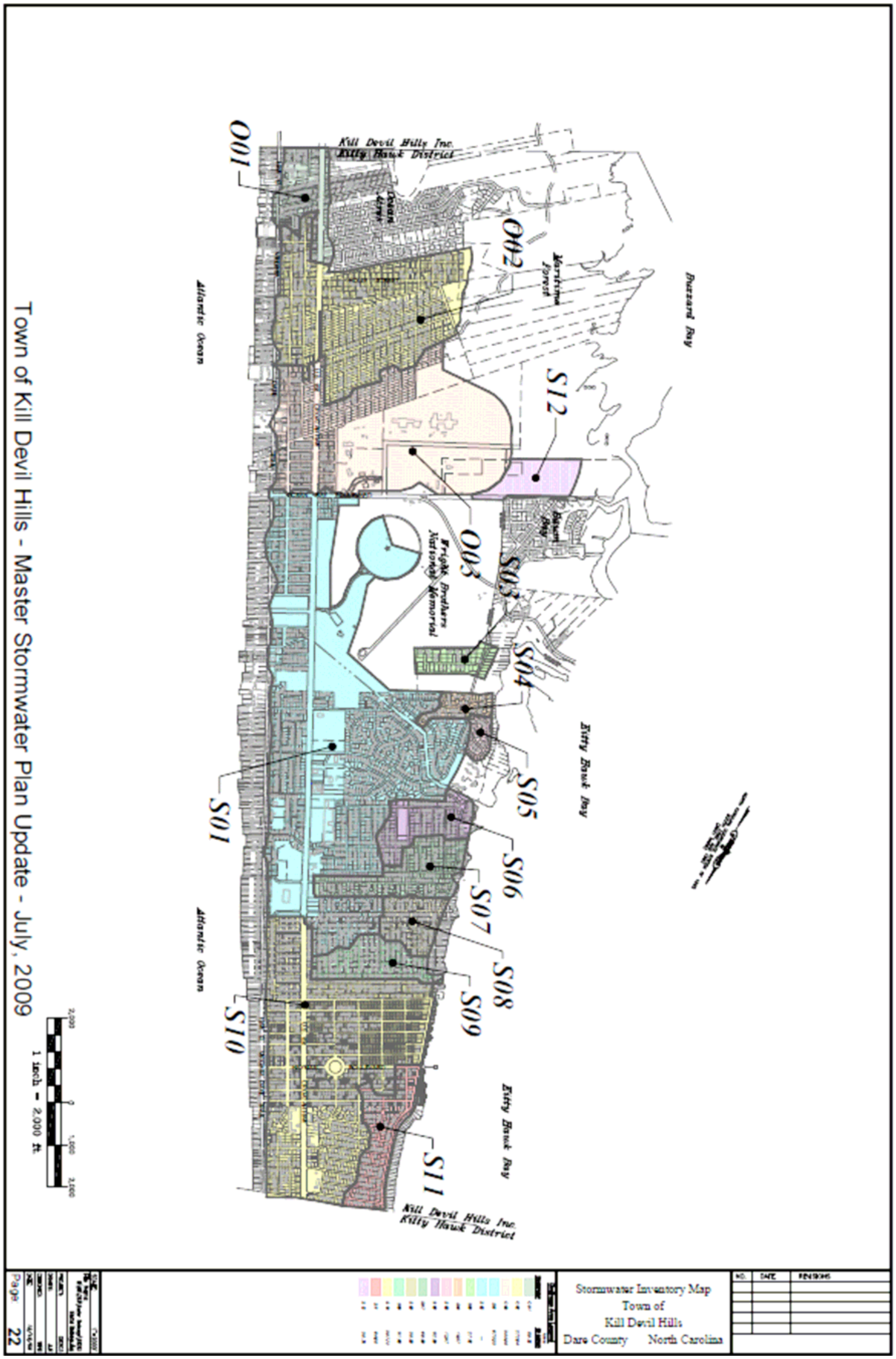
- The Oceanfront. Consistent with past studies, this area, generally from NC 12 eastward, has little or no defined surface drainage pattern and, for the most part, infiltrates into the higher, sandy soils typifying this area.
- The Ocean Acres Subdivision. This older area has few defined surface drainage features and no defined outfall. The area has historically been subject to a high ground water table which has compounded the lack of drainage. The resulting flooding demonstrates the need for a defined drainage system for this area.

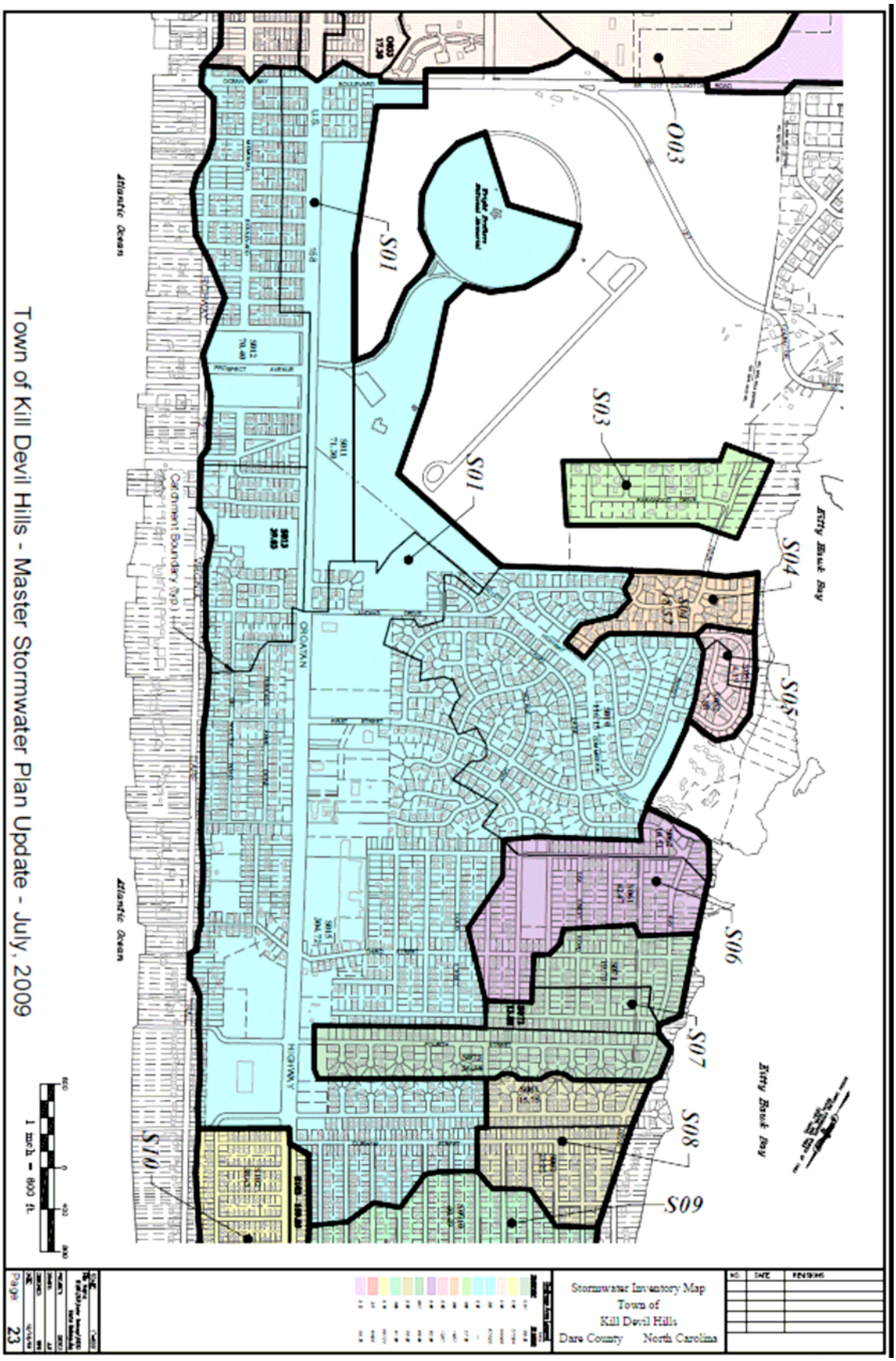
- The Maritime Forest Area. This environmentally sensitive area does not have a defined outfall. Surface flow and groundwater flow interact in a natural way, with perennial ponds occupying many lower areas.

- Most of the Wright Memorial Area. This area is owned and maintained by the United States Government. Portions are left natural, while others have some defined drainage patterns. Only those northern and eastern areas contributing to Watershed S01 have been included for study.

- The Baum Bay Subdivision. This area is not within the limits of the Town.

- Areas along the soundfront (Kitty Hawk Bay) which drain by infiltration or sheet flow directly to the water, including the rear portions of most residential lots.


Town of Kill Devil Hills - Master Stormwater Plan Update - July, 2009
1 inch = 2,000 ft.
Kill Devil Hills Inc.
Kitty Hawk District
Atlantic Ocean
Buzzard Bay
Kitty Hawk Bay
Wright Brothers National Memorial
O01
O02
O03
S01
S03
S04
S05
S06
S07
S08
S09
S10
S11
S12
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County
North Carolina
Page
22


Town of Kill Devil Hills - Master Stormwater Plan Update - July, 2009
Atlantic Ocean
Atlantic Ocean
Kitty Hawk Bay
Kitty Hawk Bay
S01
S01
S01
S03
S04
S05
S06
S07
S08
S09
S10
O03
Catchment Boundary
1 inch = 600 ft.
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
Page 23

<u>Watershed S01</u>:

1. Description:

a. **Outfall:** The NCDOT outfall canal runs generally northwestwardly from US 158 into Kitty Hawk Bay. It lies within an easement of varying width, being 80' in some areas and 100' farther downstream.

b. **Boundaries and General Extent:** The northern limit of SO1, in the area between NC 12 and US 158, is the boundary between the K-Mart site and East Avalon, or just north of East Fifth Street. West of 158, S01 extends farther north to an irregular ridgeline roughly halfway between Durham Street and Suffolk Street. The eastern limit generally follows the midline of those lots fronting the west side of NC12. The western limit is irregular, averaging about 1,600' to 2,000' west of US 158. Flow is generally southward until the several Catchments converge and discharge in to the NCDOT canal itself, which lies generally along and northwest of the northern portion of the Wright Memorial site. A southern Catchment reaches as far south as just south of Ocean Bay Boulevard, then flowing northward to the NCDOT canal.

c. **Area:** 673.32 acres, or over one square mile. This is the largest of all the Town's watersheds.

d. **Land Uses:** About three-fourths of S01 is single-family residential. About 10% of its area is within the Wright Memorial National Historic Site. The remaining 15%± is in commercial and similar uses, mostly along US 158.

2. Major Drainage Facilities:

a. The outfall canal itself gradually enlarges from US 158 to Kitty Hawk Bay, with an average cross section being about a 20' bottom, 3:1 side slopes and depth of 6'. Its bottom is typically wet for its entire extent for most or all of the year. As it leaves the Memorial property and passes through First Flight Village subdivision, it typically has wooded banks. Major culvert crossings occur at US 158 (a 54" x 72" CMP), at Landing Drive (a 72" CMP), and at West First Street (an 84" CMP).

b. The main "backbone" system, upstream of the NCDOT canal, consists of the parallel storm drainage culvert and ditch systems in US 158. A major branch of the canal occurs where the west side US 158 ditch turns near Second Street to flow west, then south, forming the rear property line of the municipal site and other properties on the west side of US 158. This ditch is about 3,400' long, crossing West First Street and Landing Drive with 48" CMP culverts.

3. Topography and Soils: For most watersheds, a general assessment on topography and soils for the entire watershed is made. However, in view of the extreme size of S01, topography and soils will be addressed for each Catchment, at the end of the "Catchments/System Condition" section.

4. Catchments/System Condition:

a. S011 consists of about 71.30 acres, generally at the southern end of the watershed and drained by the roadside ditch on the west side of US 158, from near Ocean Bay Boulevard northward to the NCDOT canal. About 2/3 of this area is the "front yard" of the Wright Memorial National Historic Site. Most of the rest is on the east side of 158, including the residential cross-streets from Ocean Bay north to Ferris Avenue, each about halfway back to Memorial. A series of 24" CMPs drain each Subcatchment to the west side of 158.

Generally, the key culverts and facilities in this system are in good condition, with structural ratings of 20 points out of 30 possible. Maintenance is generally adequate. Capacity rates compared well with most of the Town, with most key culverts conveying close to 100% of the capacity required to pass 10-year storm flows, and none worse than about 50%.

Topography is generally flat, with natural elevations in the 7 to 8 foot range.

Soils are almost entirely the very well drained Corolla fine sand, with a generally deep water table.

b. S012 is 70.40 acres draining to the Memorial Boulevard/Woodmere Avenue ditch, flowing northward from Ocean Bay along Memorial to Woodmere, then west to 158, then north to the crossing at the head of the NCDOT canal.

The Memorial ditch in this Catchment has large (24") CMP driveway culverts, many of which are in very poor condition. Some are rusted to perforation and partial collapse. Condition ratings are typically 10 of 30 points, with some worse. Sediment removal is limited due to the fragile condition of many of these culverts.

This system needs attention in the form of a systematic culvert replacement program. However, it should be deferred until further study as to whether flows, or at least overflows, from Watersheds O01, O02 and O03 should be directed northward away from the three ocean outfalls and toward the NCDOT canal and Kitty Hawk Bay. This study should follow the Coastal Studies Institute's current Ocean Outfall study effort. Without such northward flow diversion, replacement culverts would probably be 24" HDPE. With the diversion of stormwater from other watersheds, that size might double.

Topography is generally flat, with most slopes less than 0.5%. Elevations are in the 7-8 foot range. The natural land flanking Prospect Street, owned by the United States National Park Service, is about a foot lower. Some of the rear portions of lots on the east side of Memorial Boulevard rise up to 10 feet.

Soils grade from Corolla fine sand (very permeable, relatively deep water table) to Newhan fine sand (very permeable, very deep water table) from west to east.

c. S013 is 39.03 acres between NC 12 and US 158, generally flowing from Camellia Drive and Sir Walter Road north of Camellia, along with East Landing Drive, southward in the ditch along the west side of US 158, crossing Tanya Drive and Veelee Drive with 24" CMPs to discharge into the culvert under 158 at the head of the NCDOT canal. The upper Subcatchments include relatively new culverted systems, while the lower end is largely surface-drained.

The systems in this Catchment are in average to slightly better than average physical condition and are adequately maintained. Their capacity ratings are fair, typically 25 of 40 points, representing

about half of 10-year storm capacity. This rating is better than the Town-wide average. Accordingly, this Catchment is not a candidate for near-term improvements.

Topography for most of the Catchment is flat and relatively low, with elevations of 6 and 7 feet and slopes less than 0.5% predominant. Slightly higher elevations and slopes are found in some areas closer to NC 12, with elevations of 8, 9 and occasionally 10 feet.

Soils are predominantly Newhan fine sand, with a narrow strip of Corolla fine sand generally parallel and adjacent to US 158. The strip of Corolla broadens in the southern portion of the Catchment near Tanya and Veelee Drives, transitioning about mid block to Newhan soils. A small pocket of Duckston exists in the extreme southwest corner of this Catchment, near the head of the NCDOT canal. For these soils, the permeabilities are rapid, and water tables grade from deep for the Newhan, moderately deep for the Corolla, and shallow in the Duckston pocket.

d. There is no Catchment S014.

e. S015 is S01's largest at 295.14 acres. It is the northernmost portion of S01, flowing from the southeastern quarter of West Avalon subdivision along the roadside ditches in 158, then following the 3,400' branch ditch discussed in 1.b.ii above to the NCDOT canal. Some of its Subcatchments have well defined culvert systems, while others have little drainage at all. There are several large wetlands and open waterbody areas in this Catchment, notably the ponds around and behind the large retail and movie theater properties from East Third Street northward to East Fifth Street.

Structural condition is not the larger issue in this Catchment, with its key culverts having an average rating of 20 out of 30 points. However, S0151 and S0154 stand out with ratings of 10. Capacity is the greater concern, with a Catchment-wide average of 15 of 40 points, which corresponds to only about one-fourth of 10-year storm capacity. Key culverts behind the municipal complex and under West First Street and Landing Drive have ratings of 5 of 40, with only about one-eighth of 10-year storm capacity.

This Catchment needs to be modeled with a dynamic analysis modeling tool to assess the extent to which ponds in the system may be damping and mitigating flooding which should result from these poor capacities. Such a modeling effort could also suggest the most cost effective location and nature of improvements.

Topography for this large Catchment varies. For the portion between the highways (NC12 and US 158), topography is similar to S013, with flat slopes, elevations 6 to 7 feet except that higher and slightly steeper slopes exist right along NC12. A notable difference is the existence of several wet ponds and canals. These begin with a canal along a series of lots facing US 158 which back up to those lots on Sobel Drive; to the north, between Third and Fourth Streets. Wrapping the rear of the multi-cinema facility are three more ponds of varying depth and shape, separated by dikes. Another pond exists as part of the K-Mart store facility.

The portion of Catchment 015 west of US 158 has somewhat different topography. The parts nearer to 158 are similarly flat and even slightly lower than on the east side, but grade westward into relic dunes with extensive elevations in the 8 to 12 foot range interspersed with small hills with tops in the high teens to mid-20 foot range. Typically, these hills and ridges form boundaries of the Catchment.

Soils in the heart of Catchment S015, and generally associated with the lower elevation areas, are the Duckston fine sands, with relatively rapid permeability but shallow water tables. This central core of Duckston is interrupted with a band of Corolla fine sands between Third and Fourth Streets. Corolla and Newhan fine sands are generally found in the higher elevations and relic dunes around the edges.

There is no **Watershed S02**. The numbering system has generally attempted to follow that established years ago for historical consistency.

<u>Watershed S03</u>:

1. **Description**: See Page 23 for larger-scale map.

   a. **Outfall:** A 24" CMP under West First Street, near its southern terminus, discharges into an open lot line ditch westward into Kitty Hawk Bay.

   b. **Boundaries and General Extent:** S03 is essentially the Wright's Woods neighborhood (Parkwood Drive and Maple, Myrtle, Elm and Telegraph Courts), plus the front portions of the 9 lots across West First Street from Parkwood. It is surrounded on 3 sides by undeveloped areas having no discernible surface drainage pattern.

   c. **Area:** 27.52 acres.

   d. **Land Uses:** Entirely single-family residential (about 50 lots).

2. **Major Drainage Facilities**: This small watershed could be a single independent Catchment. Along the front of the lots is a network of shallow, often steep-sided roadside ditches and driveway culverts. The ends of the four courts flow to a poorly-defined southern boundary ditch which flows west to join the roadside ditch on the east side of W. First Street, and then discharges out the outfall.

3. **Catchments/System Condition**: As noted, the entire watershed is a single Catchment. Its condition is fair, with mediocre scores on all parameters. No urgent action is suggested.

4. **Topography**: The natural topography is a very slight east-to-west slope from about elevation 7 to elevation 6 (about 0.1%) in the western 1000' of the area, "steepening" to about 0.5% approaching West First Street and 1% to 2% approaching Kitty Hawk Bay.

5. **Soils**: Generally, soils transition from Corolla fine sand to Ousley fine sand, with somewhat shallower water table, in the western one-third.

Watershed S04:

1. **Description**: See Page 23 for larger-scale map.

   a. **Outfall:** Lot line ditch draining westward from Captain's Circle to Kitty Hawk Bay.

   b. **Boundaries and General Extent:** Lots along the south side of Cedar Drive from Ketch Lane to West First Street, and along Landing Drive from Anchor Court/Harpoon Drive to West First Street, and including Teakwood Lane and Captain's Circle farther west.

   c. **Area:** 18.56 acres.

   d. **Land Uses:** Entirely single-family residential (about 64 lots).

2. **Major Drainage Facilities**: Like S03, this watershed could be a single Catchment. Poorly defined roadside systems in the eastern half transition to an enclosed High-Density Polyethylene (HDPE) culvert system to the west.

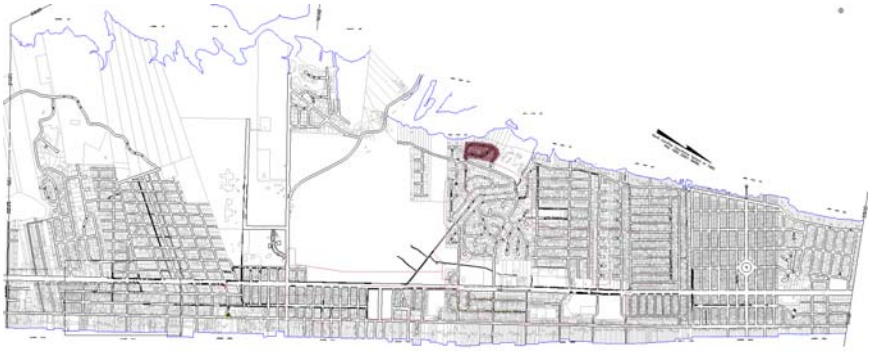
3. **Catchments/System Condition**: As noted, the whole watershed could be considered a single Catchment. Condition is fair to good, with mediocre scores on all parameters, except good ratings on physical condition. No urgent action is indicated.

4. **Topography**: The natural topography is a very slight east-to-west slope from about elevation 7 to 6 feet (about 0.1%) in the western 1000' of the area, "steepening" to about 0.5% approaching West First Street and 1% to 2% approaching Kitty Hawk Bay.

5. **Soils**: Generally, Ousley fine sand exists in most of the watershed, with a strip of Corolla fine sand bisecting it, then transitioning to a poorly drained Osier fine sand to the west, where natural elevations are lower and a shallower water table prevails.

<u>Watershed S05</u>:

1. **Description**: See Page 23 for larger-scale map.



   a. **Outfall:** Two lot line ditches between pairs of lots on the west side of Cedar Drive, each fed by a 15" Corrugated Metal Pipe (CMP).

   b. **Boundaries and General Extent:** S05 is comprised of about 53 lots or portions of lots fronting on Cedar Drive (west of First Street) and Captain's Lane North.

   c. **Area:** At 12.07 acres. This is the smallest separately delineated Watershed in the system.

   d. **Land Uses:** Entirely single-family residential (53± lots).

2. **Major Drainage Facilities**: As is the case with several of these "Watersheds" along Kitty Hawk Bay (S03, S04, S06), S05 is really a single Catchment. Shallow roadside ditches with driveway culverts lead to the two 15" CMP outfalls.

3. **Catchments/System Condition**: The entire watershed could be considered a single Catchment. Its condition ratings were fair on most parameters, but quite good on capacity, due in part to the small size of the area. No capital project is suggested in the near term due in part because recent maintenance work has put the ditch components on grade, and corrected a few off-grade culverts.

4. **Topography**: Natural topography is similar to S03 and S04, but even lower, with elevations beginning at around 5 to 6 feet at the eastern limit and falling to around 3 feet approaching Kitty Hawk Bay. Typical slopes in this direction are around 0.5%, with locally steeper slopes (up to 2%±).

5. **Soils**: Soils transition from Ousley fine sand in a strip east of Captain's Lane to a poorly drained Osier fine sand to the west, where natural elevations are lower and a shallower water table prevails.

<u>Watershed S06</u>:

1. **Description**: See Page 23 for larger-scale map.

a. **Outfall:** A 24" High-density Polyethylene (HDPE) pipe draining from the intersection of Indian Drive and Bay Drive into Kitty Hawk Bay.

b. **Boundaries and General Extent:** S06 is generally bounded on the south by the rear of lots fronting on the south side of Indian Drive, except it also includes about a 500' stretch of Bay Drive southeast of its intersection with Indian. The western boundary is Kitty Hawk Bay. The eastern boundary is a low ridgeline meandering in the vicinity of Wyandotte Street. The northern boundary is a line generally running from the west, eastward about 2/3 of the way from Indian to Third Street. Between Sea Swept and Upper Dune Roads, the area bends northward to pass through the Upper Dune/Third intersection, to include all but the northernmost two lots on both sides of Apache and Wyandotte Streets, and stopping two lots short of Clam Shell Street.

c. **Area:** 52.99 acres.

d. **Land Uses:** Entirely single-family residential (240± lots).

2. **Major Drainage Facilities**:

a. The 24" HDPE outfall pipe and its associated ditch collect flow from the two Catchments of S06.

b. Catchment S061's backbone system flows generally west along the north side of Indian Drive. Most driveway culverts are 12" HDPE, while most cross street culverts are 15" CMP (their capacities are similar), with roadside swales/ditches in between. At Indian's intersection with Upper Dune Road, a branch of similar pipe and a

gentler swale continues north, with a 15" culvert down side lot lines connecting about mid-block to serve a similar system in Apache Street.

c. Catchment S062's backbone is the ditch/driveway culvert system flowing west along the south side of Indian Drive. Culverts are 12" HDPE except at Bay Drive.

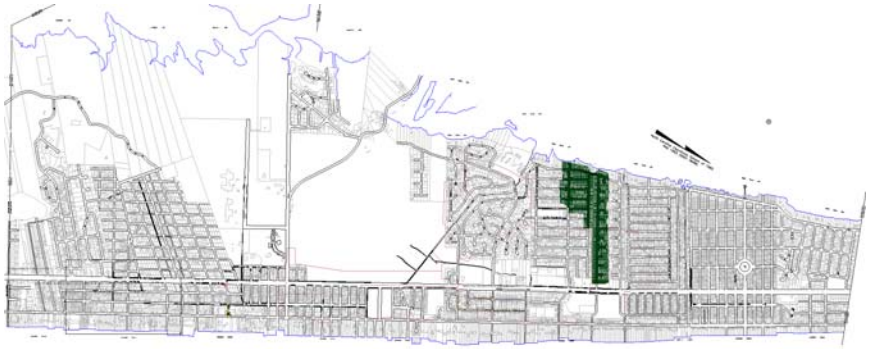
3. **Catchments/System Condition**: The two Catchments are described above. S062's backbone system has culverts of size similar to S061, but drains only about 15.45 acres. Its rating parameters are fair, and no urgent action is suggested. S061 includes 42.48 acres, thus draining about three times the area of S062 through similar culverts. While the system's physical condition is good, it received poor capacity ratings, with some elements receiving 5 or 10 of 40 points. Watershed S06 was selected for Hydraulic Modeling, which confirms that these capacity deficiencies appear to be causing Indian Drive itself to serve as a flow channel on storms with prolonged high intensity rainfall. These problems may be mitigated to an extent by the infiltrative capabilities of the higher terrain around Upper Dune Road and Apache Street. Monitoring of these areas during heavy rains, to calibrate the Hydraulic Model, is recommended. It is likely that the culverts on the north side of Indian Drive, serving S062, should be enlarged, probably to 18" HDPE, as a moderate priority.

4. **Topography**: A slight (0.5%±) but definite east-to-west slope prevails across S06. Somewhat steeper slopes begin in the 9-12 foot elevations (with local tops of relic dunes as high as 17 and 21 feet) around Upper Dune and Wyandotte. This westward slope ends around Bay Drive with 3-4 foot elevations.

5. **Soils**: Corolla fine sands dominate the Watershed, especially in the higher elevations, with the expected rapid permeabilities and deep water table. Most of Indian Drive is Ousley fine sand, with similar permeability but shallower water table. Duckston fine sand, with its even shallower water table, prevails along Bay Drive in the lower elevations.

<u>Watershed S07</u>:

1. **Description**: See Page 23 for larger-scale map.



a. **Outfall:** The outfall for S07 is an 18" High-density Polyethylene HDPE pipe down a side lot line from Bay Drive to Kitty Hawk Bay at a point about halfway between Clam Shell and Fourth Streets. A 15' drainage easement for this facility is recorded in the office of the Dare County Register of Deeds in Deed Book 1386 on page 7.

b. **Boundaries and General Extent:** S07 is bounded on the north by the common rear line of the subdivision of short cul-de-sacs off Fourth Street and the mirror-image cul-de-sacs off Fifth Street. It includes all the Fourth Street cul-de-sacs from Bay Drive to US 158, forming a "panhandle" to the Watershed area. Working southward, it includes Clam Shell Street and its lots from Wyandotte Street through Bay Drive, then Upper Dune, Sea Swept, Virginia, Sunset and Bay from Clam Shell south through Third Street and about 1/3 of the way toward Indian Drive.

c. **Area:** 70.43 acres.

d. **Land Uses:** Entirely single-family residential (320± lots).

2. **Major Drainage Facilities**:

a. The final outfall itself is an 18" HDPE. All 3 Catchments must flow through it and also through a 15" CMP under Bay Drive immediately upstream

b. Each contributing Catchment has its own system feeding the outfall. For S071, in Third Street, an open system with 15" and 18" HDPE culverts in Bay Drive transitions to an enclosed of 15" HDPE and CMP in Third Street. In Clam Shell, S072's western end is an enclosed system of 12" HDPE and 15" CMP, transitioning to a poorly defined system upstream to the east. S073

is a fully enclosed system along Fourth Street, beginning as a very weak 12" CMP at the Bay Drive intersection, then (working upstream) an 18" HDPE from Bay to Charlotte Lane, then mostly 15" HDPE eastward to Frances Lane, where it becomes mostly 15" CMP.

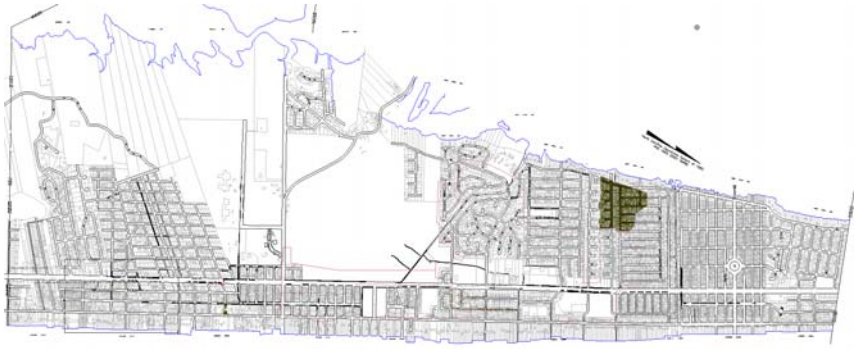
3. **Catchments/System Condition**: The general condition ratings are generally fair to better for everything but capacity. Capacity ratings are not good, ranging from poor (about 10 of 40 points) for S071 to 5 or less for the remainder. Of special concern are the components in Bay Drive which carry flow from all three Catchments. The 15" CMP/18" HDPE outfall should be schedule fairly urgently for upgrade to something on the order of 24" HDPE, along with, at a minimum, the replacement of all other CMP components in Bay Drive with not less than 18" HDPE.

4. **Topography**: Generally, there is an east-to-west fall, as is the case with most of the Sound Outfalls. For the northern "panhandle" (Fourth Street) portion of S07, however, there is a ridge at about 11 - 13 foot elevation across Fourth Street between David Lane and Fill Lane. Areas east of the ridge are lower, down to around 7 feet near US 158, but the enclosed culvert system carries their runoff through the ridge to lower areas to the west. From the toe of the ridge, slopes are irregular and poorly defined for about seven streets, until a slight but defined fall develops from about elevation 10 feet around Console Lane to 4 feet at Bay Drive, or about 0.6%. A similar east-to-west fall at about 0.5% prevails for the remaining, southern (Clam Shell and Third Streets) portions of S07, except for the relic dune tops at up to elevation 25 feet, with associated slopes of 5% to 10% around the intersection of Wyandotte and Clam Shell Streets.

5. **Soils**: In the highest areas, Dune Land prevails, with very rapid permeability and water table depths. Newhan and Corolla fine sands are found in almost all of the remainder of the Watershed, with Newhan's excellent depth to water table giving way to Corolla's lesser but good depth as elevations slowly drop. Typical of the Sound Watersheds, Duckston fine sand, with its shallow water table, occurs in the low elevations along Bay Drive.

<u>Watershed S08</u>:

1. **Description**: See Page 23 for larger-scale map.



a. **Outfall:** S08's final outfall is twin 18" Corrugated Metal Pipes (CMPs), followed by a well defined and maintained ditch down to a rip-rapped outfall into Kitty Hawk Bay.

b. **Boundaries and General Extent:** On the south, S08 includes the most westerly four cul-de-sacs off West Fifth Street. To the north, it includes West Durham Street and its six cross streets beginning with Bay Drive to the west and running to the centerline of Highview Street to the east. The northern boundary is a ridge on an angle, crossing Edenton about 2/3 of the way between Durham and Suffolk Streets, but crossing Highview Street only about ¼ of the way.

c. **Area:** 38.51 acres.

d. **Land Uses:** Entirely single-family residential (230± lots).

2. **Major Drainage Facilities**:

a. The twin-18" CMP outfall and its associated lot-line swale ditch is the final outfall for S08.

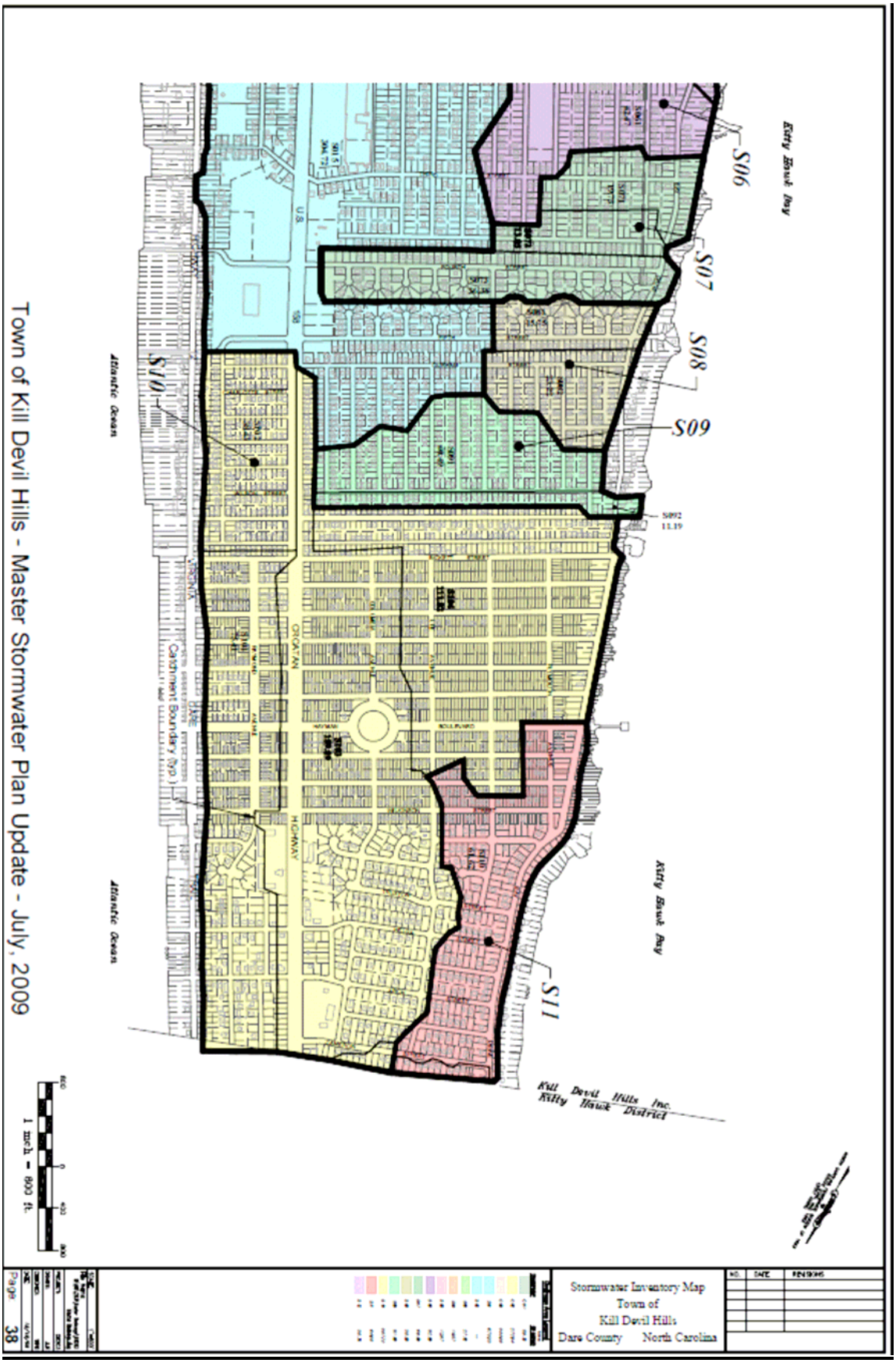
b. The two Catchments of S08 have distinct types of backbone systems. S081, serving the last four cul-de-sacs off West Fifth Street, is a fully-enclosed system with primarily 18" CMP along West Fifth. S082's backbone is the western five blocks of West Durham Street, of which only the western two blocks have a defined system (open ditches/swales with a mixture of CMP and HDPE). Most culverts are 15", but, notably, the lot at the southeast corner of Bay and Durham has a 12" CMP.

3. **Catchments/System Condition**: The Catchments are described above. S081's system rated well, with good marks on physical condition and excellent capacity. No action other than maintenance should be required until the CMP components begin to show end-of-life corrosion. S082 did not fare as well. Some of the CMPs were showing their age, and the capacity of key elements rated only 10 of 40. As a moderate priority, the more downstream CMP components in S082 should be replaced (at the corner of Bay and Durham).

4. **Topography**: Significant portions of this Watershed are lower and flatter than some of the previously-discussed Sound Watersheds. Between West Durham Street and Dock Street, the east-to-west fall from Hampton Street to Bay Drive is as low as 0.1% to 0.2%, falling from 5-6 to about 4 feet. The western two blocks of West Fifth Street is similar. Higher elevations (8 to 12 feet) and steeper slopes (1% to 5%) prevail around Sharon and Kitty Courts and Hampton and Phoebus Streets.

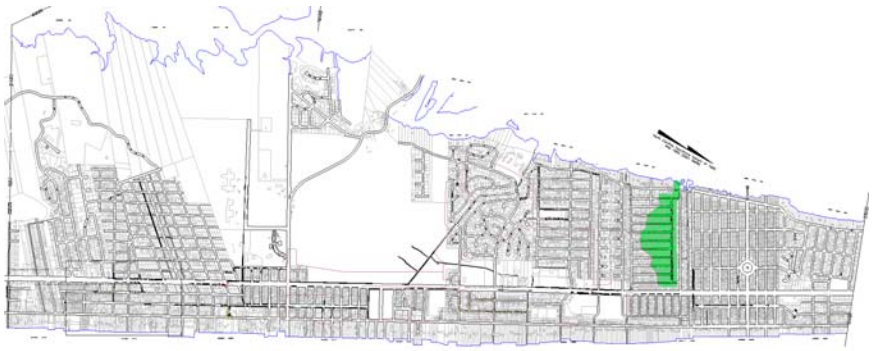
5. **Soils**: Similar to the other Sound Watersheds, Newhan fine sands typify the higher elevations, grading to Corolla fine sands in the medium elevations, with Duckston around Bay Drive. The large area of low elevations and flat slopes is a Corolla/Duckston complex. All of these areas will exhibit rapid permeability but depths to water table becoming shallower as elevation decreases.

On Page 38 is a map of the **northern part** of town, at a scale of 1" = 800', showing Watersheds S09, S10 and S11 and their respective catchments. For more detail, see Appendix C for a 9-sheet set of maps at 1" = 400' showing down to the subcatchment level.


Town of Kill Devil Hills - Master Stormwater Plan Update - July, 2009
Kitty Hawk Bay
S06
S07
S08
S09
S10
S11
Atlantic Ocean
Atlantic Ocean
Kitty Hawk Bay
Kill Devil Hills Inc.
Kitty Hawk District
U.S.
158
CROATAN
HIGHWAY
VIRGINIA
DARE
Catchment Boundary (typ.)
1 inch = 800 ft.
Page 38
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
NO.
DATE
REVISIONS

<u>Watershed S09</u>:

1. **Description**: See page 38 for a larger-scale map.



   a. **Outfall:** The outfall is a relatively strong twin-24" HDPE system, running from Bay Drive west to Kitty Hawk Bay down a common lot line.

   b. **Boundaries and General Extent:** S09 is bounded on the north generally by the rear line of those lots on the north side of Suffolk Street, from Elizabeth City Street in the east to Edenton Street in the west, then jogging north to include the south side of West Avalon Drive from Edenton to Bay Drive. Its southern boundary follows the irregular ridgeline which crosses the north-south cross streets mid-block between Suffolk and Durham. At the east and west ends, the ridge is near Suffolk, only about 1/3 of the block south toward Durham. In the middle of the Watershed it extends farther south, about ¾ of the block at Franklin, Yorktown and Highview Streets.

   c. **Area:** 51.68 acres.

   d. **Land Uses:** Entirely single-family residential (336± lots).

