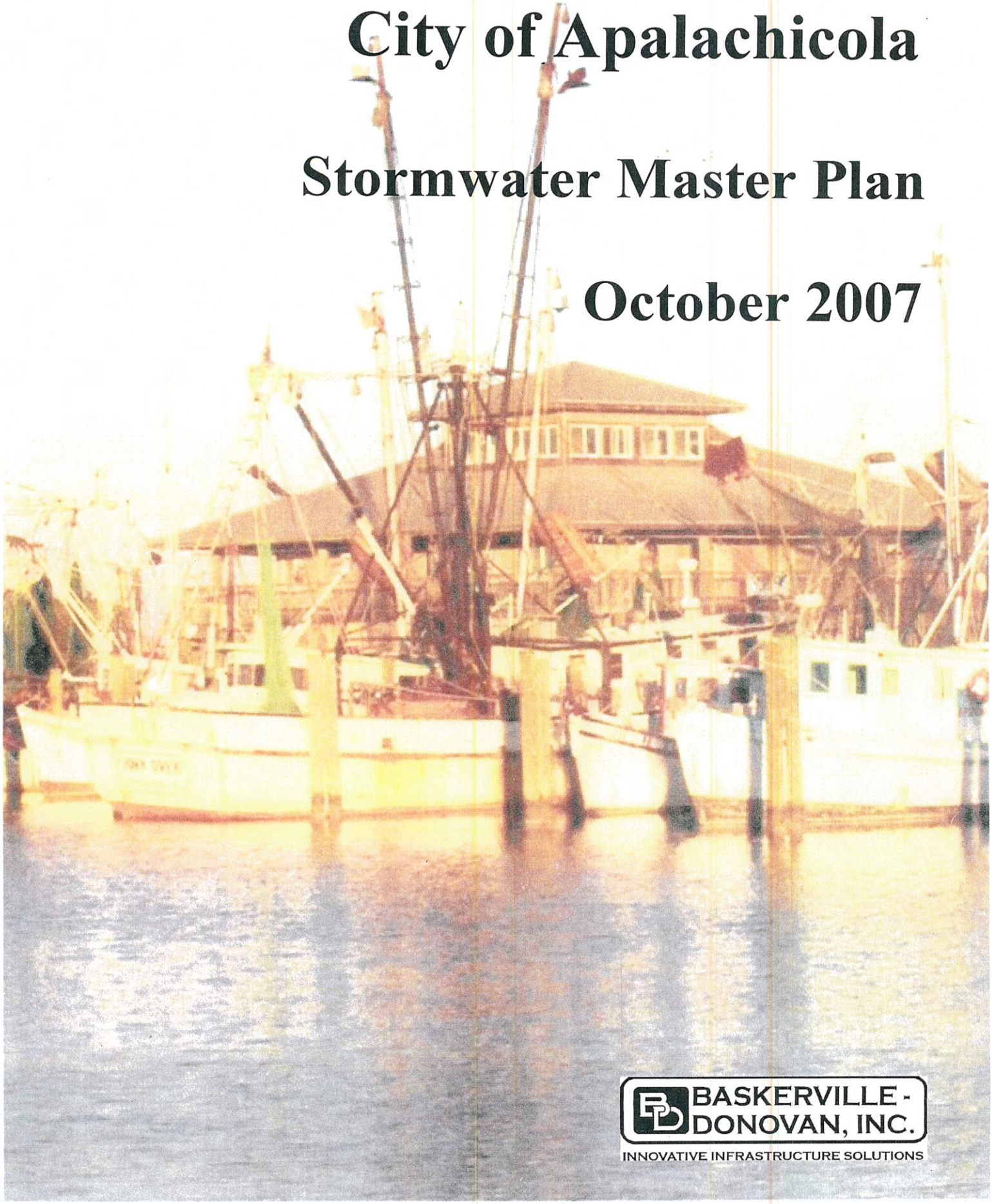
DO NOT REMOVE FROM CITY OFFICE

City of Apalachicola

Stormwater Master Plan

October 2007



BASKERVILLE - DONOVAN, INC.

INNOVATIVE INFRASTRUCTURE SOLUTIONS

City of Apalachicola

Stormwater Master Plan

October 2007

Prepared by:
BASKERVILLE-DONOVAN, INC.
325 John Knox Road
Tallahassee, Florida 32303
BDI Project No. 18438.01

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... *iv*
1.0 INTRODUCTION **1**
1.1 Background 1
1.2 Scope / Authority 1
2.0 PLANNING AREA AND PLANNING PERIOD **2**
2.1 Location and Population 2
2.2 History 2
2.3 Stormwater Regulations 4
2.4 Existing and Future Land Use 9
2.4.1 Existing Land Use *9*
2.4.2 Future Land Use *9*
2.5 Anticipated Growth 9
2.6 Planning Period 9
3.0 PHYSICAL CHARACTERISTICS **10**
3.1 Overview 10
3.2 Watershed Descriptions 10
3.3 Receiving Waters and Watercourses 13
3.4 Soils 15
3.5 Elevations and Slope 16
4.0 ANALYSIS OF PROBLEM AREAS **18**
4.1 Economic and Engineering Observations 18
4.2 Identified Drainage Problems Documented by the Public and City Staff 19
4.3 Stormwater Quality Issues 23
4.4 Existing Infrastructure 23
5.0 STORMWATER MANAGEMENT ALTERNATIVES **24**
5.1 General 24
5.2 Structural Best Management Practices 24
5.3 Non-Structural Best Management Practices 25
5.4 Other Non-Structural Actions 26
6.0 RECOMMENDED PLAN **27**
6.1 Structural Improvements to Stormwater Facilities 27
6.1.1 Stormwater Project Evaluation Matrix *27*
6.1.2 Evaluation of Costs and Values *29*
6.2 Non-Structural Actions 31
6.2.1 Best Management Plan *31*
6.2.2 Land Development Code *32*
6.2.3 Redevelopment Ordinance *32*
6.2.4 Erosion Control Ordinance *33*
6.2.5 Closed Drainage Basin Stormwater Management Ordinance *33*
6.2.6 Wetland Ordinance *33*
6.2.7 Stormwater Infrastructure Maintenance Schedule *33*
6.2.8 Fill Ordinance *34*
6.2.9 Obtain LIDAR Map of City *34*
6.2.10 Professional Review of Site Design Stormwater Management Plans *35*

List of Tables

Table 1	Water Related Soil Properties	17
Table 2	Identified Drainage Problem Areas	20-21
Table 3	High Priority Drainage Projects	22
Table 4	Stormwater Project Evaluation Matrix	28

List of Figures

Figure 1	City Location Map	3
Figure 2	Apalachicola Basin Boundaries	14

List of Appendices

Appendix A Land Use Maps
Appendix B Identified Drainage Problems Location Map
Appendix C High Priority Drainage Projects Location Map
Appendix D Stormwater Infrastructure Maps
Appendix E Drainage Maintenance Location Map
Appendix F Guidelines for Stormwater Management Programs - Best Management Practices
Appendix G Selection of NEMO (Non-point Education for Municipal Officials) Documents

EXECUTIVE SUMMARY

This document was prepared for the City of Apalachicola, Florida, and includes upstream drainage basins that flow to watercourses that traverse the City. The purpose of this document is to develop a Stormwater Master Plan for the City that presents a comprehensive engineering plan for the identification, prioritization and funding of the needed infrastructure improvements to resolve continuing stormwater quantity and quality problems.

The Plan was prepared to fulfill the Florida Department of Environmental Protection requirements for stormwater improvement systems. The Plan is a study that records and evaluates the conditions of the existing stormwater systems and explores alternatives available to correct or accommodate any issues discovered in the course of the study. The Plan, addresses the following components:

Goals:

The City of Apalachicola is taking a proactive approach to retrofit existing stormwater systems. The City's goals are to reduce localized flooding, and improve water quality in the area streams and waterways, with particular concern for the Apalachicola River and Apalachicola Bay.

Existing Condition:

The existing stormwater collection system primarily consists of open drainage ditches and closed conveyance piping. Stormwater is collected in roadside swales or inlets and pipes, with the runoff transferred directly into downstream watercourses. These conveyances provide little or no water quality treatment or attenuation. Although the City has stormwater regulations that regulate new development, the older developments and roadways in the City were not subject to such regulations. As a consequence, the stormwater runoff floods several basins and contributes to the water quality degradation of the Apalachicola River and Apalachicola Bay. The Stormwater Master Plan documents 36 areas throughout the City that have experienced flooding and drainage problems.

Proposed Action:

The Plan recommends several alternative methods to reduce flooding and improve water quality. These methods may be used singularly or collectively. One method is to utilize undeveloped property near existing conveyances for the construction of stormwater management facilities. These facilities are typically upstream of wetlands and streams and provide treatment prior to discharging into downstream watercourses. They are designed as detention facilities that provide water quality treatment and flood control.

The second method is to retrofit existing closed pipe systems with treatment vaults and baffle boxes. Typically, these systems are planned for the downstream end of existing closed pipe systems that transport runoff from heavily urbanized areas and discharge directly into

watercourses. These structural retrofits are placed near the end of the line prior to discharge and aid in the removal of trash, sediments, suspended solids, and oils and greases from runoff.

The third method is to construct flood control facilities upstream of flood-prone areas to allow the system to recover, reduce flow rates. These structures would reduce velocities and flow-rates while not affecting the hydro-period of the area. Sediments and trash are removed from down stream watercourses.

The fourth method is to utilize swales and ditch blocks in areas such as roadways with relatively flat topography and sandy soil groups. This improvement reduces localized flooding while improving water quality through infiltration, lowering runoff velocities, and promoting groundwater recharge.

Cost Estimates:

Cost estimates were developed for temporary maintenance solutions and/or minimal construction necessary to alleviate the stormwater problems of the 36 areas experiencing flooding and drainage problems. The total estimated maintenance/capital cost of these flooding and drainage projects is $1,438,500.

In addition to the temporary maintenance / minimal construction projects to alleviate flooding problems, major capital expenditures are required for long-term solutions. Also, major capital expenditures are required to rectify water quality and environmental issues, provide recreational benefits, etc. A combined list of ten high priority drainage projects was assembled, which includes flood relief projects plus critical water quality improvement projects, etc. The estimated construction cost for these priority stormwater retrofit projects alone is $4,090,000.

Action Plan:

It is recommended that the City facilitate the following action items in an effort to improve water quality, reduce flooding, and reduce degradation of the streams, waterways and the Apalachicola River and Apalachicola Bay.

A. Approve and adopt the Master Plan.

B. Continue to utilize professional assistance for review of proposed development activities.

C. Initiate non-structural actions documented in Section 6.2.

D. Prepare a yearly maintenance schedule and budget for City stormwater infrastructure.

E. Budget or seek funding assistance to implement structural improvements recommended in Section 6.1.

F. Construct the most beneficial and cost-effective stormwater improvement alternatives as funds become available.

CITY OF APALACHICOLA STORMWATER MASTER PLAN

1.0 INTRODUCTION

1.1 Background

Continued growth of the City of Apalachicola (City) and public realization of the importance of stormwater management for public safety, protection of public property and private property, and the protection of the environment and the City's need to meet Florida Department of Community Affairs (DCA) mandate prompted the City to create a Stormwater Master Plan. In 2005, the City contracted with engineering consultant Baskerville-Donovan, Inc. to develop the Plan. The Master Plan evaluates the City's stormwater quantity; identified drainage problems; and recommending improvements to minimize flooding. It also evaluates the City's stormwater quality, recommending treatments to minimize chemical and biological pollution of the City's surrounding waters.

The purpose of this document is to develop a Stormwater Master Plan for the City of Apalachicola that presents a comprehensive engineering plan for the identification, prioritization and funding of the needed infrastructure improvements to resolve continuing stormwater quantity and quality problems. The prioritized improvements may be adopted by the City, and serve as the basis for enacting a Stormwater Utility to fund the improvements.

1.2 Scope / Authority

This report is prepared pursuant to the City's Task Order Authorization of March 10, 2005, to provide Professional Engineering Services for Stormwater Program.

2.0 PLANNING AREA AND PLANNING PERIOD

2.1 Location and Population

The City of Apalachicola is located in southwestern Franklin County, in Northwest Florida, geographically positioned about 70 miles southwest of Tallahassee, Florida. It is located at the mouth of the Apalachicola River, on the north shore of Apalachicola Bay. The 2000 Census population of the City was 2,334, representing a 10-year growth rate of approximately (-)11% over the 1990 Census population of 2,602. With the current growth trends in coastal northwest Florida and the availability of undeveloped property, the population of the project planning area is expected to grow.

The Apalachicola Bay Chamber of Commerce describes the City on its website:

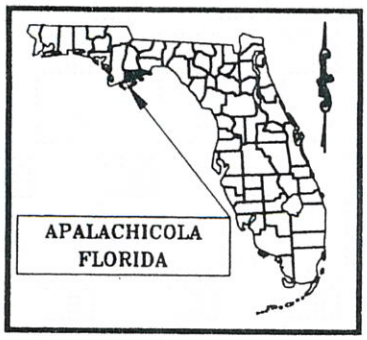
> The Apalachicola River and Bay provide great fishing opportunities for both fresh and salt water fishing buffs. Outdoor enthusiasts can explore the endless bays and waterways by kayak, canoe, riverboat or sailboat. Visitors can also spend time browsing through the City's unique galleries, stores and antique shops or touring the Apalachicola National Estuarine Research Reserve Center.
>
> Apalachicola was established in 1831. Shipping cotton was Apalachicola's big industry and it soon became the third largest port on the Gulf of Mexico. By the 1850s, the waterfront was lined with brick warehouses and broad streets to handle the loading and unloading of cotton. Steamboats laden with cotton came down the River and were unloaded. Then small shallow draft schooners (lighters) shuttled the cargo to ships moored offshore.
>
> As the railroads expanded throughout the United States, a new industry took shape in the city. Home to large cypress forests, Franklin County developed several big lumber mills in the late 1800s. Lumber magnates built many of the magnificent historic homes that line our streets.
>
> By the end of the 19th century, oysters and seafood became an important industry. Today Franklin County harvests more than 90% of Florida's oysters and 10% of the oysters consumed in the nation. Shrimp, blue crab and finfish are also very important commercially, bringing in over $11 million worth of seafood to Franklin County docks annually.

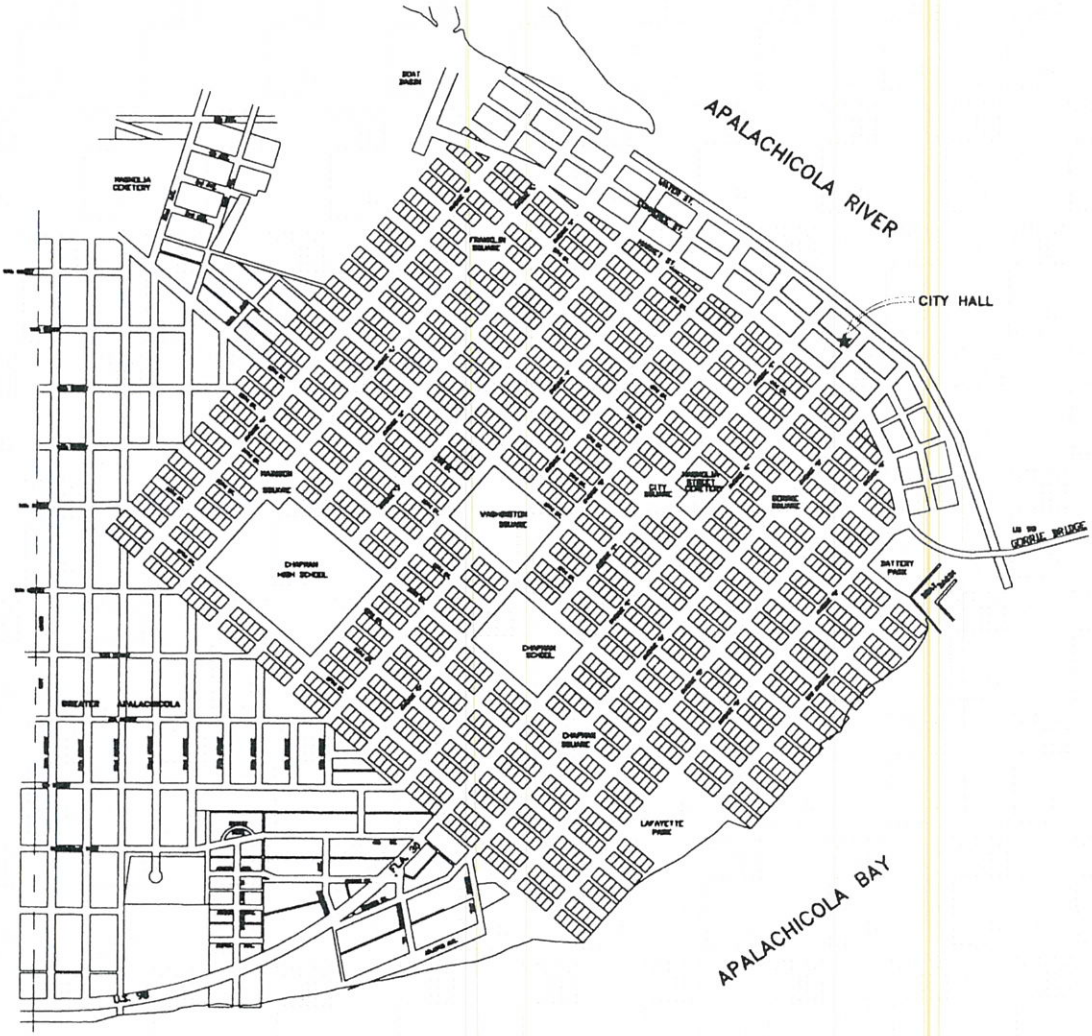
A City Location Map is included as Figure 1.

2.2 History

The following city history is drawn from documents compiled by Apalachicola Historical Society.

Indians had occupied the area around the mouth of the Apalachicola River for over 10,000 years. The name "Apalachicola" comes from the Indians and apparently described a ridge of earth produced by sweeping the ground in preparation for a council or peace fire. In 1607, indigenous Apalachee Indians sought help from the Spanish to establish a mission in the area. The Spanish mission period began in 1633 when the first priests reached the Apalachee. During the last part of the 17th century, the Spanish maintained their tenuous hold on Northwest Florida through a series of missions and the small fort at St. Marks. The 18th century also saw English and French





BASKERVILLE-DONOVAN, INC. INNOVATIVE INFRASTRUCTURE SOLUTIONS 325 JOHN KNOX RD. BLDG. 200 TALLAHASSEE, FLORIDA 32303 (850)656-1212 ENGINEERING BUSINESS: EB-0000340	LOCATION MAP CITY OF APALACHICOLA, FLORIDA PROJECT NO. : 18438.01 DATE: 11/20/2006	FIGURE 1

influence in the area. In 1821, Florida was transferred from Spain to the United States with Andrew Jackson as Governor of Florida.

The original town name was spelled with two "p"s (*Applachicola*) in the Act of the Legislative Council of the Territory of Florida in 1821. The modern Port of Apalachicola dates to 1822, when President James Monroe appointed a port collector. Cotton was initially shipped down the Apalachicola River to the port on flatboats. Two hundred sixty-six bales were shipped in 1822. The first steamboat sailed on the river in 1828. That same year, the town was renamed "West Point" by the Legislative Council. It was incorporated in 1829 with an Intendant and four councilmen. It was finally named "Apalachicola" in 1831, and in 1882 became the county seat.

Following the Civil War, the decline of Apalachicola came about because of the construction of the railroads. Railroads re-routed trade east and west, the north and south river traffic declined. In the late 1800's, the timber boom began, when lumber and naval stores were the most important commodities. Hewn logs were exported to Europe and South America, railroad ties to Mexico, and sawn pine lumber and shingles were sent north, while businesses in New Orleans were the major purchasers of cypress. By 1920, the great stands of slow-growing cypress that had sustained the area's lumber industry had become significantly depleted. Still, these operations were enough to keep steamboats on the river up through the 1927s. The John Gorrie bridge across Apalachicola Bay between Eastpoint and Apalachicola was completed in 1935, replacing a ferry service.

Seafood was commercially sold in Apalachicola as early as 1836, though oysters were not harvested in any quantity until the 1850's. Intensive efforts to exploit the beds in Apalachicola began in 1870. The Apalachicola Northern Railroad came into Apalachicola in 1907 and ran an "oyster special" to Atlanta with oysters packed in ice. By 1915, some 400 men manned 117 oyster boats under sail, 250 shuckers worked in various oyster houses, and a number of other workers worked in two canneries. Between World War I and World War II, Apalachicola went into a severe economic slump. At the present time, fishing continues as the principal industry.

In 1942, with the entry of the United States into WW II, Camp Gordon Johnston was built to the east of the City, and thousands of men were trained at the camp. For many it was the last stopover for those going to the Pacific or European theaters of war. Apalachicola was also an important port for shipping oil. The oil was shipped from Texas, through the Intracoastal Waterway to Apalachicola and then on to Jacksonville through a pipeline, where it was loaded on ships for delivery to Europe. The pipeline began at what is now known as Three Rivers.

The City presently has an elected Mayor and City Commission, an appointed City Administrator and City Clerk

2.3 Stormwater Regulations

Federal and State and City permitting requirements regulate water quality issues. City permitting requirements regulate both stormwater quantity issues and stormwater quality issues. City policies regarding the overall stormwater system performance dictate the anticipated level of stormwater controls for the City.

Federal

The U.S. Environmental Protection Agency (EPA) oversees stormwater discharges with the use of the National Pollutant Discharge Elimination System (NPDES) permit process. The NPDES program was established in 1987 as part of the Clean Water Act. Phase I of the Act required municipal and industrial treatment plant (point source) outfalls to be permitted and periodically tested. Also permitted and tested in this phase were stormwater discharges from "large" and "medium" municipal separate storm sewer systems (MS4s) located in incorporated places and counties with populations of 100,000 or more, and construction areas that disturbed areas larger than 5 acres. The NPDES program has now moved to Phase II regulations, which was finalized by EPA in December 1999. Phase II addresses additional sources, including MS4s not regulated under Phase I, and small construction activity disturbing between 1 and 5 acres.

Effective May 2003, construction sites that will result in a disturbance of one acre or more are required to seek coverage under the Generic Permit for Stormwater Discharge from Large and Small Construction Activities Operators, administered by the Florida Department of Environmental Regulation (FDEP). In addition, MS4 regulations apply if serving a jurisdiction with a population density of at least 1,000 people per square mile and a population of at least 10,000.

Operators of regulated Phase II MS4s must develop a stormwater management program (SWMP) that includes Best Management Practices (BMPs), with measurable goals, to effectively implement the following six minimum control measures:

1. Public Education and Outreach: Perform educational outreach regarding the harmful impacts of polluted stormwater runoff.
2. Public Participation/Involvement: Comply with State and local public notice requirements and encourage other avenues for citizen involvement.
3. Illicit Discharge Detection and Elimination: Implement a plan to detect and eliminate any non-stormwater discharges to the MS4 and create a system map showing outfall locations.
4. Construction Site Runoff Control: Implement and enforce an erosion and sediment control program for construction activities.
5. Post-construction Runoff Control: Implement and enforce a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. (NOTE: This minimum control is met by the State's stormwater permitting program under Part IV, Chapter 373, F.S., or Chapter 62-25, F.A.C., as a qualifying alternative program.)
6. Pollution Prevention / Good Housekeeping: Implement a program to reduce pollutant runoff from municipal operations and perform staff pollution prevention training.

State

Florida Administrative Code Chapter 62-25 provides requirements for stormwater facilities. Residential properties are generally considered exempt. Most other developed properties require stormwater general permits based on minimum design standards for stormwater treatment

facilities. Detention and retention ponds are the most common treatment facilities permitted, and are generally required to capture the first 1/2 inch of runoff for areas less than 100 acres or the first inch for areas larger than 100 acres.

Additional State documents may influence the City's stormwater planning. Although the Northwest Florida Water Management District (NWFWMD) has not delegated direct stormwater management responsibility, the NWFWMD Surface Water Improvement and Management Plan (SWIM) Priority List ranks the Apalachicola River and Bay System (including St. George Sound) as its highest priority.

City of Apalachicola

Apalachicola Land Development Code:

Section IV – *Critical Shoreline District* establishes special stormwater runoff requirements within 150 feet landward of the waters and wetlands of the City. This section regulates such issues as: minimum structure setbacks; erosion control; sewage connections; point and non-point stormwater discharges; wetland alteration; impervious surface restrictions; dredge and fill activities; marina and docking facilities; and hazardous waste storage.

Section VIII – *Stormwater Management Plan* regulates stormwater requirements for new development, providing standards for: sediment control; debris removal; stormwater treatment; detention and retention requirements; conveyance systems; discharge methods; Stormwater Management System (SWMS) maintenance; and requirements for a Stormwater Management Plan. New guidelines are being prepared by the City to expand this section to regulate areas of redevelopment.

Florida Department of Transportation (FDOT)

A permit is required from the FDOT for any project that connects to stormwater facilities of the FDOT, or for any project that would alter the conveyance capacity of the FDOT stormwater systems. All such connections of modifications must conform to Chapter 14-86 of the Florida Administrative Code (F.A.C.).

The permit application procedures as outlined in Chapter 14-86, allow the FDOT to accept a surface water management permit issued by other agencies in place of the FDOT permit. This condition applies only if the agency's requirements are equal to or greater than those of the FDOT.

Northwest Florida Water Management District (NWFWMD)

In the near future, the Northwest Florida Water Management District will be responsible for Environmental Resource Permits (ERP), wetland permits, and dredge and fill permits. The following is an excerpt from the District website concerning these changes.

House Bill 7163, (Chapter 2006-228, LOF), effective July 1, 2006, brought Florida's Environmental Resource Permit ERP) program to the Panhandle. The District and the Department of Environmental Protection are jointly developing Chapter 62-346, F.A.C., the new Northwest ERP rule. Stormwater permitting under ERP is scheduled to be implemented in March, 2007, with the wetlands, or environmental, portion of the rule (Phase II) to be developed and implemented no sooner than January, 2008.

Under the proposed activity split, stormwater permits with no wetland impacts will be processed by the District, and those involving wetlands or sovereign submerged lands will be processed by DEP. Until Phase II, dredge and fill activities will be regulated under the existing 62-312, F.A.C.

In addition, a Management and Storage of Surface Waters (MSSW) Dam Safety permit is required for the construction, alteration, repairs, or abandonment of dams in excess of 10 feet, or impounding more than 50 acre-feet, except those used for agriculture or forestry which are covered under Chapter 40A-44, Florida Administrative Code. Recreation and urban impoundments (man-made ponds) and certain stormwater facilities are regulated by this rule.

A permit is also required for other water management facilities, which reroute, restrict, or alter the rate of flow of watercourses from watersheds that exceed five square miles.

Federal Emergency Management Agency (FEMA)

One of the many programs administered by the FEMA is the National Flood Insurance Program (NFIP). The NFIP was created by Congress in 1968 in response to severe human and property losses caused by hurricanes and tropical storms in the early 1960's. The purpose of the program is to provide flood insurance for property owners in flood-prone areas through a federally subsidized program.

NFIP was modified in 1973 to require property owners in the identified flood-prone area to purchase flood insurance in order to participate in federally supported programs. Local governments identified as having flood-prone areas are required to adopt appropriate standards for construction within the flood-prone area. The flood-prone areas are identified by the FEMA on Flood Insurance Rate Maps. These maps identify the 100-year floodplain, which is the area based on topography and historical data that has a 1-percent chance of flooding in any given year.

The City participates in the NFIP. Construction within the 100-year floodplain is regulated by City Ordinance. The City code applies to new construction and substantial improvements to existing structures, in order to minimize future flood losses. While the NFIP has successfully required new buildings to be protected from damage by a 100-year flood, the program has few incentives for communities to do more than enforce the minimum regulatory standards. In an effort to encourage communities participating in the NFIP, reduce flood damages to existing buildings, manage development in areas not mapped by the NFIP, and protect new buildings beyond the minimum NFIP protection level, FEMA created a Community Rating system (CRS).

Flood insurance premium credits are available under the CRS for communities based on their classification. There are ten classes, with Class 1 having the greatest (45%) premium credit and Class 10 having no credits. A community's CRS class is based on a number of credit points

calculated for the activities that are undertaken to reduce flood losses, facilitate accurate rating and to promote the awareness of flood insurance. For each reduction in Class, the flood insurance policyholders receive a 5 percent reduction in insurance premiums. At the present time, the City has not qualified for inclusion in the CRS program, and is unable to secure premium credits for property policyholders.

The City should actively pursue application for inclusion in the CRS program. Among the major categories under the CRS for obtaining credit points are flood-damage-reduction activities. Documentation of the implementation of the recommendations of the Stormwater Master Plan related to flooding and water quality improvement should be submitted by the City to the FEMA. This could result in savings in flood insurance premiums to citizens in hazard areas in the City.

Florida Department of Environmental Protection (FDEP)

In addition to the delegated responsibility for federal NPDES MS4 permitting detailed above, currently, the FDEP regulation of stormwater management includes two primary venues: stormwater management and dredge and fill. FDEP regulates most development and retrofit projects. However, developments constructed prior to 1984 are not regulated by FDEP, unless they impact wetlands or streams.

The FDEP also is responsible for the management of state-owned lands, including state parks, recreational areas, marine fisheries, beaches, and state aquatic preserves; and for the regulation of coastal construction activities. The FDEP issues coastal construction and control line permits, and it grants easements or other forms of consent to use state-owned lands. Coastal construction and control line permits are issued pursuant to Chapter 161, Florida Statutes. Chapter 253 requires that the FDEP grant an easement, dedication, submerged land lease, or other form of consent of use of state owned or sovereignty lands.

U.S. Army Corp of Engineers (COE)

The COE regulates dredging and filling in waters of the United States under Section 404 of the 1972 Clean Water Act. Its jurisdiction differs in some respects from that of the FDEP, and it has the authority to determine that a project of low impact is covered under a General permit.

U.S. Coast Guard (USCG)

The USCG administers an advisory notification procedure for construction activities above and in navigable waters. The activities of USCG concerned are those that reduce clearance above the water, restrict anchorage, or otherwise impede boat traffic and safety. The USGS should be notified during design of any stormwater project that will penetrate navigable waters.

2.4 Existing and Future Land Use

2.4.1 Existing Land Use

The Comprehensive Plan for Franklin County, Florida (Adopted April 16, 1991) identified five Land Use categories within the City:

- Residential
- Commercial
- Industrial
- Recreation

2.4.2 Future Land Use

The Future Land Use Maps were created in 1989. Over the years, revisions have been made to these maps. There is a significant need to update these maps and to prepare them in digital format. The following generalized land use categories are identified on the Future Land Use Map:

- Agricultural
- Commercial
- Conservation
- Industrial
- Limited Residential
- Public Facilities
- Public Recreational
- Residential
- Vacant/Undeveloped

The Future Land Use Map is included in Appendix A.

2.5 Anticipated Growth

The 2000 Census population of the City was approximately 2,334, representing a 10.2% decrease from the 1990 Census population of 2,602. During the same period, the Census recorded the Franklin County population growth rate at 23.3% to a 2000 population of 11,057.

High growth rate population trends are expected in Northwest Florida. The City's Future Land Use Map identifies large areas of available residential use land. Areas of the City downtown are experiencing redevelopment, including construction of offices, retail businesses and condominiums. In addition, adjacent lands outside of the City are presently identified as agricultural, and may be susceptible to development. Thus, population growth of the City and the stormwater planning area is expected to rebound.

2.6 Planning Period

A planning period of 5 – 10 years was used in the development of this Stormwater Master Plan.

3.0 PHYSICAL CHARACTERISTICS

3.1 Overview

The principal bodies of water receiving the stormwater runoff from the City of Apalachicola are the Apalachicola River and Apalachicola Bay. The Apalachicola River is formed by the confluence of the Chattahoochee River and the Flint River at the Georgia State Line, approximately 80 miles north of Apalachicola Bay. The Apalachicola River / Chattahoochee River / Flint River drainage basins drain approximately 19,000 square miles in Florida, Georgia and Alabama.

The Intracoastal Waterway passes along the Apalachicola River, then through St. George Sound immediately south of the City. A direct connection to the Gulf of Mexico is located at East Pass, between St George Island and Dog Island.

There is a diverse array of natural communities associated with the river system and the Sound. Seagrasses, oyster beds, fish, and invertebrates abound in the estuary. The tributary rivers and springs provide freshwater habitats, while the bordering swamps and tidal marshes support wetlands habitats. Upland habitats are supported by the forests and the coastal strand in the watershed.

The Apalachicola River and Apalachicola Bay provide substantial economic benefits to the area. Commercial fishing and shellfish operations include shrimp, oysters, largemouth bass, spotted seatrout, menhaden, redfish, blue crab and mullet. Commercial barge shipping also is active along the Bay. In addition, there are many quality-of-life benefits supported by the River and the Sound, including, recreational fishing, boating, water sports, hunting, and camping. The River and Sound also enhance residential aesthetics, property values, tourism and public health.

Ten primary basins and 60 sub-basins were delineated. The characteristics of the watersheds, basins and the sub-basins are briefly described in the following section.

3.2 Watershed Descriptions

The first step in evaluating a stormwater system is delineating the basins and collecting information about the basins. Basin information is needed to estimate the performance of the City's stormwater infrastructure. Various maps were collected, including: prior City maps; current City Zoning Map (updated by Baskerville-Donovan, Inc.); USGS maps and topographic maps. Field inspections were performed to locate drainage structures such as pipes, inlets, headwalls, etc., thus creating a stormwater map. The maps were then used to divide the City and surrounding areas into drainage basins. Basins usually are divided by naturally occurring ridgelines or highways. Each basin is uniquely comprised of varying features such as drainage area, stormwater infrastructure, soil type, slope, permeability and land use.

The City of Apalachicola is a medium density urban residential community. The soils in Apalachicola are highly permeable, with a saturated hydraulic conductivity of approximately 6.0

in/hr. The watersheds are very flat with slopes ranging from 0.001 feet per feet to 0.06 feet per feet. Ten major drainage basins were identified:

- Soggy Bottom Basin – This basin is located in the northern quadrant of Apalachicola. This basin was divided into 9 sub-basins. The total drainage area is approximately 186 acres. Base flow from this basin is routed northward to tributaries of the Apalachicola River. It should be noted that this basin is adjacent to and hydraulically connected to the 23rd Street Basin. Under extreme rainfall events, or in the case when open ditches are inundated, runoff from each basin may commingle and seek the best available route. The Soggy Bottom Basin contains depressional storage area and wetlands along its outfall.

- 23rd Street Basin – This basin is located in the southwest quadrant of Apalachicola. This basin delineated into 7 sub-basins. The total drainage area is approximately 143 acres. Base flow from this basin is routed south to a large open ditch drainage system that flows to the Bay. As noted above, this basin is adjacent to and hydraulically connected to the Soggy Bottom Basin. Under extreme rainfall events or in the case when open ditches are inundated, runoff from each basin can commingle and seek the best available route north or south. Outfall for this basin is under US 98.

- Scipio Basin – This basin is located in the north central region of the City and was delineated into 16 sub-basins. The total drainage area is approximately 138 acres. Base flow from this basin is routed north to Market Street and Avenue I, where a large double-culvert cross drain transfers runoff under the road. Discharge is to Scipio Creek.

  Most of this basin is developed with residential homes and local two-lane roads. Closed drainage systems and open ditch drainage systems transport runoff to Scipio Creek. The Scipio Basin contains depressional storage areas and wetlands along the outfall.

- 12th Street Basin – This basin is located in the central region of the City and was delineated into 5 sub-basins. The total drainage area is approximately 119 acres. The 12th Street basin drains runoff from the north side of US 98 in complex closed stormwater system. Discharge is routed by closed conduit (south) at 16th Street and over to 12th where discharge is to the Bay.

  This basin appears to be completely developed with residential homes and local two-lane roads. A complex closed drainage systems transports runoff to the Bay. This system is drastically undersized. Local residents are impacted during most rainfall events.

- Battery Park Basin – This basin is located in the east central region of the City and was delineated into 4 sub-basins. The total drainage area is approximately 37 acres. Battery Park Basin drains runoff in complex closed stormwater system. Discharge is routed by closed conduit east through Battery Park to Water Street near the bridge. Discharge is to the Apalachicola River.

  This basin appears to be completely developed with residential homes and local two-lane roads. A complex closed drainage systems transports runoff to the river. This system

provides no appreciable water quality treatment, other in-line natural isolated low areas and roadside swales. Local residents are impacted during rainfall events with localized nuisance flooding.

- Bayside Basin – This basin is located in the southern quadrant of the city, between US 98 and the Bay. This basin has a drainage area of approximately 86 acres and was delineated with 10 sub-basins. There are many small outfall in this basin. Drainage is by sheet flow, shallow concentrated flow, and by closed conduit. The land area is mostly developed with single family residential lots and local roads. Some commercial land use is found near US 98. This basin has no water quality facilities and development appears to have occurred prior to the implementation of stormwater regulations.

- Water Street Basin - This basin is located in the east central quadrant of the city. Flow in generally from west to east. The Water Street Basin includes most of the downtown area which contains light commercial and river front development. Closed pipe drainage systems are found in the center of each east/west roadway. These pipe systems are old and have experienced breaks and siltation problems. This basin has a drainage area of approximately 48 acres and was delineated with 5 sub-basins. Drainage is by curb flow to inlets and several closed conduit systems. This basin has no water quality facilities and was developed prior to the implementation of stormwater regulations. Discharge is to the Apalachicola River.

- Prado Basin – The Prado Basin is due south of a small ridge line that runs east and west along Ellis Van Fleet Street. This basin has a drainage area of approximately 46.8 acres and was delineated as one large basin and one outfall. North of Prado, the land is relatively flat. Drainage is by sheet flow, shallow concentrated flow, road-side swales and closed conduit. Upstream, the land area is mostly developed with single family residential lots and local roads. Some commercial land use is found near US 98. Flow is southward to a small cross drain on Prado. Due to inadequate cross drain capacity, runoff pools in yards and driveways until the drainage system can recover. Residents have documented localized flooding on several occasions. In 2004, the city replaced approximately 160 lf corrugated metal pipe conveyance. The remaining pipe outfall is in desperate need of additional improvements. It should also be noted that an enlarged and upgraded outfall could accommodate and resolve flooding issues in the 12th Street Basin and in the 23rd Street Basin.

- Magnolia Basin – This basin is located in the northwest quadrant of the city. This basin was divided into 2 sub-basins. The total drainage area is approximately 41 acres. Base flow from this basin is routed northward to tributaries of the Apalachicola River. Drainage is by sheet flow, shallow concentrated flow, road-side swales and closed conduit. Upstream (south), the land area is mostly developed with single family residential lots and local roads. Flow is north to cross drains on 12th Street. Most of the land north of 12th Street is relatively undeveloped and include Magnolia Cemetery. The Magnolia Basin contains isolated depressional storage area and wetlands along its water course. Wetlands and an open ditch system filter runoff prior to discharge into tributaries of the Apalachicola River.