2. **Major Drainage Facilities**:

   a. The twin-24" HDPE outfall from Bay Drive to Kitty Hawk Bay extends upstream as twin-24" HDPE to Edenton Street, where it turns and becomes a single 36" HDPE. This trunk supports both of S09's Catchments.

   b. An independent 24" HDPE backbone system runs upstream (eastward) up each side of Suffolk Street.

3. **Catchments/System Condition**: These two systems, as described above, are among the stronger in Town relative to the areas they serve. S091, serving the south side of Suffolk Street and its cross streets, drains about 40.49 acres. It gets good marks for physical condition, and rates 20 of 40 points for capacity. S092, serving only the 11.19 acres on the north side, is in equally good shape and gets 40 of 40 points for capacity because it serves only 25% of the area of S091. Nothing in S09 warrants any immediate or near-term attention. As a relatively low priority, an 18" HDPE cross link under Suffolk would let the south side share in some of the north side's excess capacity.

4. **Topography**: Along the backbone of S09 (Suffolk Street) the elevations are around 6-7 feet for much of its length, but rising to 9-11 feet around Highview, Hampton, and Phoebus Streets and falling to 5 and 4 feet approaching Edenton Street and Bay Drive. This east-west profile would be similar if taken anywhere south of Suffolk Street.

5. **Soils**: The higher elevations in the middle of the Watershed are predominantly Newhan fine sands. In the eastern portion, Corolla fine sands are found for the first couple of blocks near US 158, then a fair amount of Corolla/Duckston complex where the elevations are lower, around the 6 foot elevation. Approaching Bay Drive, an area of Ousley fine sands protrudes into the Corolla/Duckston, which gives way to Duckston at Bay. Rapid permeabilities typify all these soils, but the depth to water table is shallower in the Corolla/Duckston and Duckston soils. Compared with the other Sound Watersheds, the shallow water table extends substantially farther inland from Kitty Hawk Bay. It is well that this Watershed's drainage features are free of serious capacity deficiencies, since it probably is prone to generate excessive runoff in time like 2004 when heavy rains follow prolonged wet periods.

Watershed S10:

1. **Description**: See Page 38 for larger-scale map.

a. **Outfall:** The Bickett Street ditch or canal is the outfall for this Watershed. It lies within a recorded street right-of-way for most of its length, and on a parcel owned in fee simple by the Town west of Bay Drive (Deed Book 1008, page 0441.)

b. **Boundaries and General Extent:** The portion of S10 east of US 158 extends from East Fifth Street in the south to the Kitty Hawk town limits in the north, and generally to NC 12 in the east. The portion west of 158 has two parts. The southern part runs from Avalon Drive in the south, northward to around Sothel Street, and all the way west to Bay Drive. The remainder runs north of an irregular line around Sothel then all the way to the Kitty Hawk limit and extends only from 158 west to about Lee Avenue.

c. **Area:** At 388.38 acres, this is the second-largest of the Town's watersheds.

d. **Land Uses:** S10 has a mixture of single-family residential uses (about 1,200 lots, with each two 25' lots in Virginia Dare Shores counted as one.) and commercial (about 15%, including the US 158 right-of-way).

2. **Major Drainage Facilities**:

a. The ditch, culvert, and canal system in East and West Bickett Street serves the entire watershed, and is also the backbone system for Catchment S104. Working upstream, from Bay Drive to about Columbia Avenue, it is a 60' to 80' wide, gentle-sided, almost natural canal with a 48" Corrugated Metal Pipe (CMP) under Bay Drive discharging into Kitty Hawk Bay. Along Columbia, it has been culverted with twin 36" HDPE. From there upstream to US 158, it is a trapezoidal channel which might be modeled as 15' bottom, 2:1 sides and about 6 feet deep. It crosses US 158 with a

48" CMP culvert, then extends up to Raymond Street as a ditch with about 4 to 6 foot bottom.

b. The backbone of Catchment S101 is the Raymond Street ditch, on the east side of that street, which begins near the northern Town limits as a culverted system, then discharging into the Briggs Street ditch, then into a culvert system along the north and east boundaries of the shopping center, then emerging just north of Wilkinson Street to begin a 10½-block-long open system, with culverts at cross streets and a few driveways, ranging from 24" CMP at the north end to 42" CMP for the southern two crossings. Some crossings have had the old CMP replaced with HDPE, including those accomplished with the Spring 2007 street and drainage project.

c. Catchment S102 is essentially the East Avalon area, whose backbone is the US 158 east side ditch. Its cross-street culverts begin as 18" at the upstream (south) end and become 24" HDPE at the north end.

d. Catchment S103 is the eastern portions of the Moor Shores and Virginia Dare Shores subdivisions. Their "backbone" system is the enclosed culvert system along the west side of the US 158 right-of-way. This Reinforced Concrete Pipe (RCP) system begins as 18" in the north, enlarging to 36" at the head of the Bickett Street ditch.

3. **Topography and Soils**: For most watersheds, a general assessment on topography and soils for the entire watershed will be made. However, in view of the large size of S10, topography and soils will be addressed for each Catchment, at the end of the "Catchments/ System Condition" paragraph.

4. **Catchments/System Condition**:

a. S101 includes 75.41 acres between the highways and served by the Raymond Street Ditch. While many of the key culverts are older CMPs, they are generally not near the end of their design life, receiving good ratings of 20 out of 30 points. Capacities are fair, averaging 20 out of 40 points. With some key bottlenecks having been remedied in the 2007 project, no urgent work is recommended. As the CMPs near end-of-life, they should be replaced with the same size, or one size larger, HDPE.

Topography is rather flat, with a very slight (0.1% to 0.3%) fall from north to south along Raymond Avenue, beginning at 8-10 feet near the town line, then almost flat at 7 feet from Wilkinson to

Bickett. East to west slopes are negligible, except off the low dune structure just west of NC 12, where 10 to 12 foot elevations are observed.

Soils in this area are Newhan fine sands in the dunes and nearby areas to the east, with a large Corolla/Duckston complex area in the north central, giving way to Corolla fine sands to the south and west. This suggests good permeabilities but moderately shallow water tables for much of the area. The Raymond Street ditch may be mitigating this natural condition.

b. S102 includes East Avalon, which has gotten considerable attention with the 2007-08 and 2008-09 projects. Physical condition and capacity are average, and no work is warranted, other than perhaps the New Bern Street work designed but not awarded in 2008-09.

Topography has no significant north-south trend. East to west, elevations of 8-9 feet, with the occasional 10+ foot, are seen in the remnant dune areas just west of NC 12, down to about 7 feet at the rear line of the lots on the east side of New Bern. From there, a very slight fall (0.1% to 0.2%) occurs toward US 158, where 6 feet is typical.

Soils, not unusually for between the highways, trend from Newhan fine sands near NC12, then Corolla/Duckston complex and Corolla fine sands working west. These somewhat shallow water table soils have likely contributed to this area's history of drainage problems.

c. S103 includes the east portions of Moor Shores and Virginia Dare Shores, drained by the RCP system owned and maintained by NCDOT in the US 158 right-of-way. According to the static analysis included in the Drainage System Inventory, this system has fairly significant capacity deficiencies, down to 10 out of 40 points in the downstream portion. This may be exaggerated, since the higher, very permeable, deep water table areas may be producing very little runoff in response to many rain events. This would be a good candidate for a dynamic analysis to explore this point further. It seems rather infeasible to do a major rebuild of this fully-enclosed NCDOT system. If further analysis suggests remedial measures, one or more flow-attenuating BMPs may be considered.

Topographically, the northwestern boundary of this Catchment is framed by large, rather high dunes and ridges, ranging up to elevations 20 feet and even mid-30 foot. Slopes in these hills are frequently 5% to 10%, with the slopes occasionally exceeding

20%. Once about 100' away from the toe of these features, the more typical flat grades are found, ranging from 9 -10 foot elevation in the north parts down to 6-7 feet in the south. Slopes less than 0.5% are typical.

Soils are Dune Lands, with great depth to water table and high permeabilities in the higher elevations, grading down to the Newhan and Corolla fine sands and Corolla/Duckston complex at lower elevations, with a small area of Duckston fine sand near the toe of the hill around the intersections of Columbia Avenue and Shiloh Street and of Wallace Street and Susan Drive. These high dune areas generate little runoff during most rain events; however, the Duckston and Corolla/Duckston areas are prone to flooding when a heavy rain follows a prolonged wet period.

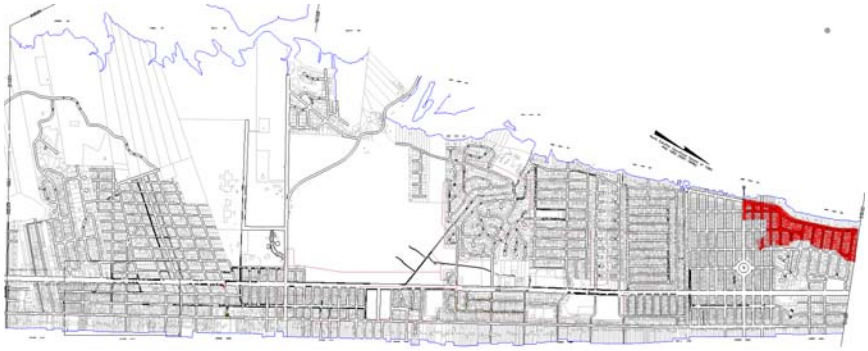
d. S104 is the Bickett Street ditch/canal itself. Most of the areas shown draining to it, comprised of the southeastern corner of Virginia Dare Shores along Plymouth and Bath Avenues, lack any defined drainage system to accomplish this. The development of such systems may be a moderate priority in future years. The open portions of the ditch itself could use some maintenance. The natural, wet-canal area from Columbia to Bay should be investigated for evidence of poorly functioning septic systems as a possible source of the contamination events which occur frequently. The 48" CMP culvert under Bay Drive for the Bickett Street ditch is probably the most pressing construction need and should be replaced with a 60" HDPE or other smooth-wall culvert of similar capacity, possibly with a low weir to promote water-quality BMP functionality upstream. There are some opportunities for quality and quantity BMPs in some of the paper street right-of-way.

This is a flat area with a slight slope (0.1% to 0.2%) which falls toward the south and west. The elevation range is generally from 8 - 9 feet down to 4 - 5 feet.

Not surprisingly, the soils follow the elevations, with Corolla/Duckston complex representing the larger areas, but Ousley and Osier fine sands found where the elevations get down to and below 5 feet. Some of these low areas are undeveloped and will require careful attention when development occurs, due to high water table and reduced infiltration.

Watershed S11:

1. **Description**: See Page 38 for larger-scale map.



a. **Outfall:** A 24" HDPE ("sock drain") installed with the 2007/08 Bay Drive Phase IA project and an older 25" x 20 Corrugated Metal Pipe-Arch (CMPA) come together in a small, wet forebay just north of the Hayman Boulevard Sound Access, then overflow through wetlands into Kitty Hawk Bay. It lies on a parcel designated as Open Space on the Plat of Virginia Dare Shores Revised, which is considered to be owned in fee simple by the Town.

b. **Boundaries and General Extent:** Watershed S11 is bounded on the west by Bay Drive and a small portion of those lots which front on the west, on the north by the Kitty Hawk town limits, on the south by Hayman Boulevard, and on the east by an irregular ridgeline roughly following Lee Avenue.

c. **Area:** 61.61 acres.

d. **Land Uses:** Entirely single-family residential (about 260 lots, with each two 25' lots in Virginia Dare Shores counted as one).

2. **Major Drainage Facilities**:

a. The trunk storm drainage system installed with the Bay Drive, Phase IA project in 2008 is the backbone for most of this Watershed. It begins as a 15" High Density Polyethylene (HDPE), "sock drain" at the St. Louis Street intersection, increasing to 18" and then to 24" at Helga Street, remaining a 24" HDPE "sock drain" all the way to the Hayman outfall.

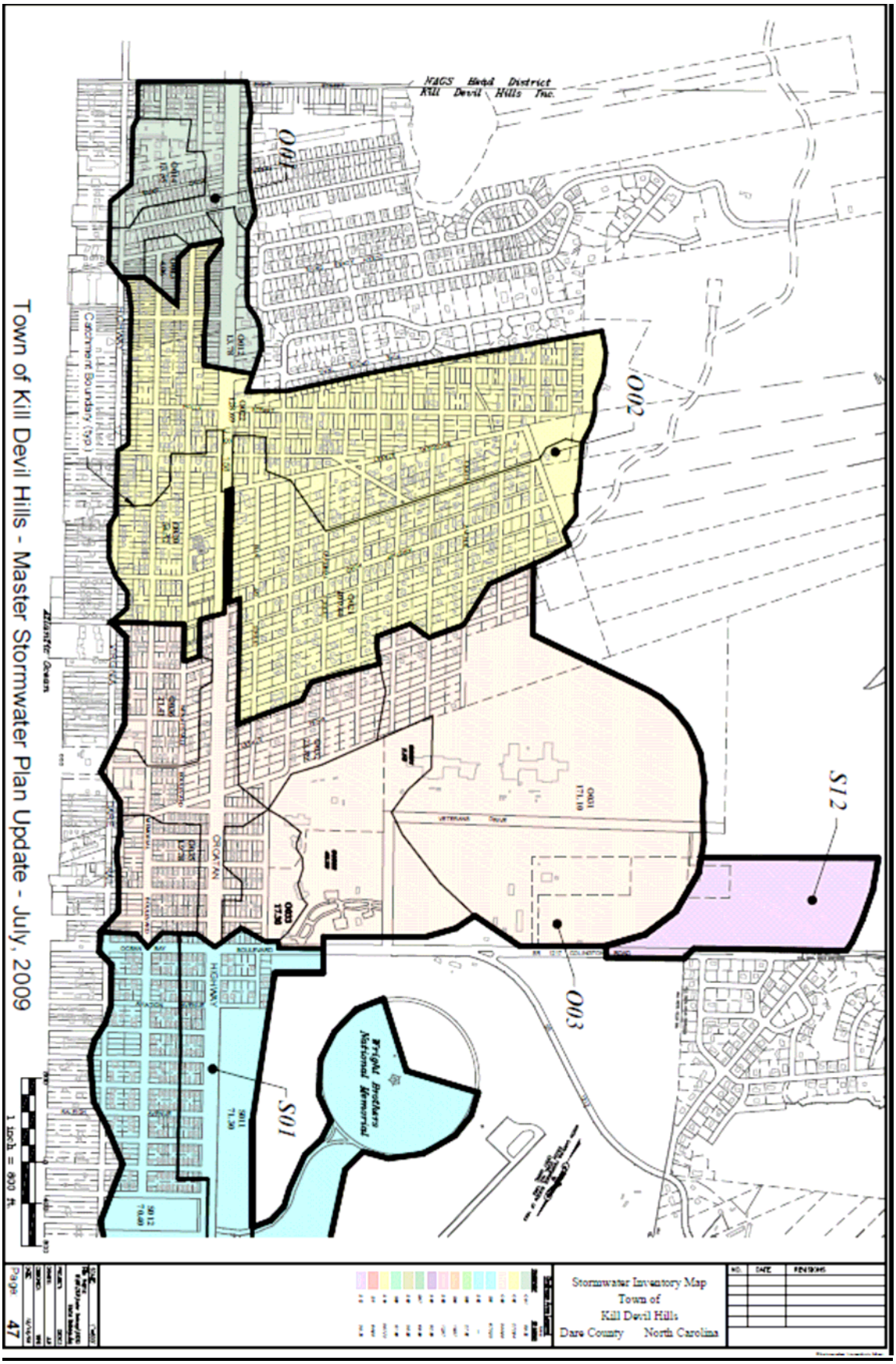
b. The other branch of the outfall, the 25" x 20" Corrugated Metal Pipe-Arch (CMPA), is fed by a 15" CMP on the west side, and an 18" by 15" CMPA on the east side, of Bay Drive. Both sides serve open systems along Bay Drive.

3. **Catchments/System Condition**: Watershed S11 is essentially a single Catchment. As such, its components are Subcatchments. The trunk system is in new condition and is of appropriate capacity in view of the permeable, deep water table nature of the soils and the infiltrative capability provided by the "sock drain." No improvements are necessary in the foreseeable future.

4. **Topography**: The northern and eastern portions of S11 are framed by the same dune/ridge system mentioned in S10, its eastern neighbor. Here, elevations reach 20 feet and even mid 30-foot elevation, with strong slopes of 5% to 10% with some slopes over 20%. Off these hills, elevations fall southward and westward, from around 10 feet at Arch Street down to 4 feet around Hayman Boulevard. Slopes are in the 0.1% to 0.5% range.

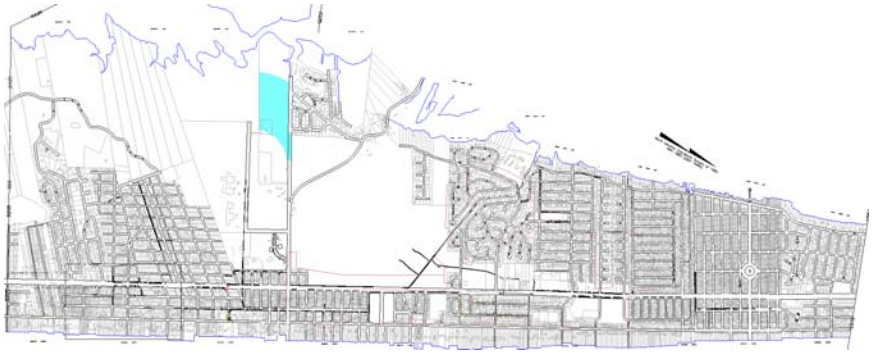
5. **Soils**: The higher areas to the north and east are Dune Lands, with their deep water tables and very rapid permeabilities, giving way to the south and west to Newhan and Corolla fine sands. A narrow strip of Duckston and Osier fine sands, with shallower water tables, is found in the immediate vicinity of Bay Drive.

On Page 47 is a map of the **southern part** of town, at a scale of 1" = 800', showing Watersheds S12, O01, O02 and O03 and their respective catchments. For more detail, see Appendix C for a 9-sheet set of maps at 1" = 400' showing down to the subcatchment level.


Town of Kill Devil Hills - Master Stormwater Plan Update - July, 2009
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
Wright Brothers National Memorial
S01
S12
O01
O02
O03
Atlantic Ocean
Catchment Boundary (typ.)
1 inch = 600 ft.
Page 47

Watershed S12:

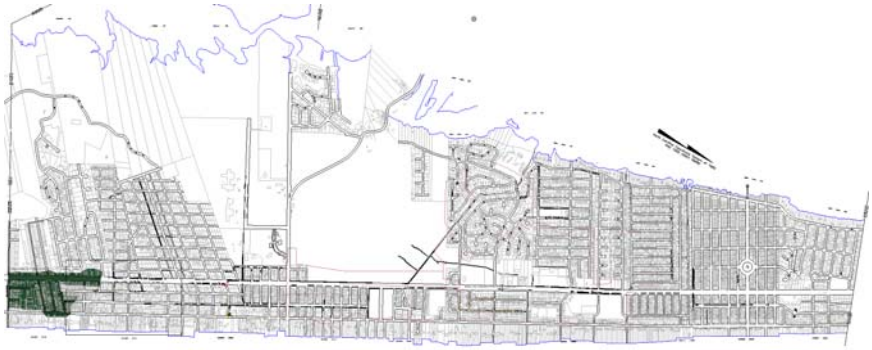
1. **Description:** See Page 47 for larger-scale map.



a. **General Description**: This designation is reserved for the Bermuda Bay development. This project is situated between ditches on the north and south which extend from the east to the west of Town. As this is a new, incomplete project, it has not been analyzed in any detail in this report.

Watershed O01:

1. **Description**: See Page 47 for larger-scale map.



a. **Outfall:** O01 is served by a 36" concrete pipe outfall directly to the Atlantic Ocean. This is one of three pile-supported ocean outfalls in Town.

b. **Boundaries and General Extent:** O01 is bounded on the south by the Nags Head town limits. Its western boundary is an irregular line generally 100' to 200' west of the western right-of-way line of US 158. The eastern boundary is generally along NC 12. The northern limit generally includes Carolyn Drive and a short section of Memorial Boulevard to the north. A portion immediately adjacent to 158 extends farther north to about Pine Grove Trail.

c. **Area:** 64.39 acres.

d. **Land Uses:** Predominantly commercial and multi-family residential (about 65%, including the US 158 right-of-way), with the remainder representing about 85 single-family residential lots.

2. Major Drainage Facilities:

a. The 36" concrete pipe outfall itself is the key facility of this system. While it is owned by NCDOT, its maintenance often includes urgent efforts by the Town to reopen it once the inwash of sand has rendered it essentially inoperable. This outfall is also known to NCDOT as Ocean Outfall #6, and was repaired and extended during 2008.

b. The main trunk system feeding the outfall appears to have been installed as part of the widening of US 158 to five lanes, and runs along Lake Drive as a 36" Reinforced Concrete Pipe (RCP). It is a twin line for portions of this length.

c. Another key component in this Watershed is the RCP system in US 158 extending upstream to the north and south of Lake Drive. Sizes range from 15" to 30"

3. Catchments/System Condition:

a. Three small Subcatchments connect directly to the main trunk system and are not considered part of any separate Catchment.

b. The outfall itself, along with all of the Ocean Outfalls on the Outer Banks, is a subject of an extensive study being performed (The Ocean Outfall Project) under the auspices of the North Carolina Department of Environment and Natural Resources (NCDENR) by Moffatt & Nichol and others. The status and future of this outfall, as well as O02 and O03, may depend on the outcome of this Study and subsequent State-level actions. Accordingly, a number of the recommendations of this Stormwater Master Plan Update may be contingent on the Ocean Outfall Study.

c. Catchment O011 is that portion served by the southern leg of the US 158 right-of-way system. Capacities are good, and physical condition is generally good. As an exception, the upstream-most Subcatchment, in the vicinity of Eight Street and the proposed Satellite Fire Station site is poorly drained. This might be remedied in conjunction with an Eighth Street project done jointly with Nags Head, or with the Fire Station project. These needs are of moderate priority, although the street improvement need may be more urgent.

d. Catchment O012 is the north leg of the 158 system. Capacity and physical condition are good, and no action is recommended.

e. Catchment O013 is the southern-most end of Memorial Boulevard, linked by a line of 24" CMP which does not follow a right-of-way and ties into the Lake Drive culvert. There are no capacity or condition issues with this branch which would give rise to the need for immediate action. However, from a broader perspective, it may become prudent to examine linking O01 and the other two Kill Devil Hills ocean outfalls, O02 and O03, to one another and ultimately to the NCDOT Canal via a system of culverts, ditches and BMPs along the Memorial Boulevard corridor. This would have significant impact on the components of Catchment O013.

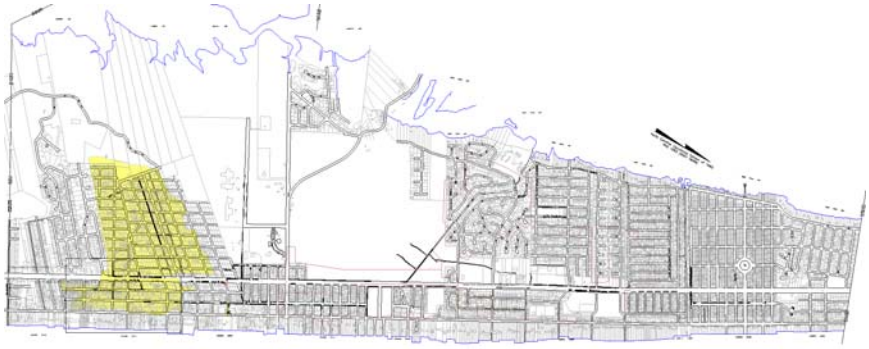
f. Catchment O014 is the southeastern portion of O01, including areas along Fresh Pond Drive and NC 12. Substantial improvements in these areas were accomplished incidentally to the recent NC 12 Water Main Improvements Project, Phase 1, and no further action is deemed necessary in the near future. Capacities and conditions are good.

4. **Topography**: Slopes are quite flat (less than 0.5%) in O01, and elevations range from 9 – 10 feet around the two highways to 7 feet in the interior areas.

5. **Soils**: The predominant soil of this Watershed is Corolla fine sand, with its rapid permeability and moderately deep water table. Newhan fine sand, with deeper water table, is typical at the higher elevations near NC 12, and a patch of Duckston fine sands, with a rather shallow water table, runs generally north-south through the heart of the between the highways area.

<u>Watershed O02</u>:

1. **Description**: See Page 47 for larger-scale map.



a. **Outfall:** Watershed O02 is served by the Martin Street ocean outfall, also known as the Atlantic/Martin Street outfall and to NCDOT as Ocean Outfall #5. Since it is much closer to Martin Street, we will refer to it hereafter as the Martin Street outfall. It is a 30" metal pipe on wood pilings, running from NC 12 to the Atlantic Ocean.

b. **Boundaries and General Extent:** The part west of US 158 is bounded on the west by the Maritime Forest area, on the south by the lots on the north side of Pine Grove Trail and Quail Lane and on the north by a line roughly along Corrigan Street. The part between the highways is bounded generally on the south by Carolyn Drive (but excluding the lots fronting on the southern 400' of Memorial Boulevard) and on the north by Calvin Street (except an additional ¾ block of the west side of Wrightsville Boulevard is included.)

c. **Area:** At 267.43 acres, O02 is Kill Devil Hills' fourth largest Watershed.

d. **Land Uses:** Predominantly single-family residential (about 750 lots), with the remaining 15%± (including the 158 right-of-way) being commercial and multi-family.

2. **Major Drainage Facilities**:

a. The 30" Ocean Outfall itself is the key facility for the entire watershed. It drains from NC 12 to the Atlantic Ocean.

b. Leading from Memorial Boulevard to the outfall pipe at NC 12 is a twin 24" HDPE. Branching northward at Memorial is a twin 18" HDPE drainage a small area.

c. Branching southward is another twin 18" HDPE, which goes upstream along Memorial to about mid-block between Atlantic and Martin, then branches again.

d. The southern sub-branch continues southward to Holly Street, where it branches again. Its southern sub-branch goes to the limits of O01, without a distinct break or "high point." This configuration suggests the possibility for a Memorial Boulevard interconnect as a strategy to assist in stormwater management of that watershed. Its western sub-branch goes west to US 158 to receive the Holly Street ditch, itself a major drainage facility, along with other flows from the 158 right-of-way.

e. The western sub-branch goes west outside of alignments of right-of-ways as a twin 18" HDPE to Wrightsville, then jogs to receive the Boundary Street ditch, itself a major drainage facility, along with other flows from the 158 right-of-way.

f. The Holly Street Ditch is a partially-open, partially culverted facility. The culvert under US 158 is a 30" CMP. From 158 upstream to Shay Street, its culverts are 24" HDPE (except a 36" HDPE "sock drain" at the commercial site fronting 158), with 24" CMP typical farther upstream.

g. The Boundary Street/Harding Street Ditch is also partially open and partially culverted. Working upstream from its 30" CMP culvert under US 158, it is an open ditch with twin 18" HDPE culverts at the one driveway off Boundary, then open channel up Blue Jay Street to the Walgreen site, where the 2007/08 drainage project added a single 30" HDPE culvert to the twin 15" CMP and replaced the twin 15" CMP with twin 24" HDPE at Martin Street. This system continues north to Harding Street as an open channel, then west along Harding Street as a partially-open, partially culverted facility, with the culverts predominantly twin-24" HDPE, changing to single 24" at Sixth Avenue and upstream.

3. Catchments/System Condition:

a. S021 is the area, entirely on the west side of US 158, served by the Harding Street Ditch and its continuation on Blue Jay Street and Boundary Street.

b. S022 is the area service by the Holly Street Ditch, about 70% on the west side of US 158 but with six small subcatchments between US 158 and NC 12.

c. The 30" CMPs under US 158 at Holly and at Boundary have serious capacity limits, receiving only 10 of 40 points.

d. Most of the twin 18" HDPE network, while in decent physical condition, is rated very badly on capacity 5 of 40 points. This portion of the system carries all 109.44 acres of O021 plus additional flows from small subcatchments between the highways.

e. The remaining portions of the Holly Street Ditch are generally not of concern. No priority recommendations are offered.

f. The remaining portions of the Boundary Street Ditch system are also generally not of concern, with the exception of the twin 18" HDPE driveway culvert for the retail store at the southwest corner of Boundary Street and US 158.

g. The 30" ocean outfall pipe itself is quite inadequate, having less than 5% of the capacity to handle 10-year runoff and rated 4 out of 40 points. Add to this the difficulties in keeping it open and the uncertain status of all the ocean outfalls. The idea of a Memorial Boulevard interconnect system seems an attractive alternate for solving the serious questions about capacity and maintainability of this ocean outfall.

4. **Topography**: As with most of the areas between the highways, elevations of 6 – 7 feet with very flat slopes (less than 0.2%) are typical. West of US 158, terrain slowly (less than 0.5%) rises from 7 – 8 feet near 158 up to 10-11 feet near the western limits of the Watershed, except that relic dune features rise to elevations in the mid-20s in the northwest corner of Watershed O02.

5. **Soils**: Corolla fine sand, with a moderately deep water table and rapid permeability is the predominant soil on both sides of US 158. Approaching the relic dunes in the northwest corner, Newhan fine sands transition to Dune Lands, with progressively deeper water tables. Two large areas of Duckston fine sand interrupt the Corolla between the highways, and a narrow strip of Newhan is found with the slightly higher elevations around NC 12.

<u>Watershed O03</u>:

1. **Description**: See Page 47 for larger-scale map.

   a. **Outfall:** The Baum Street ocean outfall serves this area. It is a 30" metal pipe, leading from US 158 at a point about 300' north of Baum Street, to the Atlantic Ocean, where it terminates on a pile support structure.

   b. **Boundaries and General Extent:** Watershed O03 is bounded on the north generally by Ocean Bay Boulevard/Colington Road, on the south by a line roughly following Corrigan Street, except the portion between US 158 and NC 12 extends farther south to Calvin Street. The eastern boundary generally follows NC 12, and the western limit generally includes the Dare County Schools complex.

   c. **Area:** At 344.88 acres, O03 is the Town's third largest Watershed.

   d. **Land Uses:** Governmental uses (the Town Hall complex and the County school complex) are the largest use group, with single-family residential next (about 250 lots). About 10% of the watershed is in commercial use, and the US 158 right-of-way is included in this.

2. **Major Drainage Facilities**:

   a. The 30" CMP Baum Street outfall itself is the most important single component in the watershed.

   b. Leading to it is a 30" HDPE system, installed with the 2007/08 drainage and water projects, running from Memorial Boulevard to the 30" CMP under NC12 to the outfall.

   c. Upstream out of the intersection of Baum and Memorial a branch extends southward to the limits of O02, continuing the opportunity for a Memorial interconnect. This system is generally open, with

culverts that are typically 36" CMP, with some twin culverts (18" HDPE and 21" CMP).

d. A northern branch out of the Baum/Memorial intersection continues all the way north to the limits of Watershed S01, which flows to the NCDOT Canal into Kitty Hawk Bay. Culverts on this branch are typically 24" CMP.

e. One block north of Baum, a branch of that northern branch picks up the Goddard Street Ditch. This ditch passes beneath US 158 through a 54" CMP culvert.

f. On the west side of US 158, the Goddard Street ditch forms the major backbone drainage system for the entire commercial area and municipal/school complex. Working upstream, its culverts slowly reduce in size from 42" CMP to 36" CMP to various smaller sizes of Corrugated Metal Pipe-Arch (CMPA).

3. Catchments/System Condition:

a. O031 is the westernmost portion of this watershed, generally including the schools complex and other publicly held land around Veterans Drive, but also the northern more portions of the Kill Devil Hills Realty Corp. subdivision. A relatively new culvert system in Veteran's Drive is the key facility for this Catchment.

b. O032 includes a small northeast portion of the Kill Devil Hills Realty Corp. subdivision, centered on West Baum Street, in which a culverted system flows generally eastward, then north in Blue Jay Street, toward the Goddard Avenue Ditch.

c. O033 is the commercial and public use area fronting Mustian Street between Colington Road and Goddard Avenue. Flow is southward in roadside systems to Goddard.

d. O034 is a strip fronting US 158 on its east side, flowing northward in a culvert system from Airstrip Road to Goddard Avenue.

e. O035 is between the highways, including Carlton and Oregon Avenues and Meadowlark and St. Clair Streets, all of which flow east to a ditch in Memorial Boulevard, which in turn flows south to join the Goddard Avenue Ditch.

f. O036, also between the highways, between Baum and Airstrip, including Clark and Corrigan Streets. These flows reach a ditch/culvert system on the east side of Memorial Boulevard, which flows north to join southward and eastward flows at the Memorial/Baum intersection.

g. Capacity concerns in O02 are more with the outfall, and to a lesser extent the main trunk just upstream of it, and the major and minor branch systems serving the catchments (O032, O033, O034, O035 and O036) to the north and south of the main trunk.

h. As was the case with the Martin Street outfall (O02), the 30" ocean outfall pipe itself is quite inadequate, having less than 5% of the capacity to handle 10-year runoff and rated 4 out of 40 points. Add to this the difficulties in keeping it open and the uncertain status of all the ocean outfalls and a real cause for concern results.

i. The 30" HDPE system just upstream of it, while in new condition physically, also presents a major limitation to flow.

j. The 54", 42" and smaller CMP and CMPA components within Goddard Street (the "main trunk" referred to above) are less of a concern, given the limits of the outfall pipe itself, and the new 30" HDPE in Baum. Mitigating this concern only slightly is the fact that some retention has been provided in the municipal and schools facilities which dominate this Watershed. A dynamic analysis should be performed on this watershed to quantify any such benefits, and the option of a major interconnect along Memorial Boulevard, all the way from Lake Drive to the Woodmere Street ditch, should be considered carefully.

4. **Topography**: Like the other areas between the highways, that portion of O03 has elevations in the 6 to 8 foot range. Slopes are flat, generally less than 0.2%. The part of O03 west of US 158 starts to rise slowly, working westward, at slopes of 0.1% to 0.3%, rising from 7 – 8 feet elevations to 10 feet or more. The slope increases a bit, up to 0.5%, and low dune remnants are interspersed, with elevations in the mid-teens to low 20s. At the western edge of the Watershed is a major dune structure with steep slopes (5% to 10%, with some exceeding 30%) is encountered. Highest elevations of this feature are in the 50s to nearly 60.

5. **Soils**: Between US 158 and NC 12, the soils of O03 are Corolla fine sands, Corolla/Duckston complex, and Duckston fine sands, all with rapid permeability but with moderate to shallow water table trending from Corolla to Duckston. Associated with the slightly higher elevations near NC 12 is a strip of Newhan fine sand. West of 158, the same soils are found, with water table depth increasing until the Dune Lands bounding the area to the west are reached.

D. NCDOT Owned and Maintained Streets, Roadways Conveyance Systems

The North Carolina Department of Transportation (NCDOT) manages the main roadways and associated stormwater management systems of US Hwy 158 Bypass (Croatan Highway) and NC Route 12 (Virginia Dare Trail). The stormwater conveyance systems convey stormwater from these roadways to either one of the three ocean outfall or to one of two drainage canals, the NCDOT drainage ditch or the Bickett Street drainage ditch. Both ditch systems are large wet canals that convey stormwater to sound outfalls. Maintenance and repair of these stormwater management systems and corresponding outfalls is under the jurisdiction of NCDOT. Maintenance includes culvert and outlet pipe maintenance, mowing of ditch banks, and sediment removal.

E. Topography, Soils & Groundwater

The Town of Kill Devil Hills does not currently regulate the type of soil or amount utilized for fill during new development projects which may be added to a property in order to comply with public health requirements or as desired by the property owner. Many sites have been filled with soils that have a variety of characteristics (Psamments) which creates difficulty in applying recommendations to those sites with a level of predictability. This also relates to fill to be imported for new development projects.

In many cases, the amount of fill currently is prescribed for on-site sewage disposal systems pursuant to State Health rules as administered by the Dare County Health Department. The review and approval pursuant to these rules address wastewater disposal but do not address stormwater effects.

Persons filling their property as directed by the Health Department may be unaware of the potential adverse stormwater effects on neighboring property. In some cases, these effects may be mitigated or eliminated by measures such as minimizing the height and extent of the fill and directing surface water away from lower neighboring property. Policy and regulatory changes should be considered to assure that such fill, when required, is done in a manner to cause the least practical adverse effect on adjacent properties.

III. Policies, Programs & Regulations

A. Federal

1. US Army Corps of Engineers

A permit from the US Army Corps of Engineers (USACE) is required by a property owner if the proposed development includes activities within navigable waters and/or has the potential to impact wetlands as defined in the Section 404 of the Clean Water Act of 1972. USACE permits are either Nationwide Permits or Individual Permits depending on the type of activity proposed as part of the development.

Typical activities that may impact Section 404 jurisdictional wetlands include:

- depositing of fill or dredged material in waters of the US or adjacent wetlands;
- site development fill for residential, commercial, or recreational developments;
- construction of revetments, groins, breakwaters, levees, dams, dikes, and weirs; and
- placement of rip-rap and road fills.

Though these regulations address fill into waters of the U.S., they do not directly address stormwater measures.

Information on USACE permits and their requirements can be found at www.saw.usace.army.mil./wetlands/faq.html.

2. Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) provides information on coastal construction as part of the National Flood Insurance Program (NFIP). There are thirty-one fact sheets (Publication Number FEMA 499) available online which provide recommendations and technical assistance on construction in coastal environments and include proper siting of buildings, design and construction components including structural connections, building envelope, and utilities. The following link provides access to the online database at http://www.fema.gov/rebuild/mat/mat_fema499.shtm.

FEMA has also developed Flood Insurance Rate Maps (FIRMs) which are a product of the Flood Insurance Study (FIS) that are conducted on communities and are downloadable maps that illustrate flood hazard areas within a particular location. FIRMs delineate Special Flood Hazard Areas

(SFHAs) which are "land areas subject to inundation by a flood that has a 1-percent probability of being equaled or exceeded in any given year. SFHAs are shaded on the FIRM map and are divided into different flood hazard zones, depending on the nature and severity of the flood hazard". FIRM maps are used by communities to show the extent of mapped flood hazard areas, determine flood insurance rates and premiums, provide regulatory elevations for community floodplain management ordinances, and potential requirements for the design and construction of both new and existing and repair of buildings. Online information on FIRMs can be found at http://www.fema.gov/hazard/map/firm.shtm**.**

B. State

1. CAMA

The Coastal Area Management Act (CAMA) was established in 1974 as a cooperative program between local governments and the State to guide development of coastal environments. A CAMA permit is required for development of properties within an Area of Environmental Concern (AEC). CAMA further instructed the CRC to call on local governments to give special attention to these areas in developing their Land Use Plans. The most germane sections in CAMA with regards to stormwater management are limitations of development within the Public Trust and Estuarine Shoreline AECs, including limitations on the percent of impervious coverage.

2. Division of Water Quality Coastal Stormwater Rules

The North Carolina Department of Environment and Natural Resources (NCDENR), Division of Water Quality (DWQ) has stormwater permit requirements for proposed projects as specified in North Carolina Administrative Code 15A NCAC 02H.1000. The criteria are outlined in 15A NCAC 02H .1003 and includes:

- development activities located within the 20 coastal counties,
- development activities draining to Outstanding Resource Waters (ORW) as defined in 15A NCAC 2B .0225, or
- development activities within one mile of and draining to High Quality Waters (HQW) as defined in 15A NCAC 2B .0101(e)(5).

The NCDENR-DWQ stormwater rules places development activities into two categories; low density projects and high density projects which describes the amount of impervious surface density that the proposed project will utilize. Currently low density projects are not required to design and implement engineered or structural stormwater controls. High density proposed projects which exceed the low density threshold are required to

design and implement engineered or structural stormwater controls. Engineered or structural stormwater control systems are designed into the proposed development plan to collect and treat the stormwater runoff generated from the impervious surfaces that are part of the new project. The NCDENR-DWQ has provided an extensive manual on approved stormwater management devices, also known as stormwater BMPs for various types of developments. This manual can be accessed and downloaded at http://h2o.enr.state.nc.us/su/bmp_forms.htm.

Detailed information on the current NCDENR-DWQ Coastal Stormwater Rules can be found at http://h2o.enr.state.nc.us/su/coastal.htm.

The Phase I and II stormwater permitting programs were established under the Federal Clean Water Act and then delegated to the NC Division of Water Quality (DWQ) for implementation.

The Phase I stormwater program began in 1990 and applies to NC local governments that had populations of 100,000 or more at that time (Raleigh, Durham, Fayetteville/Cumberland County, Charlotte, Winston-Salem, Greensboro). Each subject local government now implements a stormwater management program that includes public education, illicit discharge detection and elimination, and water quality monitoring.

The Phase II stormwater program applies to local governments that have been selected by automatic designation, State designation, or petitioning.

Phase II local governments are required to develop and implement a stormwater management program that includes six minimum measures:

a. public education and outreach on stormwater impacts,
b. public involvement/participation,
c. illicit discharge detection and elimination,
d. construction site stormwater runoff control,
e. post-construction stormwater management for new development and redevelopment, and
f. pollution prevention/good housekeeping for municipal operations.

DWQ has developed a Phase II Stormwater Program web site to assist local governments in understanding their requirements. Part of this web site includes a Phase II quick links web page that allows local governments to efficiently find rules, forms, fact sheets, and maps to assist them in implementing Phase II. The Town is not currently a Phase II community.

Best Management Practices (BMPs) have been recognized by the North Carolina Division of Water Quality (NCDWQ) as an effective tool to use in conjunction with engineered stormwater management practices to manage the quantity and quality of stormwater runoff. The Stormwater Regulations

recently adopted by the NCDWQ includes a BMP manual that addresses the benefits to water quality and quantity runoff. The primary focus is to reduce the rate and volume of stormwater runoff by promoting infiltration into the soil and nutrient uptake by vegetation.

The concept of BMPs is to join runoff in the hydrologic cycle with groundwater as close as practical to the point upon which it arrives as rainfall. This strategy not only reduces the need for large conveyance systems which reduces flooding and high capital costs but also promotes improved water quality of receiving waters.

Central to the effectiveness of BMPs is the combination of the type of development it is associated with, correct siting, proper design, and construction and maintenance. Tables in Appendix J depict information regarding the BMPs, their design criteria, limitations, and operational/maintenance requirements. Some BMPs are most appropriately used in commercial construction although all will work in residential applications.

Since most BMPs rely on infiltration, soil suitability becomes a siting concern. Very low elevations (7 feet or less) are not effective infiltration candidates. Wet detention basins or stormwater wetlands are more effective at sites with low elevations. In very low areas, cisterns may be the preferable design. Higher elevations and sandy soils are suitable for most BMPs but probably would not be appropriate sitings for stormwater wetlands nor wet detention basins.

Table 2 makes these discernments based on zoning, soils and elevation within each watershed. BMPs not listed in a watershed could be explored by the design professional to determine if specific site characteristics allow for effectiveness of a BMP. Application of all BMPs could be promoted in either the residential or commercial siting but would require special considerations of costs, space limitations, effectiveness, and maintenance.

TABLE 2: WATERSHED AND SUBCATCHMENT RECOMMENDED BMPS

Watershed & Subcatchment	Residential	Commercial	Government & Institutional
Watershed S01			
S011	Filter Strips Grassed Swales* Cistern/rain barrels	N/A	N/A
S012	Filter Strips Grassed Swales* Cistern/rain barrels	Stormwater Wetlands, Wet Detention Basins, Sand Filters, Permeable Pavement	
S013	Filter Strips Grassed Swales Cistern/rain barrels	Stormwater Wetlands, Wet Detention Basins, Sand Filters, Infiltration Devices, Cisterns, and Permeable Pavement	
S014	N/A	N/A	N/A
S015	Elevations >7': Filter Strips, Grassed Swales, Cistern/rain barrels	Elevations >7': Bio-retention Cells, Sand Filter, Infiltration Devices, Dry Extended Detention, Permeable Pavement, and Cisterns	
	Elevations<7':Filter Strips, Grassed Swales, and Cistern/rain barrels	Elevations<7': Stormwater Wetlands, Wet Detention Basins, Permeable Pavement, and Cisterns	
Watershed S02 – N/A			

Watershed & Subcatchment	Residential	Commercial	Government & Institutional
Watershed S03			
	Filter Strips, Grassed Swales*, Cistern/rain barrels	N/A	N/A
Watershed S04			
	Filter Strips, Grassed Swales*, Cistern/rain barrels	N/A	N/A
Watershed S05			
	Filter Strips, Grassed Swales*, Cistern/rain barrels	N/A	N/A
Watershed S06			
	Elevations >7': Filter Strips, Grassed Swales, Cistern/rain barrels Elevations<7':Filter Strips, Grassed Swales*, and Cistern/rain barrels	N/A	N/A
Watershed S07			
	Elevations >7': Filter Strips, Grassed Swales, Cistern/rain barrels Elevations<7':Filter Strips and Cistern/rain barrels	N/A	N/A
Watershed S08			
	Filter Strips, Grassed Swales**, Cisterns/rain barrels	N/A	N/A
Watershed S09			
	Filter Strips, Grassed Swales*, and Cistern/rain barrels	N/A	N/A
Watershed S10			
	>7': Filter Strips, Grassed Swales, and Cistern/rain barrels <5': Cisterns/rain barrels	Stormwater Wetlands, Wet Detention Basin, Permeable Pavement, and Cisterns	N/A

Watershed & Subcatchment	Residential	Commercial	Government & Institutional
Watershed S11			
	>7': Filter Strips, Grassed Swales, and Cistern/rain barrels	N/A	N/A
	<5': Cisterns/rain barrels		
Watershed S12			
	Filter Strips, Grassed Swales, and Cistern/rain barrels	Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns	Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns
Watershed O01			
	Filter Strips, Grassed Swales, and Cistern/rain barrels***	>7': Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns	
		<7': Stormwater Wetlands and Wet Detention Basins	
Watershed O02			
	Filter Strips, Grassed Swales, and Cistern/rain barrels	>7': Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns	**LI-2 and LI-1:** >7': Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns
		<7': Stormwater Wetlands and Wet Detention Basins	<7': Stormwater Wetlands and Detention Basins (Wet and Dry)

Watershed & Subcatchment	Residential	Commercial	Government & Institutional
Watershed O03			
	Filter Strips, Grassed Swales, and Cistern/rain barrels	>7': Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns	>7': Bioretention Cells, Sand Filters, Filter Strips, Grassed Swales, Infiltration Devices, Dry Extended Basins, Permeable Pavement, and Cisterns
		<7': Stormwater Wetlands and Wet Detention Basins	<7': Stormwater Wetlands and Wet Detention Basins

*Grassed Swales may have standing water for extended periods of time due to low elevations.

**Grassed Swales located in areas supporting soils in the Corolla/Duckston complex are not recommended due to the potential of ineffectiveness.

***This watershed is currently zoned Commercial, although it is currently developed with commercial, multi-family residential, and residential.

3. North Carolina Recreational Water Quality Program

The North Carolina Recreational Water Quality Program (NC Recreational WQ Program) has been testing the State's coastal recreational waters since 1997 and has several monitoring sites within the Town. This program tests the water quality to assess if the water is safe for recreation. The levels of testing are assigned different tiers depending on the frequency of use. The monitoring locations are named based upon the site location identifiers listed by the NC Recreational Water Quality Program. The following illustrates the three types of recreational waters tested by the NC Recreational Water Quality Program:

a. Tier 1 - These beaches are used on a daily basis. All ocean beaches are considered Tier 1. There are seven (7) sites in Kill Devil Hills:

- N85A – Drain at Martin Street (Ocean Outfall)
- N85 – Drain at MP 8 ¾ (Baum Street Ocean Outfall)
- N12A – Beach Access at Sportsman Drive (Ocean grab sample)
- N12B – Beach access at 3rd Street (Ocean grab sample)
- N14A – Drain at Oregon Street (Ocean grab sample)
- N14 – Bath House at Ocean Bay Drive (Ocean grab sample)
- N15 – Drain at Lake Drive beach access (Lake Drive Ocean Outfall)

b. Tier 2 - These beaches are used an average of three times per week. There is one site in Kill Devil Hills known as the N13A Kill Devil Hills/Kitty Hawk Bay Wildlife Ramp located at Dock Street.

c. Tier 3 - These beaches are used an average of four times per month, or used less frequently but intensively for special events such as triathlons. There are no Tier 3 sites located in Kill Devil Hills. The Pea Island sound access is considered a Tier 3 site.

A site map depicting the sampling locations within the Town can be found in Appendix E. Water quality monitoring data provided by the NC Recreational Water Quality Program may also be found at http://www.deh.enr.state.nc.us/shellfish/Water_Monitoring/RWQweb/aboutus.html.

The Natural Resources Defense Council (NRDC) published a report, "Testing the Waters; A Guide to Water Quality at Vacation Beaches", dated August 2007 based upon the analytical results from various State and Federal water quality monitoring programs including the NC Recreational Water Quality Program. The report reviewed analytical data from all the test

sites currently being analyzed throughout North Carolina including Dare County and provided a ranking of beaches based upon the number of sampling events which exceeded the Tier 1, Tier 2, and Tier 3 thresholds. One Tier 1 sampling site; Drain at Martin Street, had a 6% exceedance rate for 2006 while four Tier 1 sampling sites; Bath House at Ocean Bay Drive, Beach Access at Sportsman Drive, Drain at Lake Drive Beach Access, and Drain at MP 8 ¾ had a 3% exceedance rate. A copy of this report can be found at http://www.nrdc.org/water/oceans/ttw/titinx.asp.

Although there are instances when the sampling requires that these areas are posted with warnings, these are generally infrequent events that occur during the summer after large rainfall events. The NC Recreational Water Quality Program published a Draft report on the 2007 sampling results for 2007. The Bath House at Ocean Bay Drive (N14) had one swimming advisory posted for the year on April 24th, which lasted one day. Precipitation was not recorded during the sampling event. No other Kill Devil Hills sites had analytical results which warranted an advisory posting.

4. Coastal Studies Institute Ocean Outfall Study

The North Carolina Coastal Studies Institute (CSI) is conducting a joint study with the University of North Carolina Chapel Hill Institute of Marine Science (IMS) and the engineering firm of Moffat & Nichol to analyze the ocean outfalls within Dare County including three ocean outfalls located in Kill Devil Hills; Baum Street, Martin Street, and East Lake Drive. A site map depicting the CSI sampling locations can be found in Appendix E. The study hopes to "identify the key microbial constituents of stormwater in these ocean outfalls, determine concentrations and likely sources of indicator and tracer microorganisms in the storm water, and provide measures of patterns of loading in storm and ambient conditions."

Currently, the outfall study has been collecting ambient and storm water quality samples from monitoring locations at the ocean outfalls and westward within the Watersheds. In addition, hydrological modeling has been performed by Moffat & Nichol to study the surficial aquifer during ambient and storm conditions and how these conditions affect the stormwater conveyance systems. Based upon the results of this study, recommendations will be made on potential BMPs that could be implemented to aid in reducing the water quality impacts at the ocean outfalls. Studies are currently being conducted to determine if the source of the bacterial. These studies can discern bacteria from human sources such as septic systems or whether the sources are non-human such as wildlife or pet waste.

An interim pilot BMP is currently being designed for an ocean outfall at the Conch Street ocean access, located in the Town of Nags Head, and includes the utilization of SmartSponge™ technology. SmartSponge™ is a

stormwater BMP product that filters stormwater runoff, removing bacteria and other contaminants. This pilot BMP has been installed and monitoring will be conducted to determine the effectiveness of the BMP.

Additional information on the CSI Outfall Study can be found at http://csi.northcarolina.edu/content/research/outfall.htm.

C. Local

1. Water Quality Program

The Town of Kill Devil Hills initiated a Water Quality Program in 2000 to provide a monitoring program that accurately gauges the conditions of the surface waters and the groundwater within various existing conveyance systems. The Town conveyance systems consist of open and closed systems including; open ditches, grassed swales, and culvert systems. The culvert systems are either straight piped or are constructed using perforated sock drains that allow for some infiltration. Stormwater is conveyed either to eleven sound outfalls or three ocean outfalls. A site map in Appendix E depicts the monitoring locations.

From Year I through Year III of the Water Quality Program, seven monitoring sites were installed including open ditch systems that convey stormwater to the ocean outfalls, open ditch systems which convey to Kitty Hawk Bay, and a control site in Nags Head Woods. Monitoring wells were installed adjacent to conveyance systems in order to collect water quality data from the groundwater and surface water. The following list the locations analyzed during the first three years of the Water Quality Program including the watershed in which they are located.

- Monitoring Well MW-1/Surface Water SW-1 – located at Clamshell Drive/Bay Drive (Located in Watershed S07)
- Monitoring Well MW-2/Surface Water SW-2 – located at 4th Street/Bay Drive (Located in Watershed S07)
- Surface Water SW-2A – located at the sound outfall along Bay Drive between Clamshell Drive and 4th Street (Located in Watershed S07)
- Monitoring Well MW-3/Surface Water SW-3 – located at Cedar Drive West (Located in Watershed S05)
- Monitoring Well MW-4/Surface Water SW-4 – located at Cedar Drive East (Located in Watershed S01)
- Monitoring Well MW-5/Surface Water SW-5 – located at the corner of Martin Street/ Memorial Drive (Located in Watershed O02)

- Monitoring Well MW-6 – Control site located in Nags Head Woods (Not within a designated watershed)

Initial sampling parameters included fecal coliform (groundwater only) and nutrients; ammonium-nitrogen, nitrates, and total phosphates. In addition, field data was collected including; temperature, pH, conductivity, turbidity, dissolved oxygen, salinity, depth to groundwater, tidal information and weather. Analytical results provided a baseline of water quality within the selected conveyance systems and indicated that impacts to the surficial groundwater from the stormwater conveyance systems were minimal with periodic spikes in both fecal coliform and nutrients from isolated events followed by consistent low levels.

Following Year III, recommendations were made to modify the Water Quality Program including the discontinuation of several monitoring locations, addition of new monitoring locations within different conveyance systems, and analyzing both the groundwater and surface water for Enterococcus instead of fecal coliform to better correlate with the North Carolina Recreational Water Quality Program.

During Year IV, the Water Quality Monitoring Program discontinued sampling at monitoring locations, MW/SW-1, MW/SW-2, SW-2A, MW/SW-3, and MW/SW-4. Replacement monitoring locations were recommended to study different stormwater conveyance systems and included:

- Bickett Street East (Located in Watershed S10)
- Bickett Street West (Located in Watershed S10)
- Woodmere Street/Memorial Drive (Located in Watershed O03)
- Baum Street/Memorial Drive (Located in Watershed O03)

In addition to the new monitoring locations, informational signs were installed at each monitoring location. The signs described the water quality monitoring program and reminded citizens to be responsible pet owners and pick up their pet waste. To help promote the pet initiative, Dog-I-Pot stations were installed with the signs and several stations are located throughout the Town.

During Year VI, the Water Quality Monitoring Program was modified in order to study different conveyance systems within the Town. Two sampling locations - Bickett Street East and Woodmere Street - were discontinued and two new sampling locations were added:

- East Avalon Street (Located in Watershed S10)
- Atlantic Street/Memorial Drive (Located in Watershed O02)

Along with high groundwater table concerns, recommendations to help improve the water quality within the conveyance systems include a review of potential BMPs that may help reduce bacterial concentrations within the surface waters. The Division of Water Quality (DWQ) Stormwater Best Management Practices Manual lists several types of BMPs that either provides a High, Medium, or Low "Fecal Coliform Removal Ability". Three BMPs listed in the manual have a High removal ability including; bioretention cells, sand filters, and infiltration devices. BMPs which provide Medium removal ability include; stormwater wetlands, wet detention basins, dry extended detention basins, filter strips, and restored riparian buffer. BMPs which provide Low removal ability for Fecal Coliform include grassed swales, permeable pavement, and cisterns/rain barrels.

Currently, the Water Quality Program is in its eighth year. The goal of this year's water quality program is to focus on two areas; Bickett Street West and Martin Street/Memorial Drive. The Bickett Street West monitoring location displays the highest levels of Enterococcus within the surface water and the groundwater and further investigations are now underway to determine the potential source of the contamination. The Martin Street/Memorial Drive monitoring location has seen an increase in Ammonium-Nitrates within the groundwater over the last two years and further investigations were authorized to determine if a potential source could be identified. Results from these studies will aid in recommendations for mitigation and implementation of potential solutions.

Copies of the most recent Water Quality Monitoring Report for Year VII can be found at http://www.kdhnc.com/index.asp?nid=178.

2. Town Code – Zoning Chapter 153

The Town is delineated into several zoning districts, which outlines the types of development allowed in each zone and building requirements. The zoning is structured in a "tiered" format beginning with the most restrictive to the least restrictive. The most restrictive zone is the Maritime Forest Environmental District (MFED) and the least restrictive is Governmental and Institutional (G&I). A copy of the zoning map can be found in Appendix F. The following zoning districts are utilized by the Town and can be found in the Town Code, Chapter 153:

- Maritime Forest Environmental District (MFED)
- Low Density Residential (RL) Zone
- High Density Residential (RH) Zone

- Ocean Impact Residential (OIR) Zone
- Commercial (C) Zone
- Light Industrial Two (LI-2) Zone
- Light Industrial One (LI-1) Zone
- Government and Institutional (G&I) Zone

Limits on impervious groundcover vary for different zoning districts. Ocean Impact Residential allows 55% coverage of land west of the vegetation line. Low Density Residential allows 40% coverage and High Density Residential allows 55% coverage. Commercial allows for 65% coverage. Residential development has occurred in areas that are zoned Commercial and currently adhere to allowable lot coverage outlined in the Commercial zoning district.

There are several differences between regulations for residential and commercial development. Commercial building projects must develop engineered Stormwater Management Plans that are reviewed and approved by the North Carolina State Department of Environment and Natural Resources (NCDENR), Division of Water Quality (DWQ) if the development requires an Erosion Sediment Control Approval from the NC Division of Land Resources or a CAMA Permit. The developer is ultimately responsible for installing and funding of stormwater control measure in newly developed subdivisions and large commercial developments.

A Stormwater Ordinance is included within the zoning code and is listed as Chapter 153.070. The Stormwater Ordinance provides guidance for new and redevelopment to reduce the impacts of stormwater to adjoining properties and to include stormwater design as part of the engineered plan prior to approval by the Town. All properties are required to provide a comprehensive, engineered plan of stormwater management for their site with the exception of single or two-family dwellings. The Town's Public Services Department has the option to request an engineered plan if the single or two-family dwelling will be greater than 3,000 square feet. The engineered plan provides drainage information on and off the property to ensure that any stormwater generated on-site drains properly. The designed system is required to manage, at a minimum, runoff generated by a 10-year, 2-hour storm event (4.3 inches). Current stormwater designs acceptable by the Town include retention, detention, and infiltration devices.

A Soil, Erosion and Sedimentation Control Ordinance is also included in the zoning code and is listed as Chapter 153.071. The purpose of this ordinance is to regulate earth-disturbing activities to ensure that they do not adversely impact water bodies including stormwater conveyance systems or cause damage to other public or private properties. In addition, these regulations adhere to State and Federal policies. A plan to address soil, erosion and

sedimentation is required for new or redevelopment with the exception of single family or two-family dwellings unless it disturbs more than ½ acre. The Plan depicts how the site will address the land disturbing activity including design criteria, length of time for the disturbance, Plan approval by Town and State agencies, and penalties if these items are not addressed.

For more information regarding zoning and related ordinances in Chapter 153 in the Town Code you can visit the Town's website at: http://www.kdhnc.com.

3. Town Code – Flood Damage Prevention Ordinance Chapter 151

Chapter 151 in the Town Code provides guidance and regulations to help minimize public and private losses due to flooding within areas that have been identified as flood-prone locations within the Town. The provisions include:

- Restrict or prohibit uses that are dangerous to health, safety, and property due to water or erosion hazards or that result in damaging increases in erosion, flood heights or velocities;

- Require that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction;

- Control the alteration of natural floodplains, stream channels, and natural protective barriers, which are involved in the accommodation of flood waters;

- Control filling, grading, dredging, and all other development that may increase erosion or flood damage in the VE Zone; and

- Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or which may increase flood hazards to other lands. Additional information on the Chapter 151 in the Town Code can be accessed at www.kdhnc.com.

4. Street Improvement Master Plan Update

The Street Improvement Master Plan was updated in 2003. Its purpose is to provide guidance with classifications, assessments and improvements to Town-owned streets and identifies existing roadway conditions and areas which have drainage and stormwater deficiencies. The Plan is utilized by the Planning Board Street Improvement/Special Projects Subcommittee to organize and implement street and right-of-way improvements.

Improvements often include drainage improvements and address areas with stormwater runoff concerns. In September 2006 the Unimproved Right-of-Way Assessment Map was updated to depict roadways that were designated as; existing improved streets, drainage/utilities/recreation/greenways, future improved streets, and abandoned roadways. A copy of the map can be found in Appendix G.

5. CAMA Land Use Plan

The 1997 Coastal Area Management Act (CAMA) Land Use Plan (1997 LUP) was approved by the Board of Commissioners on December 20, 1999 and certified by the Coastal Resource Commission (CRC) on March 24, 2000. The 1997 LUP provides a background on the Town's history, population and future development trends along with guidance and policy for land development. Stormwater management is addressed in the 1997 LUP as an important aspect in local planning and indicates that the Town citizens support expenditures of public funds for stormwater projects. A public opinion survey conducted for the 1997 LUP documented that 59.5% of respondents either agreed or strongly agreed on allocating public funds for stormwater projects while only 9% of respondents either disagreed or strongly disagreed. Copies of the current 1997 CAMA Land Use Plan can be found at http://www.kdhnc.com.

The Town of Kill Devil Hills is currently in the process of updating the 1997 CAMA Land Use Plan. The Town Planning Board has been established as the Lead Planning Group which has been responsible for guiding the 2008 CAMA Land Use Plan effort. In addition, the Town worked with the Regional Development Institute of East Carolina University to conduct a citizen survey in 2007 to aid in determining the needs and desires of the community for current and future development goals and objectives. Recreational water quality concerns were noted as one of the most important issues expressed by respondents of the survey with 95% answering "very important" in the survey. In addition, the majority of respondents agreed that the quality of stormwater runoff which drains to the ocean should be improved. Although stormwater runoff that drains to the ocean was documented as a concern which should be improved, 48% of the respondents did not agree that residential lots should be required to maintain

stormwater onsite. The new survey reveals that support for stormwater management projects has also decreased with only 28% of the respondents willing to pay higher costs for stormwater projects compared to 48% in the 1997 citizen survey.

Additional information on the 2008 CAMA Land Use Plan can be found at www.kdhnc.com.

6. Hazard Mitigation Plan

The Town developed the Hazard Mitigation Plan in August 2004 which was revised in May 2005 and incorporated into the County of Dare plan in 2009. The Plan takes into consideration the effects of flooding and stormwater impacts from these storms and how to best develop a site to withstand these impacts. The Plan was prepared to qualify for the Disaster Assistance of the National Flood Insurance Program (NFIP) and a copy of the Storm Hazard Mitigation & Post-Disaster Reconstruction Plan can be found at the Town Hall.

The Hazard Mitigation Plan attempts to address stormwater concerns which would result from large storm events and recognizes that flooding will occur in most large storms.

IV. Computer Simulations

A. Hydrological Modeling

Watersheds S06 and S08 were selected for hydrologic/hydraulic modeling, using the Stormwater Management Model software developed and published by the U. S. Environmental Protection Agency, the consulting firm of Metcalf & Eddy and others (EPASWMM 5.0).

S06 and S08 were selected for the following reasons:

- They contain representative examples of two of the Town's prevalent types of stormwater systems, "roadside ditches and culverts" and "culverted drainage systems" as described in Section III.B above.

- Their relatively modest size made them appropriate for a first phase of a hydraulic modeling effort, as a considerable effort is often needed to "tune" the modeling techniques to an area's unique hydraulic characteristics and calibrate the model to observed conditions. Due to the relatively poor ratio of capacity to 10-year runoff in these watersheds, the tuning and calibration effort did require considerable effort.

- Selecting one of the ocean outfall watersheds was deemed inadvisable until the results of the CSI modeling effort are available.

Other watersheds may be modeled in subsequent years. Results of the modeling effort are presented as Appendix H.

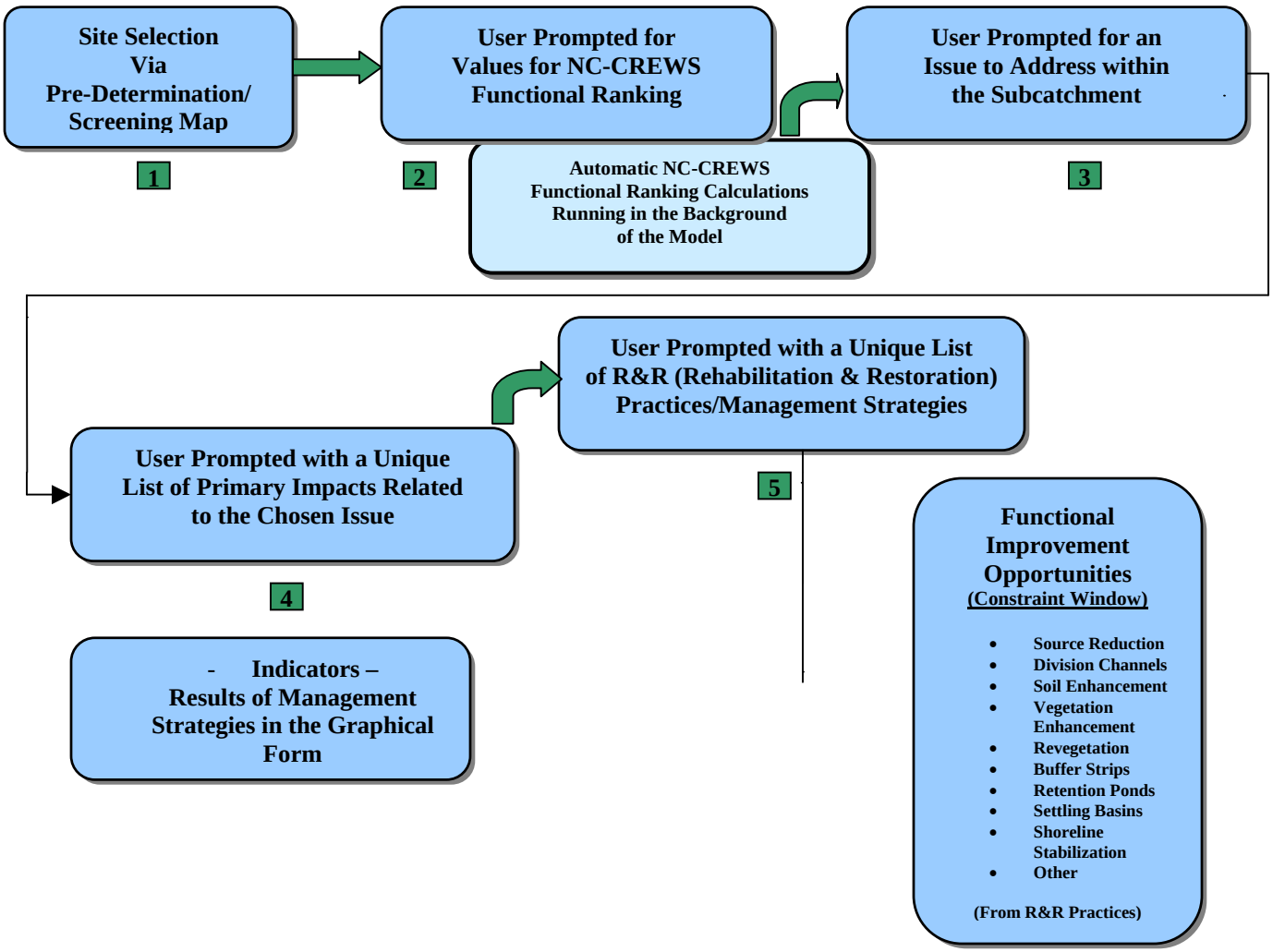
B. GIS Decision Support Model

The role of the Kill Devil Hills Decision Support System Model (DSS Model) in stormwater management focuses on four main objectives. The first objective is to create the capability to review proposed new development/redevelopment to determine whether the project adheres to existing regulations. The second objective is to evaluate potentially adverse stormwater effects from land-use activities based upon the type of development and its location within a watershed. The third is to incorporate potential BMPs that may be considered for the reduction or mitigation of impacts. The final objective is to develop a GIS-based model that provides a visualization and analysis of different BMP strategies to reduce and/or eliminate stormwater runoff entering into the Town's conveyance systems.

Existing data sets were assimilated including; infrastructure, ordinances/regulations, water quality data, and zoning types into the DSS Model. A copy of the data inventory, tables, and user guide can be found in Appendix I. As new data becomes available, the information can be easily incorporated into the DSS Model and the Model will re-analyze the information and update potential results.

The following figures illustrate the conceptual model of the DSS Model:

Figure 2: Model Process

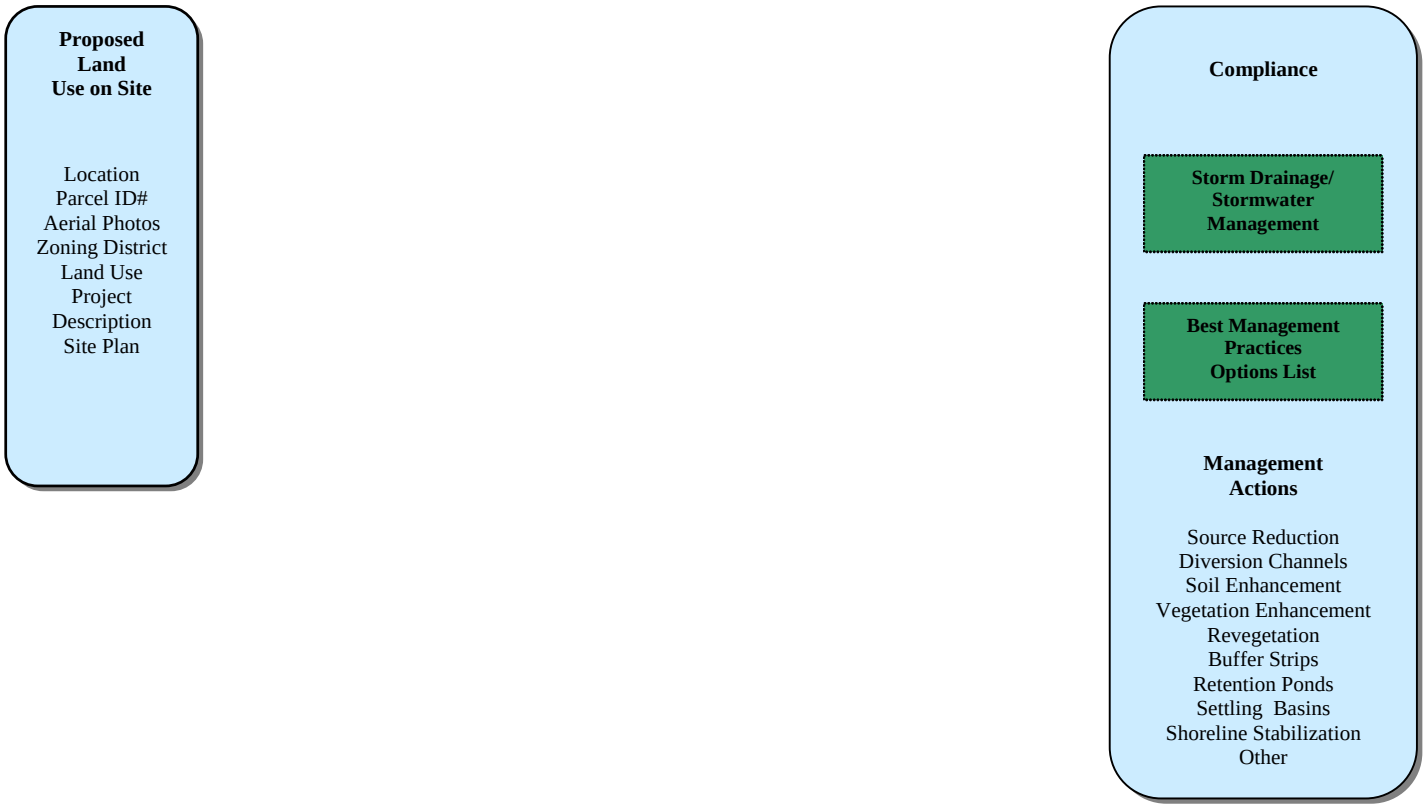


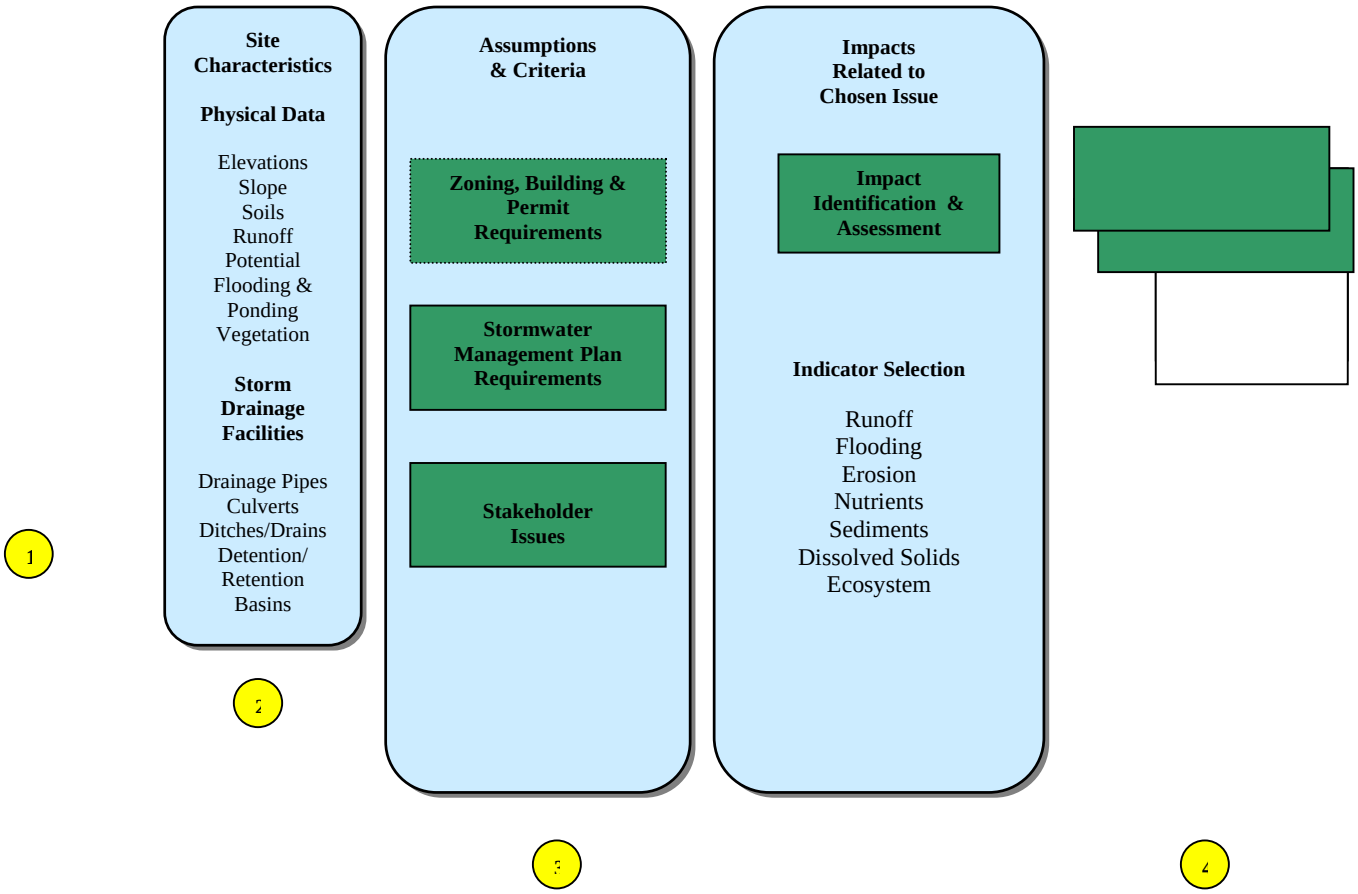
2

6

Figure 3: Model Functions

Stormwater Management Plan
Decision Support System Functions





1. User selects "Site" **Active Theme** in CVIZ using Town's GIS database and project descriptions provided by landowner.
2. CVIZ reviews GIS thematic layer **Database** and provides descriptions of physical and stormwater management characteristics on site and vicinity.
3. User selects "Identify" Tool to show which pre-determined **Indicators** (e.g. permit criteria, environmental impacts, and stakeholder issues) may be affected by site development. CVIZ provides **Alerts** for possible **Management Actions**.
4. CVIZ evaluates the site and identifies a suite of possible **Best Management Practices** and constraints to address stormwater management requirements.

V. Plan of Action

A. Regulatory Practices

1. The Town should create an "ad-hoc" committee to establish the design criteria and develop requirements for placement of significant amounts of fill soil in support of single family, duplex, commercial, multi-family, and industrial development. Consideration of this committee should include:

    a. limits to the height of fill to that which is necessary based upon on-site sewage disposal requirements;
    b. limiting flow from impervious surfaces requiring it be infiltrated or directed away from adjacent property and Town ROWs;
    c. lot grading should minimize flow of surface water toward adjacent properties and right-of-ways;
    d. fill setback requirements and maximum slope of fill; and
    e. design standards for driveways and the use of fill within the Town right-of-ways.

2. Increase the use of BMPs, such as permeable pavement systems, bioretention, stormwater wetlands, wet detention basins, sand filters, filter strips, grassed swales, restored riparian buffer, infiltration devices, dry extended detention basins, and cistern/rain collection systems. Support these BMPs through regulations and/or incentives to reduce runoff from entering the Town's conveyance systems. If BMPs are used as part of an approved Stormwater Management Plan, the Town should require that the BMPs be constructed and maintained as prescribed in the North Carolina Division of Water Quality Best Management Practices Handbook.

3. Create a design manual for stormwater management and conveyances. The design manual should include Town specific standards which promote the approach of reducing runoff and returning runoff to groundwater as close as possible to where it falls. This approach will accomplish both peak flow rate attenuation and surface water quality improvement. Examples of such standards include, but are not limited to:

    a. the use of shallow roadside swales, with profiles 2 to 4 inches lower than the adjacent driveways instead of trapezoidal roadside ditches with driveway culverts;
    b. where enclosed culvert systems are provided, use perforated pipe wrapped with filter fabric ("sock drain") where feasible;

c. incorporate small, localized infiltration areas where terrain allows; and
d. consider driveway design of both commercial and residential development to minimize and break-up flow into the public conveyance system.

4. New and modified regulations should be considered for single-family residences.

    a. Modify regulations to limit all single family and duplex development to the maximum lot coverage of the most restrictive zone (40% RL zone) with an exception for increased lot coverage with an engineered Stormwater Management Plan in those areas that allow greater than 40% coverage.
    b. Modify regulations to lower lot coverage with incentives to increase lot coverage through the use of pervious pavement products using State methods of calculations.