- Scipio Boat Basin - The Scipio Boat Basin includes approximately 52.68 acres of land area. It has been delineated into 3 sub-basins. Two sub-basins surround the boat basin, one each side, and the third sub-basin includes the tributary to a small 18" cross drain west of Scipio Creek Marina.

  The two sub-basins near the boat basin are developed with commercial land use and a shellfish nourishment program storage area. Scipio Creek Basin is also home to the majority of the area's commercial fishing fleet. Natural wetlands are found west and north of these basins.

  The third basin is relatively undeveloped at the time of this report. Upstream (west), of Market Street, the land area is partially developed with single family residential lots and local roads. Drainage is by sheet flow, shallow concentrated flow, road-side swales and open ditch.

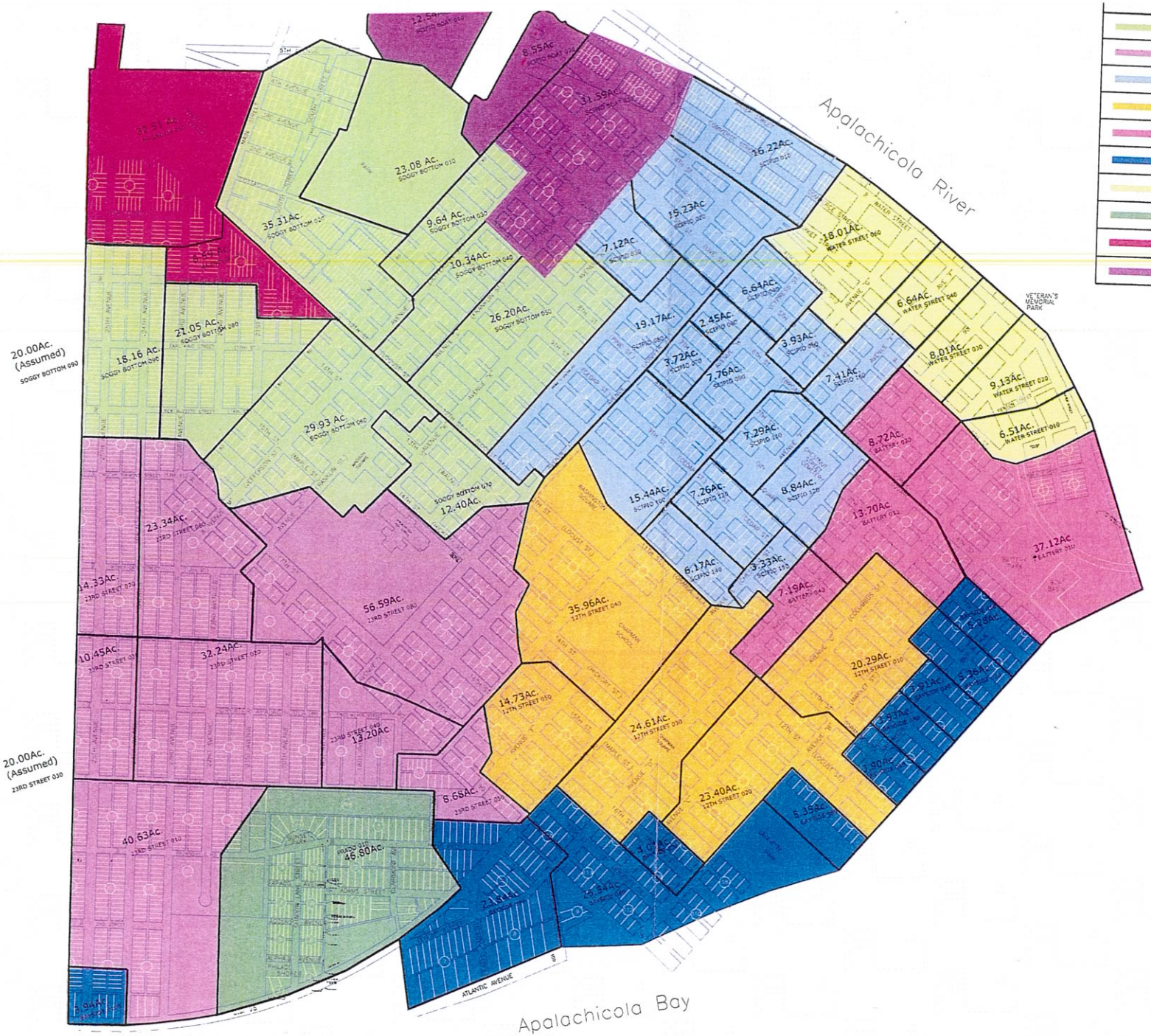
Most of these basins empty either directly into the Apalachicola River or indirectly into Apalachicola Bay and the Gulf of Mexico. A map of these basin locations is provided in Figure 2.

3.3 Receiving Waters and Watercourses

Most of the City of Apalachicola stormwater discharges directly into receiving waters of the Apalachicola River and Apalachicola Bay without any water quality treatment. The Apalachicola River System includes the Chattahoochee and Flint Rivers, whose collective drainage basins drain approximately 19,000 square miles in Florida, Georgia and Alabama.

The Apalachicola River provides the freshwater flow to Apalachicola Bay. The River is classified as Class III surface waters of the state (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife). Apalachicola Bay (with exception of area encompassed within 2-mile radius from Apalachicola entrance of John Gorrie Memorial Bridge) is classified as Class II surface waters of the state (Shellfish Propagation or Harvesting).

The River provides substantial economic benefits to the area, including: commercial fishing and shellfish operations; commercial barge shipping; recreational fishing, boating, water sports, hunting, and camping. The River also enhances residential aesthetics, property values, tourism and public health.



BASIN NAME	AREA (AC.)
SOGGY BOTTOM BASIN	186.11 AC.
23RD STREET BASIN	142.87 AC
SCIPIO BASIN	137.98 AC.
12TH STREET BASIN	118.99 AC
BATTERY PARK BASIN	56.73 AC.
BAYSIDE BASIN	86.06 AC.
WATER STREET BASIN	48.30 AC.
PRADO BASIN	46.80 AC.
MAGNOLIA BASIN	41.10 AC.
SCIPIO BOAT BASIN	52.68 AC.

3.4 Soils

The project area encompasses two general soil associations: Mandarin-Resota-Leon series and the Bohicket-Tisonia-Dirego series. The following soil descriptions are drawn from the Soil Survey of Franklin County, Florida, published by the United States Department of Agriculture, Soil Conservation Service, issued February 1994.

Mandarin-Resota-Leon – *Nearly level or gently sloping, poorly drained to moderately well drained soils that are sandy throughout; some are stained with organic matter between depths of 10 and 40 inches.*

Mandarin soils are nearly level and somewhat poorly drained. Typically, the surface layer is gray fine sand about 4 inches thick. Below this to a depth of about 25 inches is a light gray fine sand. The subsoil is a fine sand about 9 inches thick. It is dark reddish brown grading to dark brown. The substratum is fine sand. The upper 27 inches is brown. The lower part to a depth of 80 inches or more is white and has light yellowish brown and brownish yellow mottles.

Resota soils are nearly level and gently sloping and are moderately well drained. Typically, the surface layer is gray fine sand about 3 inches thick. The subsurface layer extends to a depth of about 22 inches, is white fine sand. The subsoil is fine sand and has organic stains at its upper boundary. The upper 22 inches is brownish yellow. The lower 14 inches is yellow and has reddish yellow mottles. The substratum to a depth of 80 inches or more is very pale brown fine sand that has reddish yellow mottles.

Leon soils are nearly level and poorly drained. Typically, the surface layer is dark gray sand about 8 inches thick. The subsurface layer, to a depth of about 22 inches, is white sand. The subsoil extends to a depth of 72 inches. It is sand. The upper 18 inches is very dark brown. The lower 32 inches is mixed very dark brown and dark brown. Below this to a depth of 80 inches or more is light brownish gray and dark grayish brown fine sand.

Bohicket-Tisonia-Dirego – *Nearly level, very poorly drained soils that are flooded by normal high tides; some are clayey throughout, and have an organic layer over sand, clay, or loam..*

Bohicket soils are very poorly drained. Typically, the surface layer is very dark gray silty clay about 23 inches thick. Below this to a depth of 80 inches or more is black silty clay.

Tisonia soils are very poorly drained. Typically, the surface layer is very dark grayish brown organic material about 26 inches thick. The next layer, to a depth of about 66 inches, is dark gray clay. Below this to a depth of 80 inches or more is gray and dark gray loamy sand and sandy clay loam

Dirego soils are very poorly drained. Typically, the surface layer is very dark grayish brown muck about 35 inches thick. The upper part of the subsurface layer is very dark brown mucky sand about 12 inches thick. The lower part to a depth of 72 inches or more is very dark grayish brown sand.

Within Mandarin-Resota-Leon series and the Bohicket-Tisonia-Dirego series, 14 specific soil phases have been identified in the project area:

4-Dirego and Bayvi soils, tidal
5-Aquents, nearly level
7-Bohicket and Tisonia soils, tidal
15-Ortega fine sand, 0 to 5 percent slopes
20-Lynn Haven sand
22- Leon sand

23-Maurepas muck, frequently flooded
24-Mandarin fine sand
25-Chowan, Brickyard, and Kenner soils
29-Resota fine sand, 0 to 5 percent slopes
30-Rutledge loamy fine sand, depressional
31-Rutlege fine sand
33-Scranton fine sand
36-Pinkney-Pamlico complex, depressional

Table 1 details the suitability as septic tank absorption fields, limitation for pond reservoir areas, soil permeability and organic matter of each of the soils.

3.5 Elevations and Slope

There is limited variation in elevations and slope gradients throughout the planning area. For the most part, elevations within the City, as recorded by the US Department of the Interior Geological Survey, are between elevation 2m and 4m (approximately 6.5 feet to 13 feet), with a high benchmark at 15.75 feet. In much of the City, slopes are 2 percent or less. Stormwater flow is generally to the south and east discharging through natural channels, pipes, and surface flows into the Apalachicola Bay and Apalachicola River.

Table 1
Water-Related Soil Properties

Soil Number	Soil Soil Name	Suitability as septic tank absorption fields	Limitations for pond reservoir areas	Soil permeability [Inches/Hr]	Organic matter [Percent]
4	Dirego and Bayvi soils, tidal	Severe	Severe	6-20	8-60
5	Aquents, nearly level	N/A	N/A	N/A	N/A
7	Bohicket and Tisonia soils, tidal	Severe	Slight	0.06-0.2	5-65
15	Ortega fine sand, 0 to 5 percent slopes	Moderate	Severe	0.6-20	1-2
20	Lynn Haven sand	Severe	Severe	0.6-20	2-4
22	Leon sand	Severe	Severe	0.6-20	0.5-4
23	Maurepas muck, frequently flooded	Severe	Severe	6-20	---
24	Mandarin fine sand	Severe	Severe	0.6-20	<3
25	Chowan, Brickyard, and Kenner soils	Severe	Severe	0.2-6	2-8
29	Resota fine sand, 0 to 5 percent slopes	Moderate	Severe	>20	<1
30	Rutlege loamy fine sand, depressional	Severe	Severe	6-20	3-9
31	Rutlege fine sand	Severe	Severe	6-20	3-9
33	Scranton fine sand	Severe	Severe	6-20	1-4
36	Pinkney-Pamlico complex, depressional	Severe	Severe	6-20	3-15

4.0 ANALYSIS OF PROBLEM AREAS

The City's historical location, economic development, and continued growth are linked to fishing, waterborne transportation and water recreation in the Apalachicola River and Apalachicola Bay. The Bay, with exception of an area encompassed within a 2-mile radius from the Apalachicola entrance of John Gorrie Memorial Bridge, is classified as Class II (Shellfish Propagation and Harvesting) waters of the State, while the River is classified as Class III (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) waters of the State. Both bodies are environmentally sensitive waterbodies that have a history of water quality contamination.

The City has taken a proactive approach in stormwater management for the protection of its residents and the environment. The City commissioned a Stormwater Master Plan in 2005. Documentation for the report is included in the project file, and is available for review. Elements of the assessment evaluated the City's existing stormwater quantity and quality. The findings of the assessment were that essentially all stormwater basins of the City flow indirectly or directly into the Apalachicola River and Apalachicola Bay, and the stormwater flow to those waterbodies is causing pollution, which is of concern. The following sections detail some of the report findings, with respect to stormwater quantity and quality issues.

4.1 Economic and Engineering Observations

While historically the seafood and timber industries have been the leading economic resources for the region, recently economic changes have been occurring all along coastal Northwest Florida. These changes are due to the discovery of the "Forgotten Coast" as one of the last remaining unspoiled coastal areas. The same unique environmental mix of resources that have traditionally supported the livelihood of residents for decades now draws recreational users, and tourists. Tourism is generally followed by other land demands that include seasonal housing, retail shops, restaurants, recreational fishing, and other tourism related businesses. Lately, there has been a surge of new single-home and condominium construction, which has begun to displace the seafood and boating-related industries. If left uncontrolled, this economic change has the potential to destroy the very essence of the waterfront community that attracts people to Apalachicola. It is extremely urgent that City leaders recognize the economic impact of these changes, plan for this growth, and concurrently provide creative relief for the pressures that are displacing the historic seafood industry soul of the City.

The BDI team spent many hours in the City of Apalachicola observing and documenting the City's stormwater system. At the same time, BDI also had the opportunity to review site plans and land development activity within the City. Several observations are brought to the City's attention below.

The City of Apalachicola has a tremendous quantity of quality natural resources within and surrounding its City Limits. These resources include hardwood uplands, wetlands, streams, waterways, marsh, and saltwater and brackish-water estuaries. These resources also support a diverse quantity of wildlife and plant communities. The City should adopt ordinances that control and protect these natural resource areas.

Generally, property within the City is mostly developed. Residential development is the predominant land use. It is important that the City update, adopt and enforce stormwater regulations controlling new development, to assure that stormwater runoff is properly attenuated and treated.

The initial development of Apalachicola, including roads and stormwater infrastructure, appears to have been constructed prior to the current stormwater regulations and permitting requirements. These uncontrolled infrastructure designs originally were based upon the need to get stormwater runoff from developed areas to the river or bay. No water quality treatment and attenuation was provided by these prior designs. Also noted is that these prior designs did not utilize consistent design rainfall event data. Consequently, some existing pipe systems will handle a certain rainfall event while others have a lesser capacity. This lack of proper control and design has produced the flooding and pollution conditions of present concern. With this in mind, the City has a need to provide stormwater quality retrofit for older developments and on all City roads.

Recently, land values have reached record heights. As land prices escalate and demand increases, redevelopment is likely. Limited financial resources are available to retrofit the entire City. A prudent, financially responsible method for the City to accomplish stormwater retrofit is to implement a redevelopment ordinance. Such an ordinance should stipulate that when a property is redeveloped, the developer is responsible to utilize the latest stormwater regulations and permitting. This will assure that untreated and unabated runoff from previously constructed impervious areas will one day meet the City's stormwater requirements.

4.2 Identified Drainage Problems Documented by the Public and City Staff

The Stormwater Master Plan documented information obtained from City staff interviews, field investigations, and public workshops to identify 36 areas throughout the City that have experienced flooding and drainage problems. Table 2 lists the physical location and description of the identified problem areas, and also provides the map location reference number. Map numbers relate to sites detailed on the Identified Drainage Problems Location Map found in Appendix B. Some of the drainage problems at these areas may be alleviated temporarily through maintenance efforts, such as ditch cleaning, sediment removal, outfall pipe cleaning, etc. Other solutions will require at least minimal capital expenditure for construction. The estimated maintenance and capital cost of such projects is $1,438,500.

In addition to resolving flooding problems, capital expenditures are required to rectify water quality and environmental issues, provide recreational benefits, etc. Table 3 provides a list of high priority construction projects 101 through 110, which will resolve a combination of the most critical flooding and other problem issues. Such improvements may include retrofits of conveyance structures, construction of retention/detention facilities, etc. Map reference numbers relate to sites identified on the High Priority Drainage Projects Location Map found in Appendix C. The estimated construction cost of these priority improvements alone is $4,090,000.

The Drainage Maintenance Location Map is found in Appendix E. Sites A through P appear to require only maintenance improvements for resolution of issues related to ditch cleaning, sediment removal, etc.

Table 2
Identified Drainage Problems

Map No.	Location of Problem Area	Comments	Cost Estimate
1	13th and Avenue I	Drainage infrastructure improvement project.	$10,000
2	41 25th Avenue (Mr. Dykes)	Neighbors filled low area, causing localized nuisance flooding. Maintenance required.	$2,000
3	US 98 and 16th Street	Clogged major outfall floods US 98. Immediate temporary maintenance required. See Table 3 #106 for capital cost of required construction.	$5,000
4	195 Avenue F (Brent Mabry)	Drainage infrastructure improvement project.	$15,000
5	164 8th Street	Drainage infrastructure improvement project.	$10,000
6	150 9th Street (New Drain)	Drainage infrastructure improvement project.	$10,000
7	9th and Avenue I (New Drain)	Drainage infrastructure improvement project.	$10,000
8	Alley, Block 39 between 10th Street and 11th Street (Gibson)	Drainage infrastructure improvement project: Add inlets and pipe.	$25,000
9	102 5th Street	Zingarelli Maintenance	$500
10	Avenue F, 17th Street and 16th Street. Area	Major redesign and construction of the 12th Street Basin closed conveyance system. Extremely large and expensive project for City. Routine maintenance schedule will help tremendously. Cost includes maintenance only.	$10,000
11	Conveyence improvements: 7th and 8th / Avenue C and Avenue D	Drainage infrastructure improvement project: Replace existing (vcp), add inlet and improve upstream open ditch.	$35,000
12	Myrtle Avenue and Center Street	Residential flooding. Drainage infrastructure improvement project: Add inlets and improve upstream downstream conveyance.	$25,000
13	36 Myrtle Ave (Drew Morgan)	Residential flooding. Drainage infrastructure improvement project: Add inlets and improve upstream downstream conveyance. Cost Included above.	$0
14	Ave F at 9th Street and 10th Street	Several properties experience nuisance flooding. Roadway side ditch maintenance may resolve a large part of the problem. Old pipe on Ave F may be collapsed or completely silted.	$2,000
15	Prado Outfall	Downstream conveyance requires replacement. Two Options: Major improvement to resolve 12th Street flooding. Relatively minor to replace existing dilapidated corrugated metal pipe.	$85,000
16	Poloronis /Butler Area	Improve and restore drainage way to historical flow direction. Several options. Listed cost is least expensive option.	$20,000
17	Scipio Boat Basin and Bay Avenue	Drainage infrastructure improvement project: Add inlets and piping to improve roadway drainage. Current problem will destroy roadway pavement.	$45,000
18	Apalachicola Chamber of Commerce Parking Lot	Property flooding. Drainage infrastructure improvement project: Add inlets and piping to convey off-site drainage.	$10,000
19	101 6th Street (Schroeder)	Property flooding. Drainage infrastructure improvement project: Add inlets and piping to redirect roadway and off-site drainage. Owner has stated that he is willing to donate drainage easement.	$50,000
20	17th Street and Ave G (Bryce Ward)	Property flooding. Drainage infrastructure improvement project: Add inlets and piping to improve roadway and off-site drainage.	$25,000
21	8th and Avenue G (Louis Van Fleet)	Periodic maintenance required. Problems may be resolved when Item 11 is implemented.	$2,000
		Total - This Page	**$396,500**

300,000

Table 2 (Continued)
Identified Drainage Problems

Map No.	Location of Problem Area	Comments	Cost Estimate
23	Water Street and Avenue G	Drainage infrastructure improvement project: Add inlets and piping to improve roadway drainage. Current problem will destroy roadway pavement. See Table 3 #103 for capital cost including water quality vault construction.	$100,000
24	103 21st Street (Mr. Dick White)	Drainage conveyance improvement project: Add inlets and piping to improve drainage. Periodic maintenance will help the problem. This problem may be resolved with a substantial Prado outfall improvement.	$25,000
25	Sunset Park	Drainage infrastructure improvement project: Add inlets and piping to improve drainage. Periodic maintenance will help the problem. This problem may be resolved with a substantial Prado outfall improvement.	$20,000
26	Water Street and Avenue F	Existing outfall is below tide line. System is undersized for tidal influence. Temporary maintenance required. Survey complete. See Table 3 #102 for capital cost of required construction.	$7,000
27	Water Street and Forbes	County recently designed and constructed a French drain system for this area. To date the flooding problem is not resolved. Survey complete. **County is slated to provide a remedy when they repave Water Street.**	$0
28	17th Street Open Drainage Ditch (High School)	Safety hazard. Drainage infrastructure improvement project: Add inlets and piping to enclose large open ditch. Other options are available and discussed at City Commission Meeting.	$205,000
29	Bobby Cato, 25th Avenue and Ellis Van Fleet Street	Drainage and roadway infrastructure improvement project: Add inlets and piping ensure positive drainage to 23rd Street ditch. Paving will reduce erosion and maintenance. Design plans complete.	$300,000
30	Avenue I / Scipio Basin Outfall	Frequent maintenance of existing baffle box. Consider additional water quality improvements.	$3,000
31	Bay Colony Outfall	City to ensure that the existing open conveyance ditch remains clean and operational. Upstream residential properties have experienced flooding.	$2,000
32	21st Avenue (Butler) Replace Cross Drain	Replace collapsed cross drain culvert pipe at Ellis VanFleet Street.	$20,000
33	22nd and 23rd Avenues at 17th Street	Reconstruct ditches, driveway culverts aand outfall.	$80,000
34	Prado and 24th Avenue Roadway Swales	Improve roadside drainage.	$50,000
35	15th Street and Avenue C	Improve roadside drainage.	$30,000
36	Gibson Inn to Water Street; Commerce St from Avenue E to Avenue F	Replace non-functioning drainage pipes.	$200,000
		Total -This Page	$1,042,000
		Total - Previous Page	$396,500
		GRAND TOTAL	**$1,438,500**

Table 3
High Priority Drainage Projects

Map No.	Improvements / Additions and Location	Comments	Cost Estimate
101	Ball Field Stormwater Park	Construct stormwater park for water quality in Battery Park Basin.	$600,000 NW F
102	Water Street and Avenue F	Replace/retrofit a section of existing outfall pipe system that is old and appearently undersized.	$250,000
103	Water Street and Avenue G	Add inlets, pipe, water quality vault, and reconstruct (crown) Water Street	$525,000
104	Avenue I Water Quality Improvements	Drainage infrastructure and Water Quality Improvement project.	$650,000
105	Scipio Boat Basin Drainage Improvements	Add inlets, pipe, and reconstruct (crown) roadway.	$45,000
106	US 98 and 16th Street (12th Street Basin Conveyence)	Reconstruct the conveyance system to drain to bay and add water quality improvements	$1,500,000
107	Poloronis / Butler Drainage Improvements	Drainage infrastructure improvement project.	$20,000
108	Prado Outfall Drainage Improvements	Option 1: Outfall improvement to include upstream basin flooding issues.	$150,000
108	Prado Outfall Drainage Improvements	Option 2: Outfall from alley to downstream roadway (only)	$85,000
109	Bobby Cato / 25th Street / Ellis Van Fleet Roadway and Drainage Improvements	Major redesign and construction of the 12th Street Basin closed conveyance system. Extremely large and expensive project for City. Routine maintenance schedule will help tremendously.	$300,000
110	6th Street (Schroeder) Drainage Improvements	Construct roadway drainage conveyance system to alley (Zingarelli paved drainage way). Mr. Schroeder has stated that he will donate a drainage easement.	$50,000
		* Total	**$4,090,000**

* NOTE: Total excludes $85,000 for 108 Option 2. 108 Option 1 was selected over 108 Option 2.

4.3 Stormwater Quality Issues

Stormwater quality issues refer to stormwater pollution, sedimentation, or environmental changes resulting from the discharge of stormwater runoff, particularly such runoff into the waterbodies in and around the City. Water quality issues are a primary concern of the City. The existing stormwater conveyance channels indirectly or directly discharge the City's stormwater to the Apalachicola River and Apalachicola Bay. These conveyance channels generally are not equipped with stormwater treatment, although some of the channels have natural depressions offering minimal treatment.

4.4 Existing Infrastructure

An extensive field inventory of existing drainage structures within the City was conducted for the Stormwater Master Plan. Structures were inventoried and mapped. The City was divided into ten major drainage basins with many sub-basins, and existing stormwater systems were sketched and identified. The section maps and inventory sheets are included as Appendix D.

5.0 STORMWATER MANAGEMENT ALTERNATIVES

5.1 General

Identified drainage problem areas enumerated in Section 4.0 will require capital expenditure and maintenance improvements to rectify. Concurrent with the improvements of those problem areas, other continuing stormwater management improvement are required to assure that the City maintains control of the quantity and quality of runoff.

Significant population growth of the City is expected into the next decade, as undeveloped land is transitioned into residential and commercial uses. In addition, redevelopment of existing commercial areas and density intensification of residential areas may be expected. However, most of the historic areas of the City will remain unchanged. Thus, additional stormwater management alternatives for the City will be required to consider impacts to the existing development as well as the anticipated new developments.

Resolution of the long-term stormwater quantity and quality problems requires the application of Best Management Practices (BMPs), which are rational applications of time-honored engineering and administrative solutions of similar problems. Many successful BMPs have been developed and promulgated by the EPA and by NEMO (Non-point Education for Municipal Officials education program promulgated by the University of Connecticut). Two categories of BMPs are applied:

- Structural BMPs – These are physical infrastructure improvements, generally requiring construction and/or capital outlay.

- Non-Structural BMPs – These include improved public information programs, changes in public policy, enhanced maintenance, etc.

5.2 Structural Best Management Practices

The following Structural BMPs are considered for the City. These types of improvements may be utilized singularly or in combination.

- Grassed Ditches and Swales – These improvements serve the dual purpose of providing a positive means of draining flat or locally depressed areas not presently drained, and also providing for nutrient uptake and erosion control for water quality problems. Swales are ditches with gentle cross-slopes and flat gradients, as defined by regulation. They qualify for a certain level of treatment capacity.

- Reducing Runoff from Parking Lots – These improvements lower the impact of parking lots by reducing imperviousness through the use of porous paving materials, allowing runoff to sheet-flow over vegetated areas, constructing stormwater leaching fields beneath paved areas, etc.

- Reducing Stormwater Impacts from Sidewalks – These improvements require sidewalks to follow ground contours, encouraging sheet-flow to adjacent vegetated areas. In less-dense areas, sidewalk requirements for new and redeveloped areas should be limited to one side of the road only.

- Sediment Sump – These improvements are normally constructed in conjunction with a closed drainage system. The sediment sump is a modification of a standard stormwater inlet or manhole, with the addition of a depressed (sump) bottom with a pervious gravel section. The sump allows the deposition of larger suspended sediments in stormwater. Less turbid runoff then passes through the system. The primary benefit is a reduction in the sediment load in the receiving system.

- Exfiltration Trench / Cell – An exfiltration trench or cell, otherwise known as a French drain, consists of an underground chamber created by a section of pervious pipe or other material. Usually it is surrounded by an area of stone or rock to increase the volume of the chamber and the out-flow filtration surface. These improvements are designed to store and/or exfiltrate the "first flush" of runoff. This volume of water is then dissipated through filter and/or sub-soil for treatment as a method to address water quantity and quality problems.

- Stormwater Ponds – These improvements are excavated areas, which provide for storage of excess runoff and treatment of some portion of the total runoff volume. Treatment capacity and pond volume recovery may be augmented with a sand filter or other treatment system. Stormwater ponds may be utilized to address both water quantity and quality problems.

- Oil and Grit Separators - These improvements include Sediment Baffle Boxes and Treatment Vaults. A Sediment Baffle Box is generally a concrete structure used to remove suspended solids from stormwater runoff. Stormwater is diverted from the main line system to the baffle box where large particulates, debris and suspended solids settle in the bottom of the catch basin. Sediments are periodically removed from the structure by mechanical methods. Treatment Vaults are similar to baffle boxes, in that, they are off-line systems and remove solids, but they also provide a significant amount of water quality treatment for the stormwater. They are particularly suited to remove oils and greases from stormwater. Residual sediments must also be removed mechanically.

5.3 Non-Structural Best Management Practices

Substantial portions of the City are built-out. Retrofitting stormwater facilities in these areas is expected to be extremely difficult without significant impact to private property. Non-Structural BMPs could be appropriate alternatives in these and other areas, since they are non-cost or low-cost measures to eliminate the source of pollutant loading. These measures include:

- Public education and outreach on stormwater impacts;
- Public involvement/participation;

- Illicit discharge detection and elimination;
- Construction site stormwater runoff control;
- Post-construction stormwater management in new development and redevelopment;
- Pollution prevention/good housekeeping for municipal operations.

For further details of these measures, see "*Guidelines for Stormwater Management Programs Non-Structural Best Management Practices*" in Appendix F.

5.4 Other Non-Structural Actions

The City should consider other non-structural actions of a regulatory and administrative nature, such as stormwater-related ordinances, codes, infrastructure maintenance, mapping and environmentally sensitive land evaluation.

6.0 RECOMMENDED PLAN

The following Structural and non-structural improvements are recommended to the City for formal action.

6.1 Structural Improvements to Stormwater Facilities

Ten projects are recommended for evaluation as potential stormwater capital improvement projects:

- Ball Field Stormwater Park
- Water Street and Avenue F
- Water Street and Avenue G
- Avenue I Water Quality
- Scipio Boat Basin Drainage Improvements
- US 98 and 16th Street (12th Street Basin Outfall)
- Poloronis / Butler Drainage Improvements
- Prado Outfall Drainage Improvements (Two Options)
- Bobby Cato / 25th Street / Ellis Van Fleet Drainage Improvements
- 6th Street (Schroeder) Drainage Improvewments

In addition, a number of maintenance improvement projects are required for ditch cleaning, sediment removal, etc.

6.1.1 Stormwater Project Evaluation Matrix

A Stormwater Project Evaluation Matrix (Table 4) was prepared for the purpose of comparing the ten proposed stormwater projects. Six non-costable factors (Environmental Impact, Water Quality Improvement, Ease of Construction, Social Benefit, Conveyance Improvement, and Recreational Benefit), and one costable factors (Estimated Construction Cost) are compared in the matrix.

- Environmental Benefit Factor is a relative multiplier for the degree to which the project may beneficially improve the environment (i.e. trees, wetlands, habitat, etc.);
- Water Quality Improvement Factor is a relative multiplier for the degree to which the project may beneficially improve the environment (i.e. reduce pollution, etc.);
- Ease of Construction Factor is a relative multiplier for the degree to which construction activities (i.e. trenching, dewatering, open excavation, etc.) may easily be performed;
- Social Benefit Factor is a relative multiplier reflecting the response to public concern for flooding issues and stormwater related neighborhood degradation;
- Conveyance Improvement Factor is a relative multiplier for the degree to which the project may beneficially improve conveyance or reduce localized flooding (i.e. reduce ponding, reduce downstream flooding, reduce temporary water-born insect habitat, etc.);

TABLE 4 - STORMWATER PROJECT EVALUATION MATRIX

EVALUATED FACTOR	Environmental Benefit	Water Quality Improvement	Ease of Construction	Social Benefit	Conveyance Improvement	Recreational Benefit	TOTAL SCORE	Estimated Construction Cost *
FACTOR WEIGHT	3	3	1	2	2	1		
PROPOSED PROJECT								
1. Ball Field Stormwater Park								
Raw Score	5	5	4	5	3	5		
Weighted Score	15	15	4	10	6	5	**55**	$600,000
2. Water Street and Avenue F								
Raw Score	1	1	2	3	5	1		
Weighted Score	3	3	2	6	10	1	**25**	$250,000
3. Water Street and Avenue G								
Raw Score	5	1	4	4	5	1		
Weighted Score	15	3	4	8	10	1	**41**	$525,000
4. Avenue I Water Quality Improvements								
Raw Score	5	5	3	3	3	1		
Weighted Score	15	15	3	6	6	0	**45**	$650,000
5. Scipio Boat Basin Drainage Improvements								
Raw Score	1	1	3	4	5	1		
Weighted Score	3	3	3	8	10	0	**27**	$45,000
6. US 98 and 16th Street (12th Street Basin Conveyence)								
Raw Score	5	5	1	4	5	1		
Weighted Score	15	15	1	8	10	0	**49**	$1,500,000
7. Poloronis / Butler Drainage Improvements								
Raw Score	1	2	2	3	5	1		
Weighted Score	3	6	2	6	10	0	**27**	$20,000
8.1 Prado Outfall Drainage Improvements (Option 1) [Preferred]								
Raw Score	2	2	2	4	5	1		
Weighted Score	6	6	2	8	10	0	**32**	$150,000
8.2 Prado Outfall Drainage Improvements (Option 2) [Not Preferred]								
Raw Score	2	2	3	3	3	1		
Weighted Score	6	6	3	6	6	1	**28**	$85,000
9. Bobby Cato / 25th Street / Ellis Van Fleet Roadway and Drainage Improvements								
Raw Score	4	3	4	2	4	1		
Weighted Score	12	9	4	4	8	1	**38**	$300,000
10. 6th Street (Schroeder) Roadway Drainage Improvements								
Raw Score	4	2	4	4	5	1		
Weighted Score	12	6	4	8	10	1	**41**	$50,000
Raw Score Range = 1 - 5; Where 5 = Most Desirable							**COST TOTALS ****	$4,090,000

NOTES:

* Right-of-Way costs are not included in these estimates.

** Excludes 8.2 Prado Outfall Drainage Improvements (Option 2) [Not Preferred]

- Recreational Benefit Factor is a relative multiplier for the degree the project may also benefit community recreational activities (i.e. create a park, jogging trail, public parking, etc.).

Each of the factors was assigned a Factor Weight of 1 to 3, representing a measure of community values. For example, Environmental Benefit is a high community value, and is assigned the highest ranking Factor Weight of "1". Ease of Construction, while desirable, is not high on the relative community value scale, and is assigned a Factor Weight of "3".

Then, each of the projects had its factors evaluated, assigning a Raw Score of 1 to 5 for each of its factors. The factor raw score represented the relative ranking for each factor. The Raw Score was then multiplied by the Factor Weight, yielding a Weighted Score. The Weighted Scores for each project were summed to yield the Total Score for the non-costable factors. The Total Scores were found to range from 55 (most desirable) to 25 (least desirable).

Estimates of Construction Cost were then calculated for each project, and summed to yield the combined project cost. Estimated Construction Costs ranged from $20,000 to $1,500,000.

Note: - The factor values and factor weights assigned in the evaluation are based on the engineer's experience with stormwater projects and with input from City staff. These values are subject to change based on public input during public hearing process. The project costs used in the evaluation are preliminary estimates and are not based on design prepared using survey data, property acquisition, final design and environmental permitting. Right-of-Way costs are not included in these estimates. These cost are for planning and budgetary purposes only.

6.1.2 Evaluation of Costs and Values

Based on the above evaluation, the ten potential projects were ranked and recommended in the following order:

Number 1 – Ball Field Stormwater Park – This project will construct a stormwater park for water quality improvement at the ball field in the Battery Park Basin. The park would ultimately include a walking trail, landscaping and additional parking for other recreational activities. Also, the stormwater park includes water quality improvements within a large developed basin, where currently there is none. his project had the most favorable score on the evaluation matrix (55) and is estimated to cost $600,000.

Number 2 – US 98 and 16th Street (12th Street Basin Conveyance) – This project will reconstruct and retrofit the existing stormwater conveyance system for the US 98 and 16th Street area within the 12th Street Basin. FDOT Maintenance officials are aware of the flooding of the State roadway, but have not yet accepted responsibility for the extended outfall line. The project includes water quality improvements for developed areas where

untreated runoff presently is directed to the bay. This project had the second most favorable score on the evaluation matrix (49) and is estimated to cost $1,500,000.

Number 3 – Avenue I Water Quality Improvements – This project will provide stormwater infrastructure improvements to enhance the water quality of Avenue I drainage system. This project ranked third on the evaluation matrix (45) and is estimated to cost approximately $650,000.

Number 4 – 6th Street (Schroeder) Roadway Drainage Improvements – The project is to direct roadway and off-site runoff directly to the previously constructed Zingarelli drainage system. Currently, runoff flows down and across the Schroeder's residential properties to the drainage way. Mr. Schroeder has stated that he is willing to donate a drainage easement for conveyance. This drainage structure improvement project had the highest rank/cost of all the projects. It had a matrix score of 41, and an estimated cost of only $50,000.

Number 5 – Water Street and Avenue G – This project will construct inlets, pipe and a water quality vault, and also will reconstruct the crown of portions of the Water Street roadway. In the existing condition, runoff pools after most rainfall events. Water Street and surrounding properties remains inundated for long periods of time. The roadway pavement and base are compromised by this situation. This project had a score 41 on the evaluation matrix and is estimated to cost $525,000. The cost includes water quality improvements where there are currently none.

Number 6 – Bobby Cato / 25th Street / Ellis Van Fleet Roadway and Drainage Improvements – This project includes the paving of 25th Street with drainage conveyance improvements. Steep side ditches with undersized side drains will be replaced with a uniform slope system that can easily be maintained by City staff. The project provides a major reconstruction of the 23rd Street conveyance system. This project had a score 38 on the evaluation matrix and is estimated to cost $300,000.

Number 7 – Prado Outfall Drainage Improvements – The existing piped outfall from Prado to Apaco is in desperate need of replacement. A section north of the Alley was recently replaced by City forces. The remaining downstream section (corrugated metal pipe) has rusted out. There are two options for this drainage improvement. Option 1 is more expensive but this option includes upstream improvements that will alleviate documented upstream localized flooding. Option 2 is to replace the remaining old piped conveyance from the alley to Apaco. Both options also include upsizing pipe and adding new inlets. As denoted in the matrix, Option 1 is more expensive but resolves more drainage complaints. Option 2 had a matrix score of 28 and an estimated construction cost of $85,000. Option 1 had a matrix score of 32 and an estimated construction cost of $150,000. Option 1 is preferred because it resolves more drainage problems at one time.

Number 8 – Poloronis / Butler Drainage Improvements – This project includes reestablishing the historical drainage way (open ditch) to the 12th Street System. This can only be accomplished if Project Number 2 (US 98 and 16th Street) is constructed prior to

this project. This drainage improvement project had a matrix score of 27, but had the lowest estimated construction cost at only $20,000.

Number 9 – Scipio Boat Basin Drainage Improvements – This project will construct inlets, pipe and a small water facility, and also will reconstruct the crown of portions of the adjacent paved road. In the existing condition, runoff pools after most rainfall events. The road remains inundated for long periods of time. The roadway pavement and base are compromised by this situation. This project has a matrix score of 27 and the second lowest estimated construction cost at $45,000. The cost includes water quality improvements where there are currently none.

Number 10 – Water Street and Avenue F – This project will improve stormwater conveyance by replacing a portion of the old existing undersized outfall pipe system. Currently, the existing pipe is tidally influenced and silted. This project has had the lowest matrix score of 25 and the estimated construction cost of $250,000. This system should be reevaluated when the system is thoroughly cleaned and de-silted.

6.2 Non-Structural Actions

Ten non-structural actions are recommended for adoption by the City. These actions require development and adoption of a Best Management Plan, codes, ordinances, maintenance schedule, land mapping program, environmental land use evaluation, and require a professional review of all site design stormwater management plans.

6.2.1 Best Management Plan

The City should adopt a Best Management Plan (BMP) to guide public and private activities impacting stormwater runoff. A Draft document was presented to the board in January 2003. Recommended elements of the BMP are found in Appendix F of this Plan, which includes the document entitled "Guidelines for Stormwater Management Programs - Best Management Practices". These Guidelines, which are drawn from guidance documents of the United States Environmental Protection Agency (EPA), contain a menu of brief summaries of over 70 pollution control measures. Most of the measures should be implemented by the City, and most may be implemented with minimal to very low relative financial impact. A wealth of fact sheets, technical papers, research reports, videos, etc., are available from NEMO (Non-point Education for Municipal Officials education program promulgated by the University of Connecticut). These documents are available at http://web.uconn.edu/nemo/ for guidance and use by the City. A representative selection of NEMO documents is included in Appendix G.

The extensive menu of control options available involve many City departments, other public agencies, private agencies and private volunteer groups. With so many options and actors involved, the potential exists for the control implementations to become mired in the complexity of priorities, schedules, meetings, etc. Adequate implementation of the control measures, therefore, requires that the City establish an office of Stormwater Management Practices (SMP), with an assigned administrator. The SMP administrator would be

responsible for identifying appropriate measures for implementation; securing City commitment (including budgetary authority) to proceed; securing necessary participation from City or other public and/or private agencies or groups; and sustaining the measures to accomplish their intended results.

6.2.2 Land Development Code

The 2000 Census of the City verified a 10-year growth rate of approximately (-)10.2% to 2,334 from the 1990 Census population of 2,602. During the same period, Franklin County registered a population growth rate of 23.3%. High growth rate population trends are expected to continue in coastal Northwest Florida. The City's Future Land Use Map identifies large areas of available residential use land. Much of the City downtown area is experiencing redevelopment, including construction of condominiums. In addition, adjacent lands outside of the City are presently identified as agricultural, and may be susceptible to development. Thus, population growth of the City and the stormwater planning area is expected to expand at a double-digit rate.

The City should update and adopt a revised Land Development Code with a comprehensive Stormwater Management Section to assure compliance of future land development activities with the intent of the City's goals, policies, and levels of service presented in the recently updated Comprehensive Plan. The Land Development Code will assist the City in avoiding economic and environmental burdens that unbridled development may bring. Code implementation also will require the City to review Code enforcement, variances, and penalties.

As noted previously, there are several instances where the Land Development Code, Comprehensive Plan, and State of Florida Stormwater Regulations are not consistent. This inconsistency may produced confusion and conflict between City staff and developers.

Due to the depth of the expected revisions necessary to produce a consolidated Stormwater Management Section of the Land Development Code, it is recommended that the City Planning and Zoning Board evaluate the conflicts and inconsistencies, and prepare a recommended schedule for the modifications. The Planning and Zoning Board recommendations should be presented to the Commission for approval and implementation.

6.2.3 Redevelopment Ordinance

The City has numerous properties within its limits that were developed prior to the implementation of stormwater regulations. Many of these sites are substantially covered with impervious surfaces and have no provisions for water quality treatment or runoff rate attenuation. In addition, current City regulations have no provisions for future retrofit to minimize the impacts of stormwater runoff from these sites.

Many cities across the country have adopted redevelopment ordinances requiring the retrofit of stormwater runoff during redevelopment of previously developed lands.

The City should develop and adopt a Redevelopment Ordinance to control redevelopment of existing land, to address issues such as stormwater runoff retrofit, environmental impacts, infrastructure, access, parking, sidewalks, impervious areas, runoff retention, etc.

6.2.4 Erosion Control Ordinance

The City should adopt an Erosion Control Ordinance to minimize air and stormwater pollution resulting from land erosion during development and redevelopment activities.

Most land erosion occurs during the initial construction activities, which include clearing and grubbing and infrastructure installation. Other substantial erosion occurs during building and residential construction. Stormwater facilities and erosion control features should always be constructed first. This ensures that surface runoff can be directed to these facilities during construction. An Erosion Control Ordinance will require that facilities be maintained after each rainfall event until construction is complete and vegetation is established on all disturbed surfaces.

6.2.5 Closed Drainage Basin Stormwater Management Ordinance

The City should adopt a Closed Drainage Basin Stormwater Management Ordinance to control activities impacting stormwater runoff resulting from development and redevelopment within in closed drainage basins.

A Closed Drainage Basin Stormwater Management Ordinance will address these surface water areas and protect them from degradation.

6.2.6 Wetland Ordinance

The City should adopt a Wetland Ordinance to preserve and protect wetlands and control activities impacting wetlands resulting from development and redevelopment.

Many vegetated wetlands are documented within the City Limits. Much of the runoff produced from previously developed property flows directly or indirectly into these wetlands. In many instances these wetlands function as the only treatment mechanism for removal of non-point stormwater pollutants prior to discharge into the Apalachicola Bay and Apalachicola River.

The City should produce an official ordinance protecting these natural features.

6.2.7 Stormwater Infrastructure Maintenance Schedule

The City should adopt a schedule that provides for the routine and periodic maintenance of stormwater infrastructure, including debris removal, ditch maintenance, conveyance and detention structure clean-out, etc.

Stormwater infrastructure is only as effective and efficient as it is designed and maintained. Inundation with debris and sedimentation shortens the life expectancy of infrastructure and reduces the efficiency of the original design. Adoption of a maintenance schedule will assure that the City stormwater infrastructure is retained in its designed operating condition.

6.2.8 Fill Ordinance

The City of Apalachicola has an abundance of low areas, wetlands, and depressional storage areas. The City has the topography with slopes of less that 2 percent. The City's existing drainage collection and conveyance system is in need of significant upgrades and maintenance. Currently, these depressional storage areas serve a benefit to the City in that they store runoff, reduce velocities, filter and settle out suspended solids, and provide a mean for groundwater recharge. Unfortunately, many of these features are on private property. On several occasions the City has asked the City Engineer to provide a decision on whether or not to allow fill activity. This is a very difficult and complex decision that is currently based on professional opinions and knowledge of the City's drainage network.

In addition, the engineers have noted many times where a property was filled resulting in flooding of adjoining properties. This situation has the potential to create explosive and expensive legal expenditures between neighbors. In other cases, roadside swales were filled which limit stormwater conveyance.

A better tool for the City is to create a fill ordinance that spells out what can be filled and the process for which it is allowed.

6.2.9 Obtain LIDAR Map of City

The City should obtain an accurate topographic map of the City environs prepared by LIDAR (Light Detection and Ranging) or similar cost-effective method. The map should be referenced to the State Plane Coordinate System.

There is a tremendous need to utilize the latest digital mapping technology in preparation of stormwater planning documents for basin delineation and City mapping. Prior to the availability of these more accurate techniques, most stormwater maps were produced by digitizing large scale contour maps which had wide contour intervals of five to ten feet or in the City's case two meter contours. These maps tended to produce errors and interpretations when applied to sites with relatively flat terrain, such as exist in portions of Apalachicola.

The relatively new LIDAR technology allows accuracies of existing ground elevations of one foot or less. It enables the production of a digital file that, if established to the State Plane Coordinate System, can be referenced at any time to latest aerial photography. Thus this technology produces the capability of better mapping, planning, and design accuracy.

6.2.10 Professional Review of Site Design Stormwater Management Plans

The City should adopt a formal professional review procedure for all proposed site design stormwater management plans. The procedure, to be referenced in the above proposed Code and Ordinances, should require that stormwater management plans be reviewed and approved by the City Engineer prior to the City approval of the proposed site plans.

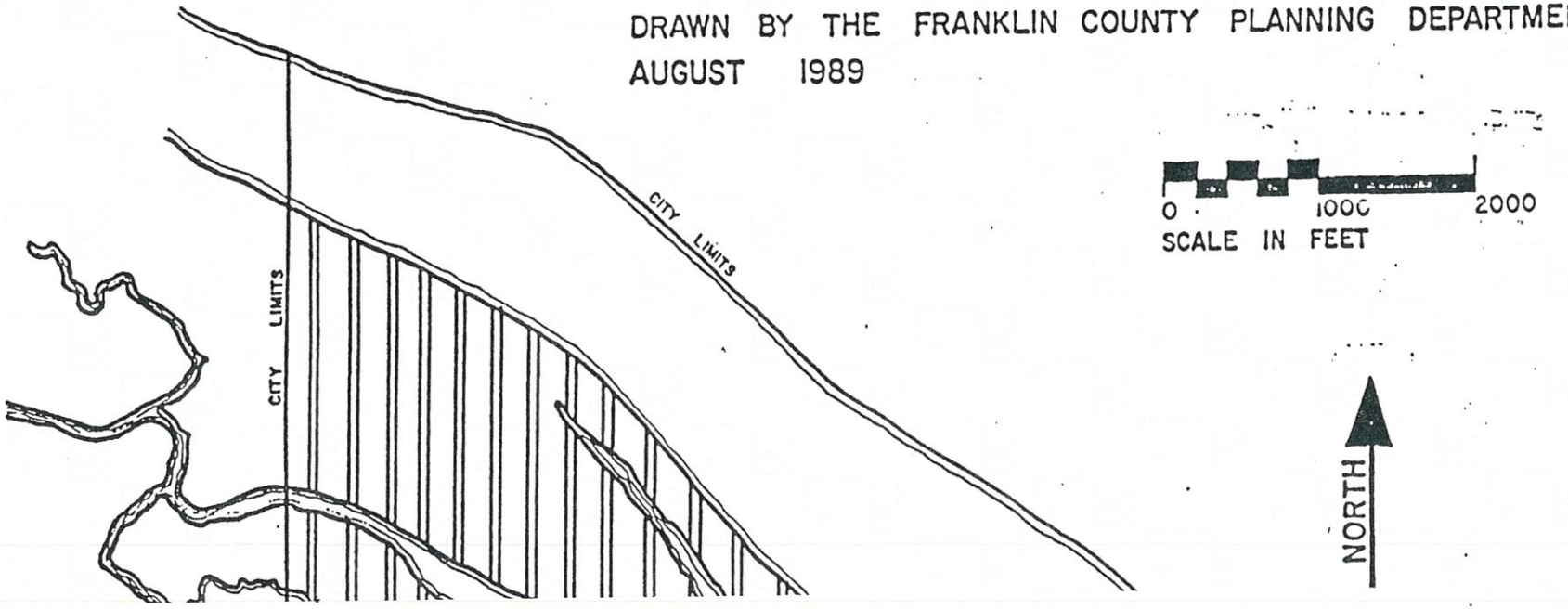
Appendix A

Land Use Maps

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT

AUGUST 1989



WETLANDS

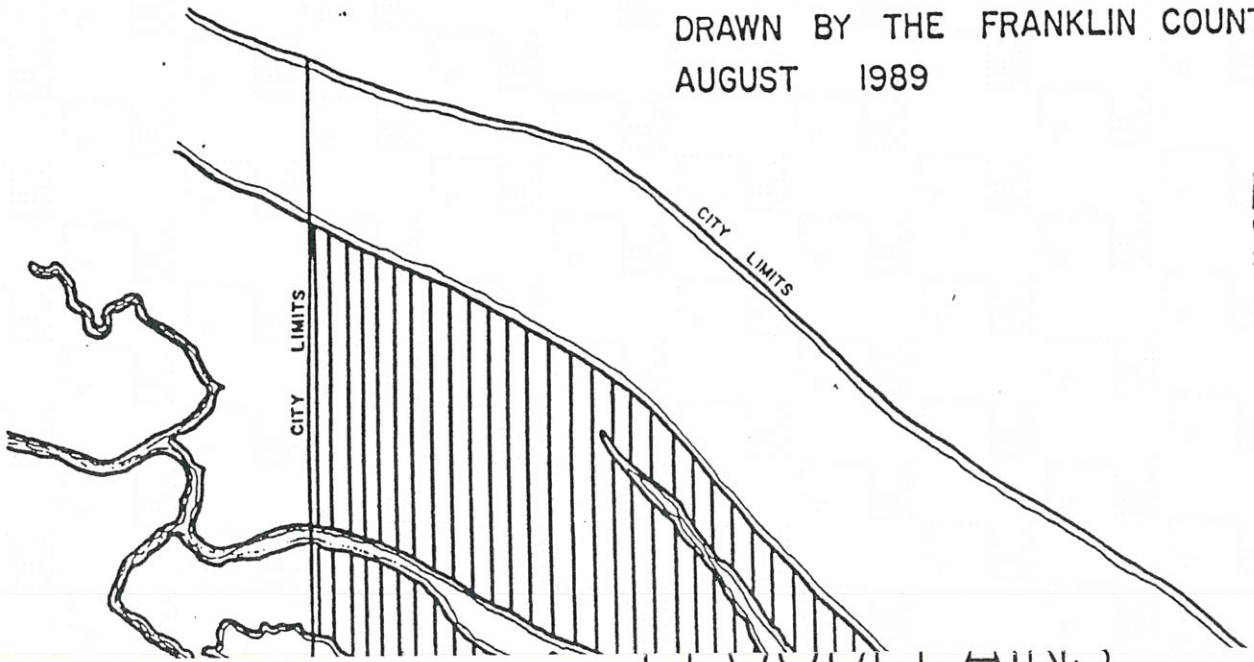
LEGEND

- BAY TIDAL MARSHES
- RIVERINE TIDAL MARSHES
- FORESTED FLOODPLAIN
- FRESHWATER MARSH/DIMINISHING SWAMP
- FRESHWATER SWAMP

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT

AUGUST 1989



0 1000 2000

SCALE IN FEET

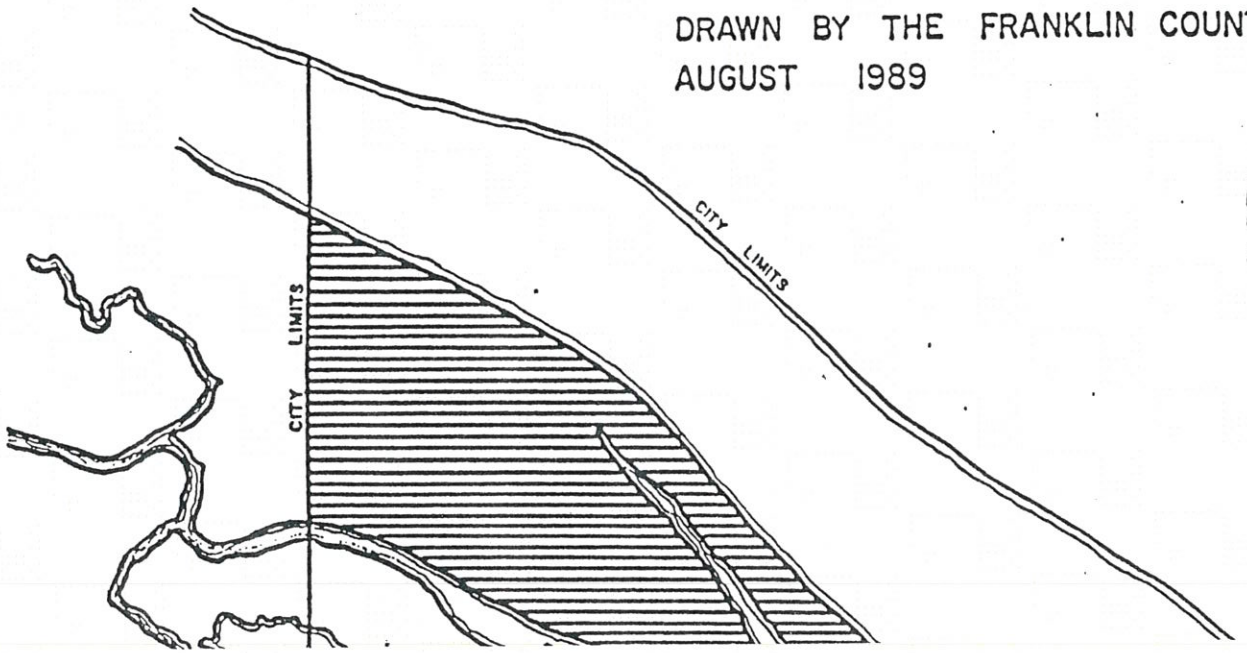
NORTH

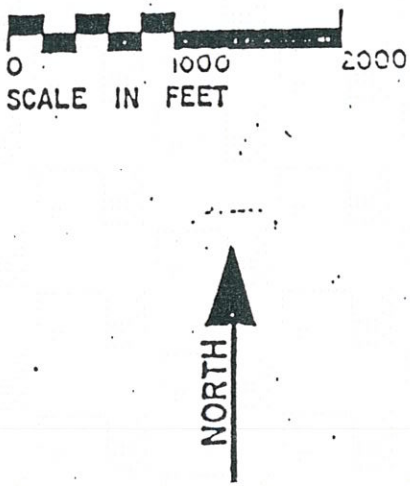
FLOOD PLAINS

APALACHICOLA RIVER FLOODPLAIN

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT
AUGUST 1989





DRAINAGE

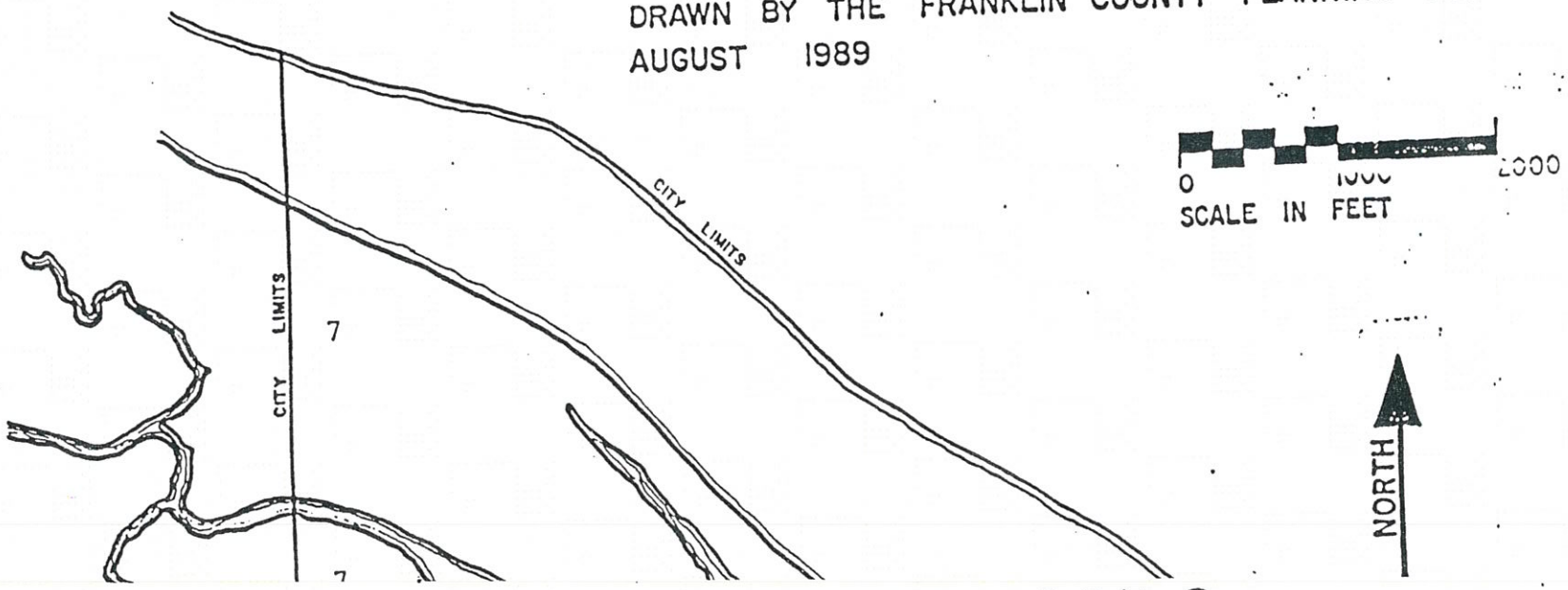
LEGEND

- VERY POORLY DRAINED SOILS (POSITIVE SHWT)
- POORLY DRAINED SOILS (SHWT = 0-18")
- SOMEWHAT POORLY DRAINED AND POORLY DRAINED SOILS (SHWT = 3-20")
- SOMEWHAT POORLY DRAINED SOILS (SHWT = 18-42")
- MODERATELY WELL-DRAINED SOILS (SHWT = 40-60")

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT

AUGUST 1989



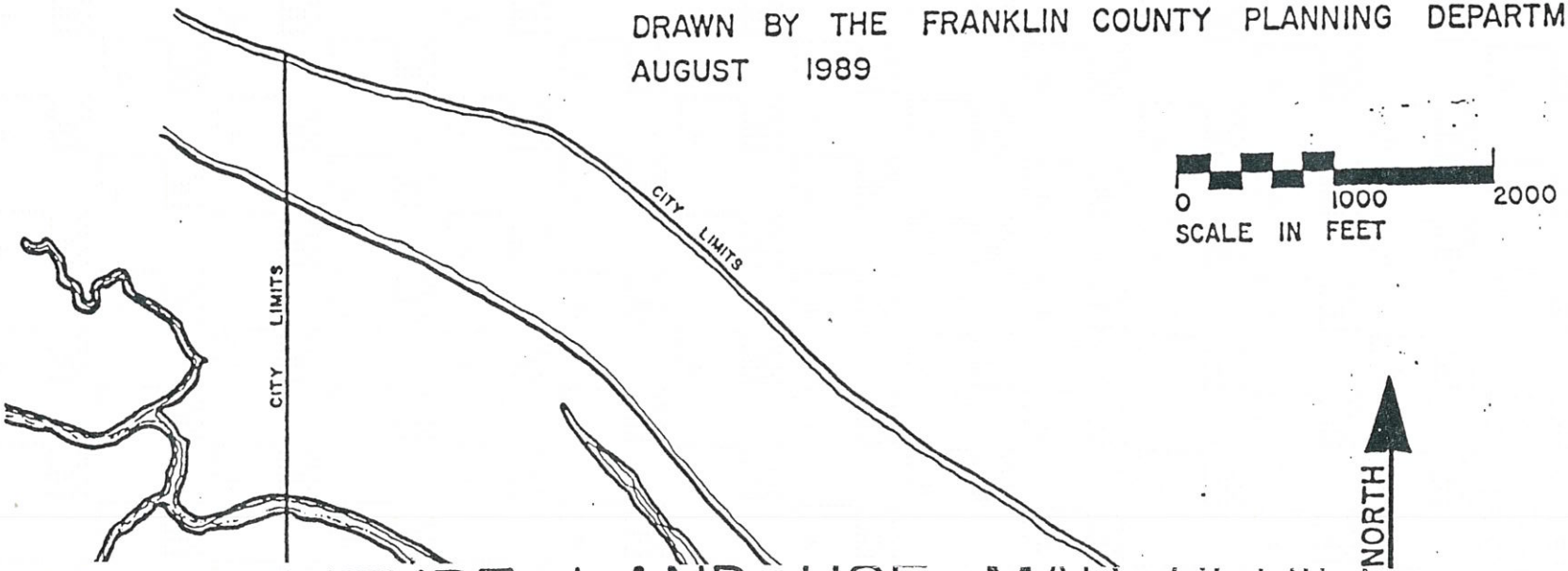
MINERALS AND SOILS

LEGEND

4 - Dirego and Bayvi soils
5 - Aquents
7 - Bohicket and Tisonia soils
11 - Dorovan-Pamlico Mucks Complex
15 - Ortega fine sand (0-5 slope)
20 - Lynn Haven sand
22 - Leon sand
24 - Mandarin fine sand (0-5 slope)
25 - Chowan, Brickyard and Kenner soils
29 - Resota fine sand (0-5 slope)
30 - Rutlege loamy fine sand Depressional
31 - Rutlege fine sand
33 - Scranton fine sand
36 - Pickney-Pamlico Complex Depressional

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT
AUGUST 1989



FUTURE LAND USE MAP SERIES

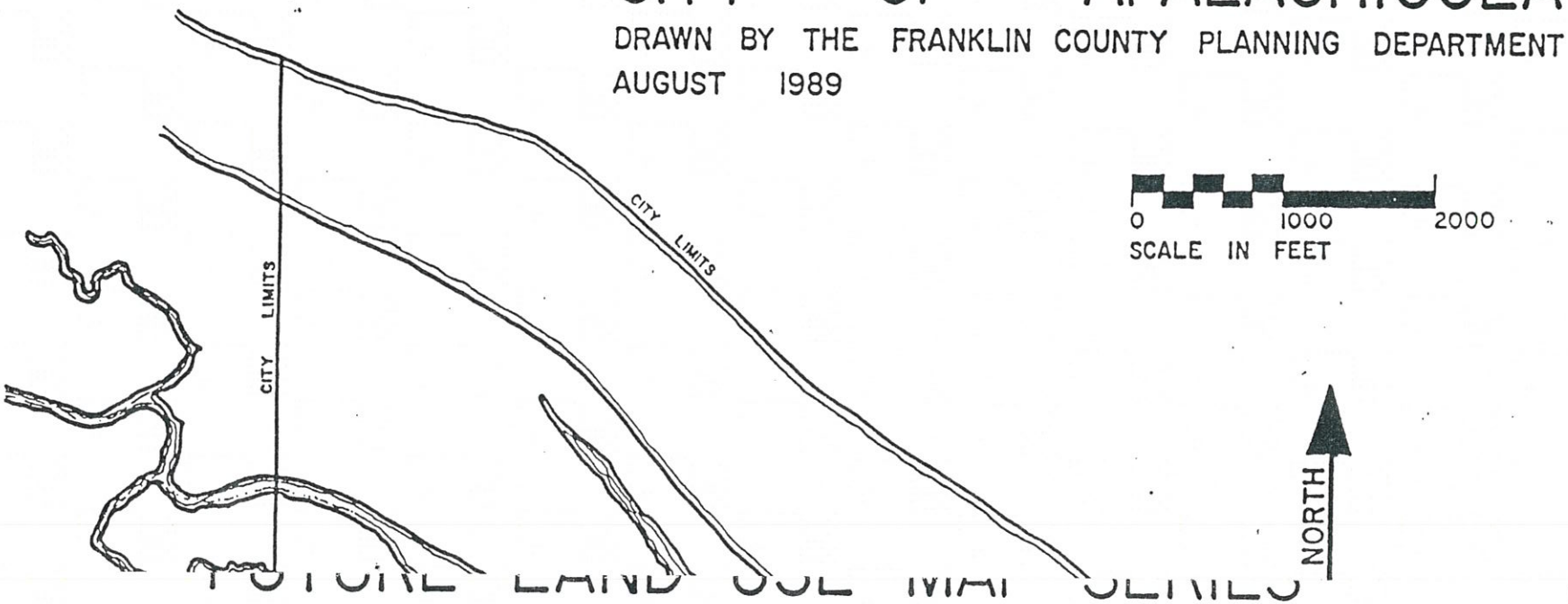
HISTORIC RESOURCES

LEGEND

- ■ HISTORICALLY SIGNIFICANT BUILDINGS
- ⊙ ARCHAEOLOGICAL SITES
- ----- APALACHICOLA HISTORIC DISTRICT

CITY OF APALACHICOLA

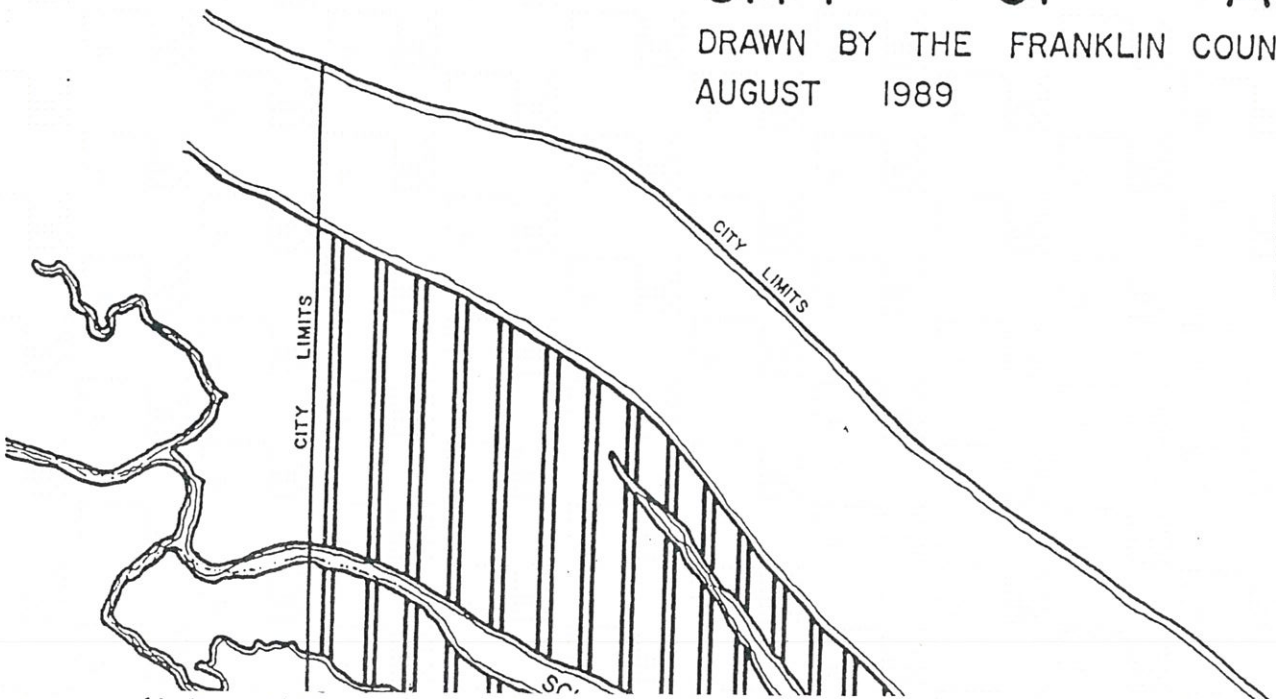
DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT
AUGUST 1989



EXISTING WATERWELLS

CITY OF APALACHICOLA

DRAWN BY THE FRANKLIN COUNTY PLANNING DEPARTMENT
AUGUST 1989



0 1000 2000
SCALE IN FEET

NORTH

conditions change.

MAP F1

FUTURE LAND USE

LEGEND

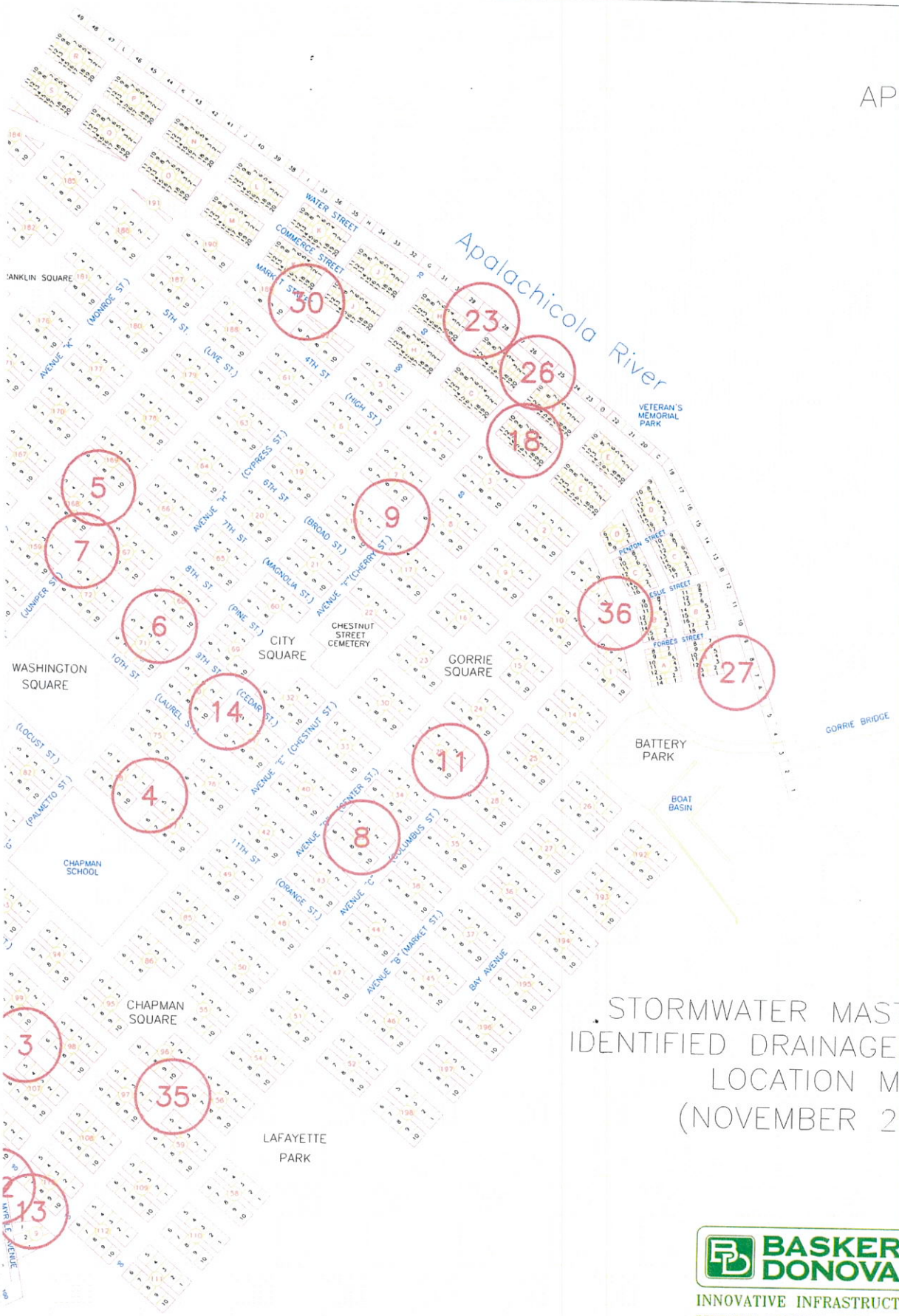
- RESIDENTIAL
- RESIDENTIAL MIXED USE
- COMMERCIAL
- PUBLIC
- RECREATIONAL
- CONSERVATION
- BAY TIDAL MARSHES

Appendix B

Identified Drainage Problems Location Map

IDENTIFIED DRAINAGE PROBLEM AREAS

1. 13th and Ave I
2. 41 25th Ave (Mr. Dykes)
3. 90 16th St.
4. 195 Ave F
5. 164 8th St.
6. 150 9th St. (New Drain)
7. 9th and Ave I (New Drain)
8. Alley, Block 39, 10th street and 11th Street (Gibson)
9. 102 5th St.
10. Ave F, 17th St. and 16th St. Area
11. Drainage Way 7th and 8th /Ave C and Ave D
12. Myrtle Avenue and Center Street
13. 36 Myrtle Ave (Drew Morgan)
14. Ave F at 9 and 10
15. Prado Outfall
16. Poloronis/Butler Area
17. Scipio Boat Basin and Bay Avenue
18. Apalachicola Chamber of Commerce Parking Lot
19. 101 6th Street (Schroeder)
20. 17th Street and Ave G (Bryce Ward)
21. Brent Mabey
22. 8th and Avenue G (Louis Van Fleet)
23. Water Street and Avenue G
24. 103 21st Street (Mr. Dick White)
25. Sunset Park
26. Water Street and Avenue F
27. Water Street and Forbes
28. 17th Street Open Drainage Ditch (High School)
29. 25th Ave and Ellis Van Fleet Street
30. Avenue I/Scipio Basin Outfall
31. East Bay Colony Outfall
32. 21st Avenue (Butler) Replace Cross Drain
33. 22nd and 23rd Avenues at 17th Street
34. Prado and 24th Avenue Roadway Swales
35. 15th Street and Avenue C
36. Gibson Inn to Water Street (Undetermined)



STORMWATER MASTER PLAN IDENTIFIED DRAINAGE PROBLEMS LOCATION MAP (NOVEMBER 2006)

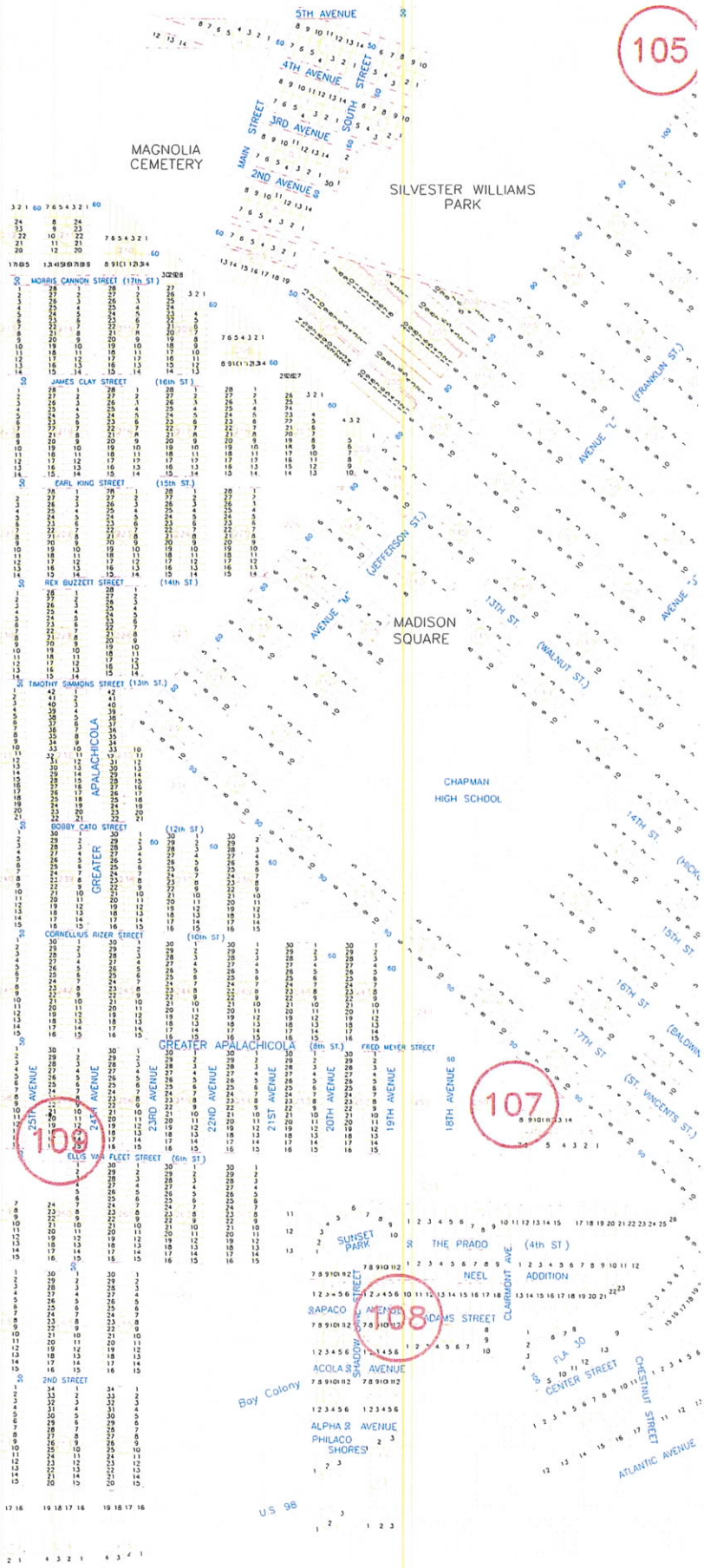
BASKERVILLE-DONOVAN, INC.
INNOVATIVE INFRASTRUCTURE SOLUTIONS
PENSACOLA ■ PANAMA CITY ■ TALLAHASSEE ■ MOBILE
325 JOHN KNOX RD. BLDG. 200
TALLAHASSEE, FLORIDA 32303 (850)656-1212