5. New regulations for commercial, industrial, and multi-family are recommended.

    a. §153.070(J) of the *Zoning Ordinance* includes the requirements to "retain" the runoff from a ten year; six hour storm (4.3 inches of rainfall). §153.070 (E) provides that "For management and control of stormwater runoff, techniques such as but not limited to retention, detention, and infiltration systems will be used." These paragraphs need to be integrated and enhanced. At a minimum, a limit needs to be established that not less than 50% of the volume required to be retained shall be in surface storage (vs. infiltration or storage in soil pore spaces).
    b. §153.070(J) of the *Zoning Ordinance* be changed to reference specifically the rainfall data contained at "Point precipitation frequency estimates from NOAA Atlas 14 Kill Devil Hills NM, North Carolina" which is presented in the table below and may be accessed at the following web link: http://dipper.nws.noaa.gov/hdsc/pfds/orb/nc_pfds.html

Table 3: Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.45	0.72	0.90	1.24	1.54	1.75	1.92	2.36	2.81	3.31	3.88	4.35	4.98	5.61	7.46	9.13	11.21	13.40
2	0.53	0.85	1.07	1.48	1.86	2.12	2.33	2.85	3.40	4.03	4.70	5.26	6.00	6.72	8.88	10.86	13.28	15.80
5	0.62	1.00	1.26	1.79	2.29	2.67	2.96	3.63	4.34	5.21	6.03	6.71	7.53	8.33	10.80	13.06	15.88	18.68
10	0.70	1.11	1.41	2.04	2.66	3.16	3.53	4.33	5.20	6.21	7.17	7.89	8.80	9.66	12.39	14.83	18.02	20.98
25	0.79	1.26	1.59	2.36	3.14	3.81	4.31	5.31	6.43	7.67	8.90	9.61	10.62	11.55	14.62	17.26	21.03	24.13
50	0.86	1.37	1.74	2.61	3.54	4.38	4.99	6.18	7.53	8.93	10.39	11.07	12.14	13.14	16.46	19.20	23.48	26.61
100	0.93	1.48	1.87	2.86	3.94	4.96	5.72	7.10	8.71	10.31	12.05	12.64	13.76	14.81	18.38	21.18	26.02	29.13
200	1.00	1.58	2.00	3.11	4.36	5.58	6.52	8.12	10.03	11.83	13.91	14.34	15.51	16.60	20.40	23.22	28.67	31.70
500	1.09	1.72	2.17	3.45	4.95	6.47	7.67	9.61	11.97	14.10	16.71	17.11	18.02	19.17	23.25	26.00	32.38	35.16
1000	1.16	1.83	2.30	3.72	5.44	7.20	8.67	10.90	13.69	16.03	19.12	19.49	20.12	21.28	25.54	28.18	35.32	37.84

*Average Return Interval

c. Based on the tabular information, the retention provision of §153.070(J) should be changed to require retaining the runoff from a ten-year, six-hour storm (4.3 inches of rainfall) to minimize flooding based on the Town's current stormwater capacity.
d. In areas where current capacity of the backbone receiving system is severely inadequate based upon results of the conveyance system ratings, (S012, S015, S061, S071, S072, S073, S082, S100, S103, 0010, 0020, 0030) the retention requirement be expanded to the 10-year, 24-hour storm (6.2 inches). Permeable pavement options, disconnection of impervious surfaces to promote infiltration, and other infiltration techniques should be encouraged in areas where capacity has been identified as inadequate.
e. When banks of a retention basin are higher than adjacent grades, the retention basin may do a poor job of containing the stored runoff. Standards should be established for such banks, including a minimum top width of at least 2', and/or the inclusion of a core of low permeability soil or other

flow barrier. The intent is to avoid stored stormwater leaking through the bank onto adjacent property or public right-of-ways.

f. §153.070(L) of the Zoning Ordinance includes a requirement that stormwater systems be constructed per the NCDOT Standards. This should be changed to allow for the Town's modified standards and special designs including; low-head drainage structures, bicycle and pedestrian safe drainage grates, etc. The NCDWQ BMP Manual should be considered as a guidance document when formulating the Town's own design standards.

g. Provisions for the use of pervious paving materials should be made in the proposed Town Design Manual. Such provisions should limit such materials to those proven effective in a coastal setting, along with requirements for periodic maintenance to assure long term effectiveness.

6. Continue to integrate stormwater management considerations in conventional street/drainage projects and water distribution projects.

7. §153.070(C) of the Zoning Ordinance should be revised to reflect the approved recommendations of this Stormwater Plan from the current language which reads, "All surface water drainage leaving the site shall be channeled to points of approved discharge, including but not limited to; a natural or man-made watercourse, a lake, a pond, ditch, stormwater drainage system…"

B. Maintenance and Operational Recommendations

1. The system of flow controls in Memorial Boulevard could be operated to direct flow northward, then northwestward, towards the NCDOT Canal rather than the ocean outfalls to the extent practical. Additional BMPs could be coupled with the flow controls to assist in reducing the amount of stormwater entering into adjoining receiving waters. The extended travel time and the addition of BMPs prior to entering the sound outfall could provide water quality benefits as well.

2. The 2008 status of culvert and structure maintenance is generally adequate. The Town should continue to keep culverts and structures free of sediment deposition. Periodic checks for structural distress should be made annually. Coordination should be made with NCDOT to assure that DOT systems receiving flow from Town systems are kept open, especially for the critical ocean outfalls.

3. Channel maintenance requires a carefully balanced approach. It is necessary to prevent the growth of trees and brush within the flow way

to the extent that it impedes capacity, while not losing the stabilizing and water quality benefits of such vegetation. A listing of all outfall ditches and canals, with a record and schedule of cleaning efforts, needs to be developed.

4. Smaller roadside ditch maintenance needs to be accomplished carefully. Where feasible, steep-sided trapezoidal or box ditches should be regraded to have gentler banks, with rounding where the slope meets a lawn. Replacement of ditches with swales is desirable.

5. Roadside swales should be designed to be at a lower grade or elevation profile than the driveway inverts they connect. Buildup of sediment and turf tends to reverse this over time. Swales established to a lower grade minimize ponding on driveways and promotes storage and infiltration of stormwater runoff.

6. At present, most stormwater BMPs in Town are those owned and operated by commercial properties. An inspection program should be developed to promote the maintenance and proper operation of these private facilities. The regulatory authority to do so could be derived from the long-standing requirement in §153.070(J) of the *Town Code* to retain the 4.3 inches of rain resulting from a 10-year, 2-hour rain event. Systems will not continue to meet this required design parameter if not maintained properly.

7. Investigation needs to be made as to the ownership and maintenance status of some of the existing open-water ponds in Kill Devil Hills. There are existing open water ponds in Town, notable are those in Watershed S01 in the area between Second Street and Fourth Street. These facilities are functioning as stormwater BMPs and will require maintenance. Steps should be taken to ensure these ponds continue to benefit the Town's stormwater system.

8. Require maintenance for commercial stormwater measures. In the case of open storage basins, the key elements are removing accumulated debris and sediments and assuring the integrity of any berms or dikes. More careful attention may be needed for systems involving underground detention or relying heavily on infiltration. The maintenance requirement should be supported by a performance bond.

C. Capital Project Strategies

1. The inventory and rating of the three Watersheds having ocean outfalls—O01, O02 and O03—reveal severe capacity deficiencies. The ocean outfall pipes themselves, at 30" and 36" in diameter, are significantly undersized for the areas they serve, as are key, backbone culvert elements between US 158 and NC 12. These key system components typically have 5% or less of the capacity required to pass the runoff from a 10-year rainfall event.

   It is recommended that an option be studied to provide a high-capacity stormwater link along Memorial Boulevard, from Carolyn Drive (and picking up flows from Lake Drive one block south) northward to Woodmere Avenue. Such a system would incorporate culverts at road and driveway crossings on the order of 48" in diameter, with innovative BMP provisions in the open sections between culverts to provide flow attenuation and water quality benefits, balanced with safety and aesthetic concerns. This system could discharge some of the stormwater through the existing culvert under US 158 into the NCDOT Canal, where additional measures to improve water quality might be considered.

   Such a project should not be undertaken until the conclusions of the CSI/DENR Ocean Outfall Study are published, a detailed hydrologic/hydraulic modeling and analysis have confirmed the technical viability of the approach, and a funding mechanism has been identified, as such a system could easily cost $3 million to $5 million to design and construct. While this seems like a large amount, the area drained is over 700 acres and the system would have low operating costs.

2. For many years, the Town has undertaken annually close to $1 million in street improvement projects, gradually reconstructing its "Poor"-rated existing roads and streets. These projects have typically included some storm drainage improvements.

   It is recommended that future capital projects take a comprehensive approach to the Town's infrastructure, seeking opportunities for projects which integrate street reconstruction, water line replacement and stormwater management objectives. Such stormwater measures should include conveyance systems, water quality measures (in the existing right-of-ways of built streets and "paper streets," where available), and outfall enhancements where feasible. Such a unified approach will result in lower total costs and reduced inconvenience to the served public.

3. Where possible, land acquisition and maintaining ownership of vacant lots currently owned by the Town which adjoin conveyance systems

should be considered if potential stormwater projects are feasible to aid in the functionality of the conveyance system and improve water quality. Areas should be prioritized by needs for improvement and availability of open space. Potential areas include vacant lots along West Bickett Street and Boundary Street drainage areas to preserve the drainage system. Paper streets should also be considered.

TABLE 4: CAPITAL IMPROVEMENTS PROJECT RECOMMENDATIONS

Watershed & Subcatchment	Project Recommendations
Watershed S01	
S011	- No near-term improvements recommended.
S012	- Replace non-functioning rusted CMPs in Memorial Boulevard with new HDPE. - Initiate a systematic culvert replacement program. - A dynamic analysis should be performed to quantify the option of a major interconnect along Memorial Boulevard from Lake Drive to Woodmere Street ditch.
S013	- No near-term improvements recommended.
S014	- N/A
S015	- This catchment needs to be modeled to determine the most cost-effective location and nature of improvements to address the capacity deficiency.
Watershed S02	- N/A
Watershed S03	- No near-term improvements recommended.
Watershed S04	- No near-term improvements recommended.
Watershed S05	- No near-term improvements recommended.
Watershed S06	- Monitor culverts on the north side of Indian Drive to determine if replacement with a larger capacity culvert is warranted. - The 240' culvert which is not in a right-of-way between Apache Street and Upper Dune Road should be upgraded from a 15" HDPE to an 18" HDPE.
Watershed S07	- Outfall pipe at Bay Drive between Clam Shell and Fourth Street should be upgraded to a larger capacity with the replacement of all other culverts along Bay Drive to increase capacity.
Watershed S08	- Replace culvert at the corner of Bay Drive and Durham Street. - The eight 15" culverts in Durham Street from Edenton to Bay Drive and along Bay Drive leading to the twin structure at the outfall should be replaced with 18" HDPE. - The portion of the Fifth Street system from Jeffrey Court to Bay Drive and along Bay Drive to the twin structure at the outfall should be replaced with 395 feet of 18" HDPE.
Watershed S09	- Construct a culvert cross link under Suffolk Street to allow the north side excess stormwater capacity to address some of the south side stormwater deficiencies.

Watershed & Subcatchment	Project Recommendations
Watershed S10	- Develop drainage system to connect Virginia Dare Shores area to Bickett Street ditch. - Replace 48" culvert for the Bickett Street ditch under Bay Drive with a 60" HDPE (or other smooth wall culvert of similar capacity) with a low weir to promote water quality BMP functionality upstream. - New Bern Street work designed but not awarded in 2008-2009 should be implemented.
Watershed S11	- No near-term improvements recommended.
Watershed S12	- No near-term improvements recommended.
Watershed O01	- Determine, through hydraulic modeling, engineering and cost analysis if flow from Watershed O01, O02, and O03 should be directed away from the three ocean outfalls to the NCDOT canal and sound outfall. - Resize ocean outfall pipes or consider an interconnect system at Memorial Boulevard. - Provide a stormwater conveyance system in the vicinity of Eighth Street and the proposed Satellite Fire Station, connecting to the NCDOT system in US 158.
Watershed O02	- Determine, through hydraulic modeling, engineering and cost analysis if flow from Watershed O01, O02, and O03 should be directed away from the three ocean outfalls to the NCDOT canal and sound outfall. - Resize ocean outfall pipes or consider an interconnect system at Memorial Boulevard. - Resize culverts under US 158 at Holly Street and Boundary Street.
Watershed O03	- Determine, through hydraulic modeling, engineering and cost analysis if flow from Watershed O01, O02, and O03 should be directed away from the three ocean outfalls to the NCDOT canal and sound outfall. - Resize ocean outfall pipes or consider an interconnect system at Memorial Boulevard.

D. Funding Methods Recommendation

1. Stormwater Utility Fee

A stormwater utility fee has become a more common regulatory action for communities to obtain funding for stormwater management projects, particularly for communities that are Phase II designated. When determining the fee to be implemented many communities refer to a parcel's impervious area. In response to the growing interest in a stormwater based utility fee and potential benefits to aid in implementing and maintaining stormwater

capital improvement projects, the Environmental Protection Agency (EPA) has begun to offer grants to municipalities to conduct utility-development feasibility studies. Several items need to be addressed when creating and implementing a stormwater utility fee including:

a. method of determining impervious area and whether it is an actual measurement or average
b. addressing classification of parcels and how to adjust fee based upon use (such as, residential, commercial, undeveloped, etc.)
c. stormwater exemptions and/or credits
d. payment responsibility and enforcement
e. billing system
f. ongoing maintenance
g. how to determine payment for streets, median, and other right-of-ways in a community

When determining how to charge a property owner, there are several options and/or combinations of options that have been utilized in already established stormwater utility fees in other communities and include:

a. total gross area
b. impervious area
c. average impervious area for single-family residences
d. effective impervious area for single-family residences
e. gross area with level of development
f. billable hydraulic area

The Town should pursue grants to conduct a utility-development feasibility study.

2. Incentive Program

An incentive program could be considered as part of any new proposed stormwater policies for the Stormwater Management Plan. Incentives are a positive compromise by allowing developers to install/implement stormwater practices as part of their design. These practices could include maintaining existing vegetation, installing stormwater BMPs, or altering development designs to disconnect impervious surfaces to promote onsite stormwater detention/retention instead of allowing stormwater to enter into Town operated conveyance systems. Typically an incentive program is attached to a stormwater utility fee where property owners are given credits or reductions in their stormwater fee when they implement stormwater measures to help reduce the amount of runoff entering into a Town operated system.

3. Grants

When implementing a comprehensive Stormwater Management Plan, it is important to fully define the goals and objectives of the Plan and provide education to its citizens who will ultimately need to support the potential policies within the Plan for better stormwater management. In addition, adequate staffing and equipment is needed to enforce the ordinances and provide the necessary operation and maintenance of stormwater improvement projects. Funding of these items is critical to a successful stormwater management system and can include funding for staff, equipment, and stormwater capital improvement projects.

There are several State, Federal and Non-profit grants available for both local government and citizens which aid in the implementation of stormwater projects and educational incentives. The following is a review of potential grants available:

a. Clean Water Management Trust Fund - http://www.cwmtf.net/
b. Coastal Land Use Planning Grants - http://dcm2.enr.state.nc.us/Planning/grants.htm
c. DOT Enhancement Grants - http://www.ncdot.org/planning/development/Enhancement/environmental/
d. EPA – Section 319 NPS Grants - http://h2o.enr.state.nc.us/nps/Section_319_Grant_Program.htm#funding
e. Five Star Restoration Grant Program - http://www.epa.gov/owow/wetlands/restore/5star/
f. BEACH Act Grants - http://www.epa.gov/waterscience/beaches/grants/
g. Community Conservation Assistance Program – http://www.enr.state.nc.us/dswc/pages/ccap_program.html
h. Other

In addition to the EPA grant recommendation in Section E1, the Town should pursue grants such as Clean Water Management Trust Funds for implementation of the proposed Stormwater Recommendations.

4. Inspection Fee for BMPs

Maintenance of BMPs is critical to ensure that they function properly. There are currently no regulations to ensure that each BMP installed within the Town is routinely maintained. An inspection program and associated fee for this service would enable the Town to monitor the BMPs constructed within the Town and ensure not only their effectiveness but the longevity of the

BMP as well. An alternative is to use funds raised by a utility fee to fund the inspection program.

5. Bonds for BMP Maintenance

Commonly referred as maintenance bonds or performance bonds, this option provides a financial arrangement used to finance final construction or maintenance of a BMP in the event of contractor default.

Maintenance bonds are often required after construction to guarantee the performance of BMPs. The goal of a maintenance bond is to protect against design defects and/or failures in construction, and to guarantee that BMPs constructed under a permit will be regularly and adequately maintained throughout the maintenance period. They are often implemented for only a limited amount of time and are not considered a solution to long-term maintenance; however can be an effective option during initial construction and short-term maintenance to ensure that it is properly functioning.

6. Partnerships with Agencies and Not for Profit Organizations

An education/demonstration site to illustrate various types of development, along with test sites to show how different techniques may improve stormwater runoff, could further enhance the Town's goal for innovative stormwater management. Demonstration sites may include a Town-owned property, Town office complex area, or work with other organizations on sites they own. A location should be visible to the public and provide education opportunity for businesses, students, and citizens. Funding could be sought from State and Federal agencies for these demonstration projects.

7. Ad-Valorum Taxes

   Similar to a stormwater utility tax, this option would generate funds for stormwater BMPs and their maintenance via a tax that would be included in the yearly assessment taxes of a property. This tax could be determined by the land use, watershed area, and/or combination of both.

E. Opportunity Areas

Drainage projects are implemented through Public Service Department and Streets Committee which are approved and funds allocated by the Board of Commissioners. In the past, drainage projects coincided with street improvement projects and this practice should continue. Since 2004 several drainage projects have been competed. Appendix K illustrates the various projects completed in conjunction with street improvement projects.

Based upon the Stormwater Inventory Rating, water quality data, physical characteristics of the various watersheds, computer models, and historic knowledge of the Town's problem areas, several areas have been identified that should be considered high priority for upcoming projects within the next five years. Potential solutions should be considered with funding allocated from both Town resources and grants that are available for stormwater projects. These areas include watersheds, catchments, or subcatchments that were identified with low capacity and structural ratings where improvements could be made to increase the capacity of the conveyance system or replace/repair structures that are no longer functioning as designed. Examples of these areas include portions of the three ocean outfall watershed (O01, O02, and O03) where there is need for structural improvements to pipes that are in poor condition. In addition, areas that have been identified with potential water quality problems, such as watershed S10 which includes the Bickett Street sound outfall, should be investigated for illegal discharges and those identified should be corrected. This drainage feature has historically shown water quality concerns and potential improvements throughout the watershed may provide water quality benefits.

F. Other Strategies

1. The Town of Kill Devil Hills is primarily developed with on-site sewage systems. Currently there is no policy to require home owners and business owners to maintain their septic tanks. The Town of Nags Head has established a septic health initiative, which promotes monitoring of septic systems to determine if they are functioning properly and provides a low interest loan to homeowners to help repair or replace failing septic systems. A similar initiative should be considered for the Town which will help reduce water quality impacts from these systems to the surrounding conveyance systems.

2. The Town should continue its partnership with the Dare County Health Department to aid in promoting new technologies and innovative systems for development or redevelopment in areas with known high water tables.

3. Additional pet waste stations should be installed throughout the Town including all beach accesses and street right-of-ways where dog walking is common such as Memorial Drive and Bay Drive.

4. Reduce the amount of pesticide and herbicides used on public and private properties by promoting the use of alternatives. The Town could promote this awareness by evaluating what types of pesticides/herbicides they use on public lands (parks, Town-owned property, etc.) and ways to reduce their use. A partnership with the Dare County Parks and Recreation could also further support the reduction of pesticides/herbicides.

5. General practices for right-of-ways and vegetation types have been the traditional grasses which require mowing maintenance. An option would be to use native vegetation along some right-of-ways such as Croatan Highway and Memorial Drive. Native vegetation would require less maintenance and could be similar to areas where NC DOT has established wildflowers or tree/shrub plantings, which also enhance the visual appearance of the right-of-way. In addition, demonstration projects could be developed to further educate the general public. Partnerships could be established between non-profit and State agencies to provide educational material to property owners and landscape businesses to use native vegetation in landscaping practices along with information on natural types of lawn maintenance techniques.

6. Green Space Program is offered through the NC Cooperative Extension Program and The Nature Conservancy which is a training program for local planners, landscapers, citizens, etc. to encourage retaining existing native vegetation during development projects and if this is not feasible utilizing natives and other types of vegetation that promote less water usage, infiltration, and less maintenance.

7. Design and implement a public outreach educational program to inform the public of the necessity for stormwater control, effectiveness of stormwater management, including the realization that some events will result in flooding regardless of the effectiveness of the stormwater management system, and the need to maintain the stormwater measures.

VI. Conclusions

The purpose of this Plan is to further assist the Town's continued efforts to reduce the negative impacts of storm water flooding while working toward improving water quality

of receiving waters. We believe the information contained herein will greatly aid the Town in this endeavor.

Major Points contained in the document:

* The Town has been and continues to be at the forefront of managing storm water runoff through an extensive system of stormwater conveyance that is unmatched on the Outer Banks. The drainage inventory contained in this document of all the major stormwater management corridors and storm water structures will prove to be extremely valuable in future system design and implementation.

* By implementing new policies promoting the use of BMPs, the Town continues to strive towards responsible stormwater management while at the same time promoting development and redevelopment.

* The use of computer simulation models has further enhanced the Town's knowledge of its environment and will aid the Town in making informed decisions on how to best manage its resources. As additional watersheds are modeled using the hydrological model, a better understanding will be established on how certain areas and their respective conveyance systems react to precipitation events. The GIS based DSS model allows the Town to visualize proposed alterations in land use that will impact the amount of stormwater entering a conveyance system. In addition, the DSS model provides input on what types of BMPs may be most appropriate.

* Potential opportunity areas for improving stormwater measures have been identified based upon results from information found within this Plan including the rating of each conveyance system, water quality information, and results from the computer simulations.

Even with the implementation of the recommendations of this Plan, there will be times when flooding occurs in the Town. This situation may occur after a large rain event or a series of rain producing storms. The inventory of the Town's conveyance system revealed that most are currently at or above capacity for the amount of stormwater anticipated to be generated by a 10-year storm.

The implementation of the Plan over the next five years will begin the process of reducing the amount of and increasing the quality of stormwater entering the conveyance system. The goal is to increase the quality of stormwater entering the adjoining water, minimize flooding potential from storm events, and reduce the capital expenditures for improvement of the conveyance systems. The Plan's recommendations place additional responsibility of managing stormwater on site and provide for education of the public to the need for adequate stormwater controls. The Plan anticipates that conveyance system improvements are coupled with street improvement projects to spread the cost of improvements over a predictable time period and provide funding for a program to ensure stormwater control measures are installed correctly and maintained.

The Plan's recommendations anticipate that development and redevelopment will occur in the next five years which provides opportunities to improve the stormwater

management within the Town. The Plan also recognizes that many new stormwater measures could be identified, tested for effectiveness, and authorized for use. Thus, the Plan should be revised in five years to review the current status of the recommendations, the effectiveness of the measures employed, assess the development trends, and explore new technologies and concepts to further improve stormwater management in the Town of Kill Devil Hills.

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APPENDIX A

STAKEHOLDER REPORT

Town of Kill Devil Hills
Stormwater Management Plan
Stakeholder Meetings

As part of the Town's Stormwater Management Plan a stakeholder group was organized to provide input from local citizens, State/Federal agencies, non-profits, and interested parties that are affected by local stormwater concerns. Stakeholder input is vital when producing a management plan that directly effects the decisions, economics, social structure, and quality of life within their respective coastal communities. A list of Stormwater Stakeholders is attached with this report. .

Stakeholder meetings were conducted to obtain input, opinions and concerns relating to stormwater issues and opportunities. The items brought fourth by the stakeholders were ranked using the Delphi process and the ranked concerns were utilized to aid in the development of both the Plan and the resulting Stormwater DSS Model. Potential solutions, including proposed policy recommendations, were also discussed with the stakeholder group.

I. Stakeholder Process and Results

A. Meetings

Four stakeholder meetings were conducted during the development of the Town's Stormwater Management Plan. The meetings were held at the Town Hall and consisted of two-hour sessions conducted by staff of Decision Support Professionals, Inc. (DSPro). Agendas were emailed to the stakeholders prior to the meeting and homework assignments, if any, were given to the stakeholders at the end of each session.

During the first stakeholder meeting on February 4, 2008 the stakeholders were introduced to the Stormwater team including members of DSPro, Engineering Services of Virginia (ESVI) and Town staff. A power point presentation outlined the goals and objectives of the stakeholder meetings, the writing of the Plan, and associated hydrological and decision support models. Following the introductions a round-table discussion was initiated where stakeholders would comment and discuss local stormwater issues and concerns. The issues were written on visual displays and over ninety (90) concerns were raised during the 1st stakeholder meeting. Finally, a homework assignment was given to the stakeholders to document the issues, concerns, and potential opportunities rose during the meeting. Disposal cameras were given to each stakeholder and photographs were to be taken of identified areas. DSPro staff developed the photographs and cataloged the descriptions given by the stakeholders. The complete list of issues and photographs can be found attached with this report.

During the second stakeholder meeting on April 7, 2008 DSPro staff gave an update on the progress of the Plan being written by DSPro and Watershed delineations conducted by ESVI. A power point presentation was then shown depicting some of the photographs that were taken by the stakeholders showing issues, concerns, and opportunities raised in the first meeting. In addition, DSPro presented handouts which showed how staff condensed the ninety (90) issues initially raised in the 1st stakeholder meeting into broader categories to ensure that each issue was adequately represented. Ranking of the issues using the Delphi Process was then performed by the stakeholders.

During the third stakeholder meeting on June 2, 2008 DSPro gave an update on the progress of the Plan and DSS Model. Mr. Pete Burkhimer with ESVI gave a presentation on the Watersheds located within the Town and the process of delineating the watersheds and ratings of the existing conveyance systems. Following the Watershed information, DSPro presented the ranking of the issues based upon the results of Delphi Process. Once the ranked issues were reviewed a roundtable discussion was conducted to discuss potential solutions to address the stormwater concerns and issues raised during the first two meetings. The potential solutions were written on display pages and discussed with DSPro, ESVI and Town staff members.

During the fourth stakeholder meeting on August 4, 2008, the stakeholders were presented an update on the development of the Plan and overviews of the Hydrological and GIS Decision Support Models. The Power point presentation explained how the watershed information, rating information, recommendations for policies and BMPs will be incorporated into the Plan and the GIS Decision Support Model. Details of the Hydrological Model were presented depicting how the EPA SWMM will incorporate rainfall-runoff simulation for various rainfall events. The outputs from the model were explained. Questions were fielded from the stakeholders, and a sincere thank you was extended to them for their persistence, inputs, and understanding of the important issues. The stakeholders were informed that they would be invited to view the final Plan.

B. Issues

Over ninety (90) stormwater issues were raised by the stakeholders during the 1st stakeholder meeting in February 2008. These concerns ranged from physical issues such as the appearance of the conveyance systems to regulatory concerns such as the lack of funding available to address current stormwater problems. In order to better manage the issues raised, DSPro staff condensed the issues into two main categories; Environmental/Physical and Policy/Enforcement. The two categories each had sub-categories listed under them and each of the ninety issues were placed into the broader categories which would allow for better management, discussion and solutions. The broad categories were initially unranked. The list of broad categories and where each issue was placed can be found attached with this report.

The following table represents the final categories;

TABLE 1: STAKEHOLDER ISSUES

Stakeholder Issues
Environmental/Physical
New Development/Redevelopment
Parking Lots/Impervious Surfaces
Storm Issues
Conveyance Systems
Water Quality
Impacts to Wildlife/Marine Environments
Public Health/Safety Issues
Vegetation
Animal Impacts
Policy/Enforcement/Implementation
Regulatory/Policy Issues
Funding
Education
Incentives

Following the discussions on the unranked issues, DSPro handed out colored dots to perform an in-house exercise in order to rank the issues using the Delphi Process. The stakeholders were asked to place a colored dot next to issues which deemed important to them. The colored dots represented a ranking system and for the Environment/Physical Issues DSPro instructed the stakeholders to rank their top five issues while for the Policy/Enforcement/Implementation Issues DSPro instructed the stakeholders to rank their top three issues.

The following colored dots were used in the ranking process;

TABLE 2: DELPHI PROCESS FOR RANKING ISSUES

Delphi Process
Environmental/Physical Issues (Rank your top 5)
Red Dot - Highest Ranking
Green Dot - 2nd Highest Ranking
Blue Dot - 3rd Highest Ranking
Yellow Dot - 4th Highest Ranking
Orange Dot - 5th Highest Ranking
Regulatory/Enforcement/Implementation (Rank your top 3)
Red Dot - Highest Ranking
Green Dot - 2nd Highest Ranking
Blue Dot - 3rd Highest Ranking

Once each stakeholder ranked their issues in order of importance, DSPro collected the information and counted the number and type of dots in each broad category.

The following table illustrates the outcome:

TABLE 3: STAKEHOLDER ISSUES - UNRANKED

Stakeholder Issues (unranked)	**Red Dots**	**Green Dots**	**Blue Dots**	**Yellow Dots**	**Orange Dots**
Stakeholder Issues - Environmental/Physical	**1st**	**2nd**	**3rd**	**4th**	**5th**
New Development/Redevelopment	**1**	**2**	**1**	**0**	**5**
Parking Lots/Impervious Surfaces	**0**	**0**	**4**	**1**	**1**
Storm Issues	**1**	**0**	**0**	**3**	**3**
Conveyance Systems	**5**	**3**	**1**	**2**	**2**
Water Quality	**3**	**5**	**2**	**3**	**1**
Impacts to Wildlife/Marine Environments	**0**	**2**	**3**	**1**	**0**
Public Health/Safety Issues	**2**	**1**	**2**	**1**	**0**
Vegetation	**2**	**1**	**1**	**1**	**1**
Animal Impacts	**0**	**0**	**0**	**2**	**1**
TOTALS	**14**	**14**	**14**	**14**	**14**

Stakeholder Issue - Policy/Enforcement	**Red Dots**	**Green Dots**	**Blue Dots**
	1st	**2nd**	**3rd**
Regulatory/Policy Issues	**8**	**3**	**2**
Funding	**2**	**5**	**4**
Education	**3**	**2**	**4**
Incentives	**0**	**3**	**3**
TOTALS	**13**	**13**	**13**

The issues in the two main categories were then ranked and the following table shows the results of the ranking and weight values used to perform the ranking:

TABLE 4: STAKEHOLDER ISSUES - RANKED

Stakeholder Issues (ranked)					
Environmental/Physical	**Ranking Totals**				
Conveyance Systems	**51**				
Water Quality	**51**				
Public Health/Safety	**24**				
Vegetation	**22**				
New Development/Redevelopment	**22**				
Impacts to Wildlife/Marine Environments	**19**				
Storm Issues	**15**				
Parking Lots/Impervious Surfaces	**15**				
Animal Impacts	**5**				
Policy/Enforcement	**Ranking Totals**				
Regulatory/Policy Issue	**40**				
Funding	**22**				
Education	**20**				
Incentives	**9**				
Values for Ranking	**Red Dot**	**Green Dot**	**Blue Dot**	**Yellow Dot**	**Orange Dot**
Environmental/Physical Issues	**6**	**4**	**3**	**2**	**1**
Policy/Enforcement	**4**	**2**	**1**	n/a	n/a

Results indicate that the two most important stormwater issues expressed by the stakeholders for Environmental/Physical are the conveyance systems and water quality while Regulatory/Policy issues ranked the highest under Policy/Enforcement/Implementation.

C. Stakeholder Recommendations for potential new policy and regulations

Following the discussions outlining the issues, concerns and opportunities within the Town, suggestions were provided on how to implement potential solutions and regulatory strategies. The following items were discussed;

1. Stormwater Utility Fee

A stormwater utility fee has become a more common regulatory action for communities to obtain funding for stormwater management projects, particularly for communities that qualify for Phase II stormwater requirements and need a source of funding to implement the new regulations. When determining the fee to be implemented many communities refer to a parcel's impervious area. In response to the growing interest in a stormwater based utility fee and potential benefits to aid in implementing and maintaining stormwater capital improvement projects, the Environmental Protection Agency (EPA) has begun to offer grants to municipalities to conduct utility-development feasibility studies. Several items need to be addressed when creating and implementing a stormwater utility fee including;

- Method of determining impervious area and whether it is an actual measurement or average
- Addressing classification of parcels and how to adjust fee based upon use (such as, residential, commercial, undeveloped, etc.)
- Stormwater exemptions and/or credits
- Payment responsibility and enforcement
- Billing system
- Ongoing maintenance
- How to determine payment for streets, median, and other right-of-ways in a community

When determining how to charge a property owner, there are several options and/or combinations of options that have been utilized in already established stormwater utility fees in other communities and include;

- Total gross area
- Impervious area
- Average impervious area for single-family residences
- Effective impervious area for single-family residences
- Gross area with level of development
- Billable hydraulic area

Customer classification recognizes the differences in land use characteristics and may be of importance if the fee is based upon gross parcel area which can then be multiplied by a land use type runoff coefficient and gives you an estimate of impervious area. Types of customer classifications may include single family residential, commercial, industrial, institutional, or vacant land.

Stormwater exemptions can become an issue when developing stormwater utility fee policy and should be considered during the planning process. Some communities take the notion that all properties that contribute to runoff should pay some type of fee while others classify some properties as exempt from payment. Examples of potentially exempt properties would be government-owned properties such as roadways, right-of-ways, unoccupied dwellings, vacant land without any structures, or properties that are tax-exempt like churches and schools. If properties are to be exempt, it is recommended to provide a defensible rationale to minimize any potential litigation and to make sure the exemption does not violate any specific local or state stormwater statutes already in place.

As an incentive to implement stormwater best management practices, many communities are also providing a stormwater credit system as part of the utility fee which provides for a reduction in the fee owed by a property owner. When including a stormwater credit option in the utility fee several items should be considered and addressed; purpose of the credit, levels of credit, eligibility, terms of the credits, maintenance of stormwater BMPs, and certification requirements for renewal of credits.

Payment responsibility and enforcement should be clearly defined before implementing a stormwater utility fee. Many communities either develop a new billing system or tag on the utility fee to an existing utility such as a water bill. By utilizing an existing utility bill enforcement of the stormwater fee can be more easily managed however if the fee is a stand-alone bill, other types of enforcement such as placing a lien on a property can also be used to secure payment of the fee. Billing systems using existing utilities may also be more efficient than building a new billing system and should be fully analyzed prior to implementing a stormwater utility fee program. Like any other type of billing system there is ongoing maintenance including updates to parcel information and ownership.

Finally, a well definite use of the capital gained by the stormwater utility fee, education on the fee, credits available, and overall understanding of the need for a stormwater fee is most important when justifying the new utility to the community. Progress reports on where the fees are being used to improve stormwater management will help with the buy-in of the citizens and reduce any negative feedback. Ultimately a well thought out utility fee and policy on how to implement the fee with aid in the success of the program.

An example of a stormwater utility fee and how it was developed was reviewed by DSPro and includes the City of Jacksonville, North Carolina. On July 1, 2006 the City of Jacksonville, North Carolina (Jacksonville) began adding an additional fee to monthly water bills to pay for stormwater management services such as maintenance and drainage improvements (http://www.ci.jacksonville.nc.us/opencms/opencms). The idea for

implementing a stormwater utility fee came about when Jacksonville was phased in by the North Carolina Division of Water Quality (DWQ) as a National Pollutant Discharge Elimination System (NPDES) Phase II community. This obligated Jacksonville to abide by mandatory stormwater regulations imposed by the State and Federal governments. No funding was allocated to pay for compliance with these new regulations so the fee was imposed out of necessity.

The fee was determined by first surveying the amount of impervious area on each lot. The average area came out to be about 2,850 square feet. During the development phase, a Stormwater Advisory Committee was established to develop cost estimates for implementing new mandates. The committee consisted of a panel of stakeholders from the community including businessmen, environmentalists, and other concerned parties. The committee determined the fee for residential properties should be a $4 flat rate per month while all other developed properties are charged $4 for every 2,850 square feet of impervious surface on the property. Credits are offered for onsite stormwater controls, usually for large commercial developments. These offered up to 25% off of the fee based on the volume of stormwater that can be controlled onsite. Before the fee was imposed, a large educational campaign was launched to inform citizens about stormwater management issues. This consisted of training for city workers, public information sessions, an advertising campaign, and programming on the Government TV channel. There have been no educational measures employed since the fee went into effect. Initially there was some objection to the fee, and citizens came to call the fee a “rain tax.” However, the reaction has generally been positive since the fee’s implementation probably because of its reasonable price.

The stormwater utility fee raises about $2.1 million per year for stormwater management. About half of that goes toward maintenance of Jacksonville’s stormwater system and the remaining pays for operational and administrative costs. Government officials acknowledge that the fee will have to be raised in the future. Maintenance costs for the stormwater management system are covered but more money is still needed for capital improvement projects. There is also concern about the leadership of the stormwater program. Stormwater is currently managed by the Jacksonville Public Works Department, but according to Wally Hansen, Jacksonville’s Infrastructure & Capital Projects Manager, there is a need for a full time department devoted exclusively to stormwater.

2. Incentive Program

An incentive program could be introduced as part of any new proposed stormwater policies for the Stormwater Management Plan. Incentives are a positive compromise when attempting to initiate what may come across as stricter stormwater regulatory measures and promote acceptance of these measures by allowing developers to install/implement stormwater practices as

part of their design. Incentives could include maintaining existing vegetation, installing stormwater BMPs, or altering development designs to disconnect impervious surfaces to promote onsite stormwater detention/retention verse allowing stormwater to enter into Town operated conveyance systems. Typically an incentive program is attached to a stormwater utility fee where property owners are given credits or reductions in their stormwater fee when they implement stormwater measures to help reduce the amount of runoff entering into a Town operated system.

3. Grant Programs

When implementing a comprehensive stormwater management plan, it is important to fully define the goals and objectives of the plan and provide education to its citizens who will ultimately need to support the potential policies within the plan for better stormwater management. In addition, adequate staffing and equipment is often needed to enforce the plan and provide the necessary operation and maintenance of stormwater improvement projects. Funding of these items is critical to a successful stormwater management plan and can include funding for staff, equipment, and stormwater capital improvement projects.

As previously discussed, a stormwater utility fee is one option to obtain funding and can also be coupled with an incentive program which would allow citizens to implement onsite stormwater best management practices (BMPs) to help improve stormwater quantity and quality while at the same time reducing their fee costs. There are also several State, Federal and Non-profit grants available for both local government and citizens which aid in the implementation of stormwater projects and educational incentives. The following is a review of potential grants available:

- Clean Water Management Trust Fund - http://www.cwmtf.net/
- Coastal Land Use Planning Grants - http://dcm2.enr.state.nc.us/Planning/grants.htm
- DOT Enhancement Grants - http://www.ncdot.org/planning/development/Enhancement/environmental/
- EPA – Section 319 NPS Grants - http://h2o.enr.state.nc.us/nps/Section_319_Grant_Program.htm#funding
- Five Star Restoration Grant Program - http://www.epa.gov/owow/wetlands/restore/5star/
- BEACH Act Grants - http://www.epa.gov/waterscience/beaches/grants/
- Other

4. Retrofit Incentive Program

Similar to an incentive program, this type of initiative could be coupled with proposed new stormwater management policies. Stormwater retrofits can either be implemented at the single-family residential level, commercial level, or be designed as a larger project targeting a particular watershed or sub-watershed and its conveyance systems. Education and public participation are two important aspects in developing a retrofit incentive program to provide citizens with information regarding the various types of retrofits available, how the retrofit will be implemented and maintained, and what types of benefits the retrofit will provide.

The Center for Watershed Protection (CWP) describes retrofits as "measures for urban watersheds designed to help minimize accelerated channel erosion, reduce pollutant loads, promote conditions for improved aquatic habitat, and correct past mistakes". The CWP suggests performing a screening of potential retrofit sites and ranking the sites on their ability to; remove pollutants, stream channel protection capability, cost of retrofit, ability to implement the retrofit, and potential for public benefit. Additional information on CWP and their insight on retrofit design and implementation of successful projects can be found at www.cwp.org.

5. Other

- **Pesticide/Herbicide Management**

  An initiative could be implemented which would focus on modifying how the Town currently manages its public lands for greener alternative methods. Management methods could include natural pesticide/herbicide products and reviewing their landscaping practices to incorporate more native species which require less or no harmful products.

- **Increased Pet Laws and Enforcement**

  Additional pet waste stations in areas including; in-between the main two roadways; Croatan Highway and Virginia Dare Trail and the residential developments to the west of Croatan Highway. Fines could also be initiated for pet owners who do not clean up their pet's waste.