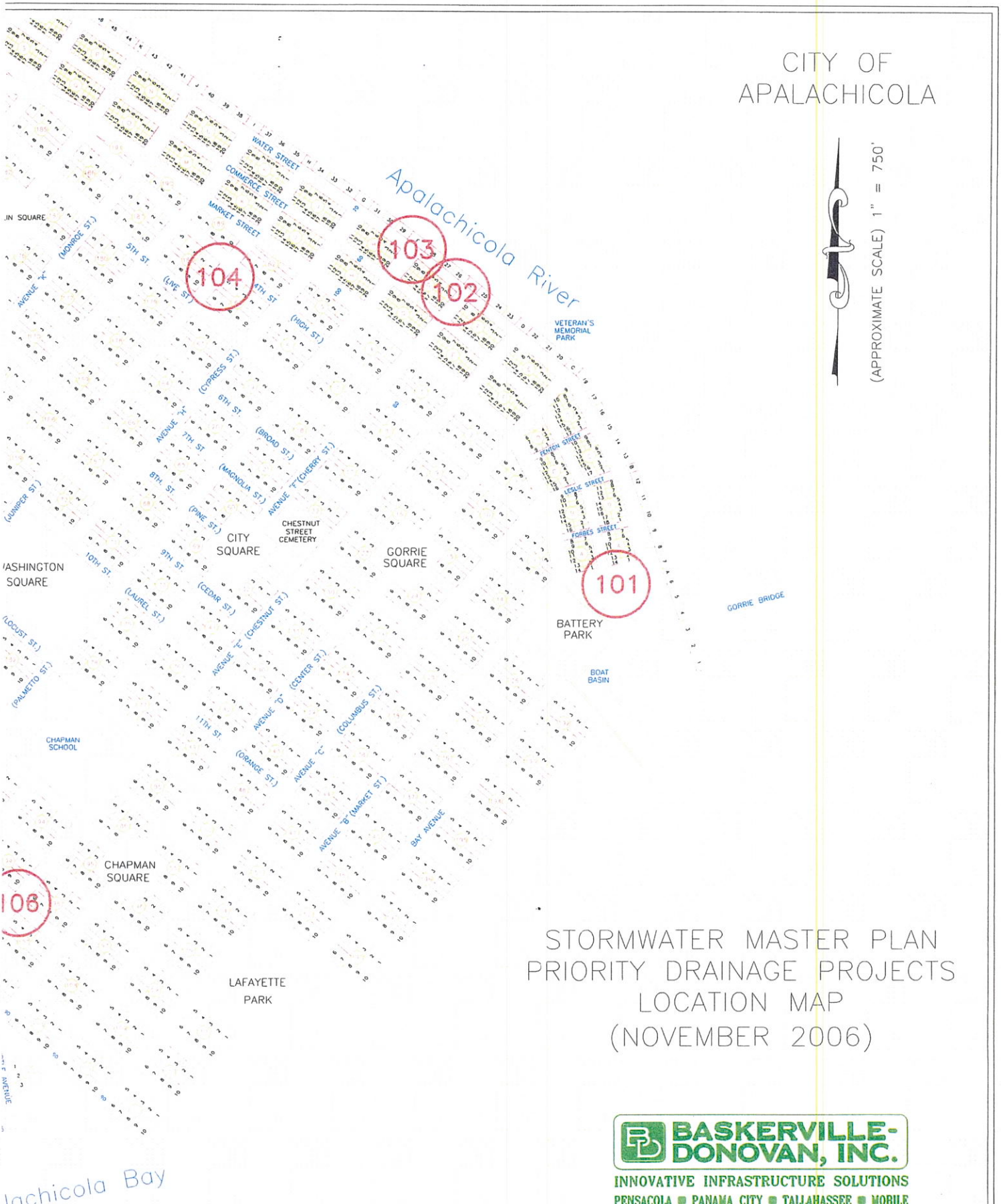
Appendix C

High Priority Drainage Projects Location Map

PRIORITY DRAINAGE PROJECTS

- 101 Ball Field Stormwater Park ✓
- 102 Water Street and Avenue F
- 103 Water Street and Avenue G ✓
- 104 Avenue I Water Quality ✓
- 105 Scipio Boat Basin Drainage Improvements
- 106 US 98 and 16th Street (12th St Basin Outfall)
- 107 Poloronis/Davis Drainage Improvements
- 108 Prado Outfall Drainage Improvements
- 109 Bobby Cato/25th Street/Ellis Van Fleet



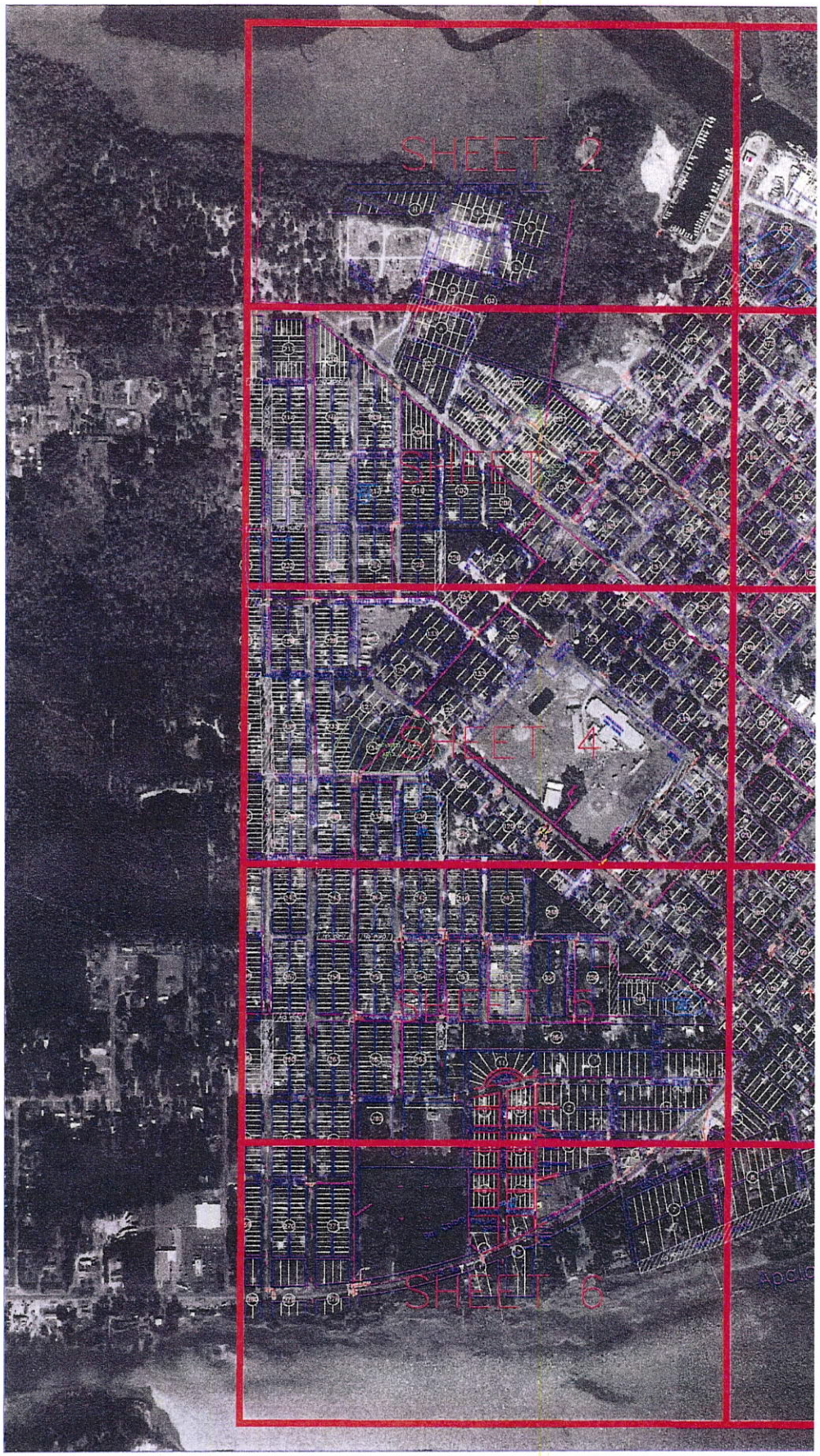


STORMWATER MASTER PLAN
PRIORITY DRAINAGE PROJECTS
LOCATION MAP
(NOVEMBER 2006)

BASKERVILLE-DONOVAN, INC.
INNOVATIVE INFRASTRUCTURE SOLUTIONS
PENSACOLA ■ PANAMA CITY ■ TALLAHASSEE ■ MOBILE
325 JOHN KNOX RD. BLDG. 200
TALLAHASSEE, FLORIDA 32303 (850)656-1212

Appendix D

Stormwater Infrastructure Maps



	INITIAL	DATE	NO.	BY	REVISIONS	DATE
FIELD BOOK						
DRAWN BY	BAM	6/2005				
SURVEYED BY						
CHECKED BY	RBL					

BASKERV
DONOVAN

325 JOHN KNOX RD. BL
TALLAHASSEE, FLORIDA 32303

PROJECT
STORMWATER MASTER PLAN
APALACHICOLA, FLORIDA

SHEET TITLE
STORMWATER INFRASTRUCTURE

COMPUTER FILE – APALACHICOLA INFRASTRUCTURE... .DWG
FILE NO.
PROJECT NO.

SHEET 1 OF 14

INITIAL	DATE	NO.	BY	REVISIONS	DATE
BAM	6/2005				

BASKERVILLE-DONOVAN, INC.

PROJECT
STORMWATE
APALACHI


PARK
COTTAGE HILL
SOUTH STREET
A
211
210
203
202
200
201
204
205
154
153
214
215
209
208
219
218
217
216
207
206
144
145
143
226
222
223
224
225
RIS CANNON ST
JAMES CLAY STREET (16th ST.)
EARL KING STREET (15th ST.)
24TH AVENUE
23RD AVENUE
22ND AVENUE
21ST AVENUE
12TH ST.
13TH ST.
(LOCUST ST.)
AVENUE
WETLAND
ISOLATED LOW AREA
WOODED LOW AREA
WOODED LOW AREA
24" RCP
18" RCP
24"RCP VERIFY
2 X 24" RCP
36" PVC
60
80

INITIAL	DATE	NO.	BY	REVISIONS	DATE
BDD					

BASKERVILLE-DONOVAN, INC.
325 JOHN KNOX RD. BLDG. 200

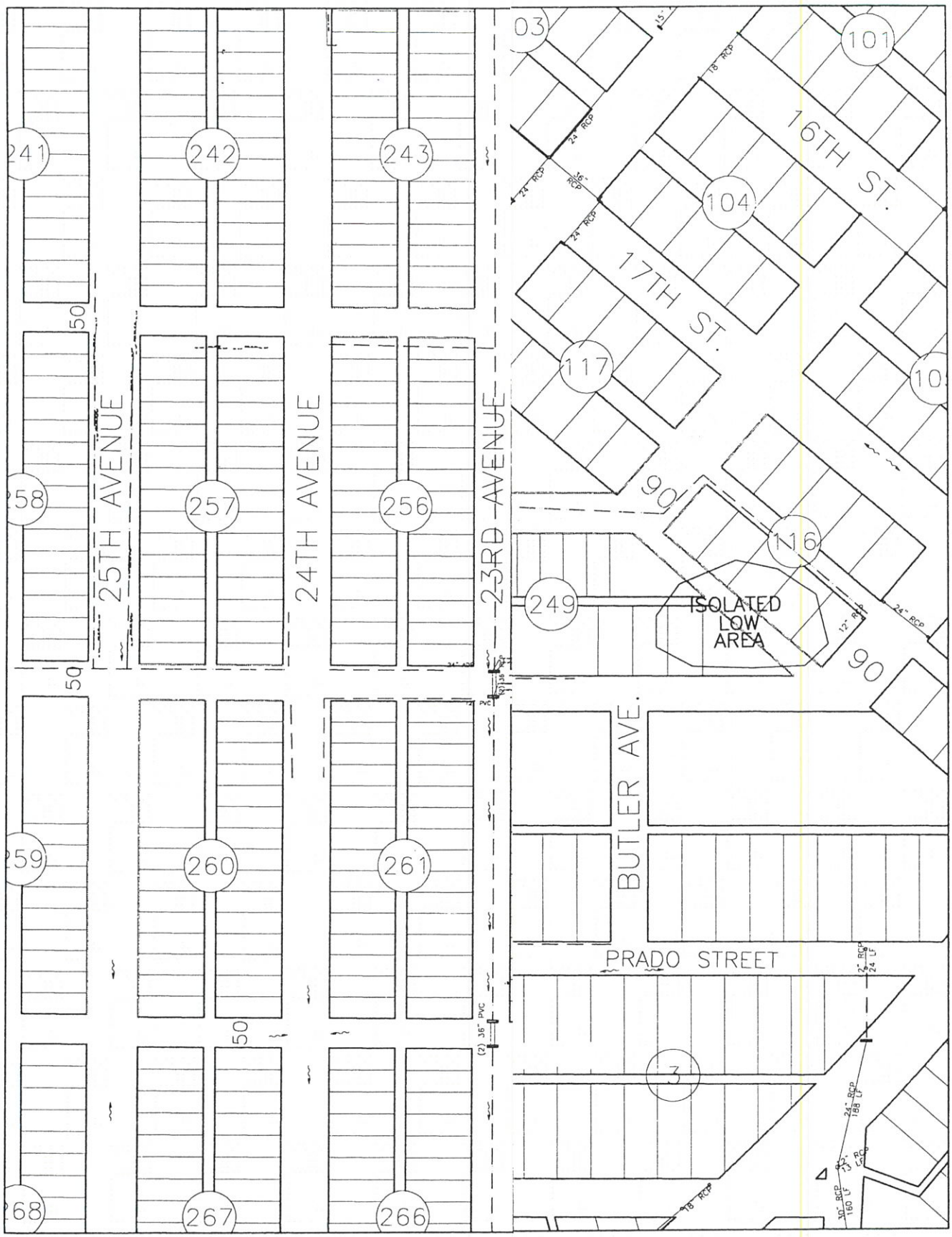
PROJECT
STORMWATE
APALACHI

FIELD BOOK					
DRAWN BY	BDD				
SURVEYED BY					
INITIAL	DATE	NO.	BY		

SHEET TITLE
STORMWATER INFRASTRUCTURE

SHEET 4 OF 14

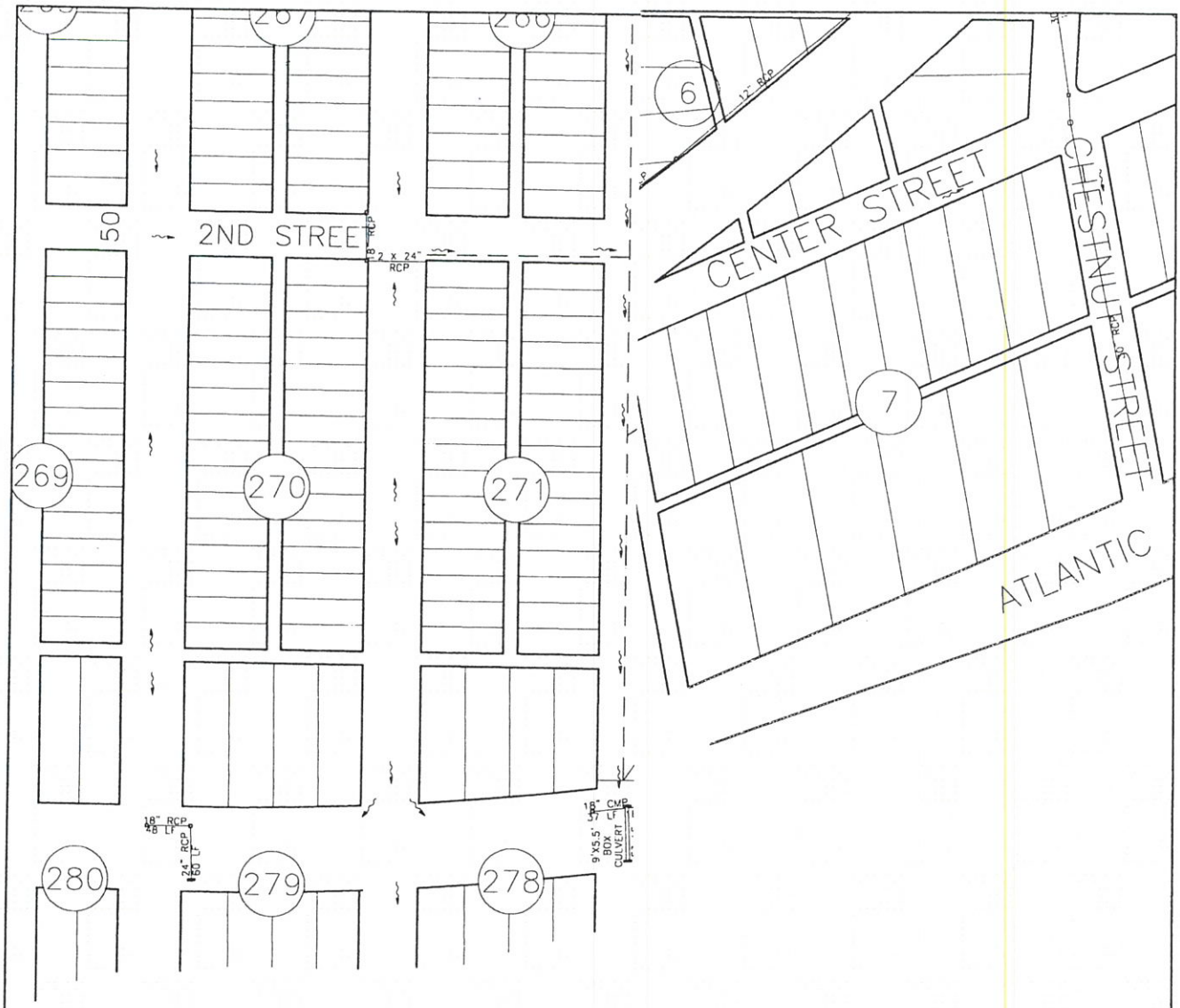
COMPUTER FILE – APALACHICOLA INFRASTRUCTURE....DWG



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

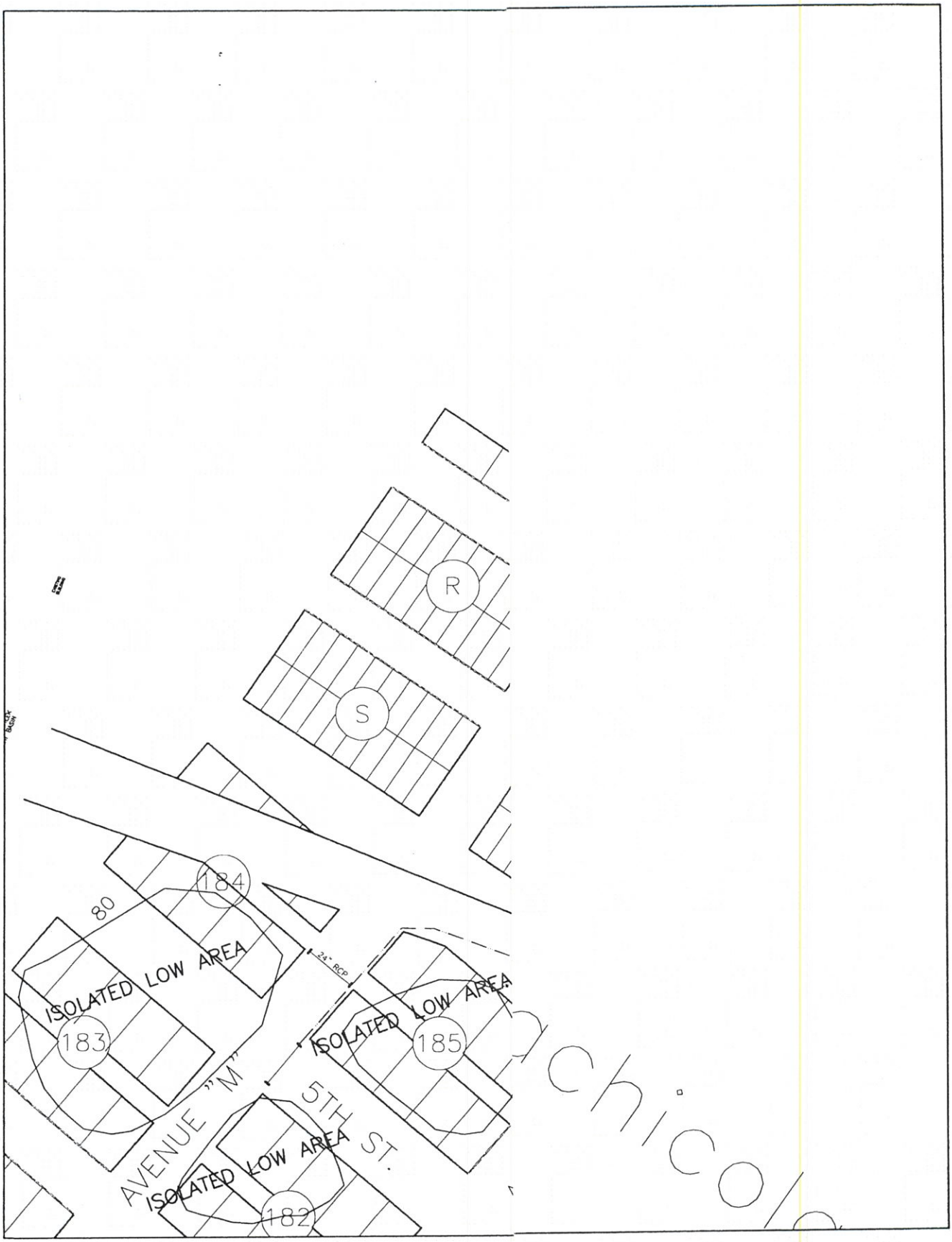
SHEET
5



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

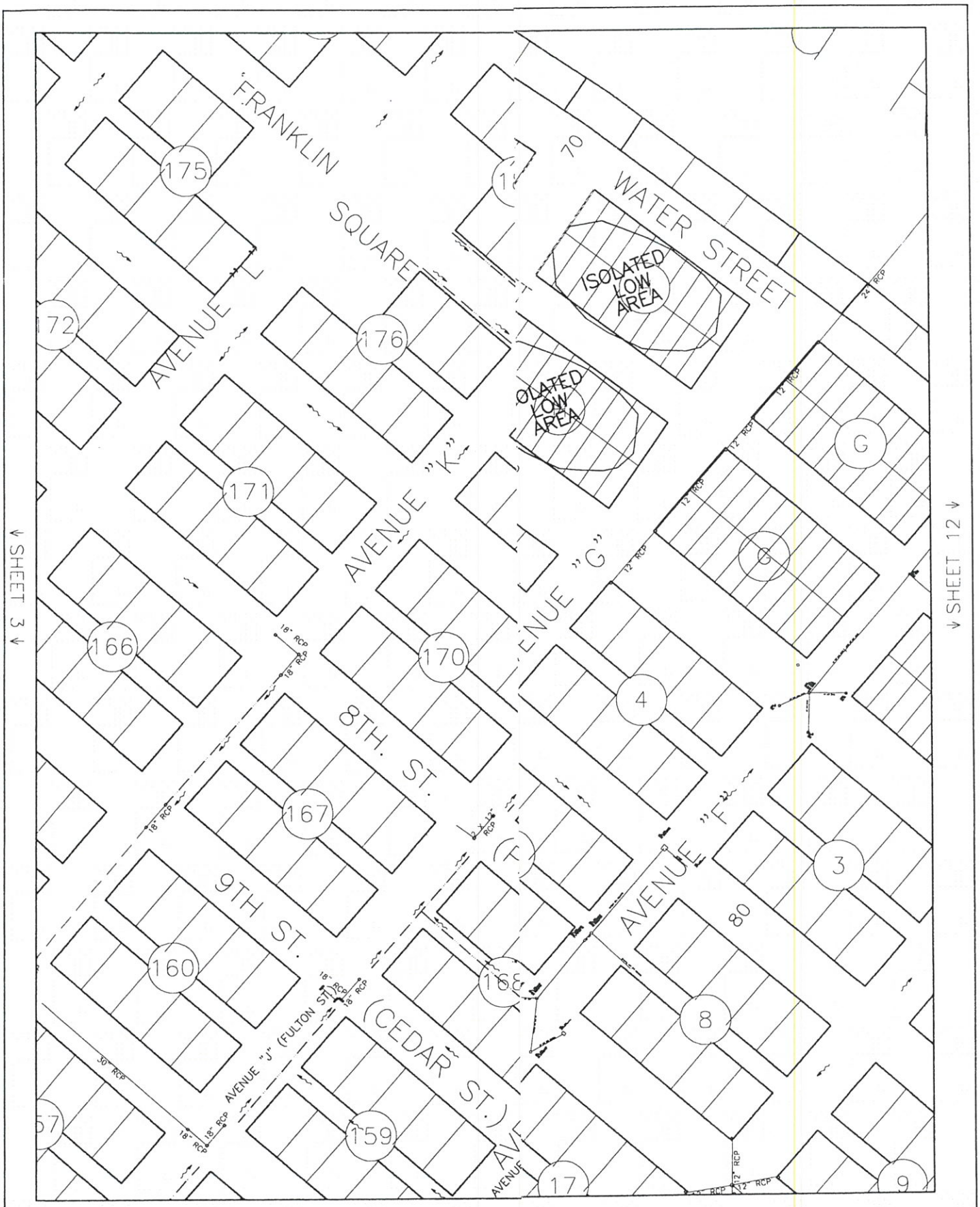
SHEET
6



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

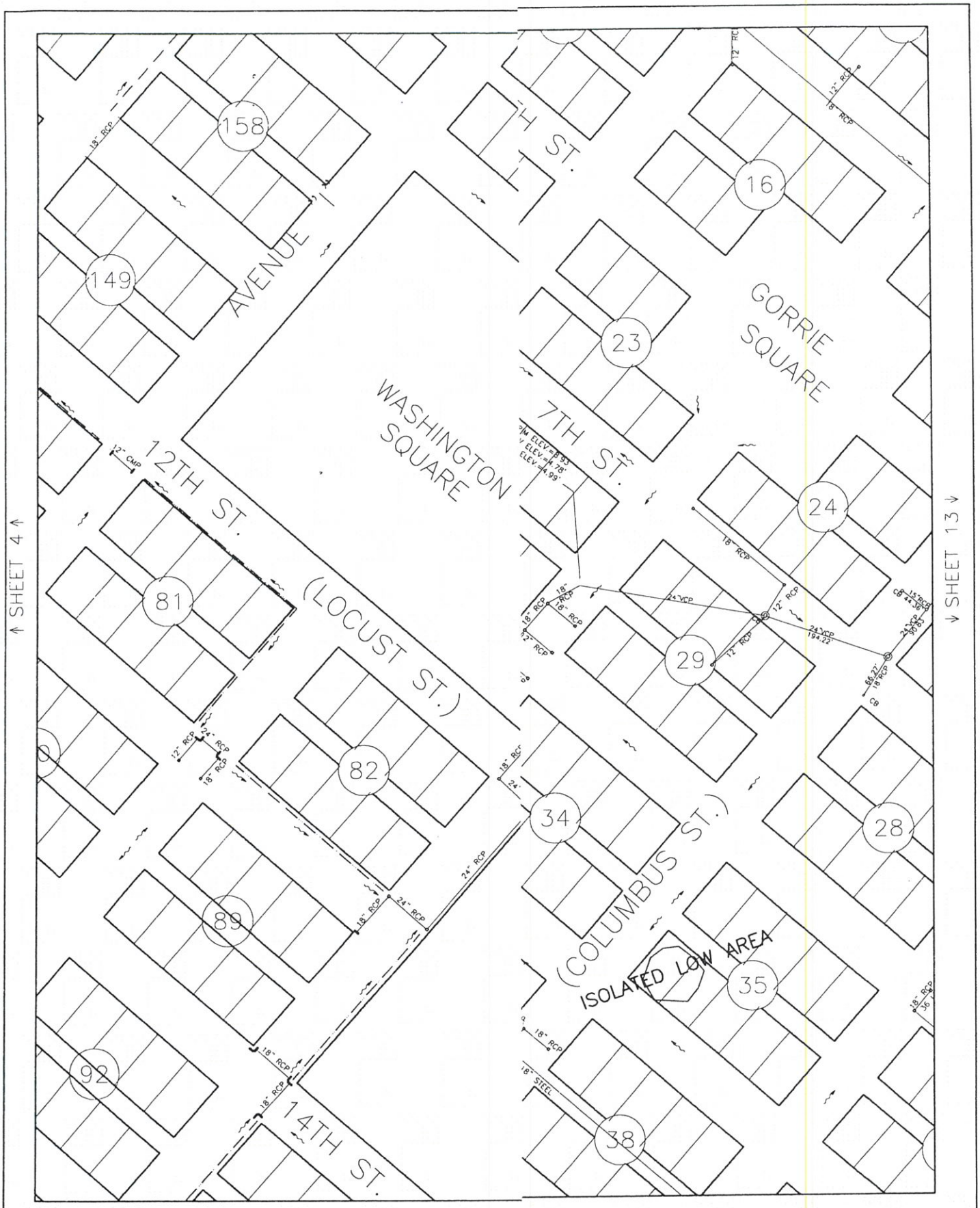
SHEET
7



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

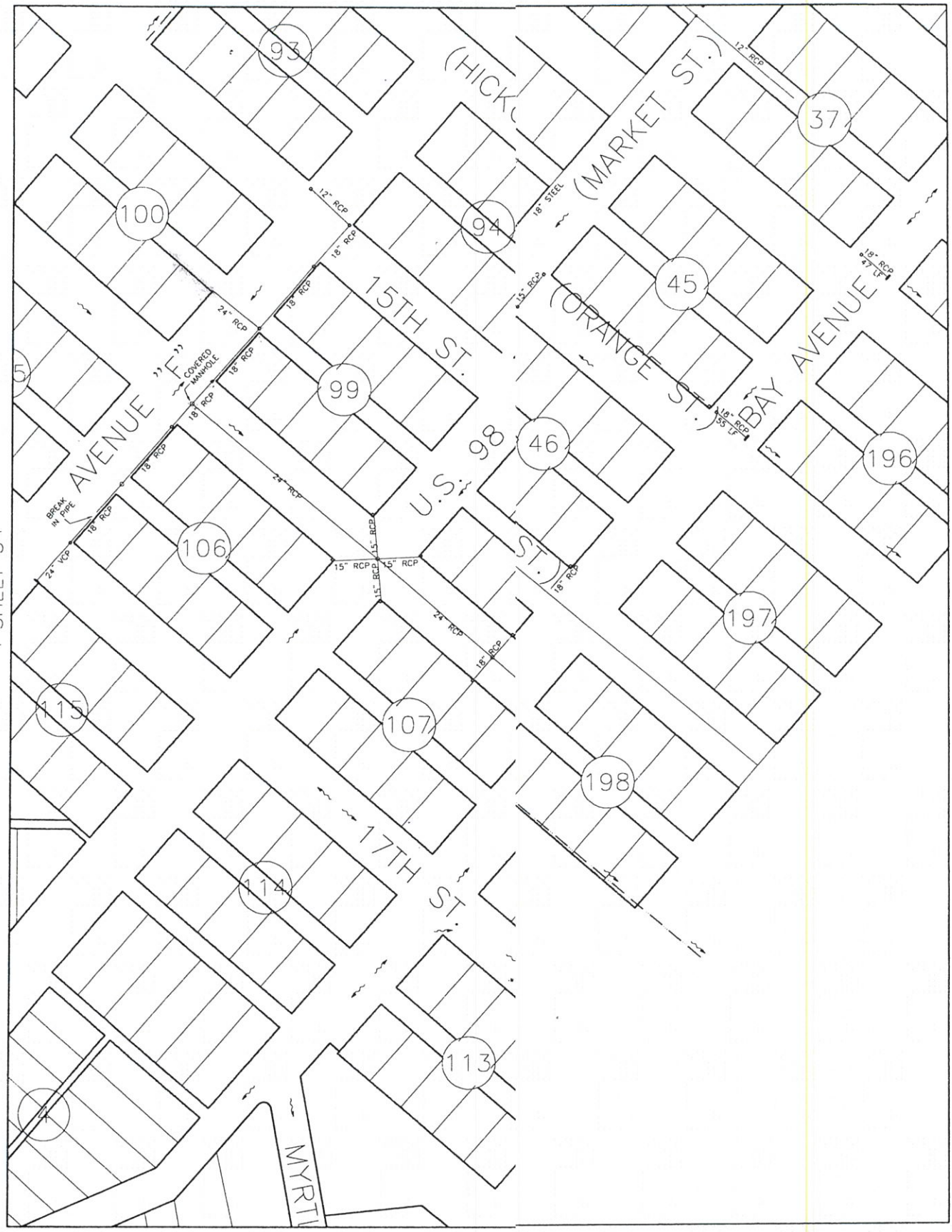
SHEET
8



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

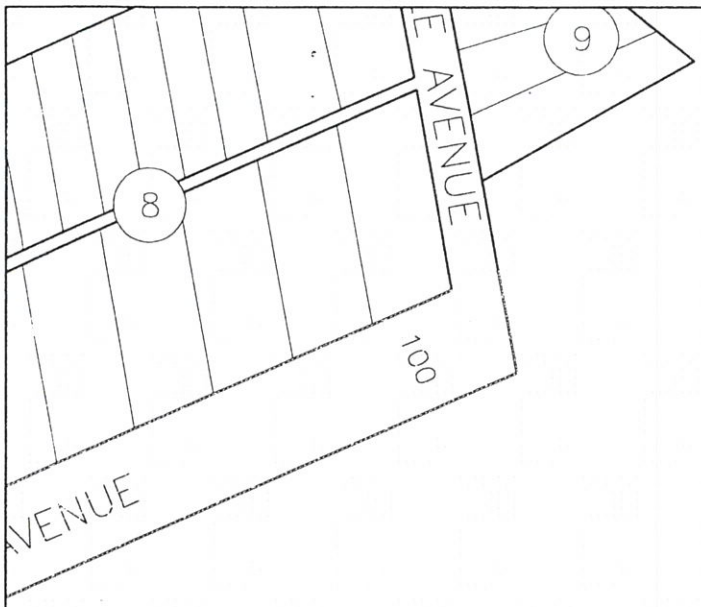
SHEET
9



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

SHEET 10



← SHEET 6 ←

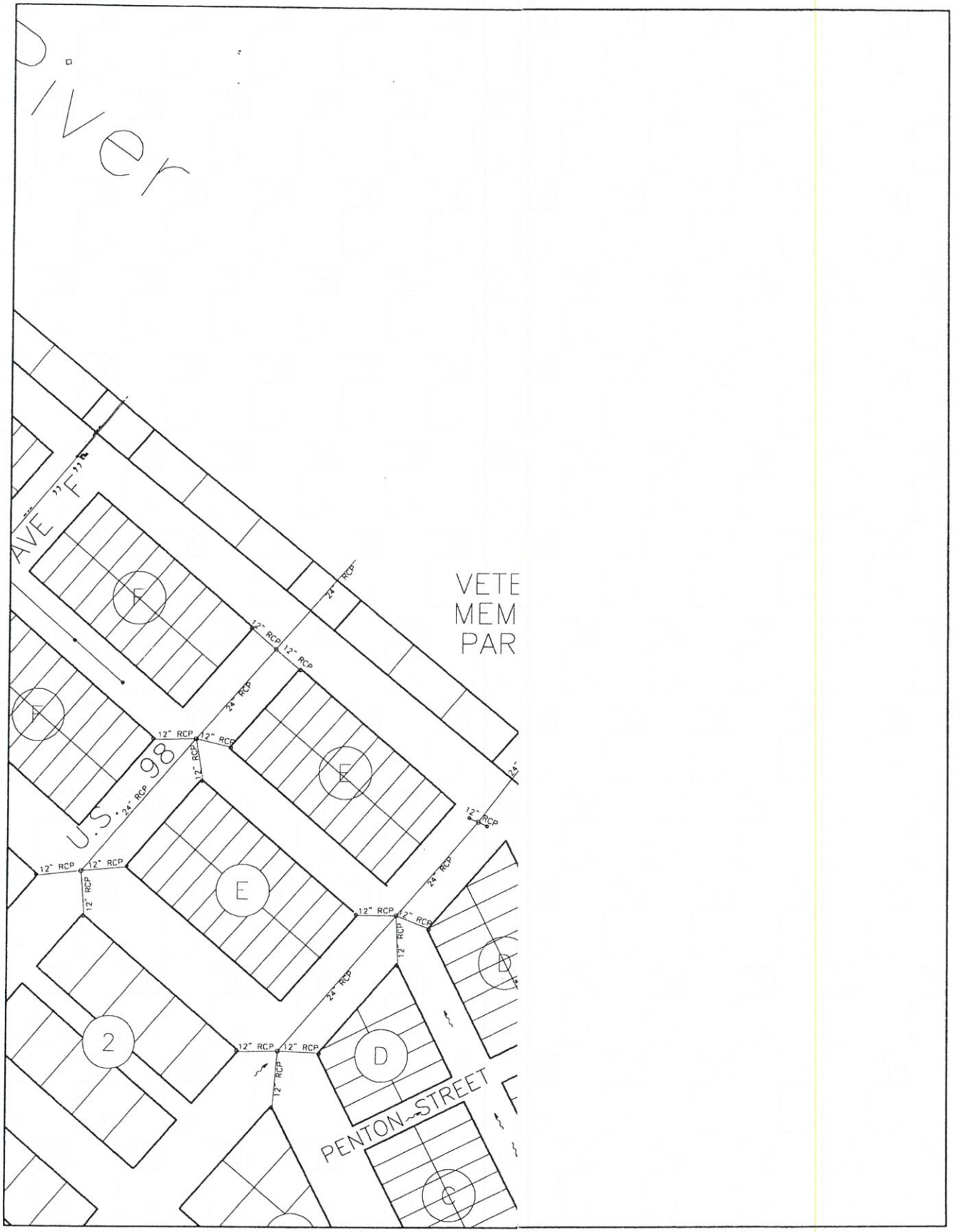
Apalach

	INITIAL	DATE	NO.	BY	
FIELD BOOK					
DRAWN BY	BDD				

N

SHEET TITLE
STORMWATER INFRASTRUCTURE

SHEET
11

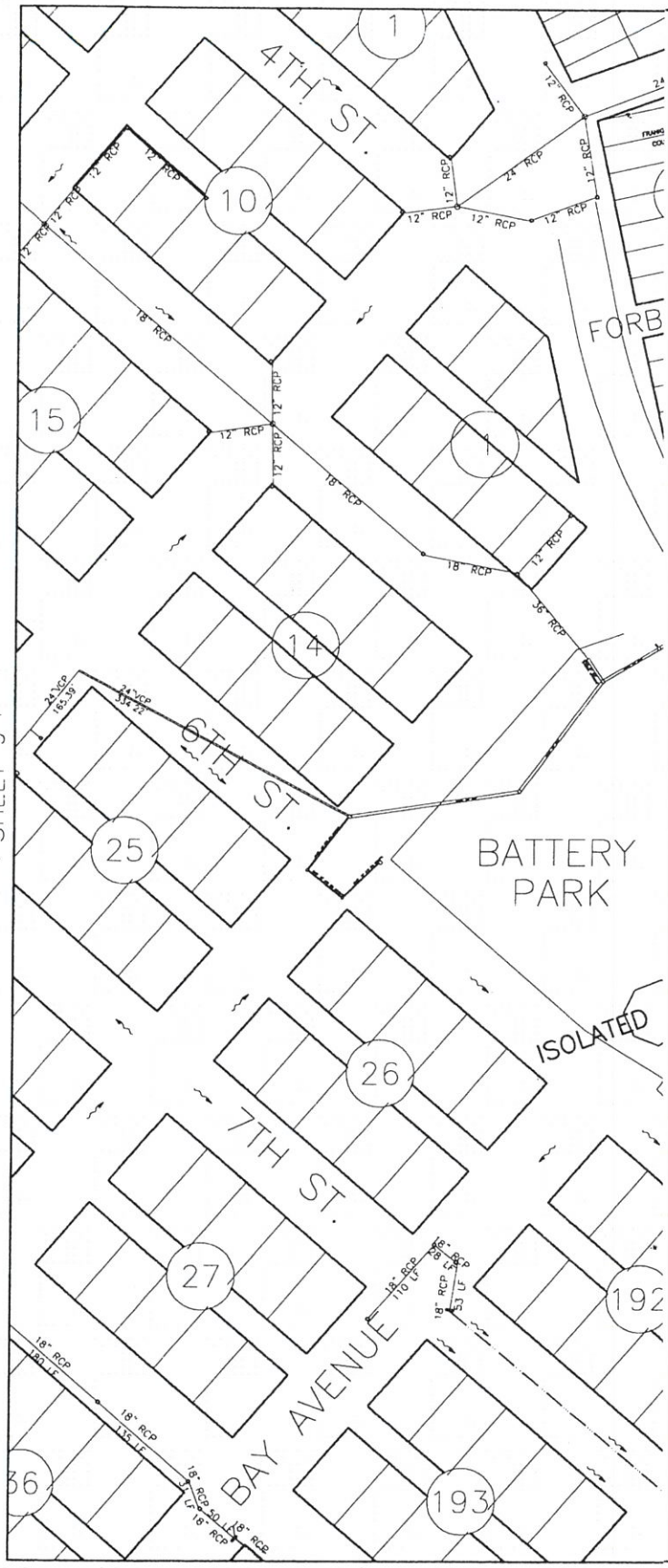


	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

N

SHEET TITLE
STORMWATER INFRASTRUCTURE

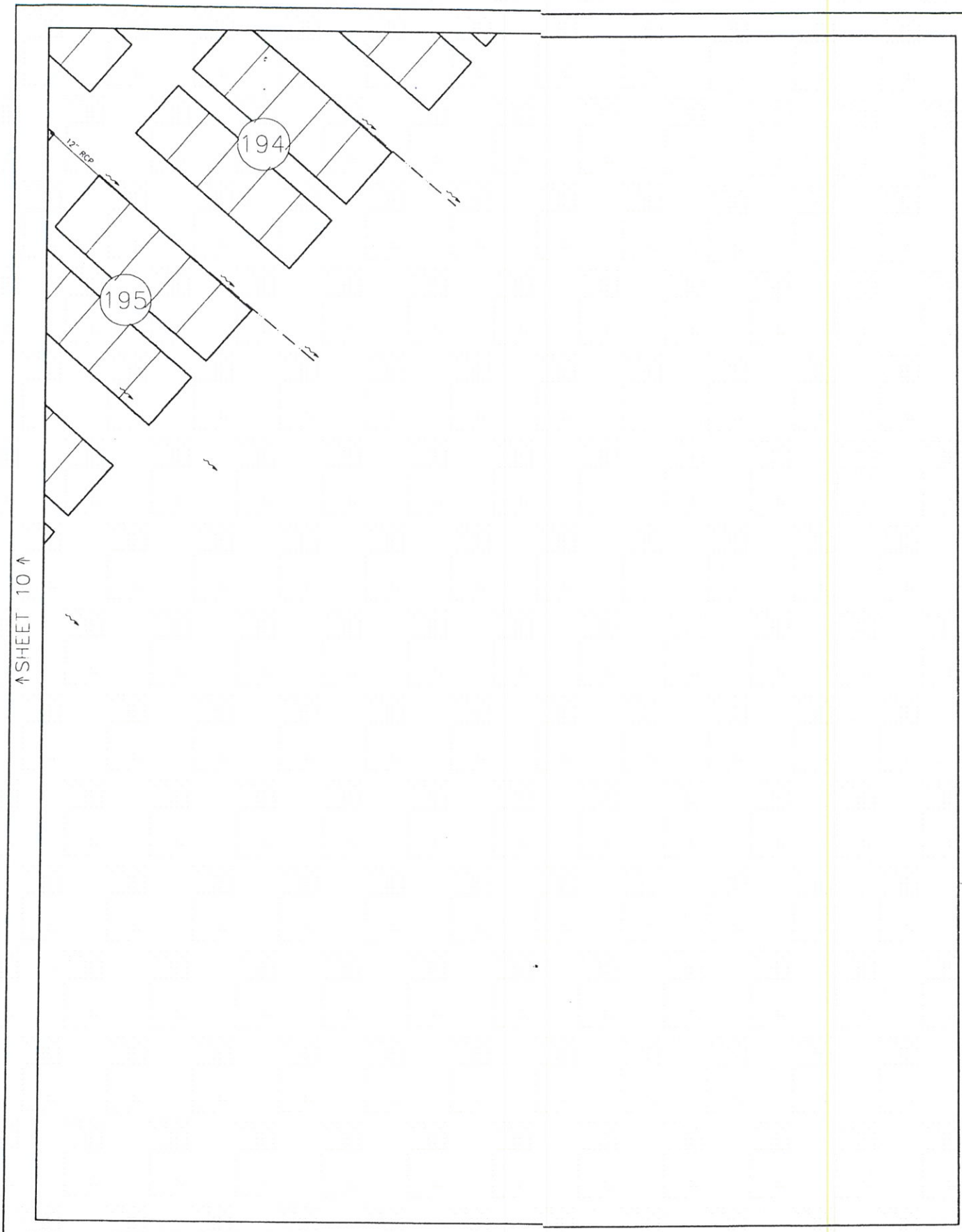
SHEET
12



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			
SURVEYED BY				

SHEET TITLE
STORMWATER INFRASTRUCTURE

SHEET
13



	INITIAL	DATE	NO.	BY
FIELD BOOK				
DRAWN BY	BDD			

SHEET TITLE
STORMWATER INFRASTRUCTURE

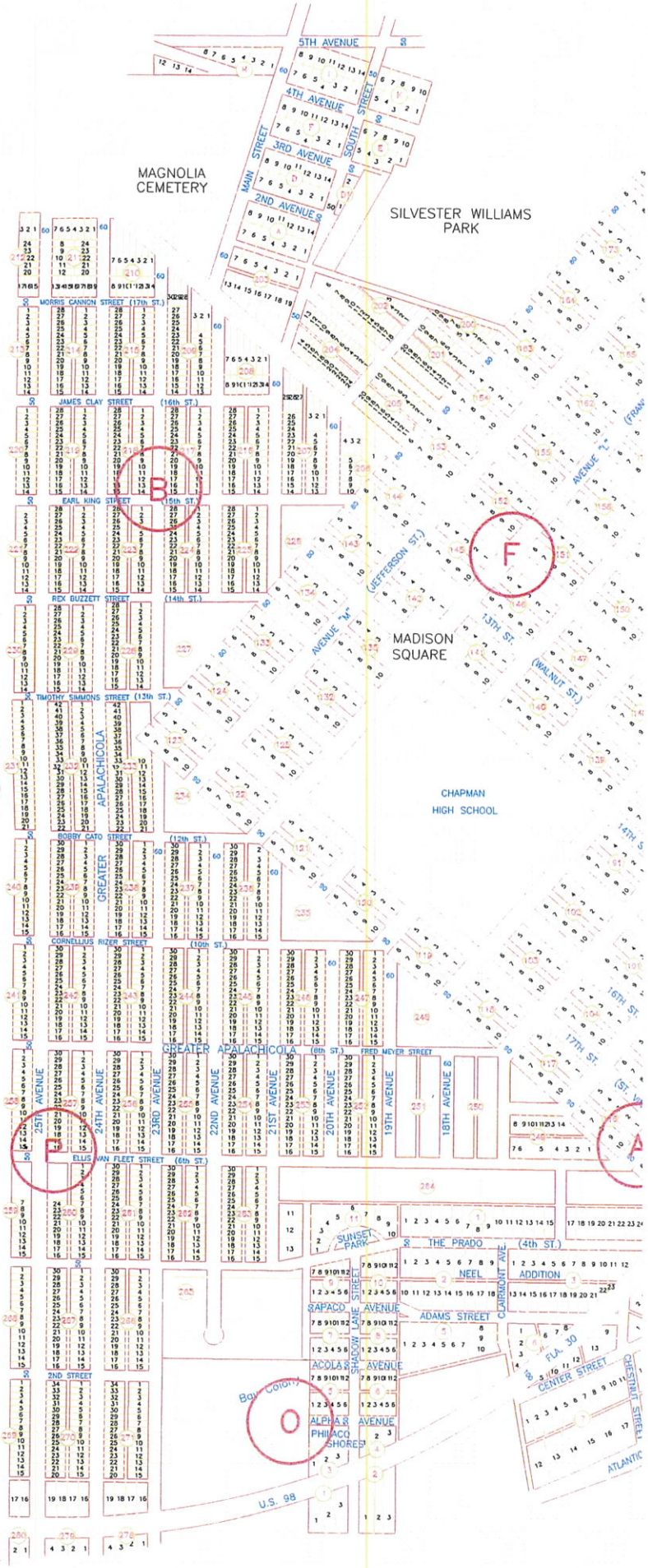
SHEET
14

Appendix E

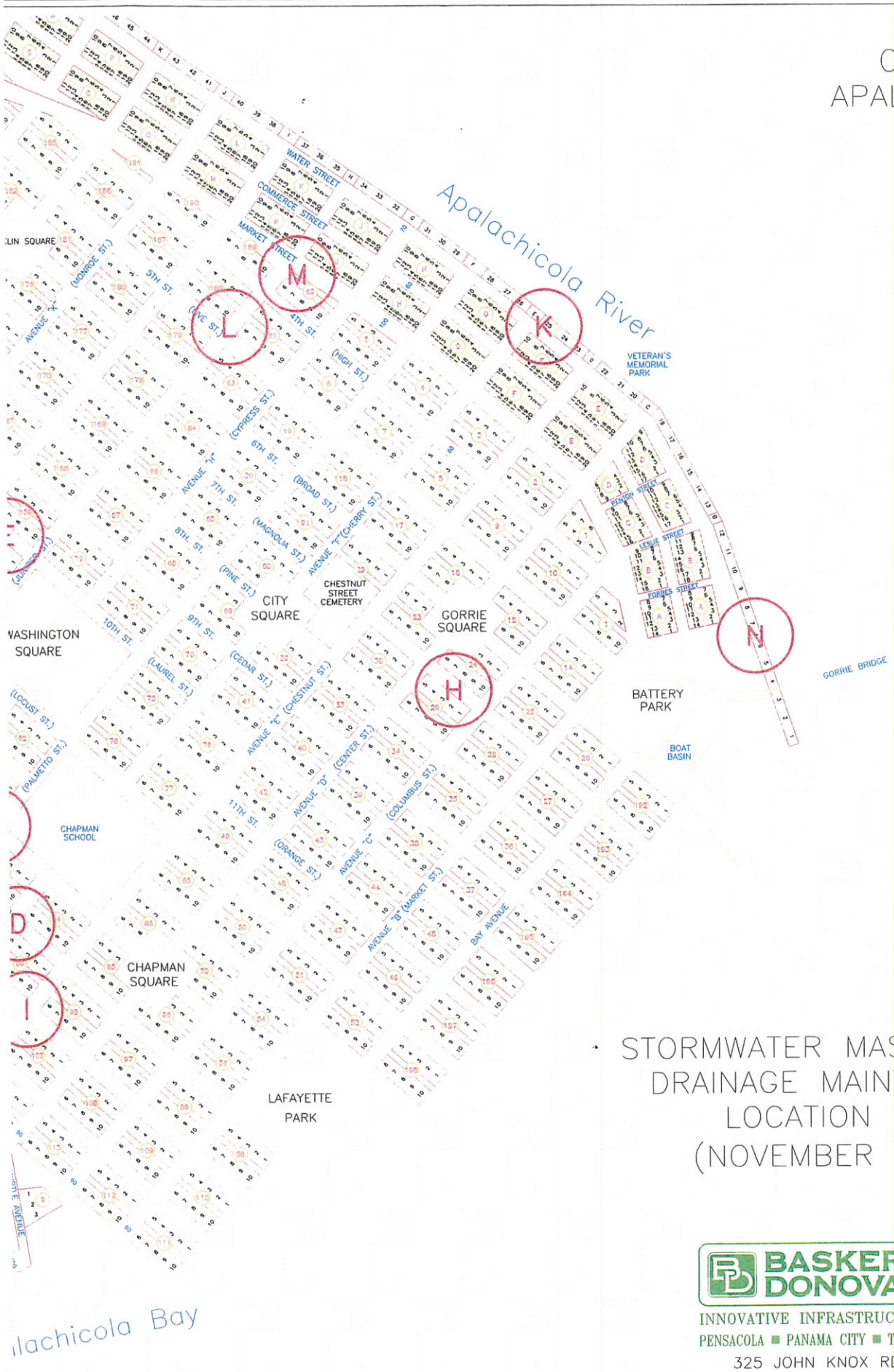
Drainage Maintenance Location Map

MAINTENANCE AREAS

- (A) 121 Ellis Van Fleet (Periodic Maint.)
- (B) 23rd and Earl King (Periodic Maint.)
- (C) 150 12th St. (Periodic Maint.)
- (D) 15th and Ave F (John Lee)(Periodic Maint.)
- (E) 170 10th St. (Ditch in alley)(Semiannual Maint)
- (F) 215 12th St. (Periodic Maint.)
- (G) 8th St. (Ron Smith)(Periodic Maint.)
- (H) 7th St. near Ave. C and D (Periodic Maint.)
- (I) US 98 and 16th Street (One Major and Regular Maint.)
- (J) 14th St. near Ave. G (Periodic Maint.)
- (K) Water St. and Avenue F (One Major and Semiannual Maint.)
- (L) Ave I Treatment Vault (Quarterly Maint.)
- (M) Ave I and Market St. Open Ditch (Semiannual Maint.)
- (N) Battery Park Outfall (One Major and Semiannual Maint.)
- (O) Bay Colony Outfall (Annual Maint.)
- (P) 25th Open Ditch (Annual Maint.)



CITY OF APALACHICOLA



(APPROXIMATE SCALE) 1" = 750'

STORMWATER MASTER PLAN
DRAINAGE MAINTENANCE
LOCATION MAP
(NOVEMBER 2006)

BASKERVILLE-DONOVAN, INC.
INNOVATIVE INFRASTRUCTURE SOLUTIONS
PENSACOLA ■ PANAMA CITY ■ TALLAHASSEE ■ MOBILE
325 JOHN KNOX RD. BLDG. 200
TALLAHASSEE, FLORIDA 32303 (850)656-1212

Appendix F

Guidelines for Stormwater Management Programs Best Management Practices

City of Apalachicola

Guidelines for Stormwater Management Programs

Best Management Practices

Prepared by

Baskerville-Donovan, Inc.

January 2003

TABLE OF CONTENTS

SECTION **PAGE**

INTRODUCTION **5**

1. PUBLIC EDUCATION AND OUTREACH ON STORMWATER IMPACTS **7**

A. Public outreach/education for homeowners ***7***
Lawn and garden activities 7
Water conservation practices for homeowners 7
Proper disposal of household hazardous wastes 7
Pet waste management 8
Trash management 8
B. Targeting public outreach/education ***8***
Education/outreach for commercial activities 8
Classroom education on stormwater 8
Stormwater educational materials 8
C. Public outreach programs for new development ***9***
Low impact development 9
D. Pollution prevention programs for existing development ***9***
Educational displays, pamphlets, booklets, and utility stuffers 9
Using the media 9

2. PUBLIC INVOLVEMENT/PARTICIPATION **10**

A. Activities/public participation ***10***
Storm drain stenciling 10
River and bay cleanup and monitoring 10
Volunteer monitoring 10
Reforestation programs 11
Wetland plantings 11
Adopt-A-River/Bay programs 11
B. Involvement/public opinion ***11***
Stakeholder meetings 11
Community hotlines 12

3. ILLICIT DISCHARGE DETECTION AND ELIMINATION **13**

Failing septic systems 13
Industrial/business connections 13
Recreational sewage 13
Sanitary sewer overflows 14
Wastewater connections to the storm drain system 14
Illegal dumping 14

4. CONSTRUCTION SITE STORMWATER RUNOFF CONTROL 15

A. Runoff Control 15

Land grading 15
Permanent diversions 15
Preserving natural vegetation 15
Construction entrances 16
Check dams 16
Riprap 16

B. Erosion Control 16

Mulching 16
Sodding 16
Geotextiles 17
Soil retention 17
Temporary slope drain 17
Vegetated buffer 17
Construction sequencing 18
Dust control 18

C. Sediment Control 18

Temporary diversion dikes 18
Wind fences and sand fences 18
Silt fence 19
Sediment filters and sediment chambers 19

D. Good Housekeeping *19*

General construction site waste management 19
Spill prevention and control plan 19
Vehicle maintenance and washing areas 20
Contractor certification and inspector training 20
BMP inspection and maintenance 20

5. ..... POST-CONSTRUCTION STORMWATER MANAGEMENT IN NEW DEVELOPMENT AND REDEVELOPMENT 22

A. Structural BMPs 22

Dry extended detention ponds 22
Wet ponds 22
Infiltration basin 22
Infiltration trench 23
Porous pavement 23
Bioretention 23
Stormwater wetland 23
Grassed swales 24
Baffle boxes 24
Grated Inlet and Curb Inlet Baskets 24
Proprietary Separator Systems 24

B. Nonstructural BMPs *25*
Buffer zones 25
Conservation easements 25
Narrower residential streets 25
Eliminating curbs and gutters 26
BMP inspection and maintenance 26
6. POLLUTION PREVENTION / GOOD HOUSEKEEPING FOR MUNICIPAL OPERATIONS **27**
A. Source controls *27*
Pet waste collection 27
Automobile maintenance 27
Vehicle washing 28
Illegal dumping control 28
Landscaping and lawn care 28
Pest control 28
Parking lot and street cleaning 29
Septic system controls 29
B. Materials management *29*
Hazardous materials storage 29
Spill response and prevention 30
Used oil recycling 30

Guidelines for Stormwater Management Programs
Best Management Practices

INTRODUCTION

The City of Apalachicola is historically, economically, socially and environmentally tied to the Apalachicola River and Apalachicola Bay. The City's historical roots trace back to the early 1800s, when it was established as a port for the cotton trade. Apalachicola quickly became Florida's largest cotton port before the Civil War and the third largest on the Gulf behind New Orleans and Mobile. At its peak, many steamboats plied the Apalachicola River, sailing between it and Columbus, Georgia, ferrying cotton to the town where it would be sold and compressed for shipment to the mills of New England and Europe. After the construction of east-west railroads siphoned off Apalachicola's cotton trade in the 1860s, the town's economy recovered with development of the area's vast timber resources. Steamships carried Apalachicola's milled cypress timbers as late as the 1920s.

Cotton and timber no longer drive the economy of the City. However, Apalachicola's economy remains tied to the River and Bay. The City's most important industries are recreational fishing and seafood harvesting. Apalachicola Bay is a very productive tidal bay system fed by the nutrient-rich Apalachicola River. Apalachicola Bay, where most of Florida's oysters are harvested, is renowned for its excellent quality oysters, blue crab, shrimp and fish. Unfortunately, the River and Bay are vulnerable to environmental conditions that impact the economy of the City. These conditions have occasionally caused the cessation of Bay harvesting. They include: periodic changes in river flow, which impacts Bay salinity; flood-borne siltation, which chokes the oyster beds; and discharges of wastewater and stormwater, which pollutes the Bay.

The State of Florida continues to seek an appropriate balance in the River flow issues. The City and the State have made significant efforts to eliminate the wastewater pollution discharges to the River and Bay. Stormwater pollution reduction must now be addressed to assure that the health of the River and Bay are protected.

The United States Environmental Protection Agency (EPA) has issued documents of stormwater discharge guidance for small municipalities to develop a stormwater management program. The guidance recommends a program of non-structural Best Management Practices (BMPs) which address six minimum control measures. The following Guidelines are prepared for application to specific existing conditions in the City of Apalachicola. The Guidelines are drawn from the NPDES guidance documents, and represent brief summaries of introduction to the wide variety of programs that the City may consider.

The six control measures addressed by NPDES guidance documents are:

1. Public education and outreach on stormwater impacts;
2. Public involvement/participation;

3. Illicit discharge detection and elimination;
4. Construction site stormwater runoff control;
5. Post-construction stormwater management in new development and redevelopment;
6. Pollution prevention/good housekeeping for municipal operations.

1. PUBLIC EDUCATION AND OUTREACH ON STORMWATER IMPACTS

This management practice guidance relates to measures, which utilize a combination of public education and outreach, to convey to the public information about the impacts of stormwater discharges on water bodies and the steps that the public can take to reduce pollutants in stormwater runoff.

A. Public outreach/education for homeowners

Lawn and garden activities

Lawn and garden activities can result in contamination of stormwater through pesticide, soil, and fertilizer runoff. The City should voluntarily decide to phase out the use of dozens of pesticides to encourage the use of less-toxic alternatives by municipal crews, and encourage residents to use the same practices in their own yards. Residents and municipal crews can partner with local nurseries and irrigation and lawn services to identify the appropriate landscape design for a specific site and to offer environmentally friendly practices to homeowners. Property owners should be encouraged to use mulches and should be informed of the benefits of these materials. Property owners and municipal crews should be discouraged from using fertilizers, or if they are used, from over-applying them. Pesticide use can be avoided entirely by selecting hearty plants that are native to the area and by keeping them healthy. The City should use ordinances as a means of controlling or preventing pesticide usage in the future.

Water conservation practices for homeowners

Water use has soared in recent years. Reduction in water consumption could limit the need for new or expanded water and sewage treatment plants, and reduce the possibility of overflow of septic system or treatment facilities during storm conditions. According to recent studies, water usage in the home can easily be reduced by 15 to 20 percent - without major discomfort - by implementing a program to conserve water in the home. The City should establish a public education and outreach program to demonstrate to homeowners that by making minor changes in water use habits, each household can reduce its water consumption while saving money on water and sewage bills, and minimizing potential for storm-caused pollution.

Proper disposal of household hazardous wastes

Many products found in homes contain chemical ingredients that are potentially harmful to people and to the environment. Chemicals such as oven cleaners, paint removers, bug killers, solvents, and drain cleaners are just a few common hazardous products in the home. The City should inform the public about the hazards of some commonly used household chemicals, and consider establishing a household hazardous waste collection facility. The City should try to partner with the solid waste disposal services for help with public education. The solid waste collection companies can also provide users with hazardous waste collection site information through their company's web site, newsletter, and billing statements. The City should emphasize to citizens that household hazardous wastes should not be flushed down the drain because these drains lead to either a home septic system or a

municipal treatment plant, neither of which has adequate capability to remove hazardous chemicals from wastewater

Pet waste management

When pet waste is not properly disposed of, it can wash into nearby waterbodies or can be carried by runoff into storm drains. Untreated animal feces can become a significant source of runoff pollution. The City should implement pet waste management programs by posting signs in parks or other pet frequented areas, sending mailings, making public service announcements, and implementing "pooper-scooper" laws that govern pet waste cleanup.

Trash management

Trash and floating debris in waterways have become significant pollutants. Trash in the river and bay contributes to visual pollution and detracts from the aesthetic qualities of the landscape. It also poses a threat to wildlife and human health. The City should install control structures, and regularly clean and maintain the structures.

B. Targeting public outreach/education

Education/outreach for commercial activities

Many commercial activities contribute to stormwater pollution (such as vehicle washing, landscape fertilization, and improper hazardous waste disposal). Therefore, it is important to address commercial activities specifically in an outreach strategy. It is also important to recognize that in most cases incentives must be provided to encourage businesses to change their behavior. There are numerous ways to provide education and outreach for commercial activities. Materials designed for businesses can include posters, magnets, calendars, flyers, brochures, and best management practices (BMPs) fact sheets or handbooks. The City should consider developing and distributing educational brochures and posters to these industries that outline BMPs that reduce urban runoff volume and pollutant concentration that result from their operations.

Classroom education on stormwater

Classroom education is an integral part of any stormwater pollution outreach program. Providing stormwater education through schools exposes the message not only to students but to their parents as well. Many municipal stormwater programs have partnered with educators and experts to develop stormwater-related curricula for the classroom. The City should work with school officials to identify their needs. For example, if the schools request stormwater outreach materials, the City can provide educational aids that range from simple photocopied handouts, overheads, posters, and slide shows to more costly and elaborate endeavors such as working models and displays.

Stormwater educational materials

The City should implement a stormwater education program for the general public. Stormwater education starts with a well-thought-out and well-developed outreach plan. The outreach plan should identify goals and objectives, classify the target audience, identify the message to be conveyed, and explain how the message will be distributed to the audience. Common distribution mechanisms include direct mail, door-to-door distribution, telephone,

targeted businesses, presentations, handouts at events, media outlets, and messages posted in public places.

C. Public outreach programs for new development

Low impact development

Using low-impact development (LID) approaches for new development can help to achieve stormwater pollution reduction goals. Through LID approaches, stormwater runoff can be controlled while development objectives are achieved. This outreach takes the form of the developer's communicating maintenance instructions and pollution prevention measures to the property owners. The public outreach program informs property owners of their responsibilities to the environment. When successfully implemented, LID education and awareness programs accomplish the following: Establishes a marketing tool that allows developers to attract environmentally conscious buyers; Creates more landscaped areas, enhancing the aesthetics of developed areas; Educates property owners on effective pollution prevention measures; Promotes the proper maintenance of best management practices; Inform commercial property owners of potential cost savings from using LID approaches.

D. Pollution prevention programs for existing development

Educational displays, pamphlets, booklets, and utility stuffers

The City should develop methods to convey its pollution prevention program to existing developments. Printed materials are a common way to inform the public about stormwater pollution. The City should utilize its public relations department or a staff member that handles these types of outreach materials, or contract with public relations firms and graphic designers to develop materials. Some common printed materials include educational displays, pamphlets, booklets, and utility stuffers. Computer desktop publishing has made the production of many of these materials easy.

Using the media

The City should work closely with the media to develop an effective pollution prevention program. The media can be strong allies to a stormwater pollution prevention campaign in educating the public about stormwater issues. Through the media, a program can educate targeted or mass audiences about problems and solutions, build support for remediation and retrofit projects, or generate awareness and interest in stormwater management. Best of all, packaging a stormwater message as a news story is virtually free! Delivering educational, promotional, or motivational messages through the news media is similar to distributing them through other channels. For best results, the message should be repeated periodically and linked to something the audience values. Coverage of watershed issues from several different angles can help to accomplish this. News is the lifeblood of the media, so the message must be packaged to attract coverage. Orienting the message to the workings of the media and the needs of reporters will help keep the message focused and effective.

2. PUBLIC INVOLVEMENT/PARTICIPATION

This management practice guidance relates to measures, to reach out and engage all economic and ethnic groups in the development and operation of stormwater pollution improvement programs.

A. Activities/public participation

Storm drain stenciling

The City should adopt a pollution awareness program, such as Storm Drain Stenciling. Storm Drain Stenciling involves labeling storm drain inlets with painted messages warning citizens not to dump pollutants into the drains. The stenciled messages are generally a simple phrase to remind passersby that the storm drains connect to local waterbodies and that dumping pollutes those waters. Stenciled messages might include: "No Dumping. - Drains to River," "Dumping Pollutes Our Bay", etc. Storm drain messages can be placed flat against the sidewalk surface just above the storm drain inlet, or placed on the curb facing the street. The City should identify only the most critical drains to stencil since there might be hundreds of inlets; and stenciling all of them would be prohibitively expensive and might actually diminish the effect of the message on the public. The City may perform the stenciling with municipal personnel, or consider recruiting volunteer groups to help.

River and bay cleanup and monitoring

An effective way for the City to promote stormwater awareness is to host a River or Bay cleanup. A public participation cleanup allows concerned citizens to become directly involved in water pollution prevention. Almost anyone can get involved in cleanup activities: schoolchildren, youth groups, neighborhood associations, local environmental groups, and individuals. Cleanups have tasks of varying levels of difficulty, so there is something for people of all ages and skills to do. The City should consider designating an individual or groups of individuals to schedule and organize the cleanup projects, recruit volunteers, coordinate trash disposal with the local solid waste authority, and assign staff for supervision of the projects. Projects should be scheduled several months in advance to provide adequate time to organize volunteers and handle logistical issues

Volunteer monitoring

Volunteer monitoring programs should be sponsored by the City to encourage citizens to learn about their water resources. These volunteer monitors: build awareness of pollution problems; become trained in pollution prevention; help clean up problem sites; increase the amount of water quality information available to decision makers at all levels of government. The volunteers conduct a variety of activities, including analyzing water samples for dissolved oxygen, nutrients, pH, temperature, and many other water constituents; evaluating the health of river and bay habitats and aquatic biological communities; inventorying waterside conditions and land uses that may affect water quality; cataloging and collecting beach debris; and, restoring degraded habitats.

Reforestation programs

A City reforestation programs can be used throughout the community to reestablish forested cover on a cleared site, establish a forested buffer along river and bay corridors to filter pollutants and reduce flood hazards, provide shade and aesthetic benefits in neighborhoods and parks, and improve appearance and pedestrian comfort along roadsides and in parking lots. It is up to the City to choose candidate sites for reforestation programs, and these decisions can be based on residents' recommendations or on overall capital improvement goals of the community

Wetland plantings

Over time, many wetland, riparian, and bay shore environments have become degraded by human-induced disturbances, such as the introduction of invasive, non-native plants. Such exotic vegetation can reduce habitat quality (e.g., loss of food supply), contribute to an unkempt, weedy appearance, and obscure the waterbody from view. These disturbances have not only affected the natural functions of these systems by causing increased erosion, a decline in natural wetland vegetation, and degraded habitats, but they have also reduced the aesthetic value of the environment. Wetlands and waterbodies are also disturbed by land development activities in adjacent areas and in upland areas within the watershed. These disturbances often result in sediment deposition, nutrient enrichment, and increased stormwater flows into the wetlands. This causes a reduction in water clarity that ultimately limits the growth of wetland plant species and submerged aquatic vegetation, the smothering of riverbeds and bay bottoms, contamination of water quality, and alteration of natural hydrology. The City should establish a program to plant wetland species to both preserve existing wetlands and enhance degraded wetland plant communities. The City may consider involving volunteer groups in the program. Similar volunteer programs conducted elsewhere have resulted in the adoption of wetlands, river and bay segments, and parks by a number of agencies and organizations in the area

Adopt-A-River/Bay programs

The City may consider establishing an Adopt-A-River/Bay program. Such programs are excellent public outreach tools to involve citizens of all ages and abilities. They are volunteer programs in which participants "adopt" a river or bay area to study, clean up, monitor, protect, and restore. Through these activities, the adopting group or organization becomes the primary caretaker of that stretch of river and bay in the watershed. Activities of the program may involve implementing river and bay cleanups, conducting riverbank and bay shore surveys, monitoring river and bay fauna and gauging water quality, executing riverbank and bay shore enhancement projects, such as tree planting, to help control erosion and stabilize riverbank and bay shore, implementing storm drain stenciling, conducting construction site surveys for proper stormwater controls, promoting education about the watershed through waterfront walks, workshops, and other activities

B. Involvement/public opinion

Stakeholder meetings

The City may consider encouraging the establishment of stormwater stakeholders groups. Stakeholders are individuals or groups in the community that are most affected by the City's

stormwater program. They have a vested interest in the waterbody and stormwater activities. Stakeholders might include citizens, fishermen, watersport organizations, local school groups, community leaders, local and state government representatives, and business owners in the watershed. Stakeholder meetings can be in the form of a local stormwater management panel, a public meeting, or any type of interactive, information-sharing event. One of the greatest benefits of stakeholder meetings is the accumulation of ideas from people of all backgrounds and all interests, and the ability to convey these ideas to City Officials on behalf of the stormwater program.

Community hotlines

The City should consider establishing a Stormwater Hotline. Hotlines provide a means for concerned citizens and agencies to contact the appropriate authority when they see water quality problems. A typical Hotline call might report a leaking automobile, concrete wash-out dumped on the street, paint in a creek, or organic debris in a drainage system or waterway. Generally, an investigation team promptly responds to a hotline call and, in most cases, visits the problem site. If a responsible party can be identified, the team informs the party of the problem, offers alternatives for future disposal, and instructs the party to resolve the problem. If the issue is not resolved by the responsible party (or the party cannot be identified), the proper authority takes action to remediate the situation and prevent future violations.

3. ILLICIT DISCHARGE DETECTION AND ELIMINATION

This management practice guidance relates to measures, to develop, implement and enforce a program to detect and eliminate illicit discharges

Failing septic systems

The goal of this program is to prevent new septic systems from failing and to detect and correct existing systems that have been failing. Failure of septic systems can be due to a number of causes, including unsuitable soil conditions, improper design and installation, or inadequate maintenance practices. Conditions that can affect septic system function include drainfield size, soil type, separation distance from the water table and bedrock, topography, flooding frequency, density of development, and distance to river or bay shorelines. Improperly functioning septic systems are recognized as a significant contributor of pollutants and microbiological pathogens. The City must adopt programs, which locate failing septic systems and cause their repair or removal. Identifying and eliminating failing septic systems will help control contamination of ground and surface water supplies from untreated wastewater discharges.

Industrial/business connections

This management practice involves the identification and elimination of illegal or inappropriate connections of industrial and business wastewater sources to the storm drain system. Any industrial discharge not composed entirely of stormwater that is conveyed to the storm drainage system or a water body is considered to be an illicit discharge. Discharges from industry and business may come from a variety of sources including process wastewater, wash waters, and sanitary wastewater. The City must adopt inspection systems for new businesses, which include preventative practices such as thorough inspection and verification during the entire construction phase, to assure that illegal connections are not made, and to avoid the need for more extensive detection techniques and disconnection. For existing industries, improper connections should be located by the City, using field-screening procedures, source testing protocols, and visual inspection.

Recreational sewage

This management measure seek to regulate wastewater generated from outdoor activities such as boating or camping by providing alternative methods to waste disposal in place of illegal overboard discharge. The proper disposal of recreational waste is necessary to avoid the impacts that these activities and their associated developments (i.e., marinas and campgrounds) can have on aquatic environments. Marina and recreational boat sewage can have substantial impact on water quality by introducing bacteria, nutrients, and hazardous chemicals into waterways. Boats can be a significant source of fecal coliform bacteria in areas with high boating densities and low hydrologic flushing, and fecal coliform levels become elevated near boats during periods of high occupancy and usage (USEPA, 1993). Several City management practices can reduce the discharge of sewage from vessels at marinas. These practices range from installation of pumpout systems to public education to designation of No-Discharge Zones, to inspection of marine sanitation devices.

Sanitary sewer overflows

Sanitary sewer overflows (SSOs) involve the release of raw sewage from a separate sanitary sewer system prior to reaching a treatment facility. The raw sewage from these overflows contains bacteria and nutrients that affect both human and environmental health. These overflows occur when the flow into the system exceeds the design capacity of the conveyance system, resulting in discharges into streets, and on to the river and bay. A common SSO is overflowing sewage manholes that send untreated sewage into the river and bay. SSOs can occur in any system due to factors such as flooding or temporary blockages. Chronic overflows are an indicator of a deteriorating system or a system where development has exceeded capacity. Many overflows are the result of inadequate operation and maintenance, improper design and construction, or poor planning that has resulted in new development exceeding the system capacity of an area. Sanitary sewer overflows can often be reduced or eliminated by a number of practices, including the following: Sewer system inspection, cleaning and maintenance; Reducing infiltration and inflow through rehabilitation and repair of broken or leaking sewer lines; Enlarging or upgrading the capacity of sewer lines, pump stations, or sewage treatment plants; Constructing wet weather storage and treatment facilities to treat excess flows; Addressing SSOs during sewer system master planning and facilities planning. The City should assure that programs are in place, which are designed to control sanitary sewer overflows and establish policies for designing, screening and maintaining the sanitary sewer system.

Wastewater connections to the storm drain system

An illicit discharge is considered to be a discharge composed of non-stormwater that enters the storm drain system through an unwarranted connection. Storm sewer systems are sometimes employed as an inexpensive or convenient alternative to proper disposal of wastewater to treatment plants. These illegal wastewater discharges can occur as illicit connections from commercial or business establishments or illegal dumping into storm drain inlets. The City should adopt a program of illicit connection detection and elimination to seek and prevent contamination of ground and surface water supplies by regulation, inspection, and removal of these illegal sources of wastewater discharge.

Illegal dumping

Illegal dumping is disposal of waste in an unpermitted area, such as a back area of a yard, a river bank, bay shore, or some other off-road area. Illegal dumping can also be the pouring of liquid wastes or disposing of trash down storm drains. Illegally dumping wastes down storm drains and creating illegal dumps can impair water quality. Runoff from dumpsites containing chemicals can contaminate wells and the waters of the river and bay. The City should install a program of education and enforcement, coupled with the Storm Drain Stenciling Program, to control illegal dumping.