TOWN OF KILL DEVIL HILLS
STORMWATER MANAGEMENT PLAN UPDATE
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252-441-7498 (fax) 252-441-8862
langfordrealty@mindspring.com

NC Cooperative Extension Program
Master Gardener
Ms. Rhana Paris
1504 Heather Lane
Kill Devil Hills, NC 27948
252-480-1884

Landmark Building & Development of NC, LLC
Mr. Mike Robinson
PO Box
Kill Devil Hills, NC 27948
252-255-8026 (c) 252-449-5006 (f)
mrobinson@landmark-nc.com

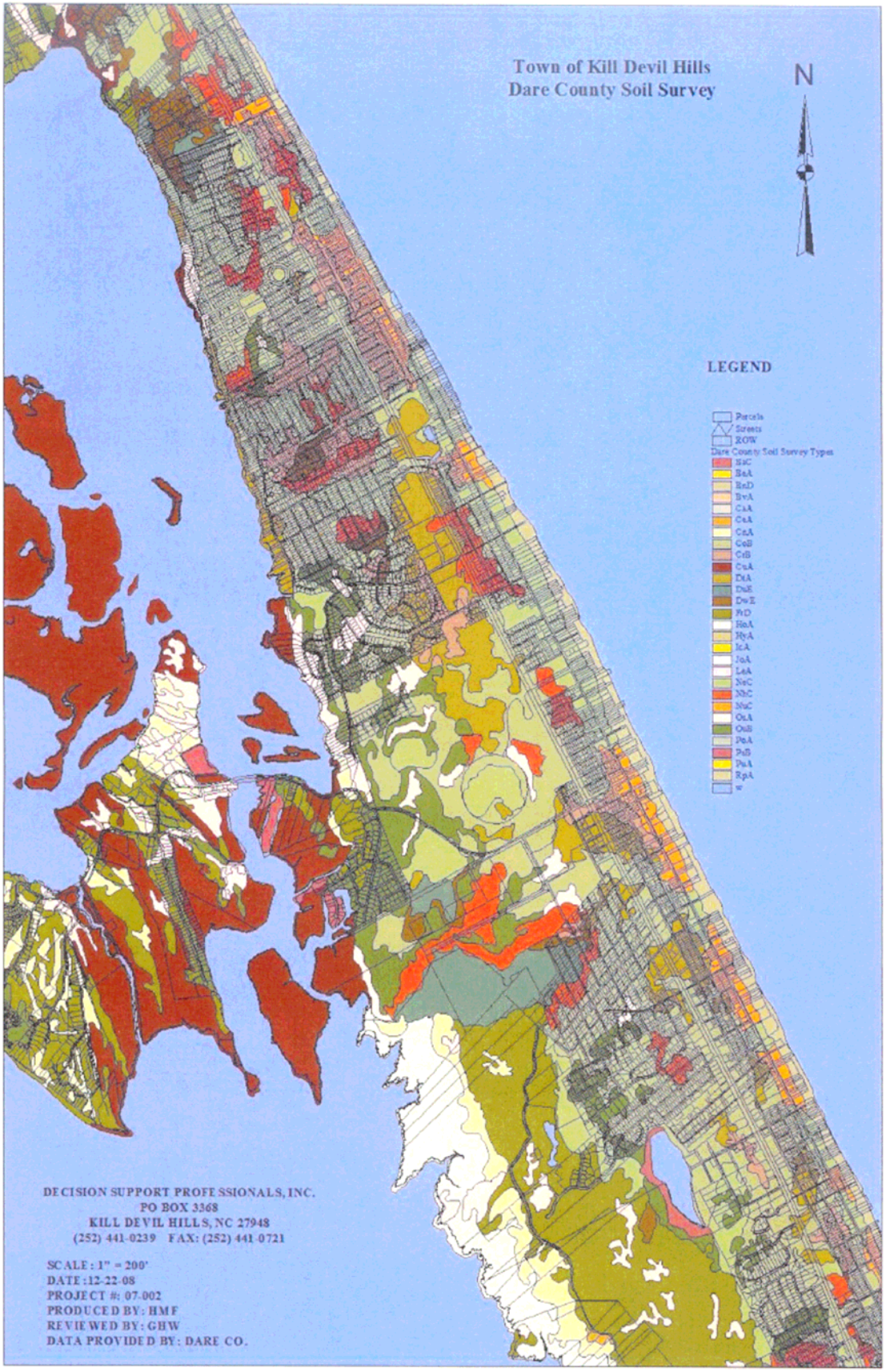
Ms. Johanne Finney
117 Rocky Mount Street
Kill Devil Hills, NC 27948
252-441-7577
Johanne479@aol.com

Mr. Mark Hibbs
916 Console Lane
Kill Devil Hills, NC 27948
252-441-4591

Dare County Chamber of Commerce
Mr. John Bone
PO Box 1757
Kill Devil Hills, NC 27948
252-441-8144 (fax) 441-0338
src@outer-banks.com

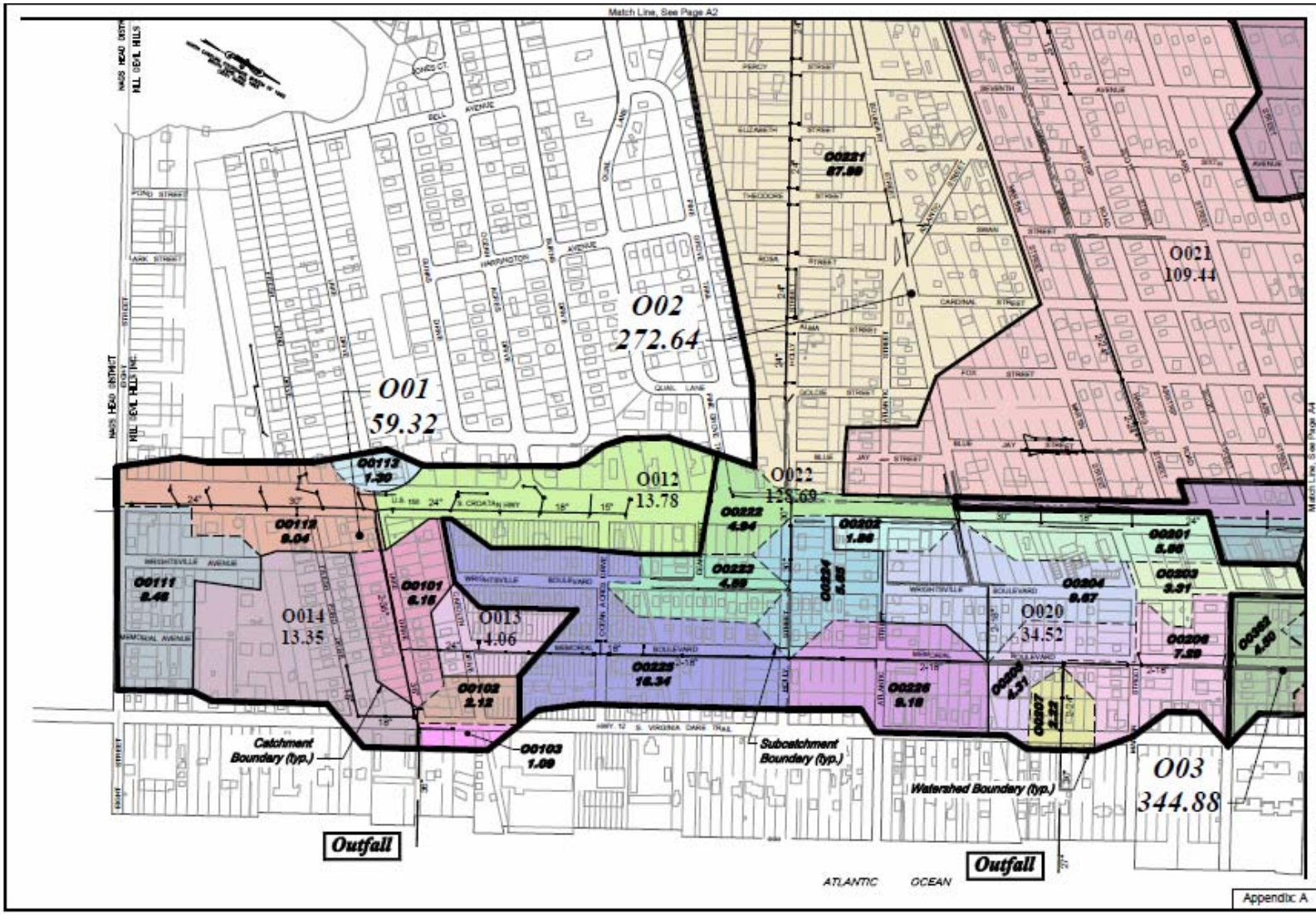
APPENDIX B

DARE COUNTY SOIL SURVEY MAP


Town of Kill Devil Hills
Dare County Soil Survey
N
LEGEND
Parcels
Streets
ROW
Dare County Soil Survey Types
BaC
BaA
BnD
BvA
CaA
CsA
CtA
CoB
CrB
CuA
DtA
DuE
DwE
FrD
HoA
HyA
IcA
JgA
LeA
NsC
NbC
NuC
OtA
OuB
PoA
PrB
PsA
RpA
w
DECISION SUPPORT PROFESSIONALS, INC.
PO BOX 3368
KILL DEVIL HILLS, NC 27948
(252) 441-0239 FAX: (252) 441-0721
SCALE : 1" = 200'
DATE : 12-22-08
PROJECT #: 07-002
PRODUCED BY: HMF
REVIEWED BY: GHW
DATA PROVIDED BY: DARE CO.

APPENDIX C

STORMWATER INVENTORY MAPS



Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina

O02
Watershed Designator
O02
Catchment Designator
O02
Subcatchment Designator

Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008

Appendix A

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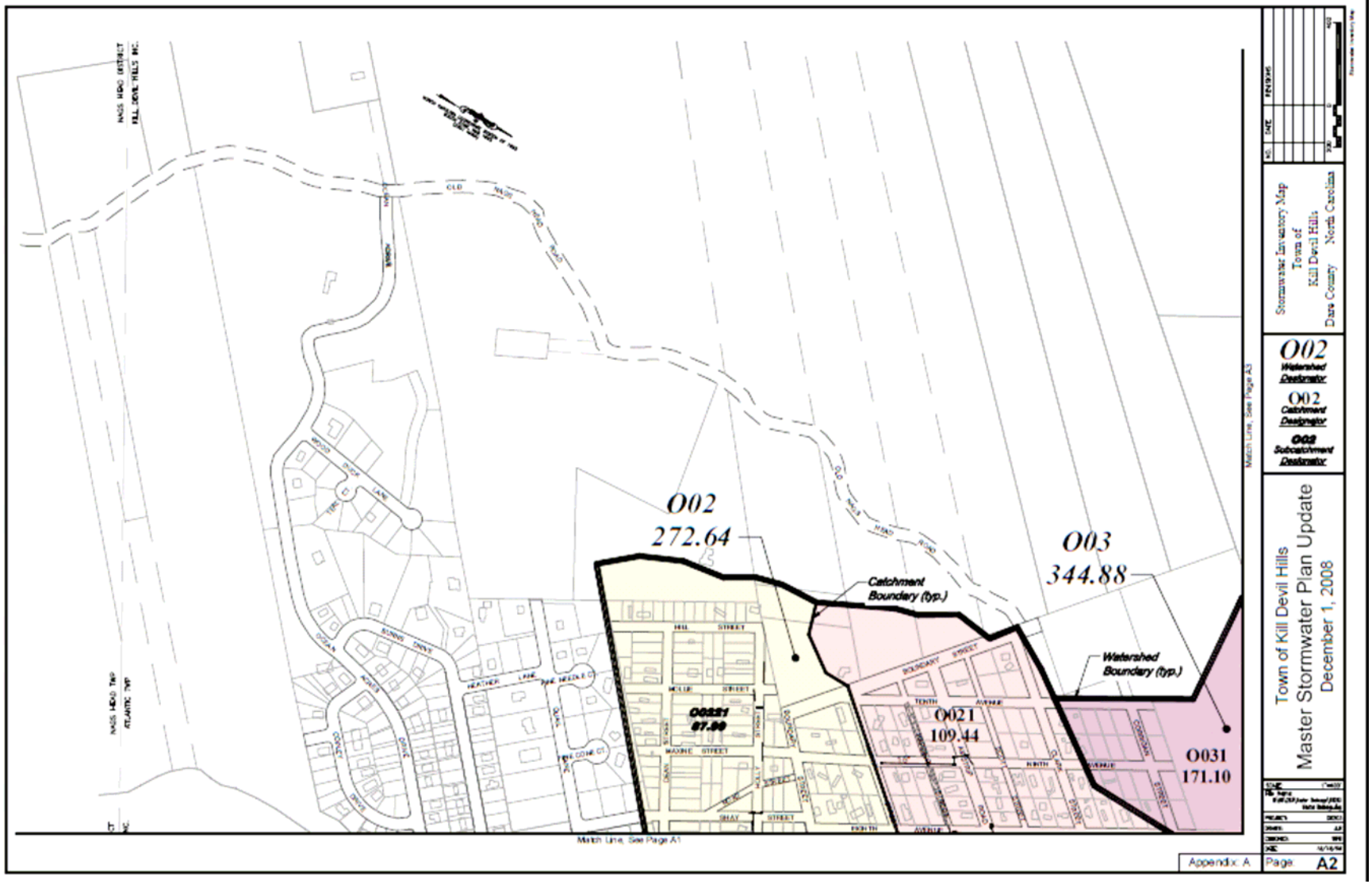
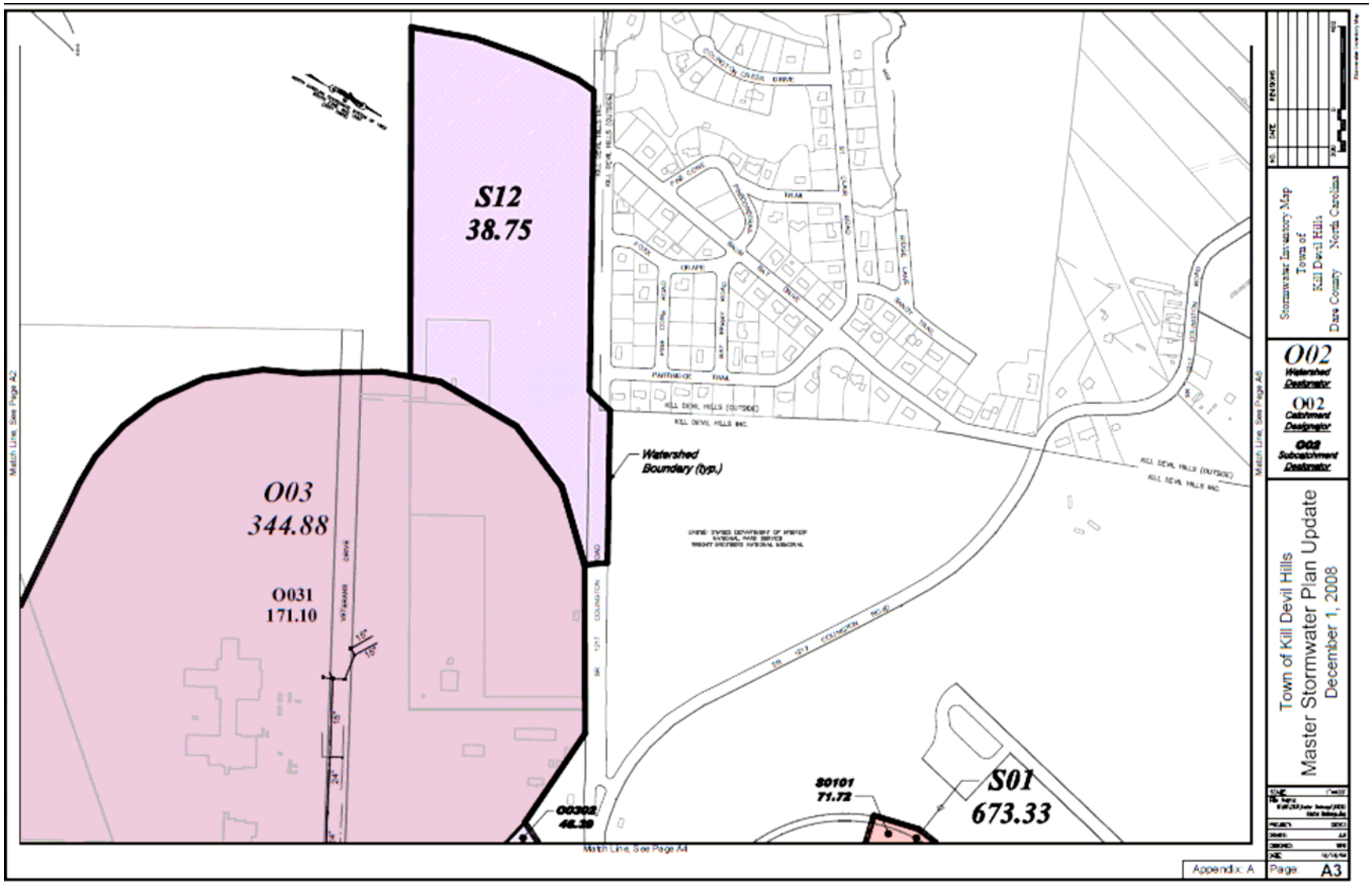
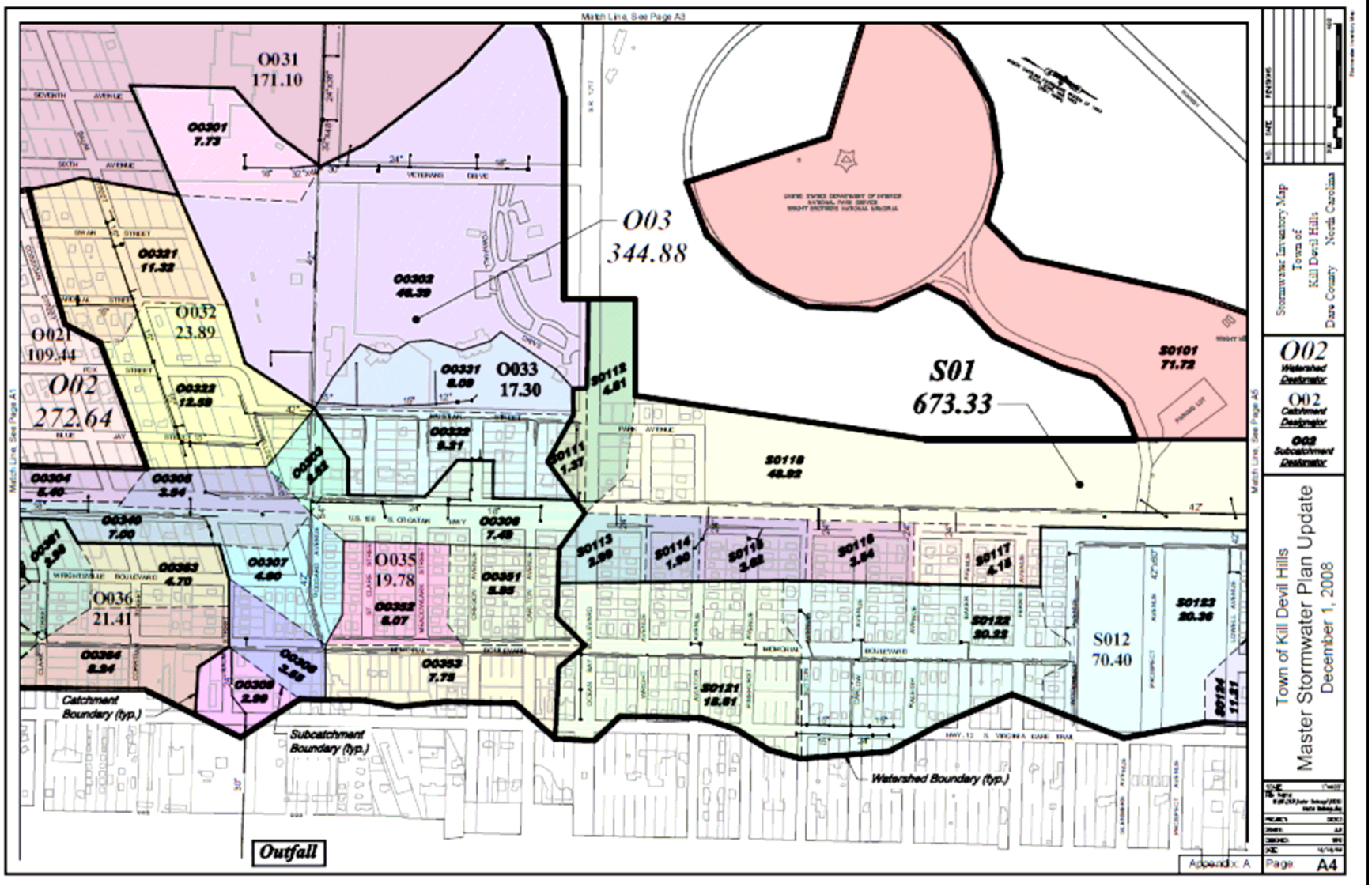

O02
272.64
O03
344.88
O021
109.44
O031
171.10
Catchment Boundary (typ.)
Watershed Boundary (typ.)
Match Line, See Page A1
Match Line, See Page A3
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
O02
Watershed Designator
O02
Catchment Designator
O02
Subcatchment Designator
Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008


S12
38.75
O03
344.88
O031
171.10
Watershed
Boundary (typ.)
S01
673.33
S0101
71.72
O0302
46.39
Match Line, See Page A2
Match Line, See Page A4
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
O02
Watershed
Designator
O02
Catchment
Designator
O02
Subcatchment
Designator
Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008
Appendix A
Page A3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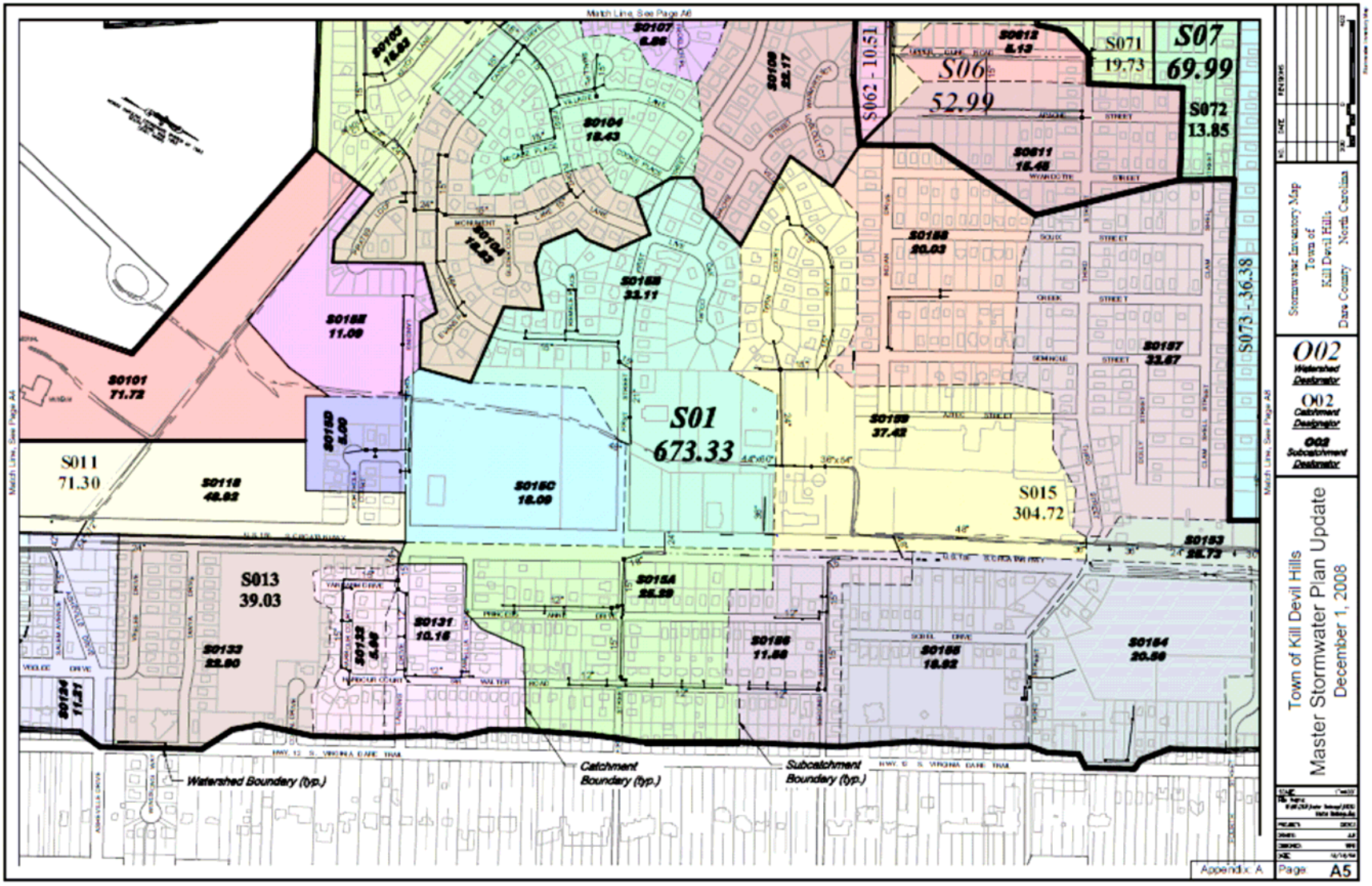
Match Line, See Page A1
Match Line, See Page A5
O031
171.10
O03
344.88
S01
673.33
O021
109.44
O02
272.64
O032
23.89
O033
17.30
O035
19.78
O036
21.41
S012
70.40
S0101
71.72
S0118
48.92
S0123
20.36
S0124
11.51
S0121
18.61
S0122
20.22
S0117
4.15
S0116
3.64
S0115
3.62
S0114
1.90
S0113
2.99
S0112
4.81
S0111
1.37
O00301
7.73
O00302
48.39
O00321
11.32
O00322
12.59
O00331
8.09
O00332
9.21
O00304
5.40
O00305
3.94
O00340
7.00
O00341
3.58
O00363
4.70
O00307
4.60
O00308
7.49
O00351
5.95
O00352
8.07
O00353
7.75
O00364
8.94
O00306
2.98
O00309
2.95
O00308
2.99
Catchment Boundary (typ.)
Subcatchment Boundary (typ.)
Watershed Boundary (typ.)
Outfall
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina
O02
Watershed Designator
O02
Catchment Designator
O02
Subcatchment Designator
Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008
Appendix A
Page A4



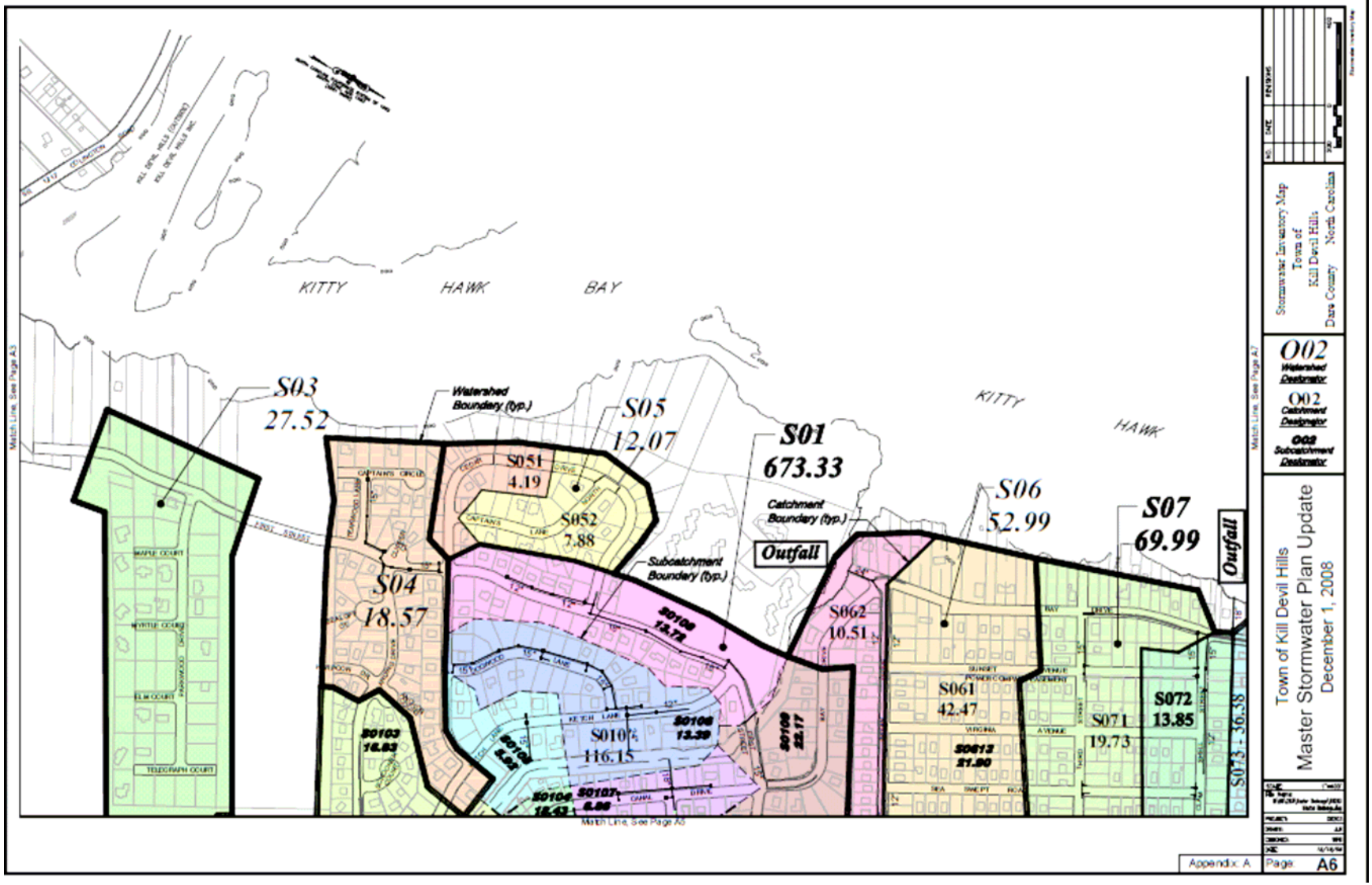
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina

O02
Watershed Designator

O02
Catchment Designator

O02
Subcatchment Designator

Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008



Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina

O02
Watershed Designator
O02
Catchment Designator
O02
Subcatchment Designator

Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008

Appendix A
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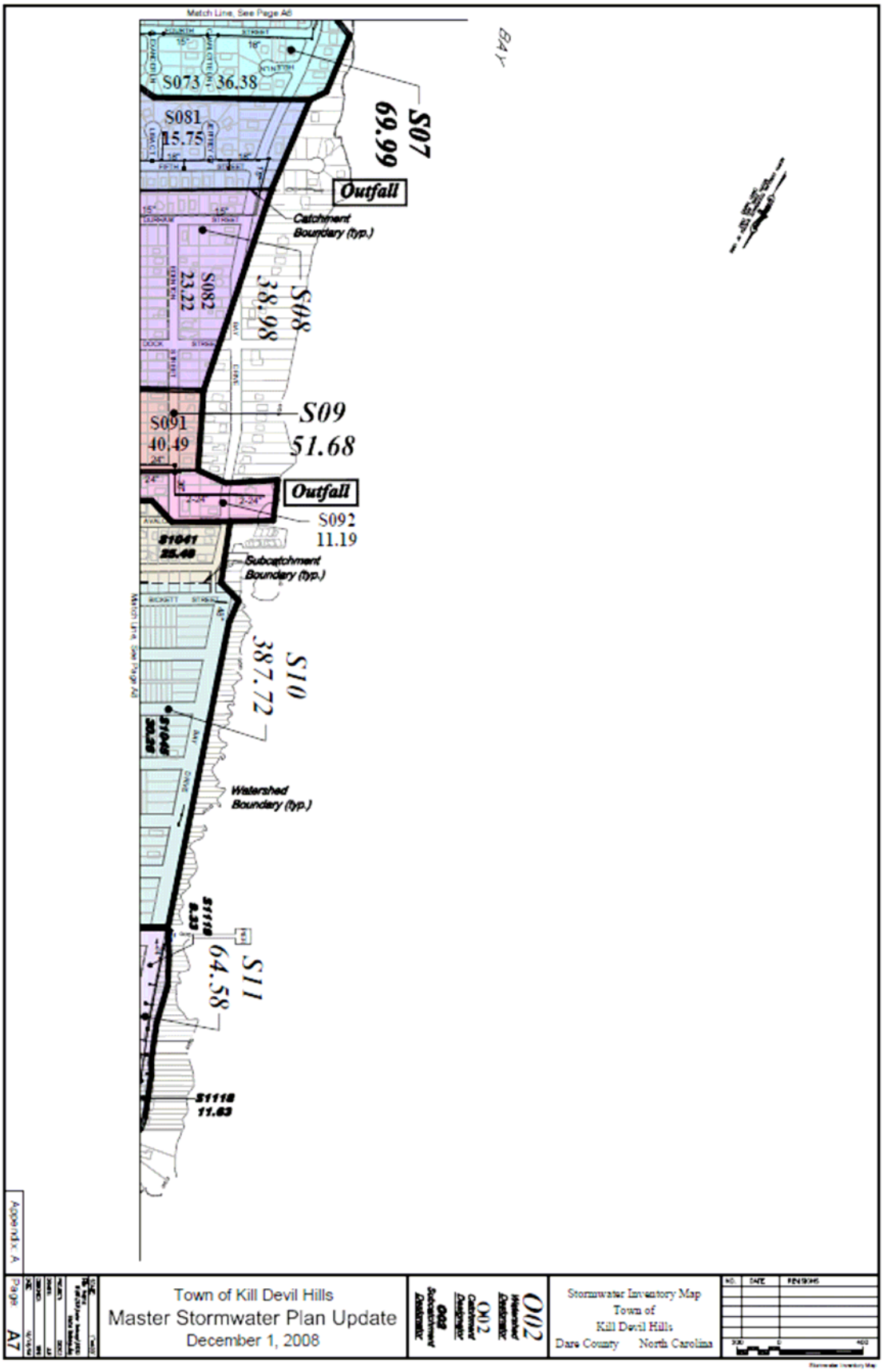

Appendix A

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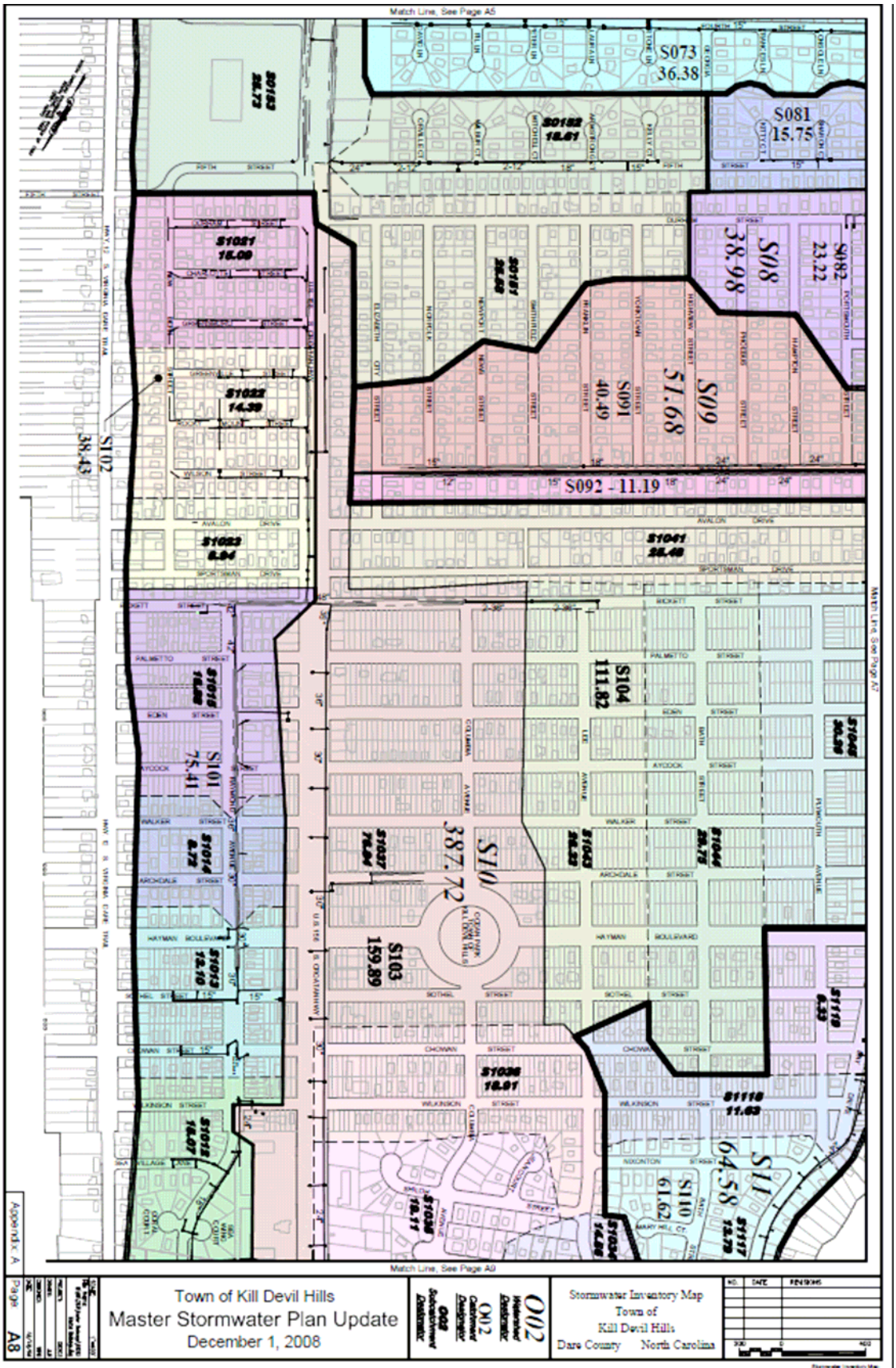
Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008

Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina

NO.	DATE	REVISIONS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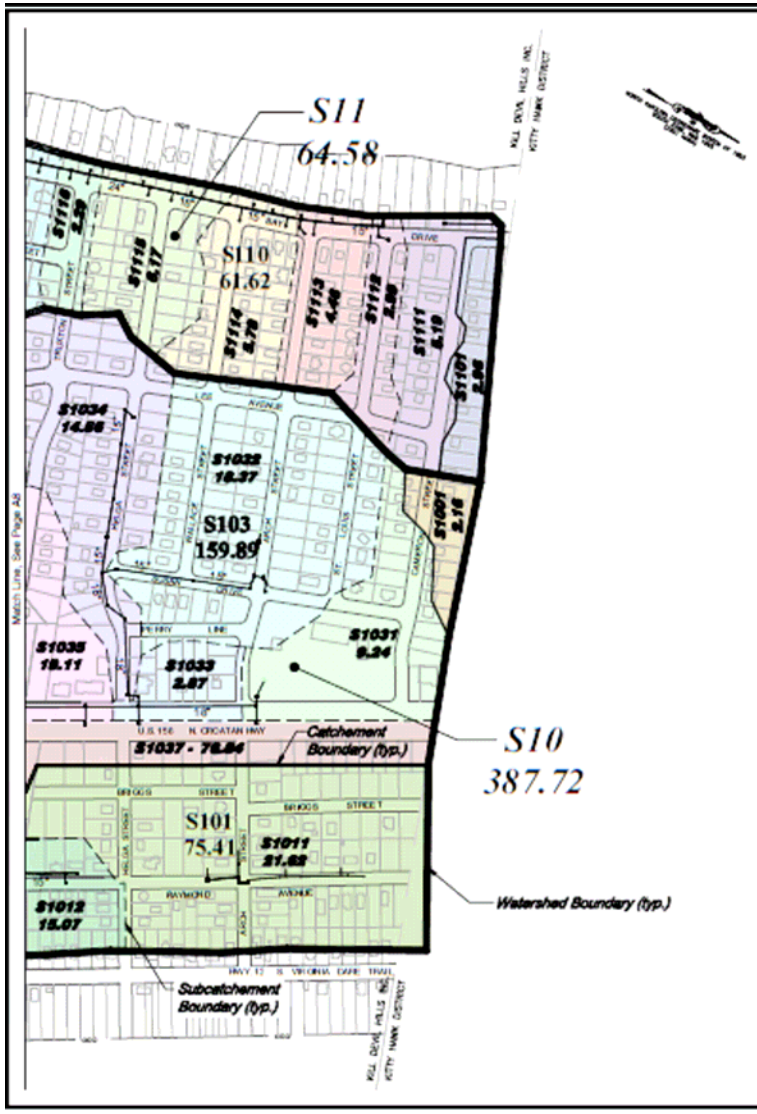
S073
36.38
S081
15.75
S082
23.22
S08
38.98
S09
51.68
S091
40.49
S092 - 11.19
S102
38.43
S101
75.41
S10
387.72
S103
159.89
S104
111.82
S11
64.58
S110
61.62
Match Line, See Page A7
Match Line, See Page A9
Appendix A
Page A8
Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008
Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina



Stormwater Inventory Map
Town of
Kill Devil Hills
Dare County North Carolina

O02
Watershed Designator

O02
Catchment Designator

O02
Subcatchment Designator

Town of Kill Devil Hills
Master Stormwater Plan Update
December 1, 2008

APPENDIX D

STORMWATER SYSTEM EVALUATION

Stormwater System Evaluation

Town of Kill Devil Hills, NC
Department of Public Services

Area Being Rated:	Entire Town of Kill Devil Hills
Rater's Name:	W. P. Burkhimer, Jr., P. E.
Date of Rating:	July, 2008
Remarks	Initial Town-wide Rating to SubCatchment Level (for Stormwater Master Plan)

O for Ocean, S for Sound	Watershed Number (2 digits)	Catchment	Subcatchment	Structure # / Point # (2 digits)	Normally Zero	S for Structure, P for Pipe, D for Ditch, W for Waterbody	Component Identifier	Area Served (acres)	Type: PIPE CMP, CAP, HDPE, RCP STRUCTURE CB, DI, MH, FES, END	Special: PIPE BIT, SMOOTH, SOCK STRUCTURE TILT, RIPRAP,84016	Num: (leave blank if single) DBL, TRPL, QUAD	Size: (no spaces or " or ' marks) PIPE diam, in ellpt, in x in arch, in x in STRUCTURE LHDI, STD, ft x ft	Structural Condition: 0 (collapsed) to 30(new)	Appearance / Fits Setting: 0 (disgusting) to 15 (perfect)	Capacity: Pro-rate by % of ability to carry 10-year Flow. 0 to 40	Maintenance Status: 0 (clogged) to 15 (fully open)	Rating: Sum of All 4 Rating Factors	Remarks: Limit to 20 Characters; don't duplicate info from previous columns
											Yellow shading: This line represents an entire WATERSHED							
											Green shading: This line represents an entire CATCHMENT							
											Blue shading: This line represents a SubCatchment							
											Pink shading: This rating for this parameter represents a Serious Deficiency							
S	01	0	0	00	0		S0100	673.29									0	NCDOT Canal, Memorial to Sound
S	01	0	1	00	0	D	S0101	71.72					25	15	30	10	80	Wright Memorial
S	01	0	2	00	0		S0102	654.49									0	reserved, further Wright breakdown
S	01	0	3	00	0	P	S0103	16.83	HDPE			24	20	10	35	10	75	Seagull Ct / Anchor Ct / Harpoon Ct
S	01	0	4	00	0	P	S0104	18.43	CMP			15	25	13	10	8	66	McCabe Pl / Small Pl
S	01	0	5	00	0	P	S0105	5.92	HDPE			15	25	13	40	10	88	N Side Cedar Dr near Ketch La
S	01	0	6	00	0	P	S0106	13.39	HDPE			24	25	13	40	13	91	Dogwood La
S	01	0	7	00	0	P	S0107	6.86	HDPE			18	25	13	40	10	88	Froelich Pl
S	01	0	8	00	0	P	S0108	13.72	HDPE			18	25	13	25	10	73	W First St near Ketch La
S	01	0	9	00	0	P	S0109	22.17	CMP			18	15	10	15	8	48	W First St near Bay Dr
S	01	0	A	00	0	P	S010A	18.83	HDPE			24	20	13	35	10	78	Canal Dr / Monument La / Pirate's Loop
S	01	1	0	00	0		S0110	71.30									0	158 W Side Ditch, South
S	01	1	1	00	0	P	S0111	1.37	CMP			15	20	10	40	5	75	S side Colington, 158 to Mustian
S	01	1	2	00	0	D	S0112	4.81					25	13	40	10	88	N side Colington, 158 to opp TownHall
S	01	1	3	00	0	P	S0113	2.99	CMP			24	20	15	40	8	83	Wright Ave Crossing of 158
S	01	1	4	00	0	P	S0114	1.90	CMP			24	20	15	40	8	83	Aviation Ave Crossing of 158
S	01	1	5	00	0	P	S0115	3.62	CMP			24	25	15	40	8	88	Sutton Ave Crossing of 158
S	01	1	6	00	0	P	S0116	3.54	CMP			24	20	15	35	8	78	Raleigh Ave Crossing of 158
S	01	1	7	00	0	P	S0117	4.15	CMP			24	20	15	30	8	73	Baker Ave Crossing of 159
S	01	1	8	00	0	P	S0118	48.92	CMP			42	25	10	25	8	68	Park, Aviation, W Right & 158
S	01	2	0	00	0		S0120	70.40									0	158 E Side Ditch, South (Mem Blvd)
S	01	2	1	00	0	P	S0121	18.61	CMP			24	10	8	25	10	53	Mem Blvd, Sutton & South
S	01	2	2	00	0	P	S0122	20.22	CMP			24	15	8	15	10	48	Mem Blvd, Carlow thru Woodmere
S	01	2	3	00	0	P	S0123	20.36	CMP			42	20	10	25	10	65	Woodmere Ave
S	01	2	4	00	0	P	S0124	11.21	CMP			54 x 72	20	13	15	8	56	Salem Ave (158 arch pipe crossing)
S	01	3	0	00	0		S0130	39.03									0	158 E Side Ditch, Middle
S	01	3	1	00	0	P	S0131	10.16	HDPE			12	25	15	30	15	85	E Landing Dr
S	01	3	2	00	0	P	S0132	5.98	CMP			18	20	15	30	13	78	Harbour Ct / Yardarm Dr
S	01	3	3	00	0	P	S0133	22.90	CMP			24	20	10	20	8	58	Tanya, Veelee, Coral
S	01	5	0	00	0		S0150	304.72									0	158 W Side Ditch, North
S	01	5	1	00	0	P	S0151	25.58	HDPE			15	10	10	10	8	53	West Avalon, Southeast (Durham St)
S	01	5	2	00	0	P	S0152	18.61	CMP			24	20	15	25	10	70	W 5th St, First 5 Courts
S	01	5	3	00	0	P	S0153	25.73	CMP			36	15	15	10	10	50	158 E Side, Kmart
S	01	5	4	00	0	P	S0154	20.56	CMP			15	10	10	5	8	33	Movie Theater
S	01	5	5	00	0	P	S0155	18.92	HDPE			15	15	8	15	8	46	Long Lakes / Sobel / Bobby Lee
S	01	5	6	00	0	P	S0156	11.58	CMP			48	25	13	30	13	81	Sir Walter N, P Ann N and Second St
S	01	5	7	00	0	P	S0157	33.67	CMP			36	20	10	10	10	50	Third / Dolly /Creek

Stormwater System Evaluation

Town of Kill Devil Hills, NC
Department of Public Services

Area Being Rated	Entire Town of Kill Devil Hills
Rater's Name	W.P. Burkhimer, Jr., P.E.
Date of Rating	July, 2008
Remarks	Initial Town-wide Rating to SubCatchment Level (for Stormwater Master Plan)

D for Ocean, S for Sound	Watershed Number (2 digits)	Catchment	Subcatchment	Structure # / Point # (2 digits)	Normally Zero	S for Structure, P for Pipe, D for Ditch, W for Waterbody	Component Identifier	Area Served (acres)	Type: PIPE CMP, CAP, HDPE, RCP / STRUCTURE CB, DI, MH, FES, END	Special: PIPE BIT, SMOOTH, SOCK / STRUCTURE TILT, RIPRAP,84016	Num: (leave blank if single) DBL, TRPL, QUAD	Size: (no spaces or " or ' marks) PIPE diam, in; elipt, in x in; arch, in x in / STRUCTURE LHDI, STD, ft x ft	Structural Condition: 0 (collapsed) to 30 (new)	Appearance / Fits Setting: 0 (disgusting) to 15 (perfect)	Capacity: Pro-rate by % of ability to carry 10-year Flow, 0 to 40	Maintenance Status: 0 (clogged) to 15 (fully open)	Rating: Sum of All 4 Rating Factors	Remarks: Limit to 20 Characters, don't duplicate info from previous columns
											Yellow shading: This line represents an entire WATERSHED							
											Green shading: This line represents an entire CATCHMENT							
											Blue shading: This line represents a SubCatchment							
											Pink shading: This rating for this parameter represents a Serious Deficiency							
S	01	5	8	00	0	P	S0158	20.03	HDPE			15	25	13	15	10	63	Indian Dr
S	01	5	9	00	0	P	S0159	37.42	CMP			36 x 54	25	15	5	13	58	Tern Ct / Dare Center
S	01	5	A	00	0	P	S015A	25.29	CMP			24	30	15	20	13	78	E First St and Princess Ann Rd, South
S	01	5	B	00	0	P	S015B	33.11	CMP			48	23	13	5	10	51	Live Oak Ct / Remele Pl / Hacker's / Mako
S	01	5	C	00	0	P	S015C	18.09	CMP			48	20	10	5	8	43	158, First to Landing
S	01	5	D	00	0	P	S015D	5.00	CMP			15	20	15	35	10	80	Porthole Ct
S	01	5	E	00	0	P	S015E	11.09	CMP			15	25	15	20	13	73	E Side Pirates Loop / Landing Dr
S	03	0	0	00	0		S0300	27.52									0	Wright Woods Outfall, end of W First St
S	03	1	0	00	0	P	S0310	27.52	CMP			24	15	8	20	8	51	W First St / Parkwood Dr
S	04	0	0	00	0		S0400	18.57									0	Captains Cir Outfall, The Landing Sect 3
S	04	1	0	00	0	P	S0410	18.57	HDPE			15	23	10	20	10	63	Clipper Ct / Captains Cir
S	05	0	0	00	0		S0500	12.07									0	Cedar Dr Outfall, First Flight Vill Sect 3
S	05	1	0	00	0	P	S0510	4.19	CMP			15	15	8	35	10	68	Captains Dr / Cedar Dr, south portion
S	05	2	0	00	0	P	S0520	7.88	CMP			15	15	8	25	10	58	Captains Dr / Cedar Dr, north portion
S	06	0	0	00	0		S0600	52.99									46	Near Bay Dr / Indian Dr
S	06	1	0	00	0	P	S0610	42.48	HDPE			24	20	8	20	10	58	N Side Indian Dr, Apache St / Bay Dr
S	06	1	1	00	0	P	S0611	15.45	HDPE			12	20	8	15	10	53	North Half Apache St, Third St / Indian Dr
S	06	1	2	00	0	P	S0612	5.13	HDPE			12	15	10	10	10	47	South Half Apache St, Third St / Indian Dr
S	06	1	3	00	0	P	S0613	21.90	HDPE			12	15	8	5	10	38	N Side Indian Dr, Bay Dr / Upper Dune Rd
S	06	2	0	00	0	P	S0620	10.51	CMP			18	20	8	15	10	53	S side Indian Dr, Bay Dr / Apache St
S	07	0	0	00	0	P	S0700	69.96									40	Outfall near Clamshell Dr / W Fourth St
S	07	1	0	00	0	P	S0710	19.73	CMP			15	13	8	10	8	39	W Third St, Sea Swept Rd / Bay Dr
S	07	2	0	00	0	P	S0720	13.85	CMP			15	15	10	5	10	40	Clam Shell Dr, Sioux St / Bay Dr
S	07	3	0	00	0	P	S0730	36.38	CMP			15	15	13	3	10	41	W Durham St, West of Portsmouth St
S	08	0	0	00	0	P	S0800	38.97	CMP		DBL	18	20	13	15	10	58	W Fifth St Outfall
S	08	1	0	00	0	P	S0810	15.75	CMP			18	20	15	40	10	85	W Fifth St, West of Georgia Ln
S	08	2	0	00	0	P	S0820	23.22	CMP			15	10	10	10	8	38	W Durham St, West of Highview St
S	09	0	0	00	0		S0900	51.68									64	W Avalon Dr Outfall, Bay Dr / Edenton St
S	09	0	1	00	0	P	S0901	40.49	HDPE			24	25	5	20	10	60	Suffolk St Ditch, S Side
S	09	0	2	00	0	P	S0902	11.19	HDPE			24	25	5	40	10	80	Suffolk St Ditch, N Side
S	10	0	0	00	0		S1000	387.69									0	W Bickett St Outfall
S	10	0	1	00	0		S1001	2.16	INFILTRATION				5	5	20	10	40	E of Lee Ave, N of Cameron St
S	10	1	0	00	0		S1010	75.41									0	Raymond Ave
S	10	1	1	00	0	P	S1011	21.62	CMP			24	20	5	20	8	53	N Raymond Ave, to Briggs St ditch

Stormwater System Evaluation

Town of Kill Devil Hills, NC
Department of Public Services

Area Being Rated	Entire Town of Kill Devil Hills
Rater's Name	W. P. Burkhimer, Jr., P. E.
Date of Rating	July, 2008
Remarks	Initial Town-wide Rating to SubCatchment Level (for Stormwater Master Plan)

O for Ocean, S for Sound	Watershed Number (2 digits)	Catchment	Subcatchment	Structure # / Point # (2 digits)	Normally Zero	S for Structure, P for Pipe, D for Ditch, W for Waterbody	Component Identifier	Area Served (acres)	Type: PIPE CMP, CAP, HDPE, RCP / STRUCTURE CB, DI, MH, FES, END	Special: PIPE BIT, SMOOTH, SOCK / STRUCTURE TILT, RIPRAP,84016	Num: (leave blank if single) DBL, TRPL, QUAD	Size: (no spaces or " or ' marks) PIPE diam, in / elliot, in x in / arch, in x in / STRUCTURE LHDI, STD ft x ft	Structural Condition: 0 (collapsed) to 30 (new)	Appearance / Fits Setting: 0 (disgusting) to 15 (perfect)	Capacity: pro-rate by % of ability to carry 10-year Flow, 0 to 40	Maintenance Status: 0 (clogged) to 15 (fully open)	Rating: Sum of All 4 Rating Factors	Remarks: Limit to 20 Characters, don't duplicate info from previous columns
											Yellow shading: This line represents an entire WATERSHED							
											Green shading: This line represents an entire CATCHMENT							
											Blue shading: This line represents a SubCatchment							
											Pink shading: This rating for this parameter represents a Serious Deficiency							
0	10	1	0	01	0	P	01A10	15.00	CMP			24	26	10	15	10	66	E. Helen St / E Wilkinson St

Rating Guide, Stormwater System Evaluation, Town of Kill Devil Hills, July, 2008

	Structure	Pipe	Swale System	Ditch/Culvert System	Major Canal or Pond
Structural Condition					
0	Complete failure	Complete failure	No definition, road lower	System or component failed	Extensive Major Bank Erosion; Control Structure Failed
5	Much damage, many leaks	Much damage, many leaks	No definition, road higher	Whole system is "poor"	More than 50% of bank eroded
10	Serious damage, some leaks	Serious damage, some leaks	Missing invert or backslope	Whole system is "fair"	25% to 50% of bank eroded
15	Moderate damage	Moderate damage	Weak invert or backslope	Many problem areas	10% to 25% of bank eroded
20	Light damage; exposed bar, cracks or chips	Light damage, crushing, lost coating	Fair config and backslope	Several bare, unstable or other problem areas	Numerous areas of minor erosion
25	Some age but good condition	Some age but good condition	Good config and backslope	Few unstable spots or bad transitions/end treatments	Few areas of minor erosion
30	Nearly new, no defects	Nearly new, no defects	Ideal configuration, good backslope height	Well defined and stabilized, appropriate end treatments	Recently Cleaned Out; Fully Stabilized
Appearance / Fits Setting					
0	Very poor, needs action	End treatment created dangerous condition	Totally out of place	Totally out of place	Dangerous and Aesthetically objectionable
5	Damaged, or dangerous in its (ankle buster, wrong grate)	Ends poor, awkward or none	Inappropriate appearance	Inappropriate appearance	Moderately objectionable appearance and/or odor
10	Cosmetic blemishes	Ends OK, not ideal	Slightly awkward appearance	Slightly awkward appearance	Generally satisfactory
15	Looks fine	Visible end treatments are ideal for setting	Looks good, fits well with adjacent property	Looks good, fits well with adjacent property	Looks fine; aesthetics are positive
Capacity					
0	Totally restricted	1%-6% of 10-yr*	No definition or capacity at all	1%-6% of 10-yr*	Silted full; no storage
5	Almost totally restricted	6%-13% of 10-yr*	Drizzle puts water on road	6%-13% of 10-yr*	0-13% of 10-yr storage
10	About 80-85% restricted	13%-21% of 10-yr*	Light rain puts water on road	13%-21% of 10-yr*	13%-21% of 10-yr storage
15	About 70% restricted	21%-30% of 10-yr*	0.1"/hr storm contained	21%-30% of 10-yr*	21%-30% of 10-yr storage
20	Significant Restriction	30%-40% of 10-yr*	0.25"/hr storm contained	30%-40% of 10-yr*	30%-40% of 10-yr storage
25	Moderate restriction	40%-53% of 10-yr*	0.5"/hr st0om contained	40%-53% of 10-yr*	40%-53% of 10-yr storage
30	Minor restriction	53%-65% of 10-yr*	1"/hr storm contained	53%-65% of 10-yr*	53%-65% of 10-yr storage
35	Very minor restriction	65%-80% of 10-yr*	2.5"/hr storm fully contained	65%-80% of 10-yr*	65%-80% of 10-yr storage
40	Unrestricted	80%-100+% of 10-yr*	4"/hr storm fully contained	80%-100+% of 10-yr*	80%-100+% of 10-yr storage

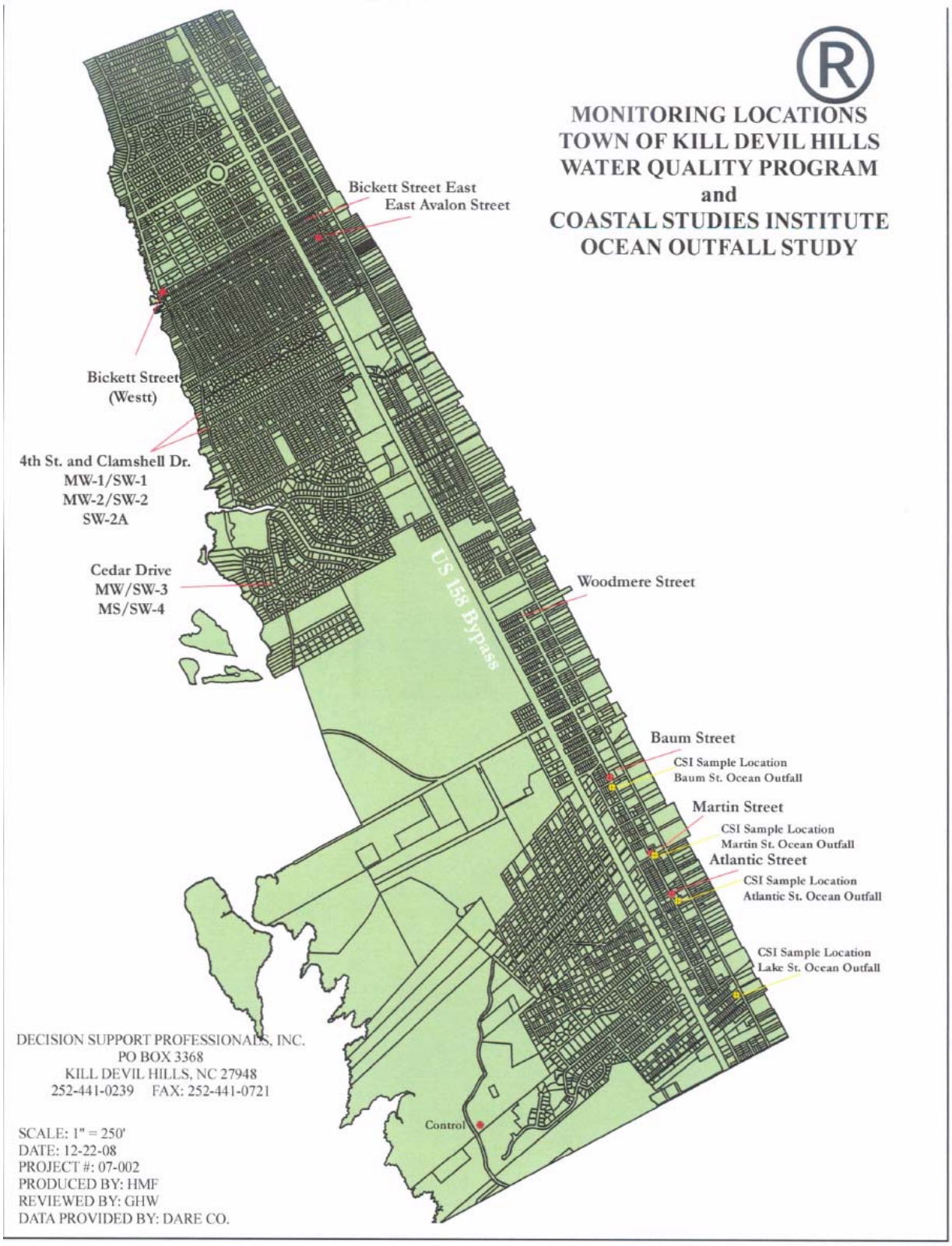
Uprate 5 to 10 points if in a high-elevation, sandy area where less capacity is needed.

Matintenance Status

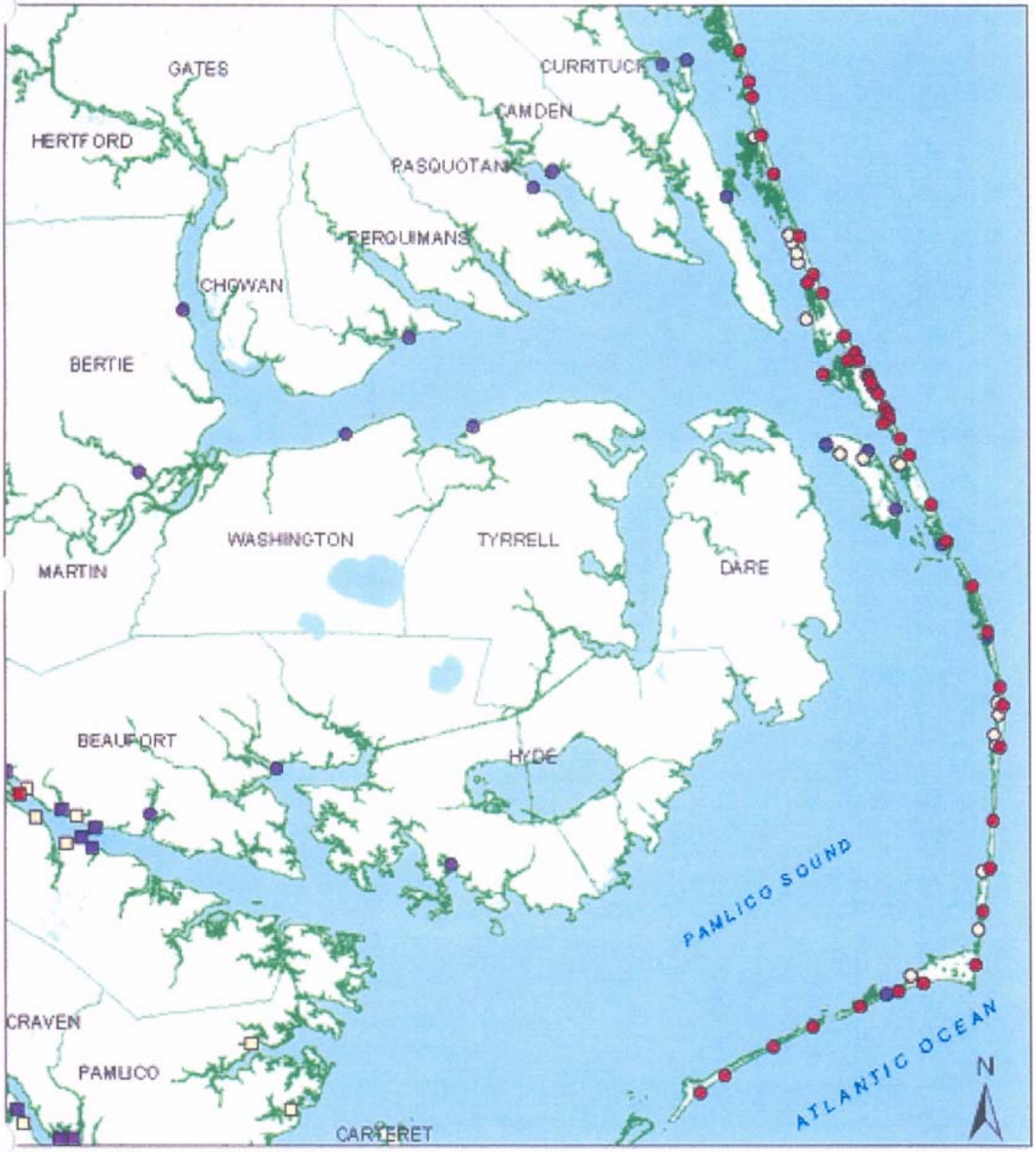
0	Needs immediate, major work	Needs immediate, major work	Completely obstructed	Needs immediate, major work	Needs immediate, major work
5	Plugged/blocked > 50%	Blocked > 50%	Major buildup, or manmade obstructions, between drives	Blocked > 50%	Significant portions need cleanout
10	Needs cosmetic maintenance	Minor sediment deposits, etc.	Some drives hold some water	Minor sediment deposits, etc.	Minor sediment deposits, etc.
15	Maintained like new	Maintained like new	Maintained like new	Maintained like new	Maintained like new

APPENDIX E

WATER QUALITY SAMPLING LOCATION MAPS

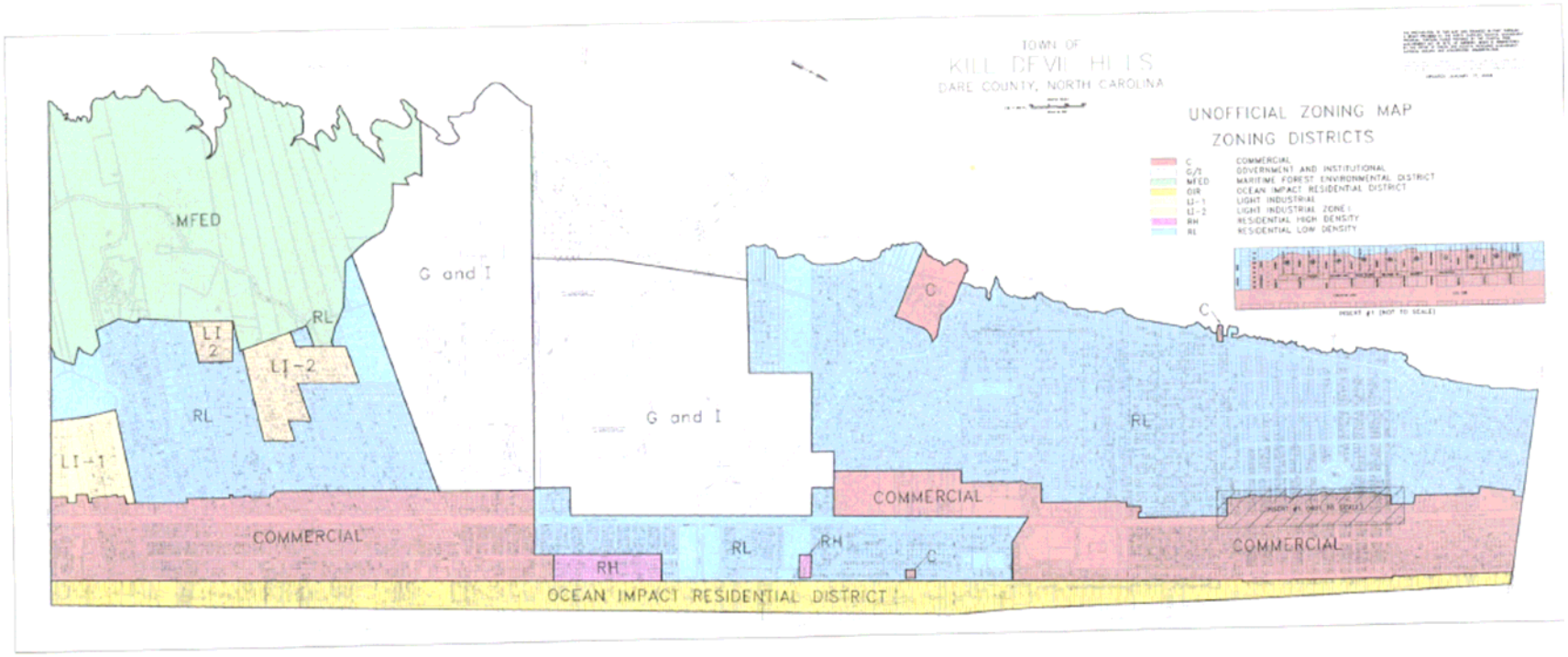

MONITORING LOCATIONS
TOWN OF KILL DEVIL HILLS
WATER QUALITY PROGRAM
and
COASTAL STUDIES INSTITUTE
OCEAN OUTFALL STUDY
Bickett Street East
East Avalon Street
Bickett Street
(Westt)
4th St. and Clamshell Dr.
MW-1/SW-1
MW-2/SW-2
SW-2A
Cedar Drive
MW/SW-3
MS/SW-4
US 158 Bypass
Woodmere Street
Baum Street
CSI Sample Location
Baum St. Ocean Outfall
Martin Street
CSI Sample Location
Martin St. Ocean Outfall
Atlantic Street
CSI Sample Location
Atlantic St. Ocean Outfall
CSI Sample Location
Lake St. Ocean Outfall
Control
DECISION SUPPORT PROFESSIONALS, INC.
PO BOX 3368
KILL DEVIL HILLS, NC 27948
252-441-0239 FAX: 252-441-0721
SCALE: 1" = 250'
DATE: 12-22-08
PROJECT #: 07-002
PRODUCED BY: HMF
REVIEWED BY: GHW
DATA PROVIDED BY: DARE CO.

NC Recreational Water Quality Program - Northern Region



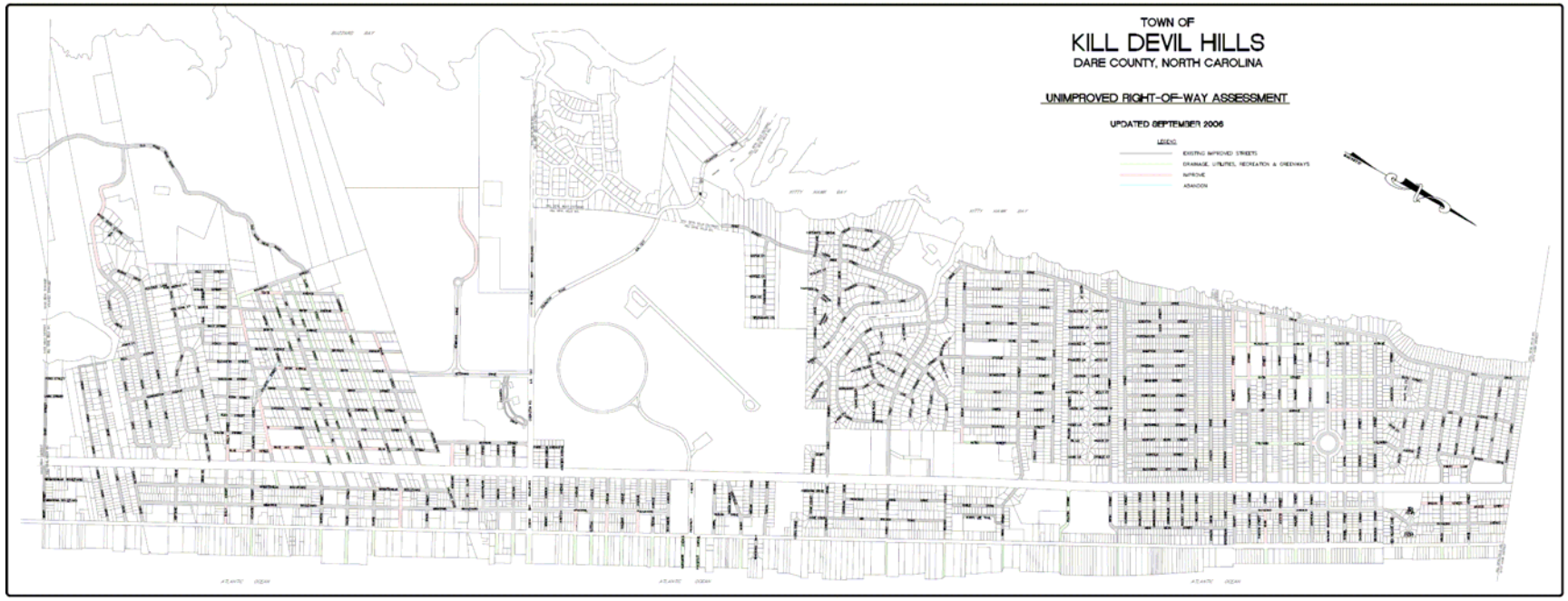
APPENDIX F

TOWN OF KILL DEVIL HILLS ZONING MAP


TOWN OF
KILL DEVIL HILLS
DARE COUNTY, NORTH CAROLINA
UNOFFICIAL ZONING MAP
ZONING DISTRICTS
C COMMERCIAL
G/I GOVERNMENT AND INSTITUTIONAL
MFED MARITIME FOREST ENVIRONMENTAL DISTRICT
OIR OCEAN IMPACT RESIDENTIAL DISTRICT
LI-1 LIGHT INDUSTRIAL
LI-2 LIGHT INDUSTRIAL ZONE I
RH RESIDENTIAL HIGH DENSITY
RL RESIDENTIAL LOW DENSITY
MFED
G and I
RL
LI 2
LI-2
RL
LI-1
COMMERCIAL
G and I
C
RL
COMMERCIAL
RL
RH
C
RH
COMMERCIAL
OCEAN IMPACT RESIDENTIAL DISTRICT

APPENDIX G

UNIMPROVED ROW ASSESSMENT MAP


TOWN OF
KILL DEVIL HILLS
DARE COUNTY, NORTH CAROLINA
UNIMPROVED RIGHT-OF-WAY ASSESSMENT
UPDATED SEPTEMBER 2006
LEGEND
EXISTING IMPROVED STREETS
DRAINAGE, UTILITIES, RECREATION & GREENWAYS
IMPROVE
ABANDON

APPENDIX H

EPA SWMM – HYDROLOGICAL MODELING RESULTS

Appendix H to Stormwater Master Plan Update:

Results of Hydraulic/Hydrologic Modeling, Watersheds S06 and S08

Town of Kill Devil Hills, NC – July 2009

I. **General**: As discussed in the Stormwater Master Plan Update itself, two of the Town's 14 watersheds were selected for detailed stormwater modeling. This Appendix presents the results of that effort.

II. **Watersheds Selected**: After careful consideration, and consultation with the Department of Public Services, the following watersheds were selected. A more detailed description of the watersheds may be found in the main document, in paragraph III.C., around page 27 for S06 and page 31 for S08.

A. **S06**: Watershed S06 consists of 52.99 acres of residential land, including the west end of Indian Drive and several side streets, flowing generally westward via a system of open roadside ditches and swales (except for one closed system running down side lot lines from Apache Street to Upper Dune Road), discharging into Kitty Hawk Bay by way of a 24" HDPE pipe. Generally, the topography of S06 is a slight but definite fall in the direction of the outfall.

B. **S08**: Watershed S08 consists of 38.51 acres of residential land, including the west end of Fifth Street and the four courts which intersect it, along with the west end of Durham Street and the southern half of the four cross streets that intersect it. Durham has an open ditch and culvert pipe system, while Fifth is entirely an enclosed pipe system. Each flows west to its intersection with Bay, cross Bay, then turn to flow toward a common point where flow west to Kitty Hawk Bay in a twin-18" pipe system followed by an open ditch down side/rear lot lines. Like S06, S08's topography is a slight slope generally toward the Bay.

C. These two watersheds were selected for the following reasons:

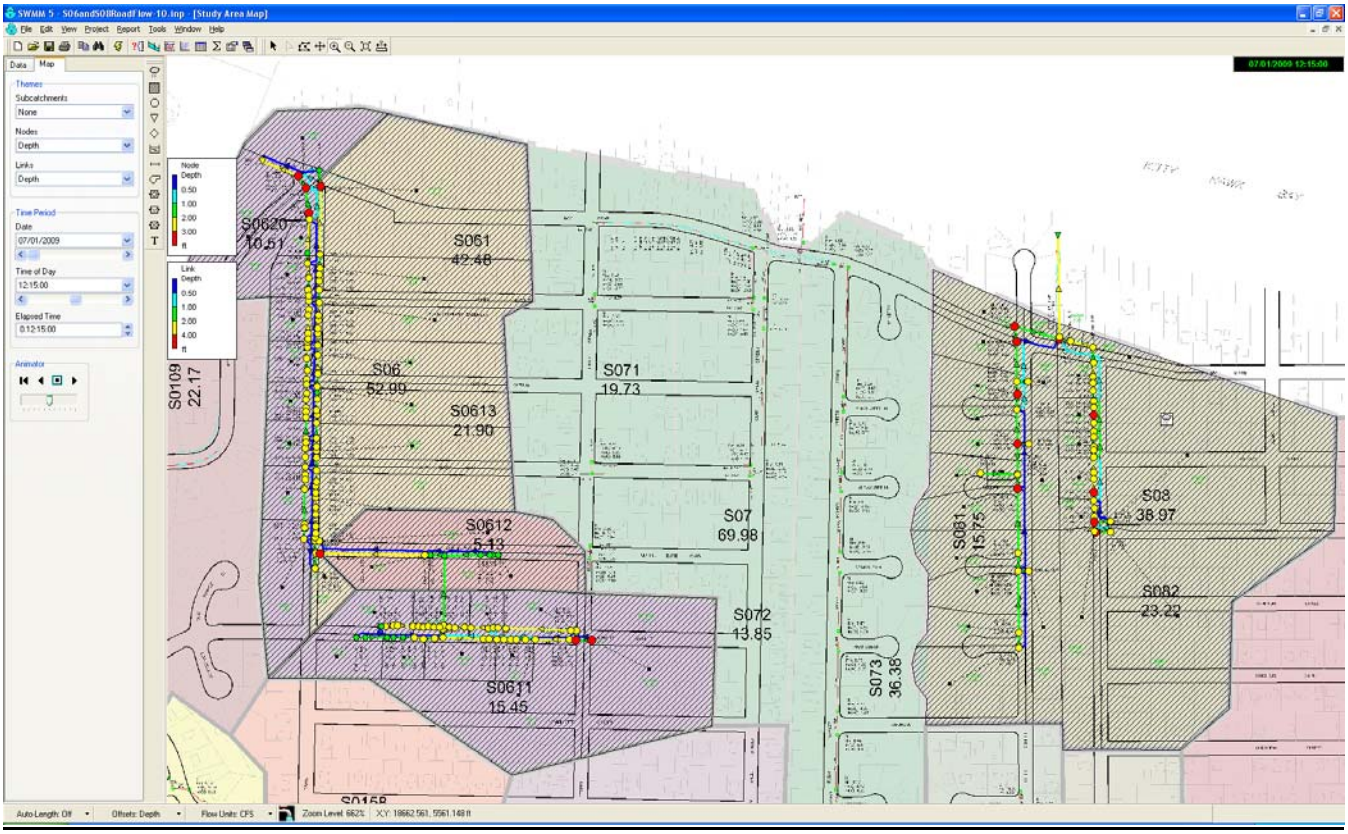
1. They contain representative examples of two of the Town's prevalent types of stormwater systems, "roadside ditches and culverts" and "piped drainage systems" as described in Section III.B of the main document.