4. CONSTRUCTION SITE STORMWATER RUNOFF CONTROL

This management practice guidance relates to measures, to develop, implement, and enforce a program to reduce pollutants in any stormwater runoff from construction activities that result in a land disturbance of greater than or equal to one acre. A sizeable volume of procedures and guidelines is available for the control of stormwater runoff from construction sites. The following are intended only as brief comments on the major techniques and approaches applicable for adoption by the City.

A. Runoff Control

Land grading

Improper grading practices that disrupt natural stormwater patterns might lead to poor drainage, high runoff velocities, and increased peak flows during storm events. Clearing and grading of the entire site without vegetated buffers promotes off-site transport of sediments and other pollutants. The grading plan must be designed with erosion and sediment control and stormwater management goals in mind; grading crews must be carefully supervised to ensure that the plan is implemented as intended. A grading plan should be prepared that establishes which areas of the site will be graded, how drainage patterns will be directed, and how runoff velocities will affect receiving waters. Berms, diversions, and other stormwater practices that require excavation and filling also should be incorporated into the grading plan.

Permanent diversions

Diversions are used in areas where runoff from areas of higher elevation poses a threat of property damage or erosion. Diversions can also be used to promote the growth of vegetation in areas of lower elevations. Diversions protect upland slopes that are being damaged by surface and/or shallow subsurface flow by reducing slope length, which minimizes soil loss. Diversions can be constructed by creating channels across slopes with supporting earthen ridges on the bottom sides of the slopes. The ridges reduce slope length, collect stormwater runoff, and deflect the runoff to acceptable outlets that convey it without erosion.

Preserving natural vegetation

Preservation of natural vegetation is applicable to all construction sites where vegetation exists in the predevelopment condition. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, riverbanks, bay shore, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain. Only land needed for building activities and vehicle traffic needs to be cleared. The following are basic considerations for preservation of natural vegetation: Boards should not be nailed to trees during building operations; Tree roots inside the tree drip line should not be cut; Barriers should be used to prevent the approach of equipment within protected areas; Equipment, construction materials, topsoil, and fill dirt should not be placed within the limit of preserved areas; If a tree or shrub that is marked for preservation is damaged, it should be removed and replaced with a tree of the same or similar species with a 2-inch or larger caliper width from balled and burlaped nursery stock when construction activity is complete; During final site cleanup, barriers around preserved areas and trees should be removed.

Construction entrances

The purpose of stabilizing entrances to a construction site is to minimize the amount of sediment leaving the area as mud and sediment attached to motorized vehicles. Installing a pad of gravel over filter cloth where construction traffic leaves a site can help stabilize a construction entrance. As a vehicle drives over the gravel pad, mud and sediment are removed from the vehicle's wheels and offsite transport of soil is reduced. The gravel pad also reduces erosion and rutting on the soil beneath the stabilization structure. The filter fabric separates the gravel from the soil below, preventing the gravel from being ground into the soil. The fabric also reduces the amount of rutting caused by vehicle tires by spreading the vehicle's weight over a larger soil area than just the tire width.

Check dams

Check dams are small, temporary dams constructed across a swale or channel. Check dams can be constructed using gravel, rock, sandbags, logs, or straw bales and are used to slow the velocity of concentrated flow in a channel. By reducing the velocity of the water flowing through a swale or channel, check dams reduce the erosion in the swale or channel. As a secondary function, check dams can also be used to catch sediment from the channel itself or from the contributing drainage area as stormwater runoff flows through the structure. However, the use of check dams in a channel should not be a substitute for the use of other sediment-trapping and erosion control measures. As with most other temporary structures, check dams are most effective when used in combination with other stormwater and erosion and sediment control measures.

Riprap

Riprap is a permanent, erosion-resistant layer made of stones or broken concrete. It is intended to protect soil from erosion in areas of concentrated runoff. Riprap may also be used to stabilize slopes that are unstable because of seepage problems. Riprap can be used to stabilize cut-and-fill slopes; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and riverbanks and grades.

B. *Erosion Control*

Mulching

Mulching is a temporary erosion control practice in which materials such as grass, hay, wood chips, wood fibers, straw, or gravel are placed on exposed or recently planted soil surfaces. Mulching is highly recommended as a stabilization method and is most effective when used in conjunction with vegetation establishment. In addition to stabilizing soils, mulching can reduce stormwater runoff velocity. When used in combination with seeding or planting, mulching can aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Sodding

Sodding is a permanent erosion control practice that involves laying a continuous cover of grass sod on exposed soils. In addition to stabilizing soils, sodding can reduce the velocity of

stormwater runoff. Sodding can provide immediate vegetative cover for critical areas and stabilize areas that cannot be vegetated by seed. It also can stabilize channels or swales that convey concentrated flows and can reduce flow velocities. Sodding is appropriate for any graded or cleared area that might erode, requiring immediate vegetative cover. Locations particularly well suited to sod stabilization are: Steeply-sloped areas; Waterways and channels carrying intermittent flow; Areas around drop inlets that require stabilization.

Geotextiles

Geotextiles are porous fabrics also known as filter fabrics. Geotextiles are manufactured from synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these materials. They are used for a variety of purposes such as separators, reinforcement, filtration and drainage, and erosion control. Geotextiles can aid in plant growth by holding seeds, fertilizers, and topsoil in place.
Geotextiles can be used as matting, which is used to stabilize the flow of channels or swales or to protect seedlings on recently planted slopes until they become established. Matting may be used on tidal or riverbanks, where moving water is likely to wash out new plantings. They can also be used to protect exposed soils immediately and temporarily, such as when active piles of soil are left overnight.

Soil retention

Soil retention measures are structures or practices that are used to hold soil in place or to keep it contained within a site boundary. They may include grading or reshaping the ground to lessen steep slopes or shoring excavated areas with wood, concrete, or steel structures. Some soil-retaining measures are used for erosion control, while others are used for protection of workers during construction projects such as excavations. Reinforced soil-retaining structures should be used when sites have very steep slopes or loose, highly erodible soils.

Temporary slope drain

A temporary slope drain is a flexible conduit extending the length of a disturbed slope and serving as a temporary outlet for a diversion. Temporary slope drains convey runoff without causing erosion on or at the bottom of the slope. This practice is a temporary measure used during grading operations until permanent drainage structures are installed and until slopes are permanently stabilized.

Vegetated buffer

Vegetated buffers are areas of either natural or established vegetation that are maintained to protect the water quality of neighboring areas. Buffer zones reduce the velocity of stormwater runoff, provide an area for the runoff to permeate the soil, contribute to ground water recharge, and act as filters to catch sediment. The reduction in velocity also helps to prevent soil erosion. Vegetated buffers can be used in any area that is able to support vegetation but they are most effective and beneficial on floodplains, near wetlands, along riverbanks, bay shores, and on steep, unstable slopes. They are also effective in separating land use areas that are not compatible and in protecting wetlands or waterbodies by displacing activities that might be potential sources of nonpoint source pollution.

Construction sequencing

Construction sequencing requires creating and following a work schedule that balances the timing of land disturbance activities and the installation of measures to control erosion and sedimentation, in order to reduce on-site erosion and off-site sedimentation. Construction sequencing can be used to plan earthwork and erosion and sediment control activities at sites where land disturbances might affect water quality in a receiving waterbody.

Dust control

Dust control measures are practices that help reduce surface and air movement of dust from disturbed soil surfaces. These airborne particles pose a dual threat to the environment and human health. First, dust can be carried off-site, thereby increasing soil loss from the construction area and increasing the likelihood of sedimentation and water pollution. Second, blowing dust particles can contribute to respiratory health problems and create an inhospitable working environment. Dust control measures are applicable to any construction site where dust is created and there is the potential for air and water pollution from dust traveling across the landscape or through the air. Typical control measures include: Sprinkling/Irrigation, Vegetative Cover, Mulch, and Spray-on Chemical Soil Treatments (palliatives). Dust control measures should be implemented on all construction sites where there will be major soil disturbances or heavy construction activity, such as clearing, excavation, demolition, or excessive vehicle traffic.

C. Sediment Control

Temporary diversion dikes

Earthen perimeter controls usually consist of a dike or a combination dike and channel constructed along the perimeter of a disturbed site. Simply defined, an earthen perimeter control is a ridge of compacted soil, often accompanied by a ditch or swale with a vegetated lining, located at the top or base of a sloping disturbed area. Located on the upslope side of a site, earthen perimeter controls help to prevent surface runoff from entering a disturbed construction site. An earthen structure located upslope can improve working conditions on a construction site by preventing an increase in the total amount of sheet flow runoff traveling across the disturbed area and thereby lessen erosion on the site. Located on the downslope side of a site, it can divert sediment-laden runoff created onsite to onsite sediment trapping devices, preventing soil loss from the disturbed area.

Wind fences and sand fences

Sand fences are barriers of small, evenly spaced wooden slats or fabric erected to reduce wind velocity and to trap blowing sand. They can be used effectively as perimeter controls around open construction sites to reduce the off-site movement of fine sediments transported by wind. They also prevent off-site damage to roads, river, bay, and adjacent properties. The spaces between fence slats allow wind and sediment to pass through but reduces the wind velocity, which causes sediment deposition along the fence. Wind fences are applicable to areas with a preponderance of loose, fine-textured soils that can be transported off-site by high winds. They are especially advantageous for construction sites with large areas of cleared land or in arid regions where blowing sand and dust are especially

problematic. Shorefront development sites also benefit from using wind fences because they promote the formation of frontal dunes.

Silt fence

Silt fences are used as temporary perimeter controls around sites where there will be soil disturbance due to construction activities. They consist of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site perimeter. The filter fabric should be entrenched in the ground between the support posts. Alternatively, silt fences may be constructed of hay bales. When installed correctly and inspected frequently, silt fences can be an effective barrier to sediment leaving the site in stormwater runoff. Silt fences are generally applicable to construction sites with relatively small drainage areas.

Sediment filters and sediment chambers

Sediment filters are a class of sediment-trapping devices typically used to remove pollutants, primarily particulates, from storm water runoff. Confined sediment filters are constructed with the filter medium contained in a structure, often a concrete vault. Sediment filters may be a good alternative for smaller construction sites where the use of a wet pond is being considered as a sediment-trapping device. Their applicability is wide ranging, and they can be used in urban areas with large amounts of highly impervious area. Because confined sand filters are man-made soil systems, they can be applied to most development sites and have few constraining factors.

D. Good Housekeeping

General construction site waste management

Building materials and other construction site wastes must be properly managed and disposed of to reduce the risk of pollution from materials such as surplus or refuse building materials or hazardous wastes. Practices such as trash disposal, recycling, proper material handling, and spill prevention and cleanup measures can reduce the potential for stormwater runoff to mobilize construction site wastes and contaminate surface or ground water. The proper management and disposal of wastes should be practiced at any construction site to reduce stormwater runoff. Waste management practices can be used to properly locate refuse piles, to cover materials that may be displaced by rainfall or stormwater runoff, and to prevent spills and leaks from hazardous materials that were improperly stored.

Spill prevention and control plan

Spill prevention and control plans should clearly state measures to stop the source of a spill, contain the spill, clean up the spill, dispose of contaminated materials, and train personnel to prevent and control future spills. Spill prevention and control plans are applicable to construction sites where hazardous wastes are stored or used. Hazardous wastes include pesticides, paints, cleaners, petroleum products, fertilizers, and solvents. Identify potential spill or source areas, such as loading and unloading, storage, and processing areas, places where dust or particulate matter is generated, and areas designated for waste disposal. Also, spill potential should be evaluated for stationary facilities, including manufacturing areas, warehouses, service stations, parking lots, and access roads.

Vehicle maintenance and washing areas

Maintenance and washing of vehicles should be conducted using environmentally responsible practices to prevent direct, untreated discharges of nutrient-enriched wastewater or hazardous wastes to surface or ground waters. This involves designating covered, paved areas for maintenance and washing, eliminating improper connections from these areas to the storm drain system, developing a spill prevention and cleanup plan for shop areas, maintaining vehicles and other equipment that may leak hazardous chemicals, covering fuel drums and other materials that are stored outdoors, and properly handling and disposing of automotive wastes and wash water. Environmentally friendly vehicle maintenance and washing practices are applicable for every construction site to prevent contamination of surface and ground water from wash water and fuel, coolant, or antifreeze spills or leaks.

Contractor certification and inspector training

Contractor certification programs are applicable for cities that require erosion and sediment control plans for construction sites. Training and certification will help to ensure that the plans are properly implemented and that best management practices are properly installed and maintained. Inspector training programs are appropriate for municipalities with limited funding and resources. The inspectors will lighten the financial and staffing burden of governing agencies to ensure compliance on construction sites. Contractor certification can be accomplished through municipally sponsored training courses, or more informally, cities can hold mandatory pre-construction or pre-wintering meetings and conduct regular and final inspection visits to transfer information to contractors. To implement an inspector training program, the City would need to establish a certification course with periodic recertification, review reports submitted by private inspectors, conduct spot checks for accuracy, and institute fines or other penalties for noncompliance.

BMP inspection and maintenance

Regular inspection of control measures is essential to maintain the effectiveness of construction site stormwater control best management practices (BMPs). Generally, inspection and maintenance of BMPs can be categorized into two groups--expected routine maintenance and nonroutine (repair) maintenance. Routine maintenance refers to checks performed on a regular basis to keep the BMP in good working order and aesthetically pleasing. In addition, routine inspection and maintenance is an efficient way to prevent potential nuisance situations (odors, mosquitoes, weeds, etc.), reduce the need for repair maintenance, and reduce the chance of polluting stormwater runoff by finding and correcting problems before the next rain. Routine inspection should occur for all stormwater and erosion and sediment control measures implemented at a site. Nonroutine maintenance refers to any activity that is not performed on a regular basis. This type of maintenance could include major repairs after a violent storm or extended rainfall, or replacement and redesign of existing control structures. The failure of structural stormwater BMPs can lead to downstream flooding, causing property damage, injury, and even death. All stormwater BMPs should be inspected for continued effectiveness and structural integrity on a regular basis for the life of the construction project. Generally, all BMPs should be checked after each storm event in addition to the regularly scheduled inspections. Inspection and maintenance of BMPs should continue until all construction activities have ended and all areas of a site have been permanently stabilized. During each inspection, the inspector

should document whether the BMP is performing correctly, any damage to the BMP since the last inspection, and what should be done to repair the BMP if damage has occurred.

5. POST-CONSTRUCTION STORMWATER MANAGEMENT IN NEW DEVELOPMENT AND REDEVELOPMENT

This management practice guidance relates to measures, to develop, implement, and enforce a retrofit program to reduce stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre. The guidance also relates to techniques for application to redevelopment areas. The following are intended only as brief comments on the major techniques and approaches applicable for adoption by the City.

A. Structural BMPs

Dry extended detention ponds

A stormwater retrofit is a stormwater management practice put into place after development has occurred to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Dry extended detention ponds are very useful stormwater retrofits. The are defined as basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Wet ponds

Wet ponds are very useful stormwater retrofits and have two primary applications as a retrofit design. In many communities, detention ponds have been designed for flood control in the past. It is possible to modify these facilities to develop a permanent wet pool to provide water quality control, and modify the outlet structure to provide channel protection. Alternatively, wet ponds may be designed in-stream, or in open areas as a part of a retrofit study. Wet ponds treat incoming stormwater runoff by settling and algal uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff in order to provide settling.

Infiltration basin

An infiltration basin is a shallow impoundment, which is designed to infiltrate stormwater into the ground water. Infiltration basins can be challenging to apply on many sites, however, because of soil requirements. Although infiltration basins have limited applications as a stormwater retrofit, they are believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus restoring low flows to stream systems. Their use is restricted to the treatment of small sites (less than 5 acres), and need a flat, relatively continuous area.

Infiltration trench

Infiltration trench retrofits generally can be applied to relatively small sites (less than 5 acres), with relatively high impervious cover. Application to larger sites generally causes clogging, resulting in a high maintenance burden. An infiltration trench is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.

Porous pavement

Porous pavement is a permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface retrofit replaces traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. There are a few porous pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous gridded systems with open areas designed to allow grass to grow within the void areas. While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Bioretention

Bioretention areas are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system. Bioretention can be used as a stormwater retrofit, by modifying existing landscaped areas, or if a parking lot is being resurfaced. In highly urbanized areas, this is one of the few retrofit options that can be employed.

Stormwater wetland

Stormwater wetlands are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic value. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the

wetland. When retrofitting an entire watershed, stormwater wetlands have the advantage of providing both educational and habitat value.

Grassed swales

One retrofit opportunity using grassed swales modifies existing drainage ditches. Ditches have traditionally been designed only to convey stormwater away from roads. In some cases, it may be possible to incorporate features to enhance pollutant removal or infiltration such as check dams (i.e., small dams along the ditch that trap sediment, slow runoff, and reduce the longitudinal slope). As stormwater runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils.

Baffle boxes

Baffle boxes are concrete or fiberglass sediment boxes constructed in-line with existing storm sewer pipes. They are typically 10-15 ft long, 2 ft wider than the pipe, and 6-8 ft high. The box is divided into 3 chambers by weirs (or baffles). There are skimmers to trap floating trash and yard debris. Manholes allow access for cleaning with vacuum trucks. Baffle Boxes are principally designed for sediment removal. Baffle boxes can be constructed under streets or within the right-of-way.

Grated Inlet and Curb Inlet Baskets

These sediment control devices are used to trap pollutants before they enter the stormwater stream. Their principal advantage is that it is more economical to keep pollutants out of the water than it is to remove the pollutants once they enter the water. Inlet devices trap trash, floating debris, sediment, hydrocarbons, and leaves and grass clippings from the streets. These devices can be customized for most sizes of grated inlets or curb opening inlets. With either type of inlet, a fiberglass or metal basket is inserted in such a fashion so as to not obstruct flows and cause upstream hydraulic head losses. Inlet Baskets consist of a basket with silt screens, which trap suspended solids and trash, as well as having an oil-skimming boom to collect hydrocarbons.

Proprietary Separator Systems

A variety of pre-constructed proprietary sediment removal systems are available for purchase and installation. These systems vary widely in purchase cost, installation method and maintenance requirements. Several such systems with potential application in the City include:

- BaySaver Separation System - This is a water quality unit that removes suspended sediments, free oils, and floating debris and other pollutants from stormwater runoff. The system is comprised of two precast concrete manholes and a high-density polyethylene (HDPE) separator unit. It relies on gravity sedimentation and flotation to remove and retain the collected contaminants.

- CDS (Continuous Deflective Separation) Technologies - Made of precast concrete and stainless steel, CDS Technologies' units combine a nonblocking, nonmechanical screening system with swirl concentration (vortex) solid separation to remove suspended solids, fine sediment, plastics, paper, leaves, and other floatable materials. The units are equipped with a conventional oil baffle to control oil and grease.

- Stormceptor System - Stormceptor products, which include in-line, inlet, and submerged units, use gravity to remove sediment, metals, nutrients, and hydrocarbons from stormwater runoff and store them for removal. The vertically oriented precast concrete units consist of a lower treatment chamber and a bypass chamber, which prevents resuspension and scouring of trapped pollutants during infrequent high-flow storm events.

B. Nonstructural BMPs

Buffer zones

An aquatic buffer is an area along a shoreline or wetland, where development is restricted or prohibited. The primary function of aquatic buffers is to physically protect and separate a river, bay or wetland from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management and act as a right-of-way during floods, sustaining the integrity of river and bay ecosystems and habitats. Technically, aquatic buffers are one type of conservation area that function as an integral part of the aquatic ecosystem and can also function as part of an urban forest. In general, a minimum base width of at least 100 feet is recommended to provide adequate river and bay protection. For optimal stormwater treatment, the following buffer designs are recommended. The buffer should be composed of three lateral zones: a stormwater depression area that leads to a grass filter strip that in turn leads to a forested buffer. The stormwater depression is designed to capture and store stormwater during smaller storm events and bypass larger stormflows directly into a channel. The captured runoff within the stormwater depression can then be spread across a grass filter designed for sheetflow conditions for the water quality storm. The grass filter then discharges into a wider forest buffer designed to have zero discharge of surface runoff to the River or bay.

Conservation easements

Conservation easements are voluntary agreements that allow an individual or group to set aside private property to limit the type or amount of development on their property. The conservation easement can cover all or a portion of a property and can either be permanent or last for a specified time. Easements relieve property owners of the burden of managing these areas by shifting responsibility to a private organization (land trust) or government agency better equipped to handle maintenance and monitoring issues. Conservation easements are thought to make a contribution to protecting water quality, mostly in an indirect way. Land set aside in a permanent conservation easement is land that will have a prescribed set of uses or activities, generally restricting future development.

Narrower residential streets

This better site design practice promotes the use of narrower streets to reduce the amount of impervious cover created by new residential development and, in turn, reduce the stormwater runoff and associated pollutant loads. Currently, many communities require wide residential streets that are 32, 36, and even 40 feet wide. These wide streets provide two parking lanes and two moving lanes, but provide much more parking than is actually necessary. In many residential settings, streets can be as narrow as 22 to 26 feet wide without sacrificing emergency access, on-street parking or vehicular and pedestrian safety. Even narrower access streets or shared driveways can be used when only a handful of homes need to be

served. However, developers often have little flexibility to design narrower streets, as most communities require wide residential streets as a standard element of their local road and zoning standards. Revisions to current local road standards are often needed to promote more widespread use of narrower residential streets.

Eliminating curbs and gutters

This better site design practice involves promoting the use of grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the storm drain and, ultimately, to the local receiving water. Consequently, curbs and gutters provide little or no removal of stormwater pollutants. Many communities require curb and gutters as a standard element of their road sections, and discourage the use of grass swales. Revisions to current local road and drainage regulations are needed to promote greater use of grass swales along residential streets, in the appropriate setting.

BMP inspection and maintenance

Regular inspection of control measures is essential to maintain the effectiveness of postconstruction stormwater control best management practices (BMPs). Generally, inspection and maintenance of BMPs can be categorized into two groups, expected routine maintenance and nonroutine (repair) maintenance. Routine maintenance refers to checks performed on a regular basis to keep the BMP in good working order and aesthetically pleasing. In addition, routine inspection and maintenance is an efficient way to prevent potential nuisance situations (odors, mosquitoes, weeds, etc.), reduce the need for repair maintenance, and reduce the chance of polluting stormwater runoff by finding and correcting problems before the next rain.

6. POLLUTION PREVENTION / GOOD HOUSEKEEPING FOR MUNICIPAL OPERATIONS

This management practice guidance relates to measures, to develop, and implement an operation and maintenance program, including a training component. It has the ultimate goal of preventing or reducing pollutant runoff from municipal operations such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance. The following are intended only as brief comments on the major techniques and approaches applicable for adoption by the City.

A. Source controls

Pet waste collection

Pet waste collection as a source control involves using a combination of educational outreach and enforcement to encourage residents to clean up after their pets. The presence of pet waste in stormwater runoff has a number of implications for river and bay water quality, with perhaps the greatest impact from fecal bacteria. It has been estimated that for watersheds of up to 20 square miles draining to small coastal bays, 2 or 3 days of droppings from a population of about 100 dogs would contribute enough bacteria and nutrients to temporarily close a bay to swimming and shellfishing. Pet waste collection programs use pet awareness and education, signs, and pet waste control ordinances to alert residents to the proper disposal techniques for pet droppings. Public education programs encourage pet waste removal. Often pet waste messages are incorporated into a larger non-point source message relaying the effects of pollution on local water quality. Brochures and public service announcements describe proper pet waste disposal techniques and try to create a storm drain-water quality link between pet waste and runoff. Signs in public parks and the provision of receptacles for pet waste will also encourage cleanup.

Automobile maintenance

This pollution prevention measure involves creating a program of targeted outreach and training for businesses and municipal fleets (public works, school buses, fire, police, and parks) involved in automobile maintenance about practices that control pollutants and reduce stormwater impacts. Automotive maintenance facilities are considered to be stormwater "hot spots", where significant loads of hydrocarbons, trace metals, and other pollutants can be produced that can affect the quality of stormwater runoff. Some of the waste types generated at automobile maintenance facilities and at homes of residents performing their own car maintenance include the following: Solvents (paints and paint thinners); Antifreeze; Brake fluid and brake lining; Batteries; Motor oils; Fuels (gasoline, diesel, kerosene); Lubricating grease. Pollution prevention programs seeking to reduce liquid discharges to sewer and storm drains from automotive maintenance should stress techniques that allow facilities to run a dry shop. Among the suggestions for creating a dry operation are the following: spills should be cleaned up immediately, and water should not be used for clean up whenever possible; floor drains that are connected to the sanitary sewer should be sealed off; a solvent service might be hired to supply parts and cleaning materials, and to collect the spent solvent.

Vehicle washing

This management measure involves educating the general public, businesses, and municipal fleets (public works, school buses, fire, police, and parks) on the water quality impacts of the outdoor washing of automobiles and how to avoid allowing polluted runoff to enter the storm drain system. Outdoor car washing has the potential to result in a high loads of nutrients, metals, and hydrocarbons during dry weather conditions in many watersheds, as the detergent-rich water used to wash the grime off our cars flows down the street and into the storm drain. Commercial car wash facilities often recycle their water or are required to treat their wash water discharge prior to release to the sanitary sewer system, so most stormwater impacts from car washing are from residents, businesses, and charity car wash fundraisers that discharge polluted wash water to the storm drain system. The development of a prevention program to reduce the impact of City car wash runoff includes outreach on management practices to reduce discharges to storm drains. Some of these management practices include the following: using a commercial car wash; washing cars on gravel, grass, or other permeable surfaces; pumping soapy water from car washes into a sanitary sewer drain; if pumping into a drain is not feasible, pumping car wash water onto grass or landscaping to provide filtration; using hoses with nozzles that automatically turn off when left unattended; using only biodegradable soaps.

Illegal dumping control

Illegal dumping control as a management practice involves using public education to familiarize residents and businesses with how illegal dumping can affect stormwater. By locating and correcting illegal dumping practices through education and enforcement measures, the many risks to public safety and water quality associated with illegal disposal actions can be prevented. For stormwater managers, illegal dumping control is important to preventing contaminated runoff from entering wells and surface water, as well as averting flooding due to blockages of drainage channels for runoff. Illegal dumping control programs focus on community involvement and targeted enforcement to eliminate or reduce illegal dumping practices, using a combination of public education, citizen participation, site maintenance, and authorized enforcement measures to address illegal waste disposal.

Landscaping and lawn care

This management measure seeks to control the stormwater impacts of landscaping and lawn care practices through education and outreach on methods that reduce nutrient loadings and the amount of stormwater runoff generated from lawns. Not many residents understand that lawn fertilizer can cause water quality problems. Informing residents, City personnel, and lawn care professionals on methods to reduce fertilizer and pesticide application, limit water use, and avoid land disturbance can help alleviate the potential impacts of a major contributor of nonpoint source pollution in residential communities.

Pest control

This management measure involves limiting the impact of pesticides on water quality by educating residents and businesses on alternatives to pesticide use and proper storage and on application techniques. The presence of pesticides in stormwater runoff has a direct impact on the health of aquatic organisms and can present a threat to humans through contamination of drinking water supplies. The major source of pesticides to urban rivers and bays is home

application of products designed to kill insects and weeds in the lawn and garden. It has been estimated that an average acre of a well-maintained urban lawn receives an annual input of 5 to 7 pounds of pesticides. Pesticide pollution prevention programs try to limit adverse impacts of insecticides and herbicides by providing information on alternative pest control techniques other than chemicals or explaining how to determine the correct dosages needed to manage pests.

Parking lot and street cleaning

This management measure involves employing pavement-cleaning practices such as street sweeping on a regular basis to minimize pollutant export to receiving waters. Sweeping of parking lots also is employed as a nonstructural management practice for industrial sites. These cleaning practices are designed to remove from road and parking lot surfaces sediment debris and other pollutants that are a potential source of pollution impacting urban waterways. Recent improvements in street sweeper technology have enhanced the ability of present day machines to pick up the fine-grained sediment particles that carry a substantial portion of the stormwater pollutant load. Many of today's sweepers can now significantly reduce the amount of street dirt entering streams, rivers, and bays, some by significant amounts.

Septic system controls

Septic system source control refers to the use of outreach programs to educate homeowners about the proper operation and maintenance of their septic systems to reduce the likelihood of failure. Septic systems are designed to treat wastewater by separating solids from liquids and then draining the liquid into the ground. Sewage flows into the tank where settling and bacterial decomposition of larger particles takes place, while treated liquid filters into the soil. When system failures occur, untreated wastewater and sewage can be introduced into ground water or nearby water bodies. Many of the problems associated with improper septic system functioning may be attributed to a lack of homeowner knowledge of operation and maintenance of the system. Educational materials for homeowners and training courses for installers and inspectors can reduce the incidence of failure. Education is most effective when used in concert with other source reduction practices, such as phosphate bans and use of low-volume plumbing fixtures.

Storm drain system cleaning - Storm drain systems need to be cleaned regularly. Routine cleaning reduces the amount of pollutants, trash, and debris both in the storm drain system and in receiving waters. Clogged drains and storm drain inlets can cause the drains to overflow, leading to increased erosion. Benefits of cleaning include increased dissolved oxygen, reduced levels of bacteria, and support of instream habitat. Areas with relatively flat grades or low flows should be given special attention because they rarely achieve high enough flows to flush themselves.

B. Materials management

Hazardous materials storage

Failure to properly store hazardous materials dramatically increases the probability that they will end up in local waterways. Many people have hazardous chemicals stored throughout

their homes, especially in garages and storage sheds. Practices such as covering hazardous materials or even storing them properly can have dramatic impacts. Maintenance of City hazardous material storage areas consists mostly of inspection and employee training. Storage spaces and containers should be routinely inspected for leaks, signs of cracks or deterioration, or any other signs of release.

Spill response and prevention

Spill prevention and control plans are applicable to construction sites where hazardous wastes are stored or used. Hazardous wastes include pesticides, paints, cleaners, petroleum products, fertilizers, and solvents. Identify potential spill or source areas, such as loading and unloading, storage, and processing areas, places where dust or particulate matter is generated, and areas designated for waste disposal. Also, spill potential should be evaluated for stationary facilities, including manufacturing areas, warehouses, service stations, parking lots, and access roads. The spill response plan should; identify individuals responsible for implementing the plan; define safety measures to be taken with each kind of waste; specify how to notify appropriate authorities, such as police and fire departments, hospitals, or publicly-owned treatment works for assistance; state procedures for containing, diverting, isolating, and cleaning up the spill; describe spill response equipment to be used, including safety and cleanup equipment. Education is essential for reducing spills. By informing people of actions they can take to reduce spill potential, spills will be reduced and/or prevented

Used oil recycling

Used motor oil is a hazardous waste because it contains heavy metals picked up from the engine during use. Fortunately, it is recyclable because it becomes dirty from use, rather than actually wearing out. However, as motor oil is toxic to humans, wildlife, and plants, it should be disposed of at a local recycling or disposal facility. Before disposal, used motor oil should be stored in a plastic or metal container with a secure lid, rather than dumped in a landfill or down the drain. Containers that previously stored household chemicals, such as bleach, gasoline, paint, or solvents should not be used. Used motor oil should also never be mixed with other substances such as antifreeze, pesticides, or paint stripper. When establishing oil-recycling programs, the City should provide the public with the proper informational resources. Programs should encourage the public to contact local service stations, City office, the county government office, or the local environmental or health departments, if they are unsure where to safely dispose of their oil.

Appendix G

Selection of NEMO (Non-point Education for Municipal Officials) Documents

NONPOINT SOURCE WATER POLLUTION

Linking Land Use to Water Quality

What is Nonpoint Source Pollution?

Nonpoint source pollution is a fancy term for polluted runoff. Water washing over the land, whether from rain, car washing or the watering of crops or lawns, picks up an array of contaminants including oil and sand from roadways, agricultural chemicals from farmland and nutrients and toxic materials from urban and suburban areas. This runoff finds its way into out waterways, either directly or through storm drain collection systems.

The term nonpoint is used to distinguish this type of pollution from point source pollution, which comes from specific sources such as sewage treatment plants or industrial facilities. Scientific evidence shows that although huge strides have been made in cleaning up major point sources, our precious water resources are still threatened by the effects of polluted runoff. In fact, the Environmental Protection Agency (EPA) estimates that this type of pollution is now the single largest cause of the deterioration of out nation's water quality.

Whatever They Call It, Why Should I Care About It?

The effects of polluted runoff are not limited to large lakes or coastal bays. In fact, chances are that you don't have to look any farther than your neighborhood stream or duck pond. Water pollution in your town, and perhaps in your own backyard, can result in anything from weed-choked ponds to fish kills to contaminated drinking water.

There's not much chance that you can ignore this problem, even if you want to. Concern over polluted runoff has resulted in an ever-increasing number of state and federal laws enacted over the last five years. At the federal level, a permit program for stormwater discharges from certain municipalities and businesses is now underway, and coastal zone management authorities are in the process of adding nonpoint source control to their existing programs. In addition to implementing these federal programs, many states have passed laws altering local land use (planning and zoning) processes and building codes to address the problem of polluted runoff. The bottom line is that both polluted runoff and its management are likely to affect you and your town in the near future.

"The bottom line is that both polluted runoff and its management are likely to affect you and your town in the near future."

What Causes Polluted Runoff?

You do. We all do. Polluted runoff is the cumulative result of our everyday personal actions and our local land use policies. Here's a brief rundown on the causes and effects of the major types of pollutants carried by runoff.

Pathogens: Pathogens are disease-causing microorganisms, such as bacteria and viruses, that come from the fecal waste of humans and animals. Exposure to pathogens, either from direct contact with water or through ingestion of contaminated shellfish can cause a number of health problems. Because of this, bathing beaches and shellfish beds are closed to the public when testing reveals significant pathogen levels. Pathogens wash off the land from wild animal, farm animal and pet waste, and can also enter our waterways from

improperly functioning septic tanks, leaky sewer lines and boat sanitary disposal systems.

Nutrients: Nutrients are compounds that stimulate plant growth, like nitrogen and phosphorous. Under normal conditions, nutrients are beneficial and necessary, but in high concentrations, they can become an environmental threat. Nitrogen contamination of drinking water can cause health problems, including "blue baby" syndrome. Over fertilization of ponds, bays and lakes by nutrients can lead to massive algal blooms, the decay of which can create odors and rob the waters of life-sustaining dissolved oxygen. Nutrients in polluted runoff can come from agricultural fertilizers, septic systems, home lawn care products and yard and animal wastes.

Sediment: Sand, dirt and gravel eroded by runoff usually ends up in stream beds, ponds or shallow coastal areas, where they can alter stream flow and decrease the availability of healthy aquatic habitat. Poorly protected construction sites, agricultural fields, roadways and suburban gardens can be major sources of sediment.

Toxic Contaminants: Toxic contaminants are substances that can harm the health of aquatic life and/or human beings. Toxins are created by a wide variety of human practices and products, and include heavy metals, pesticides and organic compounds like PCBs. Many toxins are very resistant to breakdown and tend to be passed through the food chain to be concentrated in top predators. Fish consumption health advisories are the result of concern over toxins. Oil, grease and gasoline from roadways, and chemicals used in homes, gardens, yards and on farm crops, are major sources of toxic contaminants.

Debris: Trash is without a doubt the simplest type of pollution to understand. It interferes with enjoyment of our water resources and, in the case of plastic and styrofoam, can be a health threat to aquatic organisms. Typically this debris starts as street litter that is carried by runoff into out waterways.

What Can I Do About All This?

First of all, you can begin to clean up your own act. There are many good publications and programs that can help you to do simple but important things, like conserving water, disposing of hazardous waste properly and gardening in an environmentally responsible manner.

As you can see, polluted runoff is largely the result of the way we develop, use and maintain our land. These policies are largely decided at the municipal level, through the actions of town officials and local commissions like planning, zoning and wetlands. There are many techniques and regulations that can greatly reduce the effects of polluted runoff, and there are more being developed every day. The rest of this fact sheet series is devoted to telling you about your options. If you're on a local commission, learn a little more about polluted runoff and how you can combat it in the course of your everyday decisions. If you're not on a commission, ask your friends and neighbors who are what they are doing about polluted runoff.

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

Contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone: (860) 345-4511
Fax: (860) 345-3357

Email: nemo@uconn.edu

Web Address: nemo.uconn.edu

Written by: Chester Arnold & Melissa Beristain, 1993

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

IMPACTS OF DEVELOPMENT ON WATERWAYS

Linking Land Use to Water Quality

Key Finding

Standard land development can drastically alter waterways. Increase stormwater runoff associated with development often begins a chain of events that includes flooding, erosion, stream channel alteration and ecological damage. Combined with an increase in man-made pollutants, these changes in waterway form and function result in degraded systems no longer capable of providing good drainage, healthy habitat or natural pollutant processing. Local officials interested in protecting town waters must go beyond standard flood and erosion control practices and address the issue of polluted runoff through a multilevel strategy of planning, site design and stormwater treatment.

"Polluted runoff is now widely recognized by environmental scientists and regulators as the single largest threat to water quality in the United States."

Disruption of the Water Cycle

When development occurs, the resultant alteration to the land can lead to dramatic changes to the *hydrology*, or the way water is transported and stored. Impervious man-made surfaces (asphalt, concrete, rooftops) and compacted earth associated with development create a barrier to the percolation of rainfall into the soil, increasing surface runoff and decreasing groundwater infiltration (Figure 1). This disruption of the natural water cycle leads to a number of changes, including:

- increased volume and velocity of runoff;
- increased frequency and severity of flooding;
- peak (storm) flows many times greater than in natural basins;
- loss of natural runoff storage capacity in vegetation, wetland and soil;
- reduced groundwater recharge; and
- decreased base flow, the groundwater contribution to stream flow. (This can result in streams becoming intermittent or dry, and also affects water temperature.)

Impacts on Stream Form and Function

Impacts associated with development typically go well beyond flooding. The greater volume and intensity of runoff leads to increased erosion from construction sites, downstream areas and stream banks. Because a stream's shape evolves over time in response to the water and sediment loads that it receives, development-generated runoff and sediment cause significant changes in stream form. To facilitate increased flow, streams in urbanized areas tend to become deeper and straighter than wooded streams, and as they become clogged with eroded sediment, the ecologically important "pool and riffle" pattern of the stream bed is usually destroyed (Figure 2).

These readily apparent physical changes result in less easily discerned damage to the ecological function of the stream. Bank erosion and sever flooding destroy valuable streamside, or riparian, habitat. Loss of tree cover leads to greater water temperature fluctuations, making the water warmer in the summer and colder in the winter. Most importantly, there is substantial loss of aquatic habitat as the varied natural

Hy•drolo•ogy:
A science dealing with the properties, distribution and circulation of water.

Ri•par•i•an:
Of or related to or living or located on the bank of a watercourse.

Hab•i•tat:
The place where a plant or animal species naturally lives and grows.

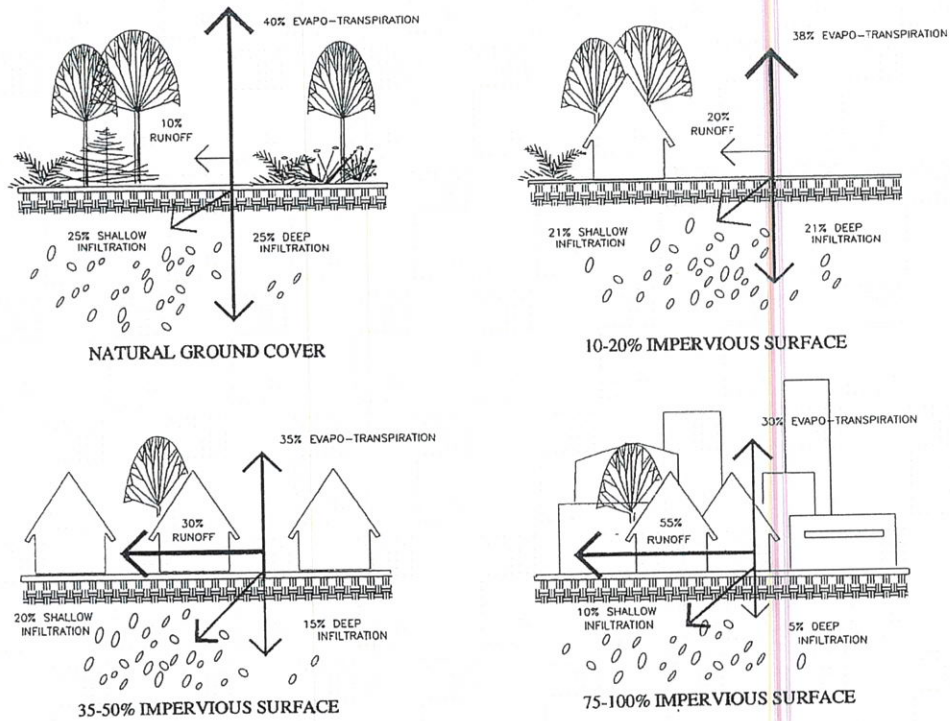


Figure 1. Water cycle changes associated with urbanization (after Toubier and Westmacott, 1981).

streambed of pebbles, rock ledges and deep pools is covered by a uniform blanket of eroded sand and silt.

All of this of course assumes that the streams are left to adjust on their own. However, as urbanization increases, physical alterations like stream diversion, channelization, damming and piping become common. As these disturbances increase, so do the ecological impacts—the endpoint being a biologically sterile stream completely encased in underground concrete pipes. In addition, related habitats like ponds and wetlands may be damages or eliminated by grading and filling activities.

Then There's Water Quality

With development comes more intensive land use and a related increase in the generation of pollutants. Increased runoff serves to transport these pollutants directly into waterways, creating *nonpoint source pollution, or polluted runoff.* Polluted runoff is now widely recognized by environmental scientists and regulators as the single largest threat to water quality in the United States. The major pollutants of concern are pathogens (disease-causing microorganisms), nutrients, toxic contaminants and debris. Sediment is also a major nonpoint source pollutant, both for its effects on aquatic ecology (see above), and because of the fact that many of the other pollutants tend to adhere to eroded soil particles. NEMO Fact Sheet #2 provides more detail on polluted runoff and its effects.

The Total Picture: A System Changed for the Worse

The hydrologic, physical and ecological changes caused by development can have a dramatic impact on the natural function of our waterways.

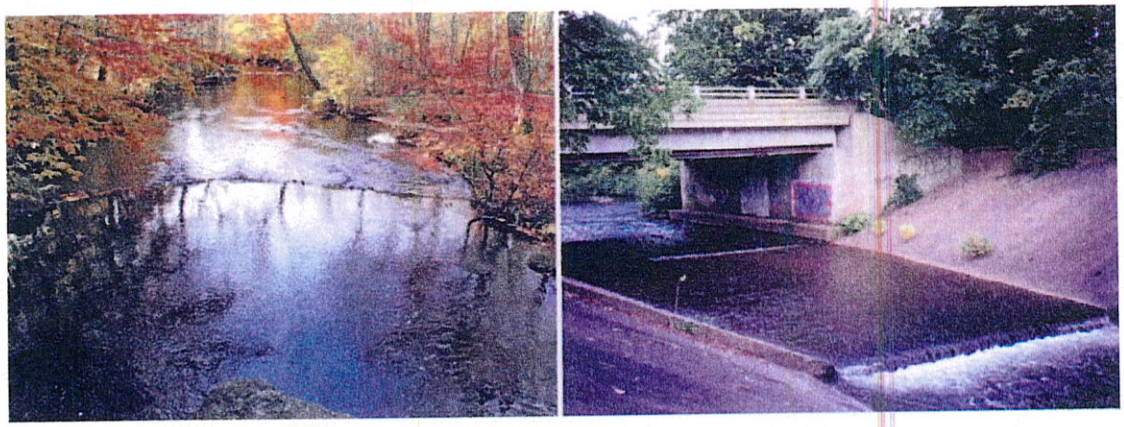


Figure 2. Changes in stream form associated with urbanization.

When increased pollution is added, the combination can be devastating. In fact, many studies are finding a direct relationship between the intensity of development in an area—as indicated by the amount of impervious surfaces—and the degree of degradation of its streams (Figure 3). These studies suggest that aquatic biological systems begin to degrade at impervious levels of 12% to 15%, or at even lower levels for particularly sensitive streams. As the percentage of imperviousness climbs above these levels, degradation tends to increase accordingly.

The end result is a system changed for the worse. Properly working water systems provide drainage, aquatic habitat and a degree of pollutant removal through natural processing. Let's look at those functions in an urbanized watershed where no remedial action has been taken:

Drainage: Increased runoff leads to flooding. Drainage systems that pipe water off-site often improve that particular locale at the expense of moving flooding (and erosion) problems downstream. Overall systemwide water drainage and storage capacity is impaired.
Habitat: Outright destruction, physical alteration, pollution and wide fluctuations in water conditions (levels, clarity, temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic riparian organisms. In addition, waterway obstructions like bridge abutment, pipes and dams create barriers to migration.

Pollutant removal: Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Damage to bank, streams and wetland vegetation further reduces their ability to naturally process pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by stormwater runoff impair natural processing by decreasing the time that water is in the system.

What Towns Can Do

Flood and erosion control have long been part of the municipal land use regulatory process, and are usually addressed with engineered systems designed to pipe drainage off-site as quickly and efficiently as possible. Flooding and erosion, however, are only two of the more easily recognized components of the overall impact of development on waterways.

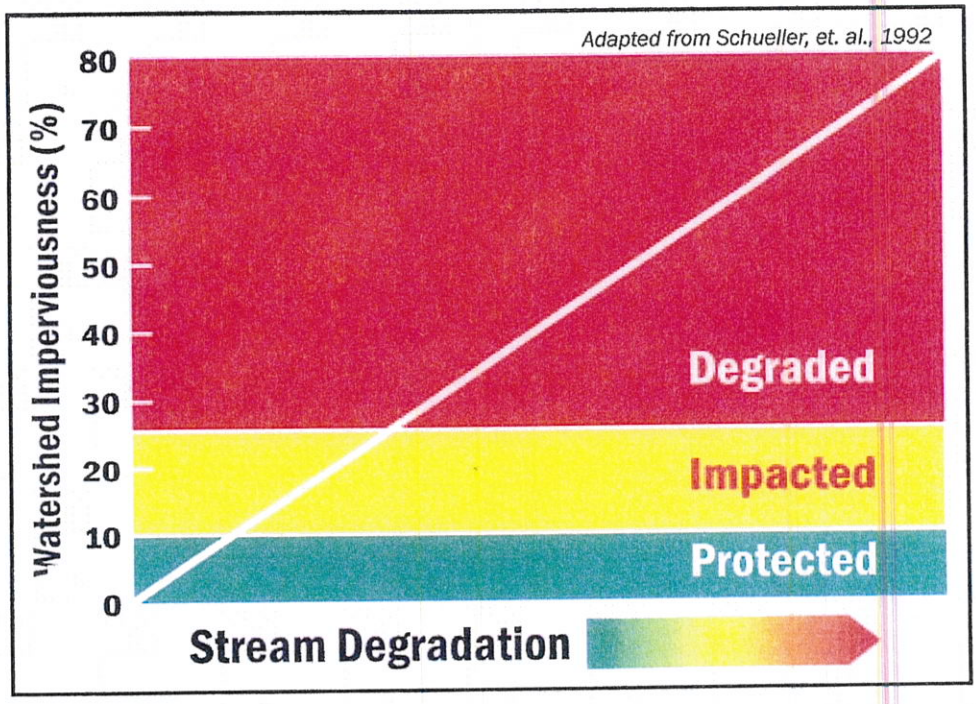


Figure 3. Stylized relationship between watershed imperviousness and receiving stream impacts (adapted from Schueler, 1992).

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

Contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone: (860) 345-4511
Fax: (860) 345-3357

Email: nemo@uconn.edu

Web Address: nemo.uconn.edu

Written by: Chester Arnold & Jim Gibbons, 1994

Illustrations by:
Dr. John Alexopoulos

Standard drainage "solutions" address neither the root cause of these symptoms—increased runoff due to the way we develop land—nor the resultant environmental effects.

To begin to truly address the impacts of development, town officials need to look at their waterways as an interconnected system and recognize the fundamental changes that development brings to the water cycle, stream form and function, aquatic ecology and water quality. Incorporating this understanding into local land use decisions can help to guide appropriate development (see NEMO Fact Sheet #5). There are a number of options that can be employed to reduce the impacts of development on water quantity and quality. Preventing such impacts in the first place is the most effective (and cost effective) approach and should always be emphasized. To this end, town officials should consider a three-tiered strategy of natural resource based planning, appropriate site design and use of best management practices (stormwater treatment). NEMO Fact Sheet #4 goes into this strategy in more detail.

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

STRATEGIES FOR COPING WITH POLLUTED RUNOFF

Linking Land Use to Water Quality

Key Finding

As the intensity of development increases, so does the generation of nonpoint source water pollution, or polluted runoff. A good indicator of the intensity of development in a given area is the amount of impervious surface. Studies have shown that the greater the impervious surface coverage in a watershed, the greater the potential degradation of that watershed's water systems. Thus, local officials can do much to protect their water resources by considering the location, extent, drainage and maintenance of impervious surfaces on the town, watershed and individual site levels. Natural resource planning, site design and use of best management practices form an effective three-tiered approach to the problem.

"Development affects both the quantity and the quality of stormwater runoff, which in turn has impacts on watercourses."

The Problem

Development affects both the quantity and the quality of stormwater runoff, which in turn has impacts on watercourses. By enhancing and channeling surface drainage in favor of natural drainage systems, impervious surfaces like asphalt, concrete and roofing increase the volume and velocity of the runoff, often resulting in flooding, erosion and permanent alterations in stream form and function (see NEMO Fact Sheet #3). In addition, by blocking the infiltration of water and its associated pollutants into the soil, impervious surfaces interfere with natural processing of nutrients, sediment, pathogens and other contaminants, resulting in degradation of surface water quality.

Because of these impacts, a growing body of scientific research is finding a direct relationship between the amount of impervious surface in watershed and the water quality of the watershed's receiving stream. Many studies find that without nonpoint source management of some kind, stream water quality becomes increasingly degraded as impervious levels climb above 15%; in highly sensitive streams, degradation can begin when as little as 8% to 10% of the watershed area has impervious cover.

What Towns Can Do

Pavement is an unavoidable fact of modern life. However, there are still many options available to the municipality interested in reducing the water quality impacts of existing or future development. Strategies can be organized into a three-tiered approach, which can be summarized as: ***plan, minimize, mitigate.***

1. Plan *Development Based on Your Town's Natural Resources.* Remember, preventing pollution by wise planning is by far the least expensive and most effective way to protect your town's waterways. To this end, a working knowledge of your town's natural resources is critical to guide appropriate development. A natural resource inventory is an essential first step. Identifying important natural resources and setting protection priorities provides a framework within which the impacts of proposed or existing development can be evaluated. Formal inclusion of these priorities in town plans and procedures is also important (see NEMO Fact Sheet #5). Broad resource protection strategies applied at the town or watershed level, such as buffer zone and setback requirements, are increasingly coming into use. With regard to impervious surfaces,

local officials should consider a "budget" approach that sets an overall limit for key areas, and above that limit requires increase in pavement on one site to be compensated for decreases on another site (or some other acceptable method of compensation). This technique might be appropriate, for instance, in a watershed where analyzes show a threat to critical water resources from future growth.

*2. **Minimize** Impacts Through Site Design.* The site planning stage offers the best chance for local officials, designers and builders to work together to reduce polluted runoff from a site. Evaluate site plans with an eye to minimizing both impervious areas and disruption of natural drainage and vegetation. Cluster development, which reduces the total area of paved surfaces and increases open space, should be considered. Are the proposed sidewalks, roads and parking lot sizes absolutely necessary or could they be reduced? Brick, crushed stone, or pervious pavement is often a viable alternative in low traffic areas. Are curbing and piping necessary, or could drainage be directed to vegetated swales? Designs which reduce grading and filling and retain natural features should be encouraged. In addition to protecting waterways, such designs can often be less expensive and more pleasing to the eye.

*3. **Mitigate** Unavoidable Impacts by Using Best Management Practices.* Best management practices (BMPs) include a whole range of methods designed to prevent, reduce or treat stormwater runoff. Choosing the correct BMPs is often highly site-specific. There are a number of agencies and publications that can provide guidance (see NEMO Fact Sheet #5). There are some basic BMP concepts to keep in mind:

- **Slow that stormwater**. This is the basic idea behind both detention basins, which are meant to slow and hold stormwater before releasing it, and retention basins, which are designed to hold the water permanently until it infiltrates into the ground. In both cases, pollutant removal takes place through settling of particles and through chemical and biological interactions in the standing water or in the soil. As with any device, these BMPs must be correctly designed in order to work properly. For instance, basins must be large enough to treat runoff generated by the combination of local climate and site configuration.
- **Avoid direct connections.** Break up the "expressway" of polluted runoff by using grass swales, filter strips or other forms of vegetative BMPs wherever possible in place of curving and piped drainage. In many cases, these methods are most effective when used in combination with structural BMPs like detention ponds.
- **Ensure regular maintenance.** Most structural BMPs require regular maintenance to retain peak pollutant-removal efficiency. Maintenance ranges from the frequent, but simple (sweeping parking lots, cleaning storm drains) to the infrequent, but complex (sediment removal from detention/retention ponds), but in all cases it must be budgeted and planned for.
- **Don't forget the two "e's": enforcement and education.** It's important to make sure that contractors are following through on agreed-upon designs and methods. Don't underestimate things like storm drain stenciling and hazardous waste disposal days, which can reduce pollution, raise public awareness and help to engender support for all your town's water protection activities.

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

Contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone: (860) 345-4511
Fax: (860) 345-3357

Email: nemo@uconn.edu

Web Address: nemo.uconn.edu

Written by: Chester Arnold 1994

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

ASKING THE RIGHT QUESTIONS

RAISING THE ISSUE OF POLLUTED RUNOFF AT A PUBLIC MEETING

Linking Land Use to Water Quality

Key Finding

The best way to protect your local waters from polluted runoff is to address the issue through your town's land use regulation process. In most communities, this regulation is done through planning, zoning and wetlands commissions. The public meetings of these commissions provide an opportunity for concerned individuals to raise important environmental issues whenever development is proposed. By asking a few simple questions, you can ensure that water quality impacts are duly considered by the proper authorities.

"The best way to protect your local waters from polluted runoff is to address the issue through your town's land use regulation process."

The Problem

Water quality is greatly influenced by land use. Stormwater runoff carries contaminants such as pathogens, nutrients, sediment, toxic materials and debris from the land to your local waterways. This is known as polluted runoff, or nonpoint source water pollution (see NEMO fact sheet #2). Municipal land use policies can therefore have a great impact on the health of local waterways, and because land use decisions are often made on a case-by-case basis, each individual development proposal counts. We've all heard it said that in America, one person can make a difference.

Although this axiom may be a little shopworn, it is nevertheless true when talking about local land use decisions. When development is proposed in your town, it is important that someone ask questions about the water quality aspects of that project. If that "someone" is not one of your municipal land use boards, then it might have to be you!

While each proposal is different, there are some basic water quality considerations that need to be taken into account. Until you hear otherwise, you can't assume that these issues have been addressed by either the applicant or the commission. Don't be afraid to ask questions —the land use regulatory system was set up specifically to allow you to participate in the process, and lack of expertise on Robert's Rules of Order or stormwater engineering should not deter you from exercising that right.

Remember that the people on your land use boards probably aren't experts on polluted runoff either—they're volunteers and your neighbors, and no matter how conscientious, they can't be expected to always understand the environmental impact of each decision.

Questions to Ask

Here are some basic questions that should be asked concerning proposed development and its possible effects on your town's water resources. They are roughly organized according to the three-tiered NEMO Program strategy of natural resource planning, environmentally sound site design and use of best management practices (see NEMO Fact Sheet #4). Although there is no guarantee that asking these questions will always result in stopping polluted runoff, there is no better way to ensure that, at the very least, the issue will be put on the table for discussion.

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

Contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone: (860) 345-4511
Fax: (860) 345-3357

Email: nemo@uconn.edu

Web Address: nemo.uconn.edu

Written by: Chester Arnold, 1994

Planning with an Eye on Natural Resource Protection

1. Does the town Plan of Development address watershed management and/or polluted runoff?
2. Where is the project located with respect to your town's water resources? For instance, is the project located within a watershed that drains into a key cove, reservoir or aquifer?
3. Does the proposed development encroach upon, or through its runoff, affect, any recognized priority natural resource areas (ex: wetlands, watercourses, aquifer recharge areas, wildlife areas, dedicated open space)?

Minimizing Impacts Through Sensitive Site Design

1. Is the natural topography and drainage system retained, or is the stormwater collected and piped off site? Where will the stormwater runoff ultimately be discharged? Does it go directly into any wetlands or watercourses?

2. Is natural vegetation retained wherever possible?

3. Does the design minimize disturbance of water resources (i.e., road and driveway crossings and bridges; piped or channelized sections)?

4. Are impervious areas minimized? Are parking and other paved areas larger than truly needed? Have pavement alternatives (concrete latticework, pervious pavement, crushed stone) been considered for use in low traffic areas?

5. Are wetlands or watercourses insulated from the development through buffer strips of open areas?

6. Is the project within any "setback" or "buffer" zone around wetlands and watercourses that restricts certain types of development or activities? If so, who will be charged with enforcing the restrictions? Will signs be posted to inform residents/owners of the restrictions?

Mitigating Impacts Through Best Management Practices (BMPs)

1. What erosion control measures will be used during the construction phase? Who will make sure that they are effective?

2. Will stormwater be contained on site, or will it be allowed off site?

3. How is the stormwater runoff going to be treated? What BMPs (oil/grit separators, detention ponds, etc.) will be used? What pollutants, specifically, are they designed to remove? What volume of water are they designed to hold or treat?

4. Who will maintain the BMPs and how often? What is their projected life span?

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

REVIEWING SITE PLANS FOR STORMWATER MANAGEMENT

Linking Land Use to Water Quality

Considering Stormwater Management in Site Plan Review

Volunteers serving on planning, zoning and wetland commissions routinely review site plans to determine compliance of proposed development with land use regulations. A major consideration of this site plan review should be the proposed development's impact on water resources, particularly from polluted stormwater runoff, or "nonpoint source pollution."

Traditionally, stormwater management has emphasized water quantity, with little concern for water quality. To address both of these factors in a comprehensive manner, each site plan should contain a stormwater management plan that details the impact of proposed land use on water quantity and quality, both on-site and within the watershed.

"Each site plan should contain a stormwater management plan addressing the impact the proposed land use will have on quantity and quality."

While the detailed engineering is best left to trained professionals, land use commissioners can review plans for compliance with general planning guidelines.

The Need for Stormwater Management in a Watershed Framework

When water falls to earth as rain or snow most of it seeps into the ground. However, if the ground is saturated, frozen or covered with impervious surfaces, excess precipitation flows over the land. Stormwater management is the process of controlling and cleansing excess runoff so it does not harm natural resources or human health.

A major focus of stormwater management should be prevention of nonpoint source water pollution. (see NEMO Fact Sheet #2.) It is more cost effective to prevent flooding and water pollution than to correct problems after damage has occurred.

Potential Impact of Development on Water Resources.

Development may disturb land and create impervious surfaces such as roads, rooftops and compacted soil that in turn drastically change natural drainage patterns. During construction, existing grades and vegetation can be damaged, resulting in soil erosion. Runoff from these areas can pollute streams. Development, through increases in impervious surfaces and installation of storm sewers, speeds movement of concentrated pollutants off-site and interferes with water infiltration to the ground. (see NEMO Fact Sheet #3.)

Traditional Approaches to Stormwater Management.

Most communities attempt to manage stormwater by emphasizing water quantity rather than water quality. The goal has been to drain water from developed sites as rapidly as possible through the use of gutters, downspouts, pipes, curbs, catch basins and culverts. Some communities require developers to install detention ponds to temporarily store a portion of the excess runoff, then gradually release it after the peak natural runoff has occurred. Many hydrologists are concerned that mandating detention ponds on each site, while controlling runoff in the

immediate vicinity, may work to collectively increase peak flows in the watershed, resulting in downstream flooding. Experts caution about reliance on one management practice to solve all drainage issues.

The Importance of Watershed Management Plans.

Stormwater management begins with an understanding that every piece of land is part of a watershed. A watershed is defined as an area in which all drainage flows to a common outlet. Comprehensive land use planning and sound site design are necessary for effective stormwater management. Water resource experts strongly recommend that towns develop watershed management plans, so that management practices on individual sites can be coordinated as to location, size and function. Comprehensive watershed management plans include data from field inspections and inventories of existing drainage structures, mapping of watercourses, analysis of runoff rates and allowable capacities, and identification of existing and potential problem areas.

"Stormwater management begins with an understanding that every piece of land is part of a watershed."

In addition to hydraulic and quantity impact analysis, watershed management plans should also address water quality issues. Things to be identified in the plan should include: priority water resources to be protected; known sources of contamination and existing pollutant levels; particular contaminants of concern; water quality goals; and overall watershed-level protection measures (such as use of buffer zones along waterways).

Within the context of a watershed plan, stormwater management should combine efforts to minimize impervious surfaces with efforts to maximize infiltration of clean runoff into the ground. Untreated stormwater should not be allowed to discharge directly into surface or subsurface waters. Site-specific runoff control measures should be based on their location within the watershed. Effective stormwater management will maintain the natural patterns of runoff within the watershed. For instance, clean runoff from the lower portions of the watershed should be allowed to pass downstream without delay (as long as the downstream floodway is capable of handling these flows), while runoff from the central and upper sections of the watershed should be slowed or held back to prevent increasing peak flow rates.

The Contents of a Stormwater Management Plan

Developers are generally required to submit site plans to help local officials determine whether proposed development complies with municipal land use regulations. Each site plan should contain a stormwater management plan addressing the impact the proposed land use will have on water quantity and quality.

Site-level stormwater management plans are generally composed of maps and a narrative. The maps and associated construction drawings show existing site features and proposed alterations highlighting the location and type of proposed stormwater management system. The narrative consists of a written statement explaining the natural and proposed drainage system, a detailed description of projected runoff quantity and quality and an explanation of why certain management practices were chosen for pollution control. Highlighted should be a detailed description of the relationship of the proposed development to drainage and runoff within the entire watershed (with reference to a watershed management plan should one exist). Provisions for site safety and maintenance of approved management measures should also be included.

Principles to Strive for in Stormwater Management

Stormwater management should include measures to control and convey runoff flow, and to collect and cleanse runoff on-site. These principles might be summarized as **"The Four Cs" of stormwater management: control, conveyance, collection** and **cleansing**. Measures do not fall neatly into one category in most cases; for instance, measures that control runoff, such as swales, may convey and clean runoff as well. These four principles, however, can provide a helpful framework for looking at stormwater plans.

1. Control. Control measures can be broken down into two categories: source control and runoff control. Source control measures focus on pollution prevention. Their objective is to avoid or limit the generation of pollutants. Typical source control measures include erosion control, street and parking lot sweeping, hazardous waste collection and reduced usage of fertilizers and pesticides. Runoff control measures focus on slowing down runoff, in order to reduce the likelihood of erosion, downstream flooding and pollutant transport. These measures include limiting impervious surfaces, directing flow over grass swales or other vegetated areas, storing runoff in ponds and installing infiltration systems.

2. Conveyance. Conveyance systems are used to drain and direct the flow of runoff generated on a site. This is often done with tile pipes feeding into catch basins and storm sewers. More natural systems using vegetated depressions and swales, which look and function much like the natural drainage system, should be used whenever possible. Existing systems can be adapted to reduce runoff; for example, perforated pipes can be used to promote infiltration. Particular attention should be given to system outlets, which commonly become restricted or blocked if poorly designed.

3. Collection. Capture and storage of runoff for more timely release is a vital component of most stormwater management systems. When runoff is collected in a vegetated storage area like a retention or detention pond, the sites' adverse impacts on water resources can be greatly reduced. For sites where total capture is infeasible, studies suggest that collecting the "first flush" of onehalf to one inch of rainfall can capture a high percentage of contaminants. All collection systems require regular monitoring and maintenance to insure their continued effectiveness.

4. Cleansing. Control, conveyance, and collection of runoff mean little without provisions for cleansing. Cleansing is commonly accomplished through techniques that promote filtration and settling of pollutants, and their natural processing by vegetation and soil. Filtering devices include engineered structures like catch basins, sediment basins, and porous pavement, but also include more natural systems like stream buffers and vegetated filter strips. Depending on their design, many collection systems like ponds and wetlands also serve to cleanse water. Infiltration of stormwater into the ground, which allows pollutants to be cleansed by natural biological and chemical processes in the soil and helps to recharge groundwater, should be encouraged wherever soil type and groundwater systems can support it.

Summary Planning Guidelines for Stormwater Management

Site-by-site evaluation of stormwater plans can be greatly improved and facilitated by having a set of guidelines clearly stating the key management principles that the commission wants each applicant to address in a site plan. As part of site plan review, commissioners should require assurances that any stormwater management plan complies with these general guidelines. The detailed engineering formulas and designs used to attain compliance with the

guidelines are best handled by referring engineers and developers to commonly accepted manuals. Review of engineering design should be left to trained staff or consultants experienced in the field of water resources.

Below is a suggested list of guidelines that applicants should address when designing a stormwater management plan. Commissions should consider using these when reviewing submitted plans. Municipalities might also consider including these guidelines in their subdivision and zoning regulations, and referencing them in watershed management plans.

The Storm Management System Shall:

1. **Consider the total environmental impact of the proposed system.**
2. **Consider water quality as well as water quantity.**
3. **Be consistent with the local Plan of Development, and any existing watershed management plan.**
4. **Coordinate with erosion control measures and aquifer protection.**
5. **Minimize disturbance of natural grades and vegetation, and utilize existing topography for natural drainage systems.**
6. **Preserve natural vegetated buffers along water resources and wetlands.**
7. **Minimize impervious surfaces and maximize infiltration of cleansed runoff to appropriate soils.**
8. **Direct runoff to minimize off-site volume.**
9. **Reduce peak flow to minimize the likelihood of soil erosion, stream channel instability, flooding and habitat destruction.**
10. **Use wetlands and water bodies to receive or treat runoff only when it is assured that these natural systems will not be overloaded or degraded.**
11. **Provide a maintenance schedule for management practices, including designation of maintenance responsibilities.**

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

For more information, contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone:
(860) 345-4511
Fax:
(860) 345-3357

Email:
nemo@uconn.edu

Web Address:
nemo.uconn.edu

Written by:
Jim Gibbons, Roy Jeffery
& Susan Brant 1998
Last Update 1-05

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

THEY CAN'T DO THAT, CAN THEY?

HOW IS LAND USE DECIDED IN YOUR CONNECTICUT TOWN?

NEMO

Linking Land Use to Water Quality

Take this quick quiz and see how you score. The answers are provided directly after the questions, so don't peak!

Did you ever drive by a new development and wonder how and why that particular subdivision/office complex/industrial park is being put there? The answers may surprise you, since myths abound about how land use is decided. Take the quick quiz below and see how you score. The answers are provided directly after the questions, so don't peek!

1. Land use is primarily determined by:

(a) federal laws.
(b) state laws.
(c) local regulations.
(d) developers.

The correct answer is (c). Local land use regulations are the primary mechanism guiding land use. The state passes on the right to regulate land use through legislation that enables municipalities to zone, and all but a few of Connecticut's 169 towns have zoning in place. Zoning allows town governments to determine what type of development is appropriate for various areas of the town, for the good of all town citizens. Federal and state regulation is largely restricted to federal and state lands, and developers are simply reacting to what local zoning laws tell them.

2. Local land use planning and regulation is done by the:

(a) Planning Commission.
(b) Zoning Commission.
(c) Conservation Commission.
(d) Inland Wetland Commission.
(e) All of the above.

The correct answer is (e), all of the above. The Planning Commission develops your town's Comprehensive Plan of Conservation and Development, which lays out the town's vision for future growth; under Connecticut law, the Plan must be updated every ten years. In addition, the Planning Commission sets subdivision regulations, which specify how and when land can be subdivided for development. The Zoning Commission is responsible for the zoning regulations that set the rules for what kind of development is allowed in each area of town. Both the Zoning and Planning Commissions (which are combined in some towns) receive input from the Inland Wetlands Commission, which determines the legality of certain development in or near wetland areas, and the Conservation Commission, which advises on natural resource protection. Wetland and Conservation Commissions are also often combined.

3. Members of local commissions and boards are:

(a) appointed by the Selectmen or Mayor.
(b) elected by the town's population.
(d) appointed by the Office of State Planning.

The correct answer is either (a) or (b), depending on the town. In recognition of the importance of their work, more communities are electing commissioners.

4. Members of local commissions and boards are:

(a) paid handsomely for their time.
(b) volunteers.
(c) compensated a little for their service.

The correct answer is (b). Your neighbors are volunteering their time. Traditional New England home rule would not be possible without the help of volunteers, since most towns have relatively few paid staff. You don't have to be a professional planner, engineer or scientist to serve on these boards, either, which highlights the critical need for training and education of new board members.

5. A controversial development proposal in town can be denied:

(a) if public opinion is running against the proposal.
(b) by a town referendum on the proposal.
(c) only if town land use regulations are changed.
(d) only if the proposal fails to meet the land use regulations in force at the time of submission.

The correct answer is (d). Once a proposal is submitted, it can only be denied if it fails to meet the current regulations in place. Of course, negative public opinion and the accompanying adverse publicity can result in an application being revised or withdrawn, but legally neither a town-wide rally nor a referendum can halt a proposal. Conversely, the blessing of each and every resident in town cannot save a proposal that doesn't meet land use regulations.

6. No one is ever allowed to build:

(a) in a wetland.
(b) on a floodplain.
(c) on prime agricultural soils.
(d) none of the above.

The answer is (d). Although there are federal, state, and local regulations that govern activities in and near wetlands, there may be occasions when limited development is permitted. On occasion, as a condition for approval, a developer may be required to create new wetlands. Building on a floodplain may be permitted in some towns, but is rarely a good idea. And finally, there are no prohibitions against building on prime agricultural soils. In fact, the site characteristics that make these areas good for farming also make them prime building sites, so a town interested in protecting its agricultural heritage should include farmland preservation in its plans and regulations.

7. Citizens can voice their concerns or ask questions about proposed development by:

(a) attending regular commission meetings, which have "public comment" periods, or writing to the commission(s).
(b) attending and participating in commission informational meetings.
(c) attending and participating in public hearings, which are convened to gather public input on a specific proposal or issue.
(d) joining a land use commission.
(e) all of the above.

The right answer is (e). There are many opportunities to learn about land conservation and development in your town, and to make your concerns heard to your fellow citizens serving on land use boards. If you have an interest in guiding the future of your town, consider joining a commission—whether elected or appointed, commission members turn over rapidly, and new volunteers are always being sought.

8. Residential development:

(a) increases the tax base of the town.
(b) is an economic drain on the town.
(c) is a "break even" proposition for the town.

The correct answer is (b). Economic studies show that most residential development creates increased needs for community services such as fire, police, education and public works that are not covered by the tax revenue from new homes. A study of 11 Southern New England

towns by the New England Forest Consortium found that, on average, for every dollar of revenue raised form the residential sector, the towns spent an average of $1.14 on services.

9. One and two-acre residential development is a chief contributor to:

(a) rural character.
(b) natural resource protection.
(c) suburban/urban sprawl.

The surprising answer is (c). Contrary to common belief, one and two acre zoning poses a major threat to rural character and natural resources like clean water, open space and wildlife. "Cookie-cutter" subdivisions eat up and homogenize local landscapes to the point where every town looks the same. Effective community planning incorporates natural resource and open space protection up front, and promotes less consumptive land development patterned after traditional villages ("neotraditional" development and "cluster" subdivisions are two prominent examples) rather than post-World War suburbia.

10. Open space planning and protection:

(a) is important for town character.
(b) is important for natural resource protection.
(c) is an economic plus for the town.
(d) must be primarily a local initiative.
(e) all of the above.

Yes, the answer is (e). As noted, preserving open space is a key to preserving your town's character and protecting your water, land, and wildlife resources (see NEMO fact sheet # 9: Conservation Subdivisions). In addition, many studies show that open space is actually a money maker for the town, bringing in more money in taxes than the cost of what little services it requires. For all these reasons, open space protection is an important local issue—and as the federal and state government get out of the business of protecting land, it's increasingly falling to towns and private local groups like land trusts.

11. Land use planning is:

(a) a dirty word around here.
(b) an anti-American plot.
(c) the most effective, and cost-effective, way for a town to protect its economic, social and environmental health.

Well, it may or may not be a dirty word, but there's nothing anti-American about self-determination for communities. The fact remains that land use planning is the key to keeping your town a nice place to live, and land use planning is nothing if not local. So, it's up to you and your neighbors serving on town land use boards to determine the future of your town, and how it's going to look and feel for the next generation.

Scoring

1-3 correct answers: You might want to look at your town's Comprehensive Plan.

4-7 correct answers: Think about joining a local land use board.

8-9 correct answers: Consider a career in planning.

10-11 correct answers: Apply to the NEMO Program for a job immediately!

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

For more information, contact NEMO at:
University of Connecticut, CES
P.O. Box 70
1066 Saybrook Road
Haddam, CT 06438

Phone:
(860) 345-4511
Fax:
(860) 345-3357

Email:
nemo@canr.uconn.edu

Web Address:
nemo.uconn.edu

Written by:
Chester Arnold 1998
Last Update 1-05

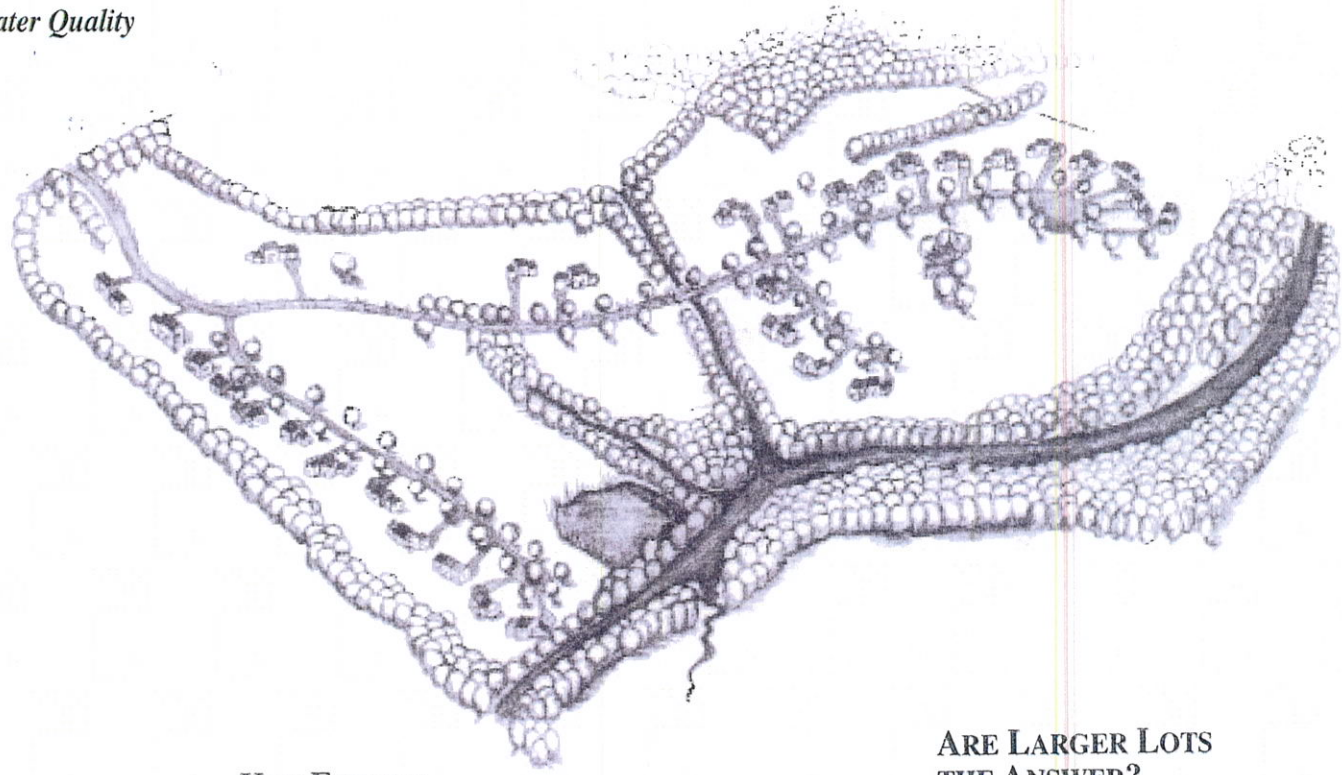
NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

Linking Land Use to Water Quality

Conservation Subdivisions

A better way to protect water quality, retain wildlife, and preserve rural character.