2. Their relatively modest size made them appropriate for a first phase of a hydraulic modeling effort, as a considerable effort is often needed to "tune" the modeling techniques to an area's unique hydraulic characteristics and calibrate the model to observed conditions. Due to the relatively poor ratio of capacity to 10-year runoff in these watersheds, the tuning and calibration effort did, in fact, prove to require considerable effort.

3. Selecting one of the ocean outfall watersheds was deemed inadvisable until the results of the CSI modeling effort (see main document).

III. Methodology:

A. **Software**: The Stormwater Management Model software published by the United States Environmental Protection Agency (USEPA) was used. Specifically, EPA SWMM 5.0 was employed. The following is a screen shot of the Network Map screen from EPA SWMM 5.0; particularly showing the junctions and conduits 15 minutes after the peak of the 10-year rain event.



1. **Rainfall**: The source of rainfall data was "POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14 KILL DEVIL HILLS N M, NORTH CAROLINA." This document gives the total rainfall **volume**, in inches, for statistical storms of recurrence intervals ranging from 1 year to 1,000 years, and for **durations** ranging from 5 minutes to 60 days. One can calculate an average rainfall **intensity** in inches per hour, by dividing the rain **volume** in inches by the **duration** in hours. For example, on the 10-year event, 1.11" may fall in 10 minutes, or 6.66 inches/hour, but for a whole hour only 2.66" will fall, or 2.66 inches per hour. In other words, the extremely high **intensity** 6.66 in/hr rate (perhaps the worst 15 minutes of a very bad thunderstorm) wouldn't keep up for a whole hour. This table of information is presented in the main document and which may accessed at the following web link: http://dipper.nws.noaa.gov/hdsc/pfds/orb/nc_pfds.html.

2. **Hyetograph Derivation**: For each of the 2-year, 10-year and 100-year rainfall events, the volume vs. duration data is extrapolated to generate a table of rain rate (in/hr) vs. time throughout t 24 hour simulation day, beginning at midnight. The resulting graph is called a "hyetograph," or raingraph. Every 10 minutes, a value of instantaneous rain intensity is generated, with an assumption that the most intense rain occurs at the very middle of the event ("noon") and that the rain pattern is symmetrical (same rain rate occurs at 11 a.m. as 1 p.m., same at 10 a.m. as 2 p.m., etc.) In our experience, the exact time pattern or shape of the simulation event is not very important; what is important is that the correct total amount of rain is accounted for, and that the effects of the sharp peak of intense rain embedded within the overall "storm" are accounted for. Our hyetograph passes both tests.

3. **Runoff Generation**: The rainfall pattern of the hyetograph is applied to each portion (drainage area) of each subcatchment. Depending on the parameters of the drainage area and the rain pattern, some of the flow soaks into the ground, with the rest generating surface runoff. The runoff, in turn, is simulated to flow across the surface to a junction or node in the pipe/ditch network, where it may join other flows from other areas.

a. There are several widely-used methods of calculating the amount of infiltration, so that the remaining runoff can be generated. We chose Horton's equation

b. This method is based on empirical observations showing that infiltration decreases exponentially from an initial maximum rate to some minimum rate over the course of a long rainfall event. Input parameters required by this method include the maximum and minimum infiltration rates, a decay coefficient that describes how fast the rate decreases over time, and the time it takes a fully saturated soil to completely dry (used to compute the recovery of infiltration rate during dry periods).

c. The most important parameter in Horton's equation is the infiltration rate. For this value, we generally used 20 inches per hour for the better drained soils in the watersheds.

d. The amount of rain infiltrated vs. running off, for each storm, is presented below:

Year Storm	Runoff (inches - %)	Infiltration (inches - %)	Total Rain (inches)
2	1.60 – 40%	2.42 – 60%	4.03
10	2.67 – 40%	4.03 – 60%	6.71
100	4.12 – 40%	6.19 – 60%	10.31

4. **Stormwater Routing**: Once runoff is generated and arrives at each node, the process of computing how much water flows in which direction, through which ditch or pipe, versus how much rises up and is stored as surface ponding, and how much arrives at the final outfall at each time interval, is all called Stormwater Routing. A complex, dynamic balancing act between flow (possibly between multiple possible flow paths) and storage, takes place. Fortunately, these computations which would take weeks to accomplish by hand are accomplished in about 2-3 minutes per simulation run by the EPA SWMM software. Our simulations have good storage and routing continuity error percentages of les than 2%, which is excellent for a model with many short conduits (ditches and pipes). The Dynamic Wave method of routing was used, which is best suited for complex systems such as this.

5. **"Road Flow"**:

a. **General**: In a stormwater/storm drainage system, the normally desirable outcome is that the system itself—in this case, the roadside pipes and ditches—carry the flow from a "design storm" of some frequency. A 5-year or 10-year event is frequently used. It is recognized that when a stronger storm occurs, the system will carry all it can but will be overtaxed and stormwater will rise up and spill out of the ditch banks onto roads and lawns. We call that "flooding." If it's of short duration, shallow depth and low velocity, it is a minor inconvenience to be tolerated for an hour or two once every 5 or 10 years. Certainly, deeper, long-duration flooding and high-velocity flooding are serious problems which threaten property and even life and safety.

b. **S06 and S08**: The two watersheds, and probably most areas of Kill Devil Hills, have stormwater conveyance systems which can carry only 10% to 25% of the runoff from a 10-year event. Even a 2-year event substantially exceeds the carrying capacity of many components of these systems. Fortunately, when runoff exceeds the capability of the defined roadside pipe and ditch systems, it is typically able to flow on the shoulders, on the roads themselves, and in the front portion of lawns. We are calling this phenomenon "road flow" for purposes of this study.

c. **Modeling**: We tried several approaches to modeling what actually happens when roadside systems such as this are overtaxed. We lacked sufficiently précised topographic data to try to model the ponding of stormwater in localized low areas. We tried several options which assumed such ponding capacity was distributed throughout each area, but

concluded the approach could not be defended. We settled on the approach of including the roadways themselves as broad, shallow flow channels, where flow begins only once the water surface in the pipe/ditch systems rose up to meet the road shoulder elevation. This gave credible results and stable modeling performance.

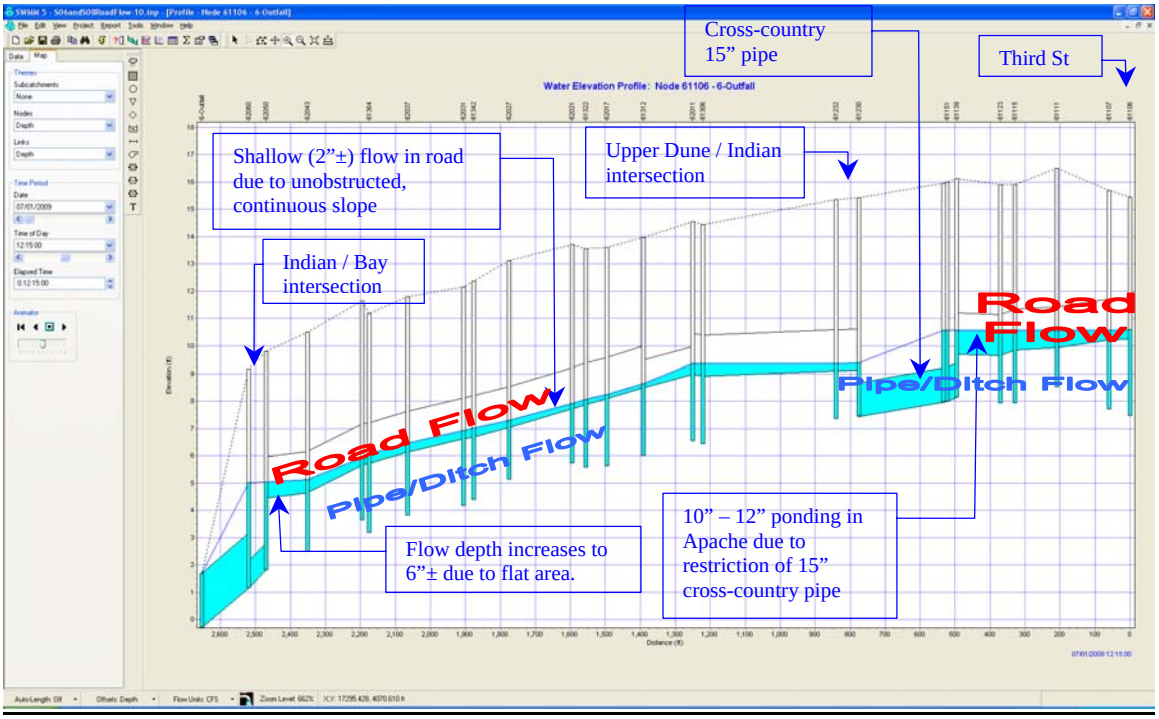
d. **Depth of Ponding**: Whether or not such flow on Town roads is acceptable depends on how deep, for how long, and how often.

i We found that, as long as the roads in question slope generally downhill in the direction of the watershed's outfall, the depth and duration of ponding seemed acceptable on all storms. See a specific example below.

ii If a key road is generally falling toward the outfall, but includes a low spot followed by a rise in elevation, or a prolonged flat spot, the depth of ponding tended to increase from acceptable to undesirable levels. The more pronounced the adverse grade or "dip", the worse the effect would be.

iii There are a few cases where the "safety valve" of road flow is not available. For example, Apache Street flows toward the middle of its block, then "cross country" through an enclosed pipe down side lot lines to Upper Dune Road. By the time the water surface would rise high enough mid-block in Apache to begin sheet-flowing across to Upper Dune, water would be deeper in Apache than desirable.

e. **Apache / Upper Dune / Indian**: As an example of the road flow effect, see the annotated graph below. It covers from the Apache/Third Street intersection, through the connector to Upper Dune, then south to Indian, then west to Bay and the outfall.



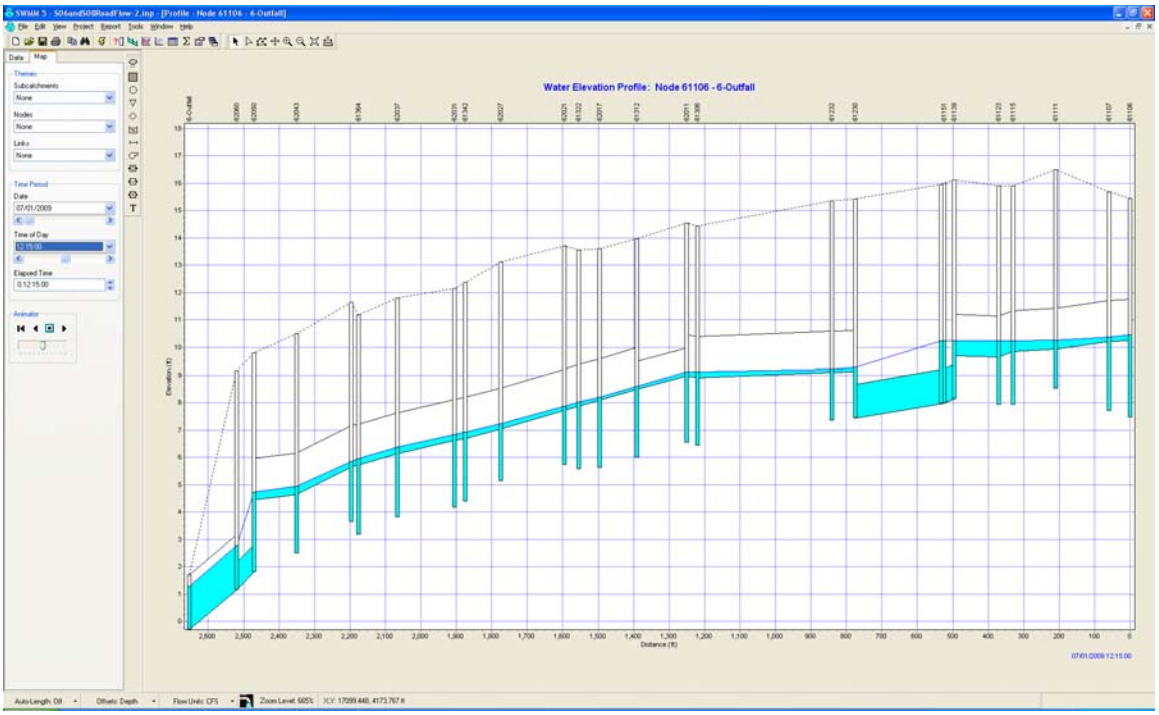
10-year; "road flow" zones are labeled in red, pipe or ditch flow zones in blue.

(Note: The profile graph above and all below are at Time 12:15, or 15 minutes after the peak of the rain event. This generally coincides with the time of greatest flow and water depth. The gridlines for the vertical axis of each graph represent a 1' interval of elevation. Gridlines for the horizontal axis represent distance along the route; the S06, Apache/Upper Dune/Indian profile graph appears compressed because it represents a greater distance.)

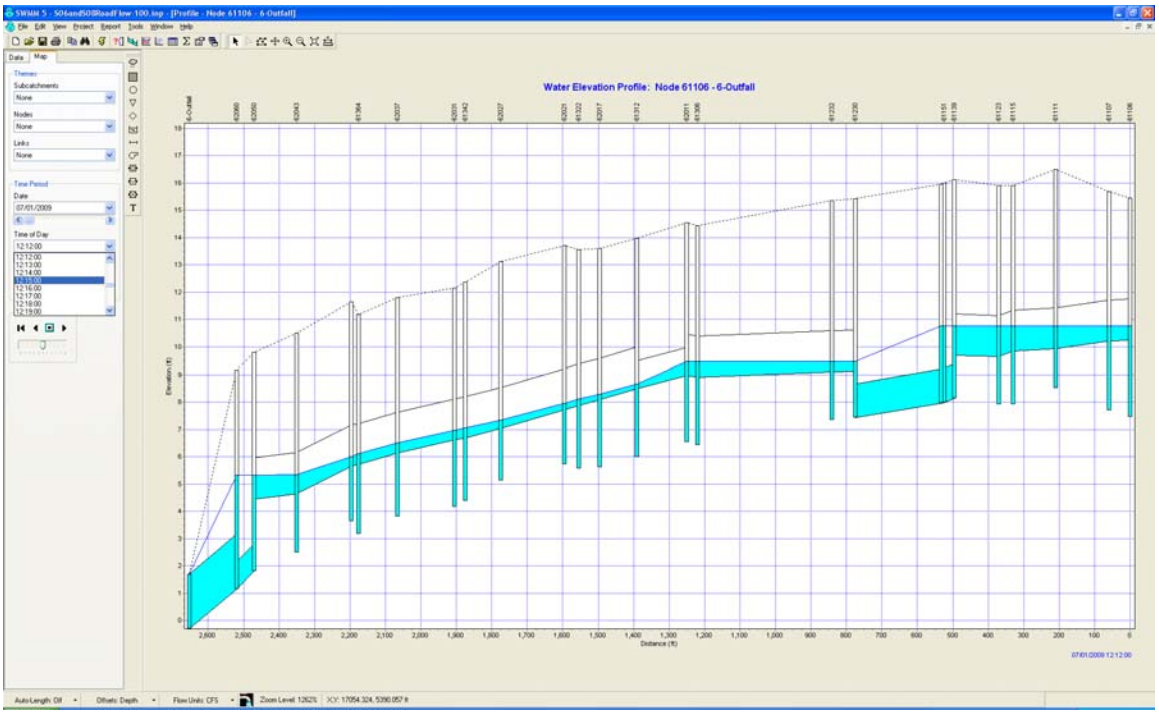
IV. **Conclusions**: Our findings and recommendations, as a result of this modeling effort, are as follow:

A. The observations along the backbone of the S06 network (Apache / Upper Dune / Indian) can be generalized to the whole Town: We should search for low spots and spots where there is limited potential for relief by surface flow. In such areas, there is the potential for capacity failures to result in flooding 1' to 2' deep or more, not just nuisance flooding of a few inches deep. These areas can be identified by looking at the topographic information we do have, by field observation, by inquiries of maintenance staff, and from complaint records.

B. The difference in performance between the 10-year storm (6.7" of rain), the 2-year (4.3" of rain) and the 100-year (10.3" of rain) is not as great as we might have anticipated. Compare the two graphs below (2-year followed by 100-year) with the 10-year on the previous page:

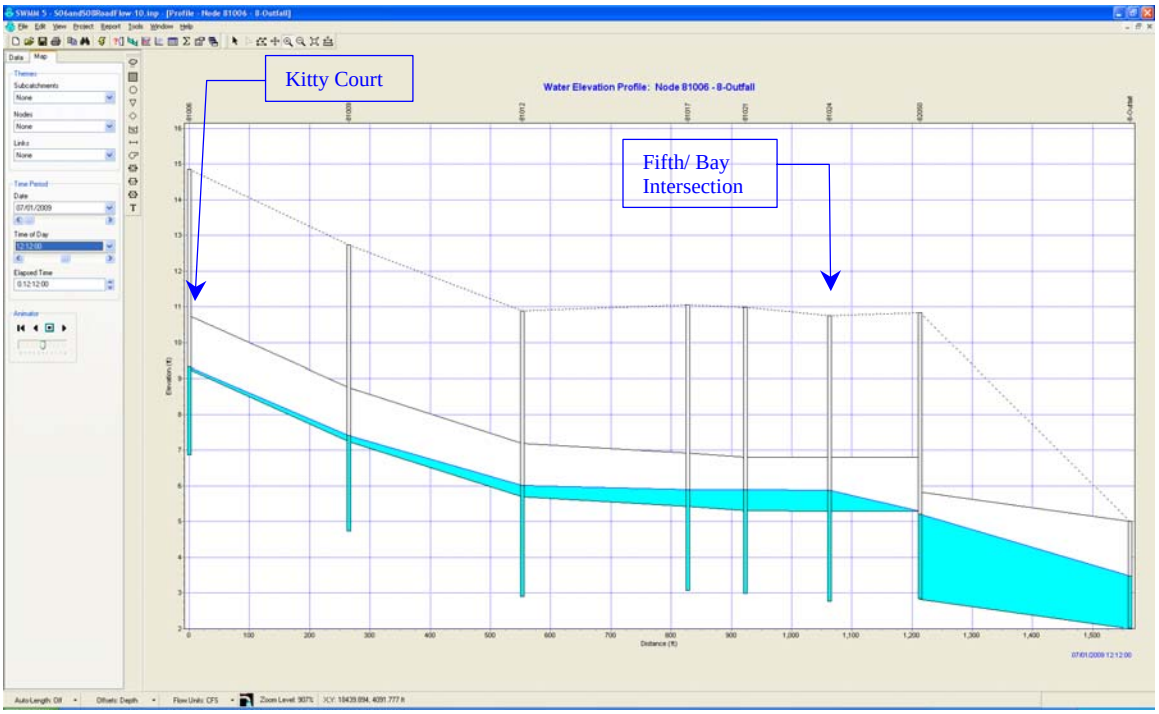


2-year; maximum ponding in Apache Street is about 7", vs. 10" to 12" on the 10-year event.

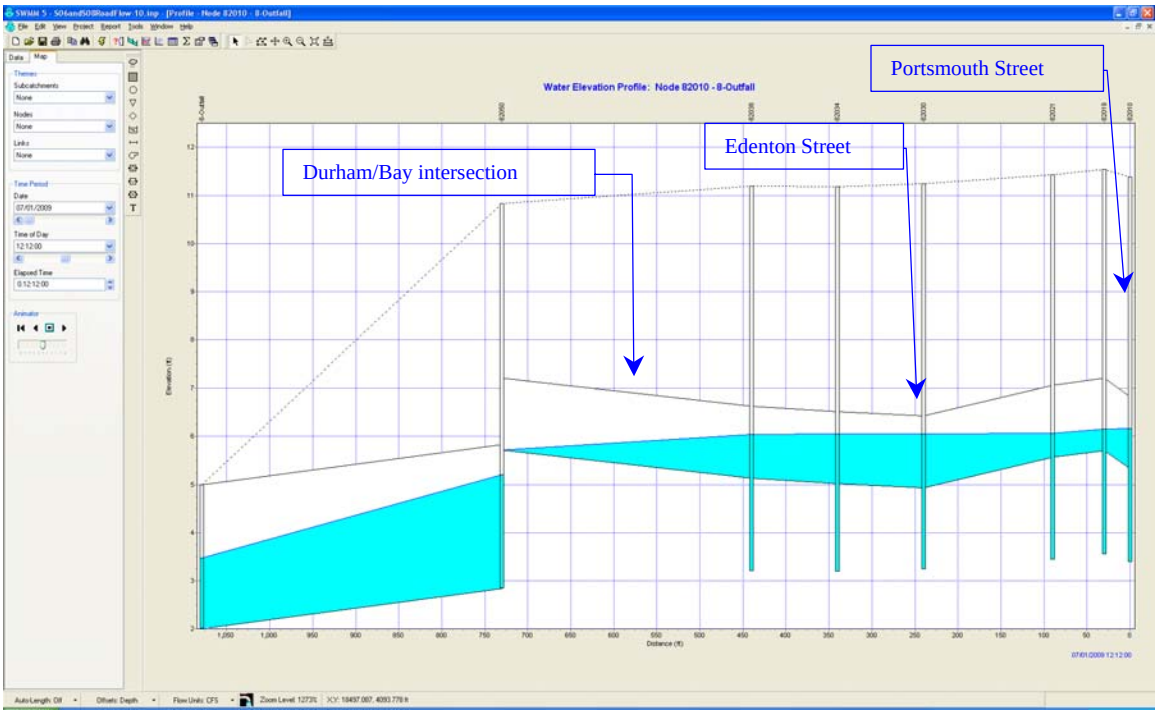


100-year; maximum ponding in Apache Street is about 14”, vs. 10” to 12” on the 10-year event.

C. The effect of deeper flow or ponding where the road flattens out or turns to an up-grade can be seen in the following graphs from S08:



Fifth Street, 10-year event. In the steeper areas to the west, Kitty and Sharon Courts (left end of plot), ditches and pipes are flowing full, and very shallow (1” to 2” deep) flow is occurring on the shoulder of the road and up into lawns to make up for pipe capacity shortfall. Moving downstream (rightward to middle of plot) to Lisa and Jeffrey Courts, total flow accumulates from upstream, slopes get flatter, but the pipes only get one size larger. The result is that flow on the shoulders, and now Fifth Street itself, gets deeper, reaching 4” to 6”. Approaching Bay Drive, the depth increases to 8” or 9” as the road elevation stays flat from the Bay/Fifth intersection to the point where the outfall departs Bay down a side/rear lot line.



<u>Durham Street</u>, 10-year event. Intersection of Durham and Edenton is about elevation 4.9, rising to about 5.3 at Durham/Bay and 5.5 on Bay where the outfall heads west. This adverse grade prevents the "road flow" effect from relieving the overtaxed Durham pipe system as well as it could. Real-life ponded depths are probably lesser if water from Portsmouth and Edenton Streets are have difficulty getting to the Durham system due to their poorly defined drainage.

D. The following improvements are recommended for S06:

1. The 240' cross-country pipe between Apache Street and Upper Dune Road should be upgraded from a 15" HDPE pipe to an 18" HDPE pipe, and a swale should be left above it down the common side lot lines (Culvert S61233-S61304). A larger pipe is suggested by the total flow, but we don't want to overload the downstream components. This is a moderate priority and should cost on the order of $12,000, not including design, construction administration or contingencies.

2. All culverts along the north side of Indian from Upper Dune to Bay, most of which are now 12" HDPE, should be replaced with 18" HDPE. These include the following: (S61306-S61305, S61305-S61307, S61307-S61308, S61308-S61309, S61310-S61311, S61312-S61313, S61314-S61315, S61319-S61321, S61322-S61323, S61324-S61325, S61326-S61327, S61328-S61329, S61340-S61341, S61342-S61343, S61344-S61345, S61346-S61347, S61360-S61361, S61362-S61363, S61364-S61365, S61365-S61370, S61370-S61372, and S61372-S62055, totaling about 575' of pipe. This is a lower priority and should cost on the order of $75,000, not including design, construction administration or contingencies.

E. The following improvements are recommended for S08:

1. The portion of the Fifth Street system from Jeffrey Court to Bay, and along Bay to the twin structure at the outfall, should be replaced with about 395' of 18" HDPE pipe (S81019-S81021, S81021-S81024, S81024-S81030 under Bay, and S81030-S82049). Even larger pipe, approximately 24", could be justified based on capacity to serve the drainage area, but would substantially increase the load on the outfall. This is a lower priority and should cost on the order of $20,000, not including design, construction administration or contingencies.

2. The eight 15" culverts in Durham, about 260' in total length, from Edenton to Bay and along Bay leading into the twin structure at the outfall, should be replaced with 18" HDPE pipe (Culverts S82048-S82049, S82046-S82047 under Bay, S82040-S82041, S82038-S82039, S82036-S82037, S82034-82035, S82032-S82033, S82024-S82030). Even larger pipe, approximately 24", could be justified based on capacity to serve the drainage area, but would substantially increase the load on the outfall. Detention opportunities should be considered in contributing Portsmouth and Edenton Streets. This is a moderate priority and should cost on the order of $30,000, not including design, construction administration or contingencies.

F. A pause in the modeling of additional watersheds should be taken, to give the opportunity for this model to be calibrated with observed conditions during very heavy bursts of rain. We propose to have a representative be poised to visit, observe and photograph S06 and S08 in any rain event appearing to have intensities of 2 in/hr or more. Particular attention will be paid to depth of flow in the roadside systems and the "road flow" phenomenon.

G. To model accurately the road flow effect, it became necessary to do a limited topographic survey of the key roadways (Apache, Upper Dune, Indian, Bay, Fifth and Durham). The existing county LiDAR-derived topography was not sufficiently precise; this should be factored in to future modeling efforts.

H. In summary, the modeling effort has reinforced our knowledge, originally gained through the Drainage Inventory and Rating process, that most components of the Town's drainage system have flow capacities of less than 25% (and many as low as 3% to 20%) of the 10-year runoff rate the receive. The resulting system-wide "failure" is often less severe than might be expected due to KDH's generally good soil infiltration rates, flat topography with opportunities for flat, relatively harmless ponding, and due to the "road flow" discussed above. Since a rebuild of the Town's whole drainage infrastructure is unlikely, it seems prudent to seek out depressed areas where "road flow" can't provide relief, or where some other "weak link" in the system creates a constriction and threatens to result in deeper ponding than typical.

Such an effort to identify and correct weak links should become ingrained in the ongoing thinking of the Town's Engineer and Public Services staff. Detection of problems, and of solution opportunities, may be integrated into the planning of drainage- and non-drainage capital projects, the carrying out of maintenance activities, the review of private development projects, and other activities.

APPENDIX I

GIS DECISION SUPPORT MODEL
DATA INVENTORY AND USER GUIDE

Decision Support Professionals Inc.
presents:

Kill Devil Hills Stormwater Model Training

Using CommunityViz 360

Course contents

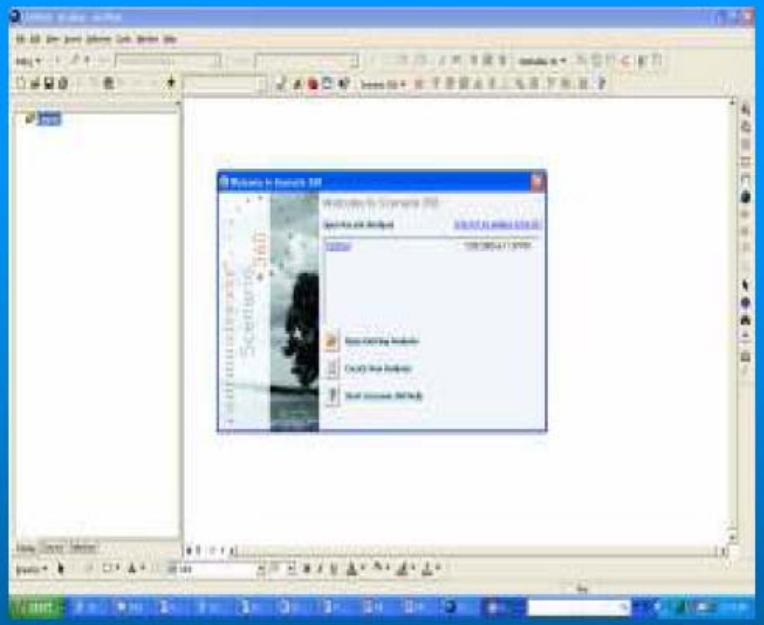
- Overview: Using the Stormwater Model
- Lesson 1: Opening a Project
- Lesson 2: Creating a proposed Development
- Lesson 3: Evaluating a proposed Development
- Lesson 4: Modifying a proposed Development
- Lesson 5: Generating Reports

Overview

- In addition to a traditional stormwater plan, a decision support model was incorporated in the Plan whose goal is to aid the decision makers when reviewing proposed development or changes in development and its impact potential impacts to the stormwater conveyance systems and current regulations.

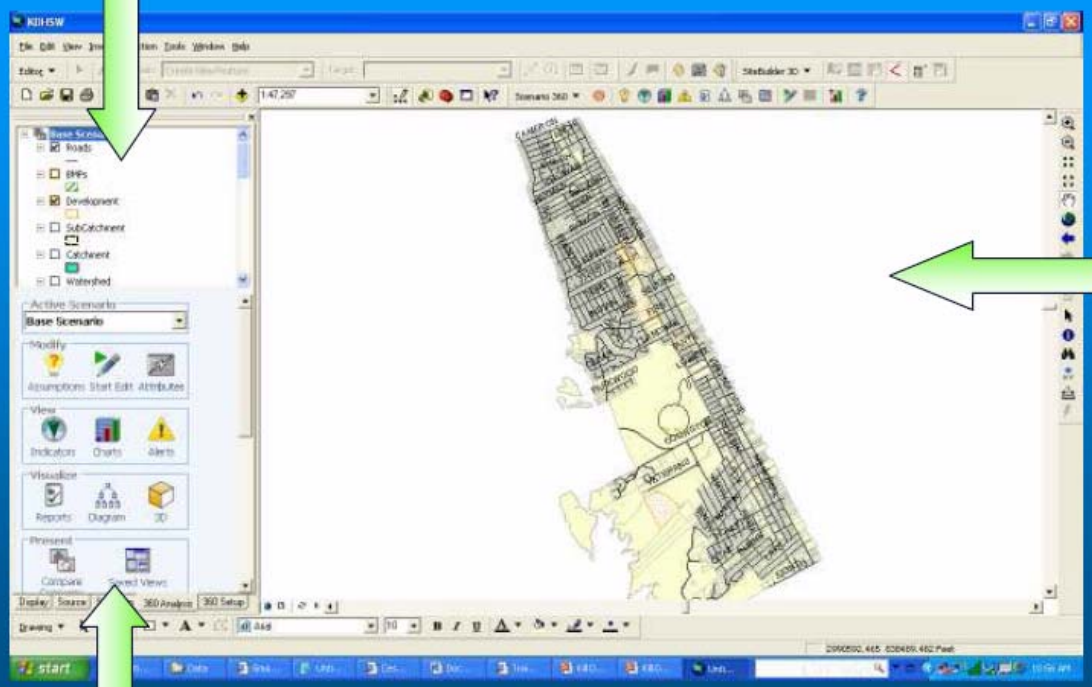
- This model has been developed using Geographic Information System (GIS) and CommunityViz an extension of ArcGIS and is a visual tool which can review "what if" scenarios before implementing them. The existing information and new information provided by the models and stakeholder input aided in the development of the Plan's final recommendations including regulatory, maintenance, capital improvement projects, opportunity areas and other strategies to improve the effectiveness of the Town's conveyance systems.

Lesson 1: Opening the Project



- Open CommunityViz 360 from your Windows Start menu
- Select "Open existing Analysis" and navigate to "KDHSW" or Select "KDHSW" if shown in recent analysis window

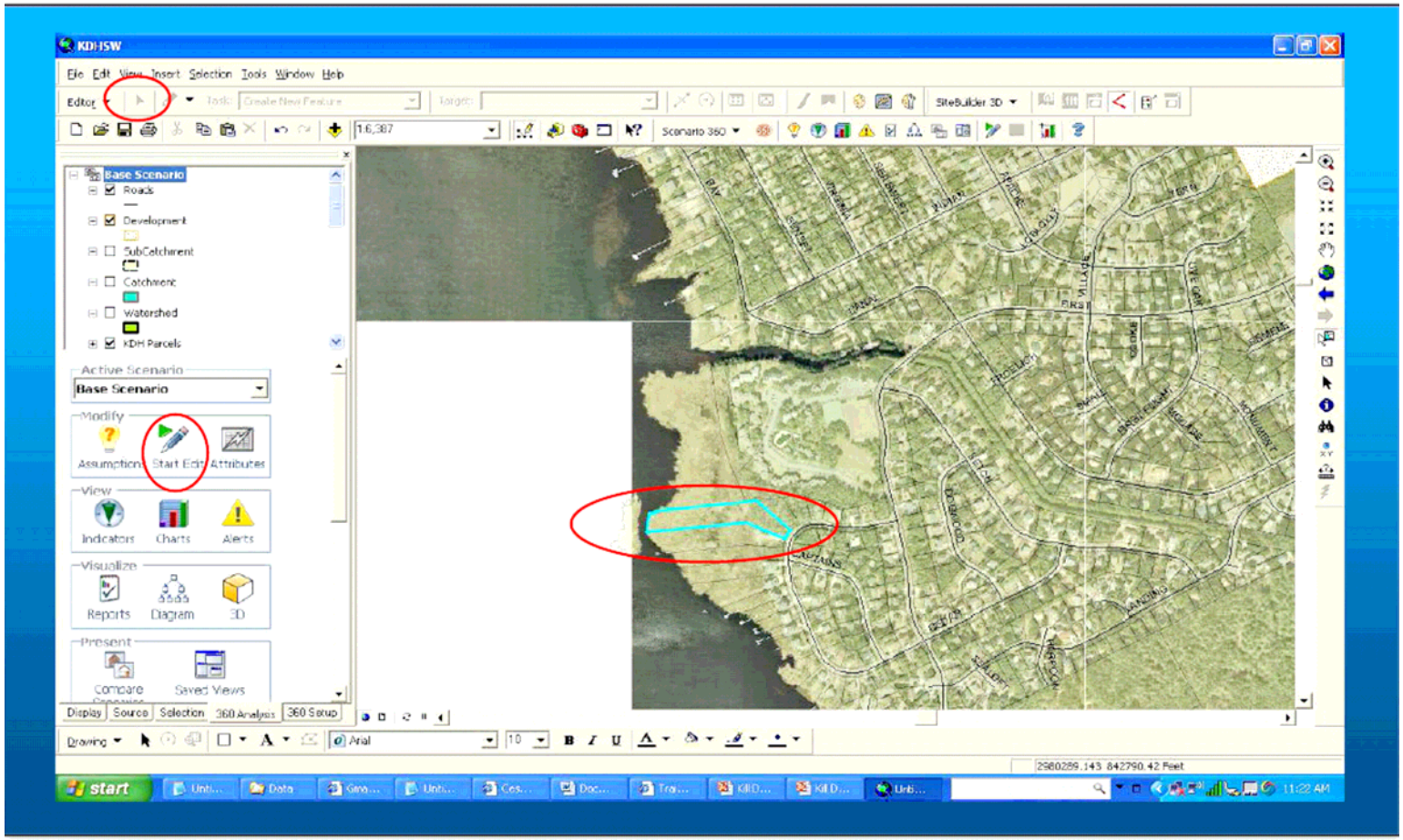
Lesson 1: Opening the Project



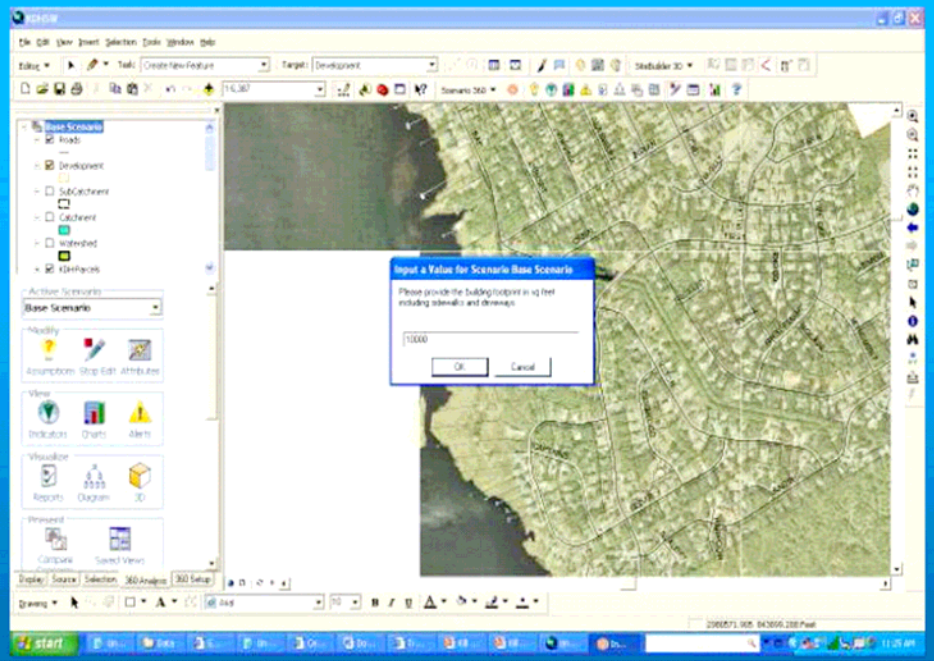
Lesson 2: Creating a Proposed Development

- Zoom into the area where the proposed development will be placed
- Turn on the parcel data layer for boundary reference
- Make sure the "360 Analysis" tab is selected below the CommunityViz tools
- Then click the "Start Edit" button in the CommunityViz tools
- Make sure the "edit tool" is selected in the ArcView edit tool bar
- Click the parcel you want to develop and the boundary should change color to indicate that it has been selected
- Right click your mouse within the parcel boundary and select "copy", repeat the right mouse click again and this time select "paste"
- The system will begin modeling this parcel and will ask the user to provide input parameters for calculating purposes

Lesson 2: Continued

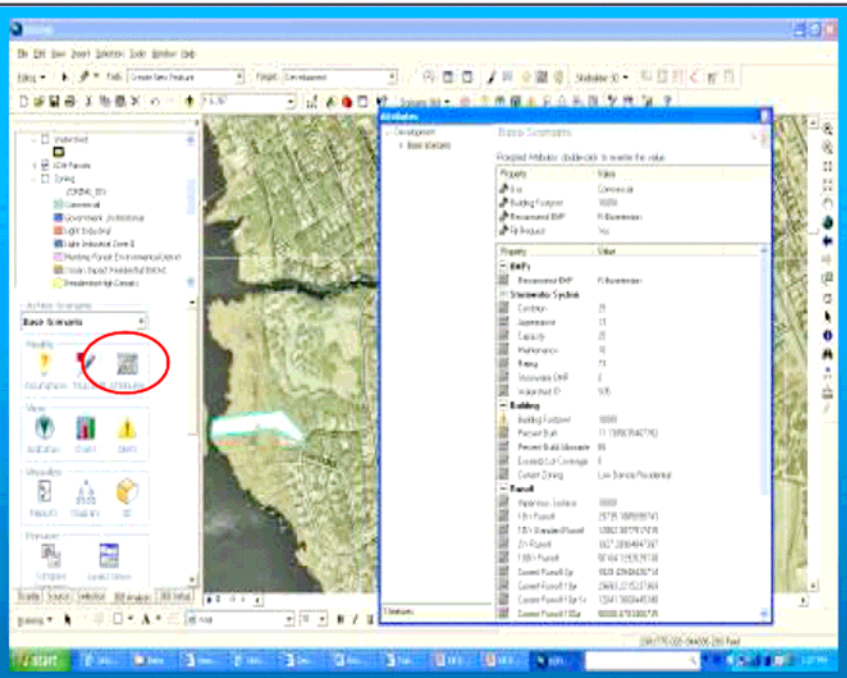


Lesson 2: Continued



- The model will ask a series of question
- Provide building footprint in sq feet, including sidewalks and driveways
- Provide answer to question – Will the site require more fill than required by the State Health Dept.
- Provide the proposed land use
- Select from list of recommended BMP's at that location

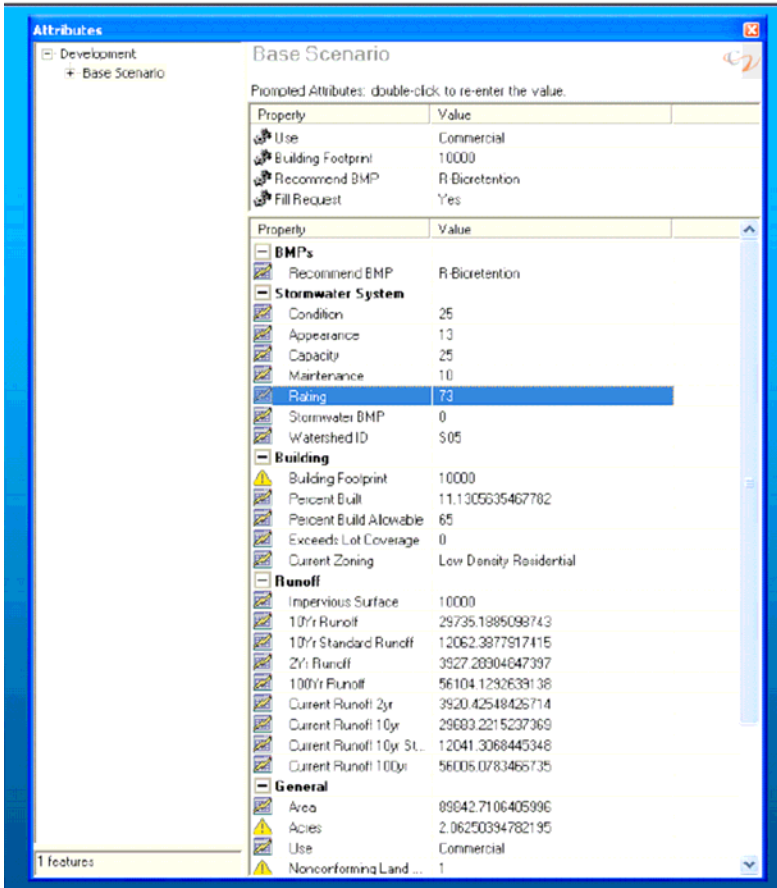
Lesson 3: Evaluating a Proposed Development



Once you have completed drawing the proposed development, you can evaluate the modeling results.

- Click the "Attributes" button in the CommunityViz tools. This will open a window that displays the categorized attributes of the newly proposed development.

Lesson 3: Continued



The attributes are divided into 6 categories (User Inputs, BMP's, Stormwater System, Building, Runoff, and General).

- User Inputs provides lists the inputs the user provided at the beginning of the model run
- BMP's are the user selected BMP's that the model recommended
- Stormwater System provides the engineer ratings for different categories of the current stormwater infrastructure
- Building provides information pertaining to coverage, zoning, or and footprint of the development
- Runoff provides the current runoff and new runoff in gallons produced from the development.

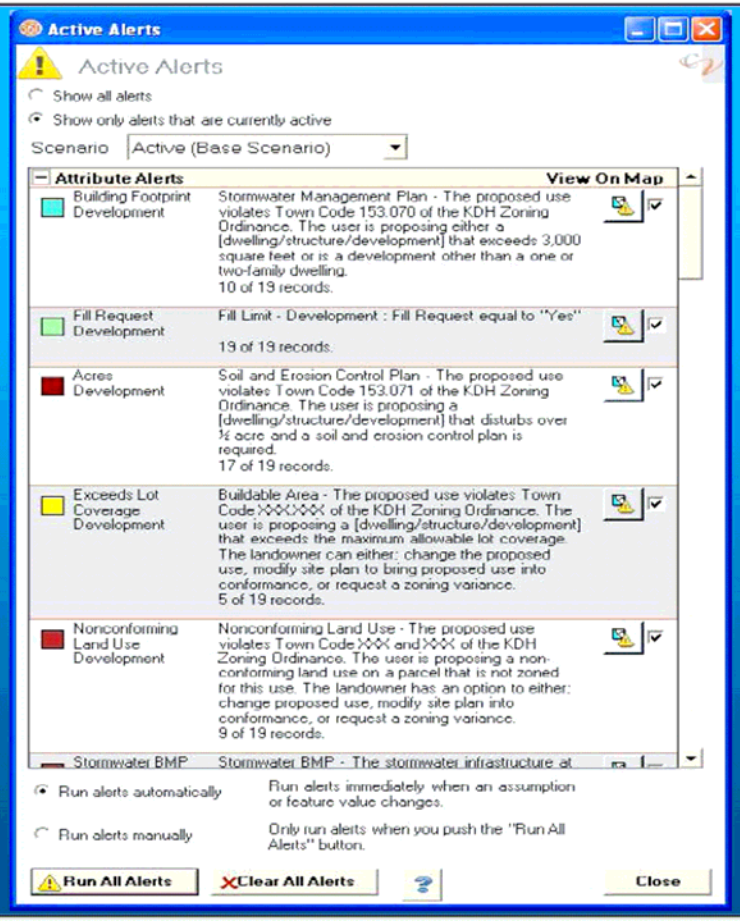
Lesson 3: Continued

Attributes that display a small yellow symbol with an explanation mark indicate that an alert has been triggered for this attribute. An alert notifies the user of a potential conflict or alerts them to pay particular attention to an issue produced by this development.

You can also view all the alerts for a particular development by clicking the "Alerts" button in the CommunityViz tools.

- First click "Stop Edit" in the CommunityViz tools, it will ask if you want to save your edits, select yes.
- Next click the "Alerts" button in the CommuntyViz tools

Lesson 3: Continued



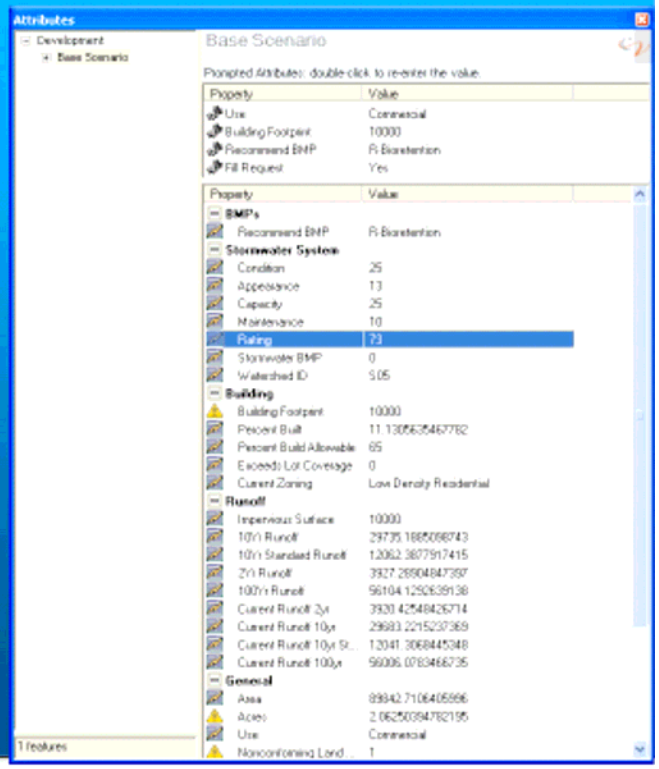
The Active Alerts window provides 6 alerts, stormwater management plan, fill request, soil erosion, buildable area, nonconforming land use, and stormwater BMP.

Each of the alerts provides a detailed description of the alert and provides a town code number for the zoning ordinance that may have been violated.

By clicking on the check button next to the alert you can see which alerts your development has violated. If your development is highlighted in the color next to the alert, it has violated that alert.

Lesson 4: Modifying a Proposed Development

- To modify an existing development click the "Start Edit" button in the CommunityViz tools
- Next click the "Attributes" button in CommunityViz to open the attributes window
- Select your development by clicking on it
- Double click any of the attributes in the top portion of the window to change their values and recalculate the impacts of the development



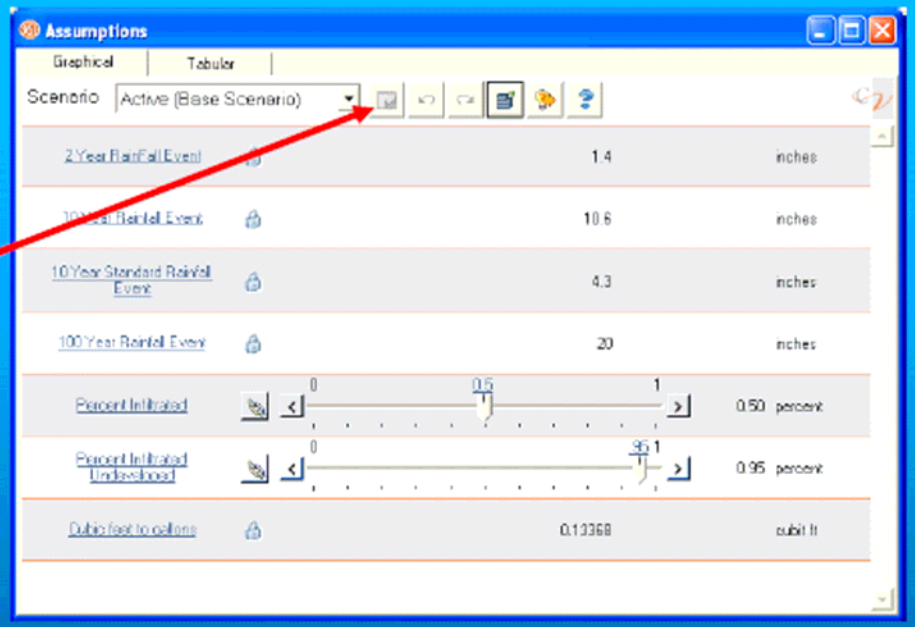
Lesson 4: Continued

Some of the calculation involved in the stormwater model use certain assumptions, some these assumptions are fixed, such as inches of rain in a 10 year rainfall event. Other assumptions are considered variable and can be changed by the user.

- By clicking on the "Assumptions" button in the CommunityViz tools you can open the fixed and variable assumptions.
- Variable assumptions will be indicated by a slider bar that can be moved to adjust the assumption measurement. There are two variable assumptions with this model for rainfall infiltration on undeveloped land and percent of water infiltrated on a given development.

Lesson 4: Continued

You can adjust the slider bar and click the "Apply Assumption Changes" button.



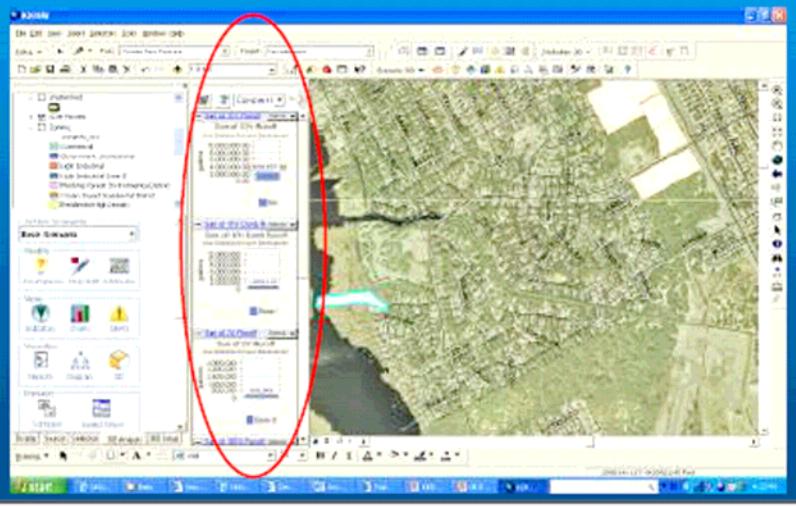
This will update all of the proposed developments and recalculate their impacts based on the new assumption value.

Lesson 5: Generating Reports

Charting Indicators

There are four indicators for the four different rainfall events. These indicators keep a cumulative record of the total new runoff produced by a new development.

- Click the "Charts" button in the CommunityViz tools to open the assumptions in a chart indicating the total gallons of runoff



Lesson 5: Continued

Generate Reports

You can generate reports easily in CommunityViz to view file dependencies, assumptions, and attributes, or summarize and compare different scenarios.

- To generate a report click the "Reports" button in the CommunityViz tools. This will open a reporting wizard that will guide you through generating a report of your analysis.

Analysis File Dependency Report

The analysis KDHSW uses the following files. To transfer the analysis to another computer, you will need to transfer all of these files.

Analysis Folder
c:\CVFiles\KDHSW\

Data Layer Files
C:\Data\mapfldhazar_Project.dbf
C:\Data\mapfldhazar_Project.prj
C:\Data\mapfldhazar_Project.sbn
C:\Data\mapfldhazar_Project.sbx
C:\Data\mapfldhazar_Project.shp
C:\Data\mapfldhazar_Project.shp.xml
C:\Data\mapfldhazar_Project.shx
C:\Data\GIS\Dare\USECODES.DBF
C:\Data\GIS\Dare\kdhills7.dbf
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C:\Data\Temp\two_dxf Polyline (This file is the 2 ft lidar data, but currently is only available for display and needs processing before it can be used dynamically with the model.)

Stakeholder Issues	Primary Issue	Impacts	Best Management Practices	Alerts	Other
New Development / Redevelopment	Increase runoff volume	Erosion	DDB - Dry Detention Basin WDB - Wet Detention Basin	(OIR) - The proposed use violates Town Code 153.100 and 153.101. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
Ocean Impact Residential (OIR)	Decrease infiltration	Reduced Retention	ART - Stormwater Wetland	(RL) - The proposed use violates Town Code 153.120 and 153.121. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
Low Density Residential (RL)	Runoff from impervious surfaces	Increase flood volumes	SND - Sand Filter	(RH)The proposed use violates Town Code 153.160 and 153.161. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
High Density Residential (RH)	Increase flows to conveyances	Increase sedimentation	BIO - Bioretention	(C) - The proposed use violates Town Code 153.180 and 153.181. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
Commercial©		GW contamination	IDV - Infiltration Devices	(LI-2)The proposed use violates Town Code 153.210 and 153.211. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
Light Industrial Two (LI-2)		Increase runoff velocity	RIP - Restored Riparian Buffer	(LI-1) -The proposed use violates Town Code 153.230 and 153.231. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	
Light Industrial One (LI-1)		Increase compaction	PAV - Permeable Pavement]	(G&I -Public) - The proposed use violates Town Code 153.250 and 153.251. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.	

Government and Institutional (G&I) Public			FIL - Filter Strip	(G&I-Private) - The proposed use violates Town Code 153.270 and 153.271. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.
Government and Institutional (G&I) Private			SWL - Grassed Swale	(MFED) - The proposed use violates Town Code 153.140 and 153.141. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either; change proposed use, modify site plan into conformance, or request a zoning variance.
Maritime Forest Environmental District (MFED) Planned Unit Development (PUD)			RBL - Rooftop Runoff Management	153.300 and 153.301. The user is proposing a non-conforming land use on a parcel that is not zoned for this use. The landowner has an option to either;
Impervious Surfaces / Parking Lots	Increase runoff Decrease filtration	Increase pollution	PAV - Permeable Pavement Bioretention FIL - Filter Strip SWL - Grassed Swale IDV - Infiltration Devices	Alert would be based upon Zoning and allowable % of impervious surfaces
Storm Issues	Water quality Exceed capacity of outfalls	Groundwater contamination Increase sedimentation	DDB - Dry Detention Basin WDB - Wet Detention Basin ART - Stormwater Wetland BIO - Bioretention IDV - Infiltration Devices RIP - Restored Riparian Buffer PAV - Permeable Pavement] FIL - Filter Strip SWL - Grassed Swale RBL - Rooftop Runoff Management	No alert?
Water Quality	Decrease water quality Public Health risks GW contamination SW contamination Ocean/sound contamination	Clogging of culverts Cloggin of outfalls Decrease water clarity Ecological health risks Increase sedimentation Mosquitos	DDB - Dry Detention Basin WDB - Wet Detention Basin ART - Stormwater Wetland SND - Sand Filter BIO - Bioretention IDV - Infiltration Devices	Alert if in proximity to major branch of watershed?

		Introduction of pathogens Decrease water clarity	RIP - Restored Riparian Buffer FIL - Filter Strip SWL - Grassed Swale Mosquitos management (perhaps dunks?)		
Impacts of Wildlife / Marine Life	Introducation of pathogens Increase bacteria SW contamination	Public safety	RIP - Restored Riparian Buffer ART - Stormwater Wetland FIL - Filter Strip SWL - Grassed Swale BIO - Bioretention	No alert?	
Public Health / Public Safety	Decrease WQ near outfalls Introduction of pathogens		DDB - Dry Detention Basin WDB - Wet Detention Basin ART - Stormwater Wetland SND - Sand Filter BIO - Bioretention IDV - Infiltration Devices RIP - Restored Riparian Buffer PAV - Permeable Pavement] FIL - Filter Strip SWL - Grassed Swale RBL - Rooftop Runoff Management	?	
Conveyance Systems	Flooding Reduced capacity Erosion along ditch banks Poor drainage/flow volumes Public health Public safety Ocean/Sound impacts	Invasive species Sedimentation Flooding Clogging of system Reverse flow	ART - Stormwater Wetland IDV - Infiltration Devices RIP - Restored Riparian Buffer FIL - Filter Strip SWL - Grassed Swale	Alerts could occur if sub-watersheds are identifed with different conveyance system conditions/problems (i.e. Memorial Drive and erosion along ditch banks) Alert if proposed change in LU is adjacent to failing culvert? Alert if property is adjacent to sound/ocean outfall? Alert would occur if culvert was needed for driveway access	Needs to be sub-watershed specific
Vegetation	Loss of native vegetation Loss of natural buffers Soil compaction	Loss of soil structure Decrease filtration Erosion	ART - Stormwater Wetland BIO - Bioretention RIP - Restored Riparian Buffer	Alert if Town determines to limit lot clearing or implement a tree/native plant ordinance	

	Introduction of pathogens Increase runoff	Sedimentation GW Contamination	FIL - Filter Strip SWL - Grassed Swale	
Animal Impacts (Domestic and Wild)	Public health/safety Increase bacteria in conveyance systems Erosion of ditch banks Nuisannce	Flooding Burrows Septic tank (drainfield) problems	Habitat management Mechanical removal Apply biological controls Erosional BMPs (like compost) Slope stabilization Pet waste stations ART - Stormwater Wetland BIO - Bioretention RIP - Restored Riparian Buffer FIL - Filter Strip SWL - Grassed Swale	No Alerts
Regulatory / Policy				*Alert would occur if proposed project did not adhere to existing Town stormwater regulations/ordinances/policies *Alert would occur if proposed project did not adhere to existing State stormwater regulations/policies *Alert would occur if proposed project did not adhere to existing Federal stormwater regulations/policies *Alert would occur if retrofit required permits/design, etc. *Alert would occur if specific sub-watershed area required specific design criteria (sub-watershed specific)
Funding	Lack of funding for sw projects Education on funding opportunities			Alert if particular type of funding would be available?

	Funding for maintenance Retrofit Funding for existing development	No Alerts?
Education	lack of education @ conveyance systems LID education BMPs education links to additional local studies	Alerts directing user to education links Alerts directing user to BMP/LID designs
Incentive	incentives for sw mitigation retrofit incentives assistance in building BMPs	Alert if incentive program opportunity is available for proposed project Alert if retrofit incentive is available

Code for BMPs

DDB - Dry Detention Basin

WDB - Wet Detention Basin

ART - Stormwater Wetland

SND - Sand Filter

BIO - Bioretention

IDV - Infiltration Devices

RIP - Restored Riparian Buffer

PAV - Permeable Pavement]

FIL - Filter Strip

SWL - Grassed Swale

RBL - Rooftop Runoff Management

APPENDIX J

BEST MANAGEMENT PRACTICES TABLES

BMP	Indicator	Metrics	Theme Layer	Resources
Permeable Pavement Systems	Infiltration - Slope	< 0.5% slope	Parcel	NCDWQ BMP Manual 2007 (Section 18-1)
	Infiltration - Soil	≥ 0.52 in. / hr. infiltration capacity	Soil	
		Top 3-ft of soil must have no finer texture than Loamy Very Fine Sand (determined by soil analysis)	Soil	
	Infiltration - Size	Only 2 arcre-feet of soil per acre disturbed can be graded for permeable pavement footprint	Parcel	
	Infiltration – Location	Low traffic area (less than 100 cars per day)		
		No upland land disturbance		
Bioretention	Filtration - Slope	Must be < 20%, not in non-permanently stabilized drainage areas	Parcel	NCDWQ BMP Manual 2007 (Section 12-2)
		Side slopes stabilized with vegetation no steeper than 3:1	Parcel	
	Filtration - Location	Minimum 30 ft from surface waters, 50 ft from Class SA waters	Hydrology	
		Not in an area where seasonably high water table is < 2 ft below bottom of BMP	Hydrology	
		In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Minimum 100 ft from water supply wells	Hydrology	
	Filtration - Soil	Media permeability of 0.52-6 in/hr required (1-2 in/hr is preferred)	Soil	
		Underdrain installed if in-situ soil drainage is < 2 in/hr or if there is in-situ loamy soil. *Clean-out pipes must be provided if underdrains required	Soil	
		Low P-index (between 10 and 30)	Soil	
	Filtration - Size	Considers all runoff at ultimate buildout, including off-site drainage		
		Ponding depth ≤ 12 in (9 in is preferred)		
		Media depth based on vegetation used (grassed cells- 2-ft min; shrubs or trees- 3-ft min)		
		No dimension (length, width, radius) less than 10 ft		

	Filtration - Flow	Excess volume must bypass the bioretention cell		
		Excess volume must be evenly distributed across a minimum 30-ft long vegetative filter strip (some locations will require 50-ft filter)		
		Energy dissipating services must be used if inflow is not sheet flow (1 ft/sec)		
		Ponded water must completely drain into soil within 12 hours. In 24 hours, it must drain to 24 inches below soil surface.	Soil	
Stormwater Wetlands	Retention - Size	Considers all runoff at ultimate buildout, including off-site drainage	Parcel	NCDWQ BMP Manual 2007 (Section 9-2)
		Based on storage volume requirements		
		≥ 3,630 ft^3 treatment volume		
		≤ 1-ft land depth		
		Min length to width ratio of 1.5:1		
	Retention - Slope	Side slopes stabilized with vegetation no steeper than 3:1		
	Retention - Location	Requires pretreatment		
		In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Deep pools must be 6-in below seasonably low water table OR Clay liner must be installed such that the min infiltration rate is 0.01 in / hr (topsoil may be added to clay liner to support plant growth)	Hydrology, Parcel	
		Must be stabilized within 14 days of construction		
		No cattails planted		
	Retention - Flow	2-5 day drawdown	Soil	
		Must be as lengthy as possible		
		Forebay required		
		Min 30-ft vegetative filter for overflow (some projects will require 50-ft filter)		
Wet Detention Basin	Detention - Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section 10-2)
		Discharge distributed evenly across a min 30-ft vegetative filter strip (unless it has 90% TSS removal) (some locations will require a 50-ft filter)		
		Min 3-ft average depth of permanent pool		

		Min 10-ft vegetated shelf installed around perimeter. Inside edge 6” below the permanent pool elevation; outside edge 6” above permanent pool elevation		
	Detention - Slope	Vegetated slopes no steeper than 3:1	Parcel	
		Side slopes stabilized with vegetation above the permanent pool level		
		Pond side slopes no steeper than 3:1		
	Detention - Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Does not adversely affect water levels in adjacent wetlands	Hydrology	
	Detention - Flow	Design storage shall be above the permanent pool		
		1-in rainfall shall have 2-5 day drawdown	Soil	
		Flow within pond does not short-circuit the pond		
		Forebay required		
		Forebay volume should be 20% of total permanent pool volume, leaving 80% of design volume in the main pool		
		Basin designed with sufficient sediment storage to allow for proper operation between scheduled cleanouts		
		Freeboard shall be a minimum 1-ft above the max stage of the basin		
Sand Filter	Filtration – Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section 11-2)
		Min. width (parallel to flow) of sedimentation chamber or forebay is 1.5 ft		
		Sand media min. of 18” deep (12” over drainage pipes)		
		Min. 5-ft clearance between surface of filter and bottom of the roof of the underground structure for underground sand filters		
	Filtration – Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Seasonally high groundwater table must be min 2 ft below bottom of filter for open-bottom designs	Hydrology	
		Minimum 30 ft from surface waters, 50 ft from Class SA waters	Hydrology	

		Min 100 ft from water supply wells	Hydrology	
		Seasonally high groundwater table must be min 1 ft below bottom of filter for closed-filter designs (Exception may be made)	Hydrology	
	Filtration – Slope	Vegetated slopes no steeper than 3:1		
	Filtration - Flow	Excess volume must bypass filter		
		Excess volume must be evenly distributed across a minimum 30-ft long vegetative filter strip (some locations will require 50-ft filter)		
		Max contributing drainage basin is 5 acres		
		Completely drains within 40 hours		
Filter Strip	Natural Conveyance-Size	Considers all runoff at ultimate buildout, including off-site drainage	Parcel	NCDWQ BMP Manual 2007 (Section 13-1)
		Length and width must be determined in accordance with requirements of applicable stormwater regulatory program		
	Natural Conveyance-Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Filter strip must be densely vegetated		
		Licensed design professional must prepare grading and vegetation plan		
	Natural Conveyance-Flow	Distribution service must be used to evenly distribute runoff across the BMP		
		Sustained sheet flow required, typically through the use of a concrete level spreader		
Grassed Swale	Natural Conveyance-Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section 14-2)
	Natural Conveyance-Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
	Natural Conveyance-Flow	Design non-erosively passes the peak runoff rate for the 10-year storm		
		Convey design discharge while maintaining a 0.5-ft freeboard and without exceeding the max permissible velocity		
	Natural Conveyance-Slope	Max longitudal slope of 5% where practicable		

Restored Riparian Buffer	Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section15-1)
		Width must be 50 ft, divided into 2 zones. 30 ft closest to the stream must be wooded and outer 20 ft must be grassed.		
		Length- Min 13 ft ; Max 130 ft (set by level spreader length requirements)	Parcel	
	Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel, Hydrology	
		Constructed adjacent to a perennial or intermittent surface water as shown in most recent NRCS Soil Survey or USGS1:24,000 scale quadrangle topographic map	Parcel	
		Existing riparian buffer must be “impaired”		
	Flow	Used only when flow to the level spreader is < 3 cfs.		
		Level spreaders required if unable to prove that stormwater entering buffer is sheet flow		
	Slope	< 6%		
Infiltration Devices	Infiltration - Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section 16-1)
		Trench depth of 3-8 ft		
	Infiltration - Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Minimum 30 ft from surface waters, 50 ft from Class SA waters	Hydrology	
		Minimum 100 ft from water supply wells	Hydrology	
		Minimum 2 ft above seasonably high water table	Hydrology	
		Not sited on fill material	Parcel	
		Min 15 ft downgradient of any structure		
		Bottom min of 2 ft above underlying impervious soil horizon or bedrock	Soil, Parcel	
		Upstream area stabilized	Hydrology	
		Not on industrial sites or designated contaminated land uses or areas subject to frequent oil / other petroleum contamination	Parcel	
		Pretreatment devices provided		
		1 observation well provided		

	Infiltration – Slope	Vegetated slopes no steeper than 3:1	Parcel	
		0-0.05% grade (level)	Parcel	
	Infiltration – Flow	Excess volume must bypass the device		
		Excess volume must be evenly distributed across a minimum 30-ft long vegetative filter strip (some locations will require 50-ft filter)		
		Storage volume must draw down to seasonable high water table under seasonally high water conditions in 5 days	Parcel, Hydrology	
		Trenches must be shallower than their largest surface dimension		
		Handles max of 2 acre-inches of runoff		
	Infiltration – Soil	Min hydraulic conductivity of 0.52 in/hr	Soil	
Dry Extended Detention Basin	Detention – Size	Considers all runoff at ultimate buildout, including off-site drainage		NCDWQ BMP Manual 2007 (Section 17-2)
		Max depth of 10 ft		
		Min length to width ratio-1.5:1		
	Detention – Location	In a recorded drainage easement with a recorded access easement to a public ROW	Parcel	
		Minimum 2 ft above seasonably high water table	Parcel, Hydrology	
		Design includes a drain		
		Forebay required if design flow to facility is over 10 acre-inches		
		Freeboard must be min 1-ft above the maximum stage of the basin		
	Detention – Soil	Sediment depth indicator provided	Soil	
	Detention – Slope	Vegetated slopes no steeper than 3:1	Parcel	
	Detention – Flow	Has additional 25% storage volume for sediment deposition		
		Controlled energy of influent flow		

APPENDIX K

STREET SUBCOMMITTEE IMPROVEMENT PROJECTS
2004 THROUGH FEBRUARY 2008

Town of Kill Devil Hills

Street And Drainage Improvements Recommendations

February, 2008

FY 2008-2009 Projects

Street	Street Condition (Jan 2008)		Length	Comments	Estimated Cost, including Design, Constr. Admin. & Contingency: $(000)	Cumulative Length, Poor Streets Fixed 2005 to Present
St. Louis St (Susan to Bay)	Poor	41.4	1,426		$221	11,726
Wallace St (Susan to Lee)	Poor	**22.6**	717		$111	12,443
Truxton St (Lee to Bay)	Poor	43.8	744		$115	13,187
Wilkinson St (Lee to Bay)	Poor	44.4	1,253		$194	14,440
Palmetto St (Lee to Bath)	Poor	**22.0**	529		$90	**14,969**
Total LF of Poor Streets Updgraded:			**4,669**		**$731**	
06-07, E Avalon Drainage, Phase 3				No Award Fall 07; some New Bern wk	$220	(see below)
Lee Ave (Wilkinson to Cameron)	Fair3	54.0	**2,342**	2" overlay & minor drainage only	**$141**	
					$1,092	

$641

FY 2009-2010 Projects

Pirates Loop	Poor	47.0	709		$121	15,678
W First St (Canal to Ketch)	Poor	50.6	468		$80	16,146
W First St (Cedar to south end)	Poor	46.1	2,129		$362	18,275
Myrtle Ct	Poor	48.4	227		$39	18,502
Parkwood Dr	Poor	50.4	1,352		$230	19,854
W Third St (US 158 to Creek)	Poor	43.3	1,193		$203	21,047
Coral Drive	Poor	48.4	302		$51	21,349
Harpoon Drive	Poor	48.4	241		$41	**21,590**
			3,315		**$1,127**	

FY 2010-2011 Projects & beyond

W Ocean Acres Dr (Burns to top of hill)	Poor	49.0	669		$114	22,259
Pond St	Poor	50.6	152		$26	22,411
Shay St (Dean to Quail)	Poor	49.0	428		$73	22,839
Jones Ct	Poor	43.0	138		$23	22,977
Wrightsville Blvd (8th to north end)	Poor	49.0	738		$114	23,715
Memorial Blvd (Baum halfway to Corrigan)	Poor	37.4	200		$31	23,915
Memorial Blvd (Raleigh to Woodmere)	Poor	41.2	773		$120	24,688
W Carlton Ave	Poor	41.2	773		$120	25,461
Dock St (Portsmouth to Bay)	Poor	46.6	549		$85	**26,010**
			4,420		$706	
Raymond Ave (Arch to Town Line)	Fair 3		600	Designed; No Award Spring 07	$75	
Various Drainage Projects				to be discovered by drainage inventory	$400	
			600		**$1,181**	

07-08, denotes Plan Year (FY) per Albemarle & Assoc. 2005 Multiyear Drainage Plan; ND = Not Determined

Town of Kill Devil Hills

Street And Drainage Improvements Recommendations

February, 2008

Blocks Below Summarize Previous Years' Projects

Note: Projects whose names are in RED have been bid one or more times previously, but not awarded.

2005 Fall Project	(May 2003)		Poor Streets Fixed This Season: 400 ft	Cumulative Length, Poor Streets Fixed
Street	**Street Condition**	**Length**	**Status**	
Eighth Ave (Martin to Airstrip)	Semi-improved	450	Completed	
Ninth Ave (Martin to Airstrip)	**Poor**	**400**	Completed	400
Culvert repairs	Not applicable		Completed	

2006 Spring Project	(May 2003)		Poor Streets Fixed This Season: 380 ft	Cumulative Length, Poor Streets Fixed
Street	**Street Condition**	**Length**	**Comments**	
West Baum St	Unimproved	600	No Award Spring 05, Fall 05, Spring 06	
W. Fresh Pond/ W. Lake Drive Connector	**Poor**	**380**	Completed	780
Creek St (Third to Indian)	Drainage	600	Completed	
Cardinal St (800 Block)	Drainage	425	Completed	
Cedar Dr (600 Block)	Drainage	500	Completed	

2006 Fall Project	(May 2003)		Poor Streets Fixed This Season: 720 ft	Cumulative Length, Poor Streets Fixed
Street	**Street Condition**	**Length**	**Comments**	
Sir Walter Rd	**Poor**	**1920**	Completed	2,700
Princess Anne Dr (Camellia to First)	**Poor**	**720**	Completed	3,420
Camellia Dr (Sir Walter to Princess Anne)	**Poor**	**350**	Completed	3,770
East Landing Dr (Cove to US 158)	**Poor**	**660**	Completed	4,430

2007 Spring Project	(May 2003)		Poor Streets Fixed This Season: 500 ft	Cumulative Length, Poor Streets Fixed
Street	**Street Condition**	**Length**	**Comments**	
Seagate Ct	**Poor**	**100**	`	4,530
Sea Village La	**Poor**	**500**	Completed	5,030
Sea Wing Ct	**Poor**	**100**	Completed	5,130
Raymond Ave (Wilkinson to Arch)	**Poor**	**1625**	Completed	6,755
Raymond Ave (Arch to Town Line)	Fair 3	600	No Award Spring 07	
E. Chowan St (NC 12 to Raymond)	**Poor**	**595**	Completed	7,350
E. Sothel St (NC 12 to Raymond)	**Poor**	**600**	Completed	7,950

2007-08 Project	(May 2003)		Poor Streets Fixed This Season: 0 ft	Cumulative Length, Poor Streets Fixed
Street	**Street Condition**	**Length**	**Comments**	
Bay Dr (Nixonton to Town Line)	Poor	2350	Includes Multi-Purpose Trail	10,300
Bay Dr (Hayman to Nixonton)(Drainage)	Good	1300		
Various Drainage Projects			(without East Avalon, Phase 3)	

Town of Kill Devil Hills

Street And Drainage Improvements Recommendations

February, 2008

Blocks Below Summarize Projects Completed & Remaining

Drainage Only Areas Completed

(per Albemarle & Associates 2005 Multiyear Drainage Plan)

Street or Area	Nature of Problem	Comments
06-07, East Avalon, Phase 1	Residential property Flooding	Avalon St; Completed Fall 04
07-08, Cardinal St	Residential property Flooding	Completed Spring 06
07-08, Creek St	Residential property Flooding	Completed Spring 06
07-08, Cedar Dr	Residential property Flooding	Completed Spring 06
06-07, East Avalon, Phase 2	Residential property Flooding	Completed Winter 07-08
Second St / Princess Anne Dr	Residential property Flooding	Completed Winter 07-08
Martin St / Blue Jay St	Commercial property flooding	Completed Winter 07-08
Baum St / Memorial Ave	Failing CMP, roadway damage	Completed Winter 07-08
East Fresh Pond Dr	Residential property Flooding	Completed Winter 07-08
East Holly St	Open ditch; safety issues	Completed Winter 07-08

07-08, denotes Plan Year (FY) per Albemarle & Assoc. 2005 Multiyear Drainage Plan; ND = Not Determined

Drainage Only Areas Remaining

(per Albemarle & Associates 2005 Multiyear Drainage Plan)

Street or Area	Nature of Problem	Comments
Memorial Ave Ditch	Standing water, flooding	Design questions; could serve as reliever for ocean outfalls
Third St	1200	Complete with Street work.
Sea Swept / Virginia Avenue / Sunset		Not supported by Residents
09-10, Quail La / Shay / Dean St		Could be included in 10-11 Various Drainage package
08-09, Sioux St		Could be included in 10-11 Various Drainage package
ND, Ocean Acres	No existing drainage system	No existing drainage system
ND, Clark St		
Eighth St / NC 12		Partner with NCDOT & Nags Head
Wright Shores		subdivision drainage

07-08, denotes Plan Year (FY) per Albemarle & Assoc. 2005 Multiyear Drainage Plan; ND = Not Determined

POOR Streets Remaining

(January 2008)

(Streets highlighted with and are in primary & alternate proposals for 2008-09)

(Streets in purple type moved up from Poor to better in January, 2008 and aren't inlcuded in total)

Street	Street Condition	Length	Comments	Type (C ollector or L ocal A ccess)
West First St	Poor	2,129	Cedar to south end	C
West First St	Poor	468	Canal to Ketch	
Memorial Ave	Poor	200	from Baum halfway to Corrigan	C
West Third St	Poor	1,250		C
West Palmetto St	Poor	677		LA
Pirates Loop	Poor	665		LA
West Ocean Acres Dr	Poor	669		C
Wrightsville Blvd	Poor	738		C
Dock St	Poor	549		LA
Random St	Poor	570	*too narrow for Powell Bill pmts*	LA
West Carlton St	Poor	420		LA
Shay St	Poor	428		LA
Coral Dr	Poor	302		LA
Harpoon Dr	Poor	241		LA
Jones Ct	Poor	138		LA
Plymouth Ave	Poor	93		LA
Pond St	Poor	152		LA
Wilkinson St	Poor	1,253		LA
Truxton St	Poor	744		LA
Wallace St	Poor	717		LA
St. Louis St	Poor	1,426		LA
Parkwood Dr	Poor	1,352		LA
Myrtle Ct	Poor	227		LA
	Last Year			
Total Remaining	**15,321**	**14,838**		Both Types
	8,861	**4,986**	Collector Streets	C
	6,660	**9,852**	Local Access Streets	LA

Town of Kill Devil Hills

Street And Drainage Improvements Recommendations

February, 2008

FAIR 3 Streets Remaining (January 2008)

(Streets in orange type moved down to Poor in January, 2008 and aren't in total)

Street	treet Condition	Length	Comments	Type (C ollector or L ocal A ccess)
Lee St	Fair 3	1,814		C
Truxton St	Fair 3	776	744' Moved to Poor 01-08	LA
St. Louis St	Fair 3	0	1,385' Moved to Poor 01-08	LA
Sixth Ave (Baum to Airstrip)	Fair 3	1,357		LA
Parkwood Dr	Fair 3	0	1,352' Moved to Poor 01-08	LA
Shiloh St	Fair 3	1,090		LA
Susan Dr	Fair 3	885		LA
Wallace St	Fair 3	0	717' Moved to Poor 01-08	LA
Raymond Ave (Arch to Town Line)	Fair 3	568		C
Memorial Ave	Fair 3	460		C
Jean Ct	Fair 3	270		LA
Elm Ct	Fair 3	245		LA
Myrtle Ct	Fair 3	0	227' Moved to Poor 01-08	LA
Armstrong Ct	Fair 3	215		LA
Pine Needle Ct	Fair 3	195		LA
E. Helga St	Fair 3	974		C
Briggs St (S of Arch)	Fair 3	234		LA
Columbia Ave	Fair 3	777		LA
Mary Hill Ct	Fair 3	241		LA
W. Hayman Blvd (circle to Bay)	Fair 3	1,734		LA
Ocean Park Cir	Fair 3	1,271		LA
W. Sportsman Dr	Fair 3	3,033		LA
Cooke Pl	Fair 3	262		LA
Teakwood La	Fair 3	364		LA
Captain's Cir	Fair 3	383		LA
Anchor Ct	Fair 3	79		LA
Schooner Ct	Fair 3	196		LA
Mustian St	Fair 3	1,625		C
Telegraph Ct	Fair 3	400		LA
W. Clark St (Swan to 158)	Fair 3	1,396		LA
Pine Grove Tr (Quail to Goldie)	Fair 3	1,607		LA
Quail La (Pine Grove to Heather)	Fair 3	1,337		LA
Harrington Ave (Quail to Pine Grove)	Fair 3	960		LA
Pine Cone Ct	Fair 3	160		LA
W. Ocean Acres Dr. (Burns to Gunas)	Fair 3	2,986		C
Burns Dr.	Fair 3	3,750		LA
	Last Year		23,769	
Total Remaining	**12,362**	**31,644**		Both Types
	2,842	**8,427**	Collector Streets	C
	9,520	**23,217**	Local Access Streets	LA