Key Finding

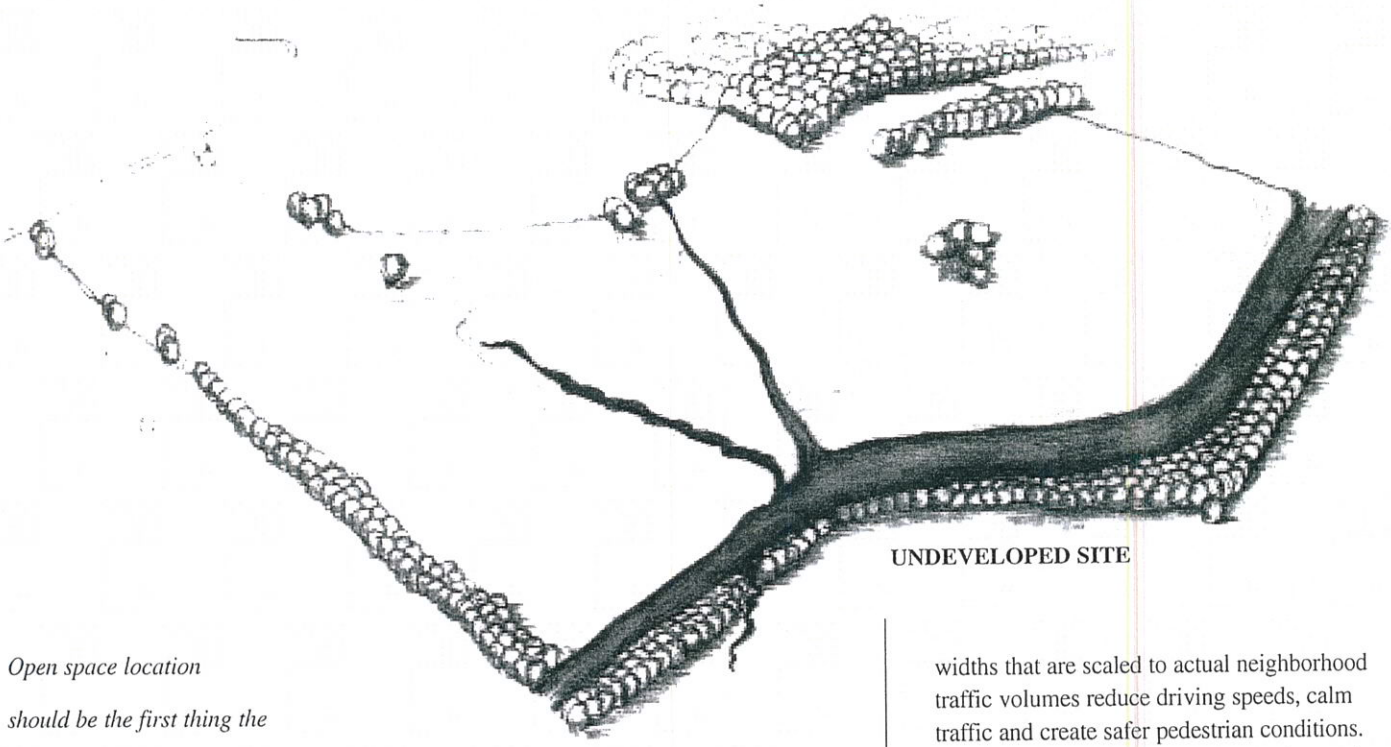
Attitudinal surveys show that many people value their community's rural character, but few realize this cherished character is programmed to disappear. That's right, programmed. Local zoning and subdivision ordinances serve as blueprints for converting undeveloped forest and fields into residential, commercial and industrial lots. Except for permanently protected open space, sooner or later those beloved woods and meadows are almost certain to disappear.

In other words, every acre of unpaved and buildable land is typically zoned for some type of development. Maybe it won't happen tomorrow, but in the future your town probably will look very different. Not only will rural character suffer, but wildlife habitat and water quality will diminish as well. Pollutants wash off developed areas into streams and ponds, harming fish and wildlife. While development isn't inherently bad, we must question whether current patterns of sprawl are what we really want, or whether there is a better way.

A Joint Publication of UConn Cooperative Extension's NEMO Project and The Natural Lands Trust.

Are Larger Lots the Answer?

Typical subdivisions are often designed with cookie-cutter sameness. Development with structures evenly distributed on large lawns served by wide, straight roads is expensive to build and maintain, and does a disservice to the people living there and the wildlife that once roamed the woods and swam the streams. It is ironic that developments designed to conserve open space and protect water quality are often rejected in favor of more costly and harmful arrangements, especially since conservation designs are based on traditional, New England small town and village layouts. Large lot zoning (e.g., 2, 3, or 4 acres) is *not* the answer to retaining rural character and protecting wildlife and water quality, as it promotes leap frog development that paves land and fragments natural areas.



UNDEVELOPED SITE

Open space location should be the first thing the landowner or developer designs, not the last...

Also available:
NEMO **Fact Sheet #1:** *Project Brief*
NEMO **Fact Sheet #2:** *Nonpoint Source Water Pollution*
NEMO **Fact Sheet #3:** *Impacts of Development on Waterways*
NEMO **Fact Sheet #4:** *Strategies for Coping with Polluted Runoff*
NEMO **Fact Sheet #5:** *How to Get Started: Protecting Your Town from Polluted Runoff*
NEMO **Fact Sheet #6:** *Asking the Right Questions: Raising the Issue of Polluted Runoff at a Public Meeting*
NEMO **Fact Sheet #7** *Reviewing Site Plans of Stormwater Management*
NEMO **Fact Sheet #8** *They Can't Do That (Can They?!!)*
NEMO **Fact Sheet #10** *Carving up the Landscape*

So What's the Solution?

A large part of the answer lies in "conservation subdivision" design. Using this tool, developers can design subdivisions that maximize open space protection without reducing the number of homes to be built. This is achieved by locating the structures on half (or less) of the property with the remainder permanently protected through conservation easements. It is important to note there is **no reduction** in the total number of structures - they are simply carefully situated to protect land and water resources, in direct contrast to the adverse impacts of aimlessly scattered lots that fragment the landscape and obliterate underlying resources.

How Conservation Subdivisions Help Protect Water Quality

When neighborhoods are developed with conservation in mind, roads can be shorter and narrower than in conventional developments. Less pavement reduces the amount of impervious surface and consequently the potential for polluted storm water runoff. (See also NEMO Fact Sheets 1-7). Pavement can be further reduced where development is designed to resemble traditional villages, with homes close to streets, thereby reducing driveway lengths. In addition to protecting water quality, street widths that are scaled to actual neighborhood traffic volumes reduce driving speeds, calm traffic and create safer pedestrian conditions. Where appropriate, open space may be used to treat contaminated stormwater associated with development. For example, instead of directing road runoff to the nearest stream, it might flow to common open areas containing naturalistic drainage facilities, such as swales or wet ponds that help filter pollutants and recharge local aquifers.

It Matters Where The Open Space is Located

Designated open space should be located to protect environmentally sensitive features. In most cases, it can also provide nearby residents benefits such as scenic vistas and recreation areas which add value and increase marketability. The location and functions of neighborhood conservation areas should be the *first* thing the developer designs, not the last. If the property is blessed with a good fishing stream or notable wildlife habitat, the conservation areas should be configured to protect these resources. While recreational use of the open area is often appropriate, locating a ballfield on the banks of a trout stream, where soil and fertilizer might wash to the water, should be avoided. Ultimately, to retain rural character and protect habitat, conservation areas need to viewed in a regional perspective and possibly linked to form greenways. (See NEMO Fact Sheet #10)

What Homeowners Find Valuable

Locating homes to protect open space addresses a need that people have expressed in attitudinal surveys. Real estate market researchers have found that people want to live in small towns providing a sense of community, as opposed to cookie-cutter developments offering nothing more than house lots and streets. In addition, people value available open space and informal trails and will pay more to live near them. In fact, surveys show that 40-80% of people living in golf course developments are *not* golfers - they choose to live there because of the open space visible from their windows.

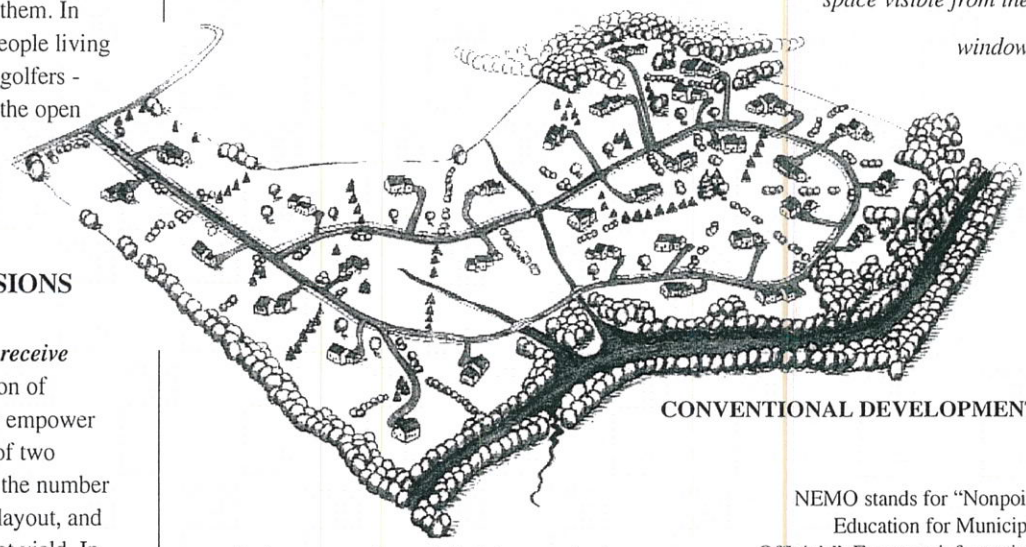
Frequently Asked Questions About Conservation Subdivisions

How can we be guaranteed we will receive quality open space? A new generation of conservation subdivision regulations empower commissions to require submission of two subdivision plans: a sketch showing the number of lots achievable in a conventional layout, and a conservation design for the same lot yield. In the conventional plan, a certain percentage of the land, often 10%, may be dedicated as open space. Under conservation subdivision, anywhere from 40 to 70 percent of the land, *in addition* to wet, flood prone or steep areas, is set aside as permanent conservation land. The planning commission decides which design is best for the community. The provision of quality open space should be a key consideration when deciding which design most benefits the community.

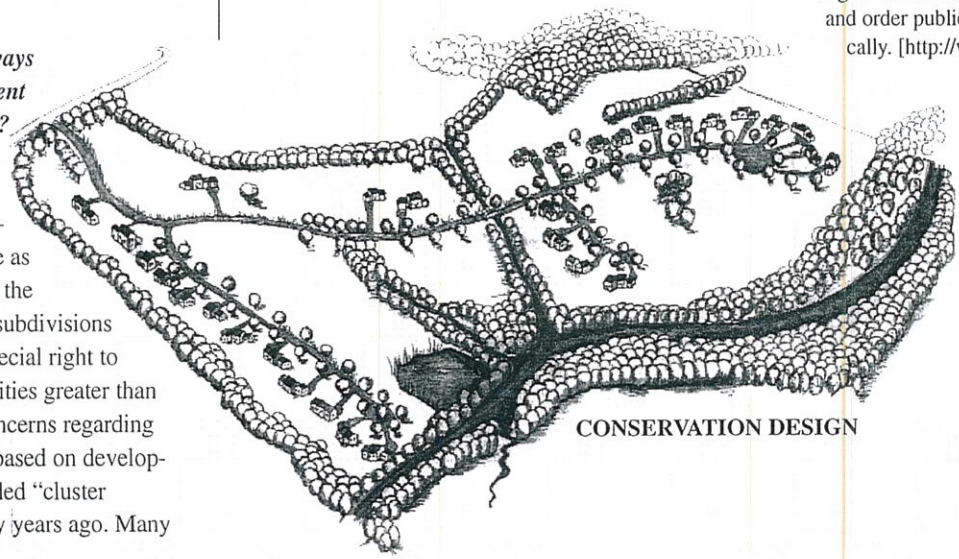
Don't these developments always result in high density apartment and condominium complexes? Zoning generally requires that the housing types and densities permitted in conservation subdivisions be the same as are normally permitted within the zoning district. Conservation subdivisions do not give developers any special right to build attached units or at densities greater than generally permitted. Many concerns regarding density and housing type are based on developments built under poorly worded "cluster zoning" adopted thirty or forty years ago. Many of these developments allowed attached units at densities greater than permitted by conventional zoning. The result was tightly packed attached units will little common open space. The modern conservation subdivision regulations are a world apart from these early provisions, in that they are designed to protect the municipality and the environment while providing developers design flexibility to produce better layouts. As such, if the community wishes to preserve 50% of land in addition to areas deemed unbuildable, or limit conservation subdivisions to single family detached dwellings, they may include these provisions in their regulations. Some communities choose to offer modest density bonuses when developers agree to conserve more than the required minimum open space.

Who will own, maintain, be liable for and pay property taxes on the conservation land? Whoever owns the conservation land is responsible for all the above. Generally there are four

Surveys show that 40-80% of people living in golf course developments are not golfers - they choose to live there because of open space visible from their windows.



CONVENTIONAL DEVELOPMENT



CONSERVATION DESIGN

NEMO stands for "Nonpoint Education for Municipal Officials". For more information, contact the NEMO Project c/o Chester Arnold, University of Connecticut CES, 1066 Saybrook Road, Haddam, CT 06438-0070. Tel: (860) 345-4511. Fax: (860) 345-3357. Internet: carnold@canr1.cag.uconn.edu.

On the World Wide Web? Check out the NEMO Home Page! Learn more about NEMO, and order publications electronically. [http://www.canr.uconn.edu/ces/nemo/]

basic ownership options: individual landowners, homeowners' associations, land trusts and the municipality. Municipalities generally prefer not to hold title to the common open space within subdivisions unless the land would help complete a town trail system or provide active recreation areas. In most instances, homeowners' associations own and manage conservation lands and have typically encountered few problems when a few basic management principles are followed.

What You Can Do

Whether you're a local land use official, resident or business owner, you can ask whether your town has an updated plan of conservation and development. You can discuss with your neighbors the role conservation subdivision design might play in meeting neighborhood and community goals. You might review your local land use regulations to see if they encourage development protective of your town's character and valuable natural resources or whether your town has programmed itself for more sprawl, in which all lands are eventually converted to house lots and streets. You might consider serving on a local land use board to insure local plans and regulations include provisions for conservation subdivision design. In any case, do not rely on someone else to take the initiative. You can help place your town in the driver's seat regarding its future, or you can leave it to someone else with interests quite different from yours.

Advantages of Conservation Subdivisions

Compared with conventional layouts, conservation subdivisions offer the following advantages:

Economic advantages

For the municipality:

- Open space enhances the municipality's quality of life, one of its chief assets in attracting quality businesses and in encouraging economic growth.
- Municipal service provision is cheaper when homes are not widely scattered.
- Open space dedications may provide public parkland, reducing public land acquisition costs.

For the developer:

- Site plan review is smoother when development plans conform with local planning objectives.
- Development costs are reduced as utility lines, streets, driveways and sidewalks are shorter.
- Conservation subdivisions have marketing and sales advantages, as buyers prefer lots close to or facing protected open space.
- Homes in conservation subdivisions tend to appreciate faster than counterparts in conventional developments.
- Where zoning permits, a variety of housing types, ranging from single family detached to attached units, may be more easily accommodated.

Environmental Advantages

For water quality:

- Common open space can be designated as buffers to protect wetlands, streams and ponds.
- Water quality is enhanced when impervious surfaces such as streets, driveways and pipes are minimized.
- Where appropriate, stormwater and sewage treatment facilities can be located within the open space.

For wildlife:

- Common open space, if properly sited and managed can provide wildlife habitat with the three basic requirements of shelter, food and water.
- When linked to other existing open areas, the common open spaces can serve as wildlife corridors and unfragmented wildlife preserves.
- Common open space can be used to protect "unique or fragile" habitat as identified by local, regional or state natural resource surveys.

Social and Recreational Advantages

- Common open space provides attractive areas for neighbors to meet informally and socialize.
- Common open space may be designated for recreational uses such as biking, walking or ball playing all of which promote social interaction.
- Smaller yards to tend can provide residents with more leisure time.

This fact sheet is a collaboration of the NEMO Project and The Natural Lands Trust. It was written by Rosemary Monahan, Jim Gibbons and Chester Arnold is based on the work of Randall Arendt, Vice President for Conservation Planning at the Natural Lands Trust.

For more information on open space development, contact the University of Connecticut CES or

The Natural Lands Trust
1031 Palmers Mill Road, Media, PA 19063, Phone # (618) 353-5587.

NEMO is a project of the University of Connecticut's Cooperative Extension System, collaborating with the University of Connecticut Natural Resources Management and Engineering Department and the Connecticut Sea Grant College Program. Major funding provided by The Water Quality Program, USDA Cooperative State Research, Education and Extension Service.

3/99

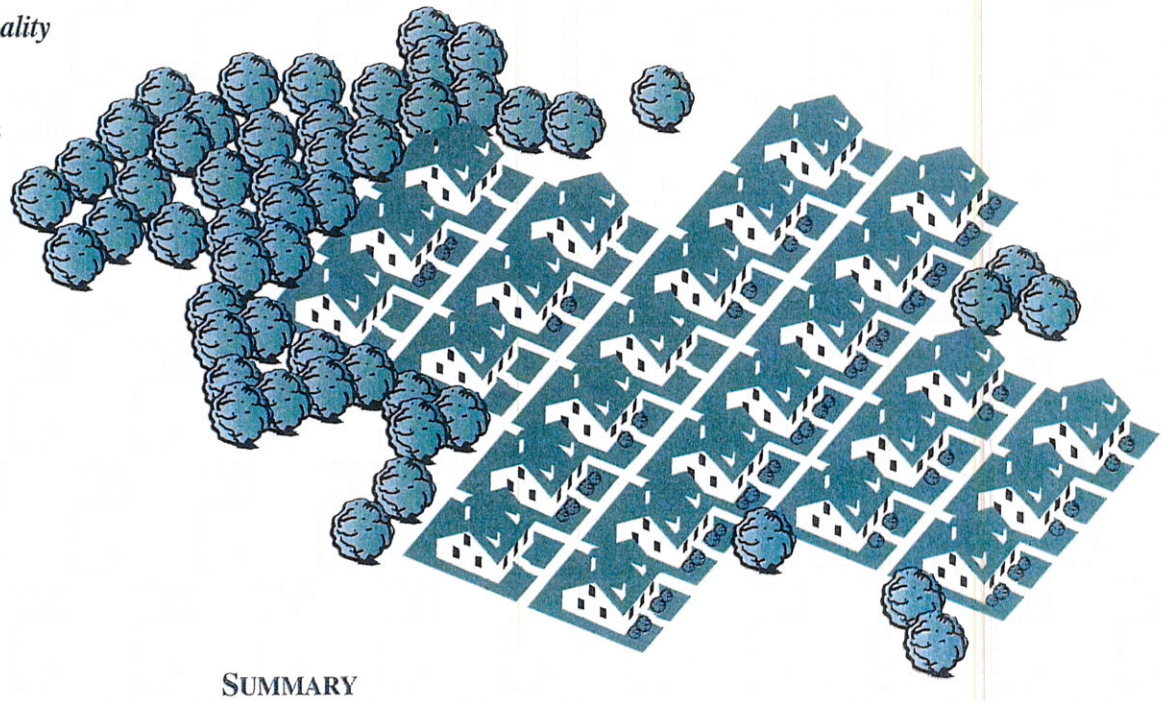
University of Connecticut
Cooperative Extension System
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Kirklyn M. Kerr, Director, Cooperative Extension System, University of Connecticut, Storrs. The Connecticut Cooperative Extension System is an equal opportunity employer.

Linking Land Use to Water Quality

Carving up the Landscape

Habitat Fragmentation and What to Do About It



SUMMARY

The rise of suburban sprawl as the prevalent developmentt pattern in America has resulted in extensive disruption, or fragmentation, of the landscape. Fragmentation reduces the diversity of wildlife, contributes to the degradation of water resources, and impacts community character. Retaining the environmental, social and economic benefits of unfragmented open land requires a strategy that combines natural resource-based community planning and design, land conservation, and wise management of both developed and natural areas.

A Joint Publication of UConn Cooperative Extension's NEMO Project and Forestry Program

WHAT IS FRAGMENTATION?

As development occurs, elements like roads, houses, railways, parking lots and utility lines divide the natural landscape into ever-smaller pieces, or fragments. Natural habitat areas are reduced in size and quality, and native populations of plants and animals decline. Some of the more sensitive species disappear. Compared to the obvious damage of a filled wetland or a clear-cut forest, the effects of fragmentation are subtle. However, we have begun to realize that "everyday" development can disrupt and degrade ecosystems even where substantial natural lands remain.

Every type of animal or plant has certain requirements to "make a living" — key elements like food, water, and shelter needed for survival. The minimum area required to provide these needs and the amount of human disturbance that can be tolerated within this area vary widely by species, and are subject to much scientific scrutiny. As research continues, it is becoming clear that for many types of wildlife, it's not the total acreage of habitat that counts, but how much of that habitat exists in large, undisturbed tracts.

FRAGMENTATION IMPACTS

- *habitat destruction*
- *critical changes to vegetation and hydrology*
- *increased predation by domestic animals*
- *increased access for other predators*
- *barriers to wildlife movement*
- *road kill*
- *health effects caused by pesticides and other pollutants*
- *behavioral effects caused by noise, lights, and other disturbances*

Also available:
NEMO **Fact Sheet #1:** *Project Brief*
NEMO **Fact Sheet #2:** *Nonpoint Source Water Pollution*
NEMO **Fact Sheet #3:** *Impacts of Development on Waterways*
NEMO **Fact Sheet #4:** *Strategies for Coping with Polluted Runoff*
NEMO **Fact Sheet #5:** *How to Get Started: Protecting Your Town from Polluted Runoff*
NEMO **Fact Sheet #6:** *Asking the Right Questions: Raising the Issue of Polluted Runoff at a Public Meeting*
NEMO **Fact Sheet #7** *Reviewing Site Plans of Stormwater Management*
NEMO **Fact Sheet #8** *They Can't Do That (Can They?!!)*
NEMO **Fact Sheet #9** *Conservation Subdivisions*

SO WHAT?

Does it really matter if you haven't seen a warbler in your neighborhood lately, or if there are no more otter or bobcats in the woods? The answer is yes. Biological diversity is a measure of both our natural wealth and health, and a certain level of it is essential for our environment to function. If too much diversity is lost, the food web breaks down and an ecosystem becomes unable to renew itself: its species, its soils, and its habitats. Natural processes like decomposition and nutrient cycling, upon which we all depend, begin to break down.

Fragmentation also impacts water resources. Nonpoint source pollution, carried by runoff from developed areas into watercourses and wetlands, is now the number one water quality problem in the country. As development occurs, pavement and other impervious surfaces disrupt the water cycle, channel pollutants into waterways, and otherwise contribute to the degradation of our water resources *(NEMO fact sheet #2 and #3)*. Suburban sprawl, the post-World War II pattern of development founded on automobile transportation, creates more impervious surfaces and eats up more open space than more compact styles of development *(NEMO fact sheet #9)*.

Natural resources are not the only thing affected as the landscape is transformed from green to gray. The homogenizing effects of sprawl wreak havoc on community character, as strip malls replace traditional village or urban centers. Furthermore, studies from around the country indicate that sprawl is costly, while other studies show that open space is important both to the economic and social health of a community. Public opinion surveys consistently highlight the importance of natural lands, clean drinking water and healthy waterways to citizens.

HOW DOES FRAGMENTATION WORK?

Fragmentation can have many different impacts on native species (see box). For instance, as wooded areas shrink, forest birds like the cerulean warbler, which build nests on or near the ground, become susceptible to housecats and other suburban predators. Similarly, amphibian populations decline as ponds and vernal pools become surrounded by developed areas. Research in southern New England suggests that to survive, frogs and salamanders need undisturbed woodland contiguous to their aquatic habitat. For these small species even minor aspects of development can have a major impact — road curbs, for example, can serve as barriers preventing movement to and from vernal pools *(See Figure 1)*.

Fragmentation also affects large mammal and bird species. Large predators needing sizeable hunting ranges, like bears, bobcats, and owls, seem most affected. Some species are so adaptable to human landscapes that they make generalizations hard to make; for instance, deer populations in southern New England are at record highs. Even this gain may be connected to fragmentation, since most experts believe that the deer explosion is due, in part, to the absence of large predators (including hunters). Fragmentation can also directly affect human health; for instance, most experts believe that Lyme disease, carried

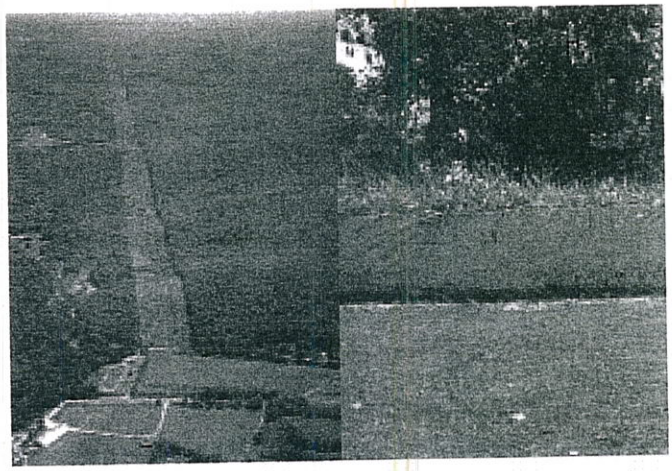


Figure 1: What constitutes fragmentation is highly species-dependent. A power line may be a barrier to forest birds, while a salamander's eye view of fragmentation might be a simple road curb.

by the "deer" (wood) tick, has spread as deer populations have grown.

The toll of disappearing species is mounting. While our understanding is incomplete, it's generally true that the wildlife base dwindles as the average size of natural parcels decreases *(Figure 2)*.

WHAT CAN BE DONE?

In the past 30 years, much of New England has actually experienced a growth in wooded areas, as unused farmland reverts to forest. This has allowed animals like moose, fisher, and even bear to return to some areas they had long abandoned. So, it is possible that some species of wildlife can make a comeback, if given the opportunity in the form of suitable habitat. However, the landscape conversion now taking place — that of forest and field to developed land — entails more permanent changes from which recovery is unlikely, if not impossible.

Development will continue, but we can do a much better job guiding how and where development occurs. Minimizing fragmentation requires an approach that combine several overlapping strategies:

1. natural resource-based community planning and design;
2. land conservation;
3. wise management of both conservation land and developed land.

STRATEGY #1: NATURAL RESOURCE-BASED LAND USE PLANNING & DESIGN

Comprehensive, natural resource-based community planning is the most effective way to combat fragmentation. Natural resource-based planning typically involves these steps:

- conducting a natural resource inventory;
- reaching consensus on priority natural resources on which to focus protection efforts;
- directing development (through town plans and zoning regulations) to areas where it has the least impact on priority natural resources.

Unlike traditional development-driven planning, natural resource-based planning considers the long-term economic and environmental health of the community *(NEMO Soapbox Editorial #3)*.

An open space plan identifying community goals, uses, and funding for open space preservation is a critical component of the natural resource-based planning approach

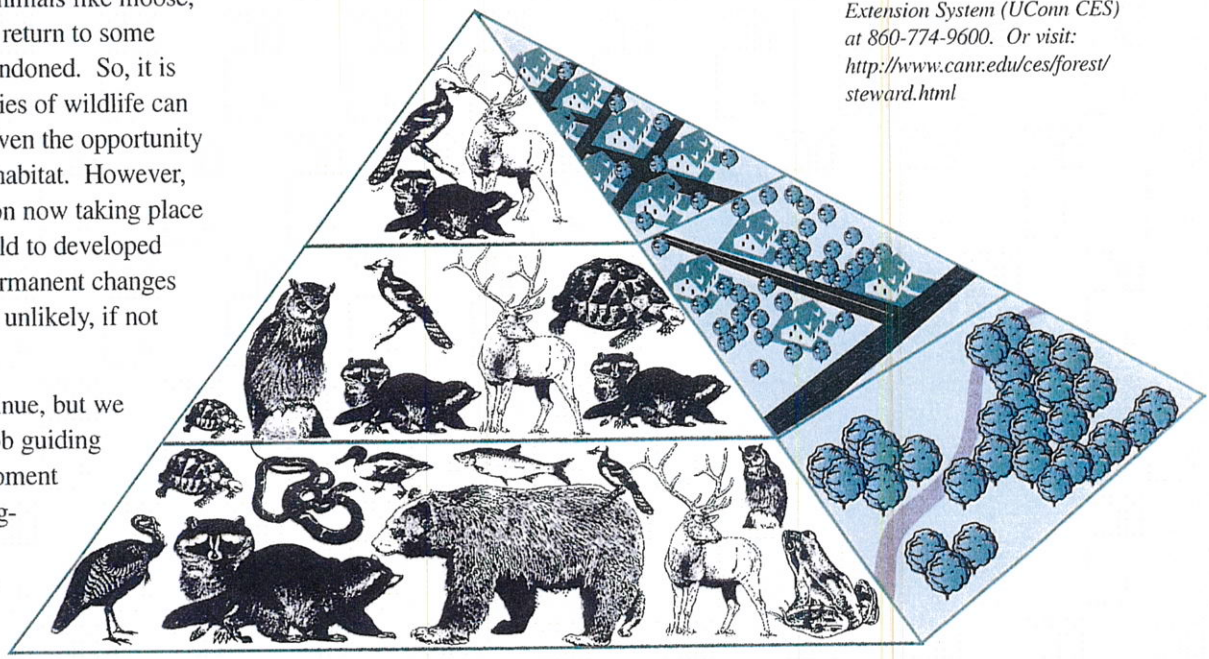
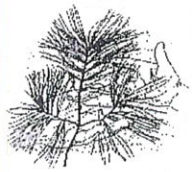


Figure 2: In general, as "patch size" of unfragmented land decreases, so does the diversity of native wildlife (species shown are for illustrative purposes only).

(UConn CES Open Space Packet). In Connecticut, Planning Commissions and Conservation Commissions need to take the lead in municipal open space planning. Planning Commissions should see that the town Plan of Conservation and Development includes or references an open space plan. The enabling legislation for Conservation Commissions charges them with conducting natural resource inventories and ad vising the other land use boards on conservation of priority resources; this mandate makes Conservation Commissions the ideal group to provide leadership in open space planning, particularly in the context of a regional approach where inter-town



FOR MORE INFORMATION

The University of Connecticut Forestry Program educates forest owners on managing forest and wildlife resources, and on methods for long term protection of their lands, including estate planning. Call the University of Connecticut's Cooperative Extension System (UConn CES) at 860-774-9600. Or visit: http://www.canr.edu/ces/forest/steward.html

cooperation is needed. Local land trusts can be key players as well. Although land trusts are private organizations, they can provide leadership and expertise to municipal open space planning efforts.

As noted, good natural-resource based planning addresses where development should occur and what type of development is desired. Zoning and subdivision regulations then implement plan goals, including design elements that can reduce fragmentation. At the neighborhood level, for instance, conservation or cluster subdivisions can help to conserve open and sensitive areas like wetlands, wildlife corridors, and agricultural fields *(NEMO fact sheet #9)*. On the individual site level, design elements that reduce impervious surfaces, retain natural vegetation, protect riparian corridors, and make use of vegetated stormwater systems help to reduce fragmentation and support wildlife populations, while serving to protect water quality.

NEMO stands for "Nonpoint Education for Municipal Officials". The NEMO Project offers educational programs on linking land use with water quality, impervious surface reduction, watershed management, open space planning, and homeowner practices to protect water quality.

For more information, contact the NEMO Project c/o Chester Arnold, University of Connecticut CES, 1066 Saybrook Road, Haddam, CT 06438-0070 Tel: (860) 345-4511 Fax: (860) 345-3357 Internet: carnold@canr1.cag.uconn.edu.

On the World Wide Web? *Check out the NEMO Home Page! Learn more about NEMO, and order publications electronically. [http://www.canr.uconn.edu/ces/nemo/]*

STRATEGY #2: LAND CONSERVATION

Permanent conservation of land — both private and public — constitutes a major portion of any strategy to preserve open space and minimize fragmentation. It's beyond the scope of this fact sheet to review conservation mechanisms *(see Open Space packet)*. However, below are a few general concepts regarding open space and fragmentation that are important when considering conservation priorities.

Conservation Objective #1: Protect a few large tracts of natural land.

For biodiversity, bigger is better. Ecologists tell us that we need to maintain relatively large areas of continuous, unfragmented natural lands with a diversity of habitat types — grassland, shrubland, and forest. This may seem like a tall order, but it's still achievable in many parts of the country. You might be surprised to learn how much conservation land already exists in your area.

To ensure the protection of sensitive species, you need a lot of unfragmented land. Research in southern New England, for example, shows that forest interior birds seem to require a minimum of 1500 acres, while 5000 acres or more is ideal. This may be an extreme example, but even tracts this size may be possible to protect when you take a regional view, such as a watershed perspective. By building partnerships and combining forces with neighboring counties, towns, state and federal agencies, and non-profit organization, it may well be possible to protect a large block in perpetuity.

Conservation Objective #2: Protect a network of smaller tracts.

Experts also suggest that we need a scattering of moderate size natural areas, in the 125 to 500 acre range. These "satellite" preserves can support species that don't need really large forests in which to breed, and may even support small populations of the more sensitive species. Wildlife from these satellite areas can repopulate the larger tracts should something catastrophic happen there. Ideally, these smaller tracts should be as close as possible to any larger tracts, contain a diversity of habitat/landscape types, and be connected to other natural areas *(see below)*. As tracts decrease in size, their shape can become an important factor. Most biologists agree that straight-line boundaries encourage harmful "edge effects" that include predation and competition from generalist species. Gradual, nonlinear transitional edges help to minimize these impacts.

Conservation Objective #3: Make connections.

Isolated pockets of natural lands are of value to the community, but to maximize ecological value it's important to connect open space wherever possible. Parcels contiguous to existing large and medium-sized tracts should be given high priority for conservation. Stream valleys and ridge tops also should be targeted — these areas often do "double duty," serving as both critical habitat and wildlife corridors. Riparian (streamside) corridors, for example, are used by almost 70% of all vertebrate species. Protected land in riparian corridors should include the banks and floodplain areas, as well as contiguous upland forest on at least one side. The width of wildlife corridors is subject to

debate, but some studies have suggested that corridors must be at least 100 meters in width to maintain at least some "interior" (as opposed to "edge") conditions.

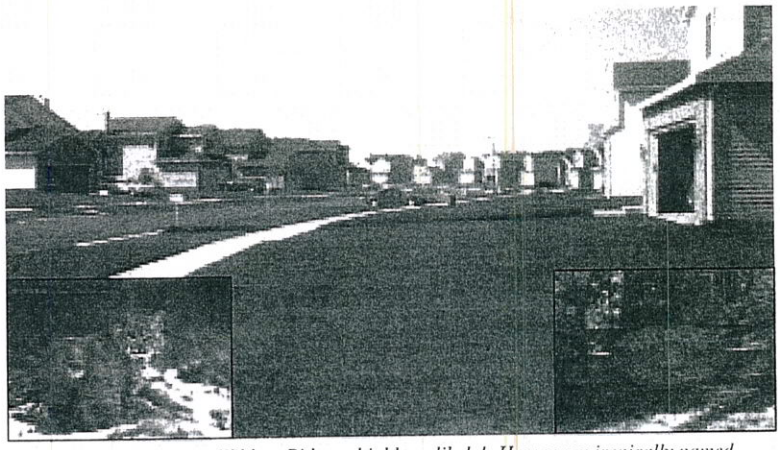
Small but strategic properties can often be protected through conservation easements or other creative techniques. At the community or regional scale, "greenway" initiatives are obviously good opportunities to make connections. (Note: conservation biologists are concerned about the spread of invasive species, so when connecting land please consider this factor.)

To make connections, it's invaluable to see it on a map. This gets back to the value of natural resource inventories, and knowing what you've got. Examining a map showing the mosaic of existing open space in your town or watershed, and how it relates to waterways, wetlands, ridgetops and other key areas, is one of the best ways to get a handle on implementing the conservation strategies listed above.

Wise Land Management

Property owners (both public and private) can further protect natural resources and minimize fragmentation through management and design, whether their property is in a natural or developed state.

Management Objective #1: Manage conservation lands to provide diverse habitat. Not only do we need to add to conservation land, but we also need to manage conservation lands and other property to support key species. Whether natural lands are publicly or privately owned, management usually means making some decisions about what constitutes a "key" species. For instance, birds that live in grassy or shrubby habitats, like the bobolink, eastern meadowlark, and blue-winged warbler, have declined dramatically in the past 30 years as farmland shrinks. To preserve these species, some conservation lands must be managed to create or maintain shrub and grasslands (clearing, mowing, burning, etc.). On the other hand, some forest species require extensive tracts of undisturbed forest. The need for a diversity of habitats further underscores the value of having large parcels that can accommodate different landscapes.



The elusive bobcat near Wildcat Ridge – highly unlikely! How many ironically named subdivisions like this have you seen around your town?

Management Objective #2: Manage individual properties to provide diverse habitat.

There are many species that don't need large forests in which to live. These are species that you may catch glimpses of as you walk through nearby woods, or that may come into your backyard to feed, even if they live in more secluded areas. For these species, such as woodpeckers, many song birds, small mammals and some larger ones, even narrow woodland corridors can provide critical travel routes. As noted, often such pathways are located on ridgetops or along waterways. Permanent conservation of these small but important areas is ideal, but wise management by private landowners can also work. Streamside buffers of natural vegetation, and the use of naturalistic landscaping in these areas instead of lawns, are important contributions that individual homeowners can make. For owners of large forested properties, a forest stewardship plan (see page 6) can help enhance their property's value to wildlife while accommodating timber harvesting or other economic activities.

The Wildlife Conservation Research Center (WCRC) of the University of Connecticut offers a practical means for helping communities and individuals resolve difficult questions on habitat fragmentation and other wildlife issues. Supported by private donations and gifts, WCRC brings the resources of a Land Grant University to bear on wildlife issues. For information call 860-486-5896.

BUT WHAT CAN I DO? GET SPECIFIC!

Reducing habitat fragmentation may seem a bit overwhelming for the individual. But there are many things that you can do to help, based on the strategies listed above. Here are a few ideas:

- You can contribute time and/or money to land conservation in your area, whether it's accomplished through a local land trust, your town's land use boards, or nonprofit conservation organizations.
- You can ask whether these groups have open space plans. Many towns and local groups simply take any piece of property that comes their way, with no attempt to target critical areas like streamside corridors and areas contiguous to existing open space. Municipal open space plans should prioritize land to be acquired, and address funding mechanisms.
- You can check with your town's Conservation Commission — have they conducted a natural resource inventory, identified priority natural resources, or developed an open space plan? If the answer to these questions is *"we're too busy regulating wetlands to take on new responsibilities,"* suggest that the town consider separating their Inland Wetland and Conservation Commissions to allow for more proactive conservation.
- If you own farm or forest land and you wish to preserve it for future generations, you can investigate conservation easements, estate planning, and other tools that can make conservation a economically feasible option.
- You can manage your own property to improve wildlife habitat, employing naturalistic landscaping, stream buffers and other mechanisms. If you are a forest owner, you can implement a stewardship plan. Even if you live on a quarter acre lot in the middle of town, you can grow native, berry-producing shrubs and other plants that are food sources for local wildlife.
- You can ask your local land use boards to rethink their land use plans and regulations to ensure they protect critical natural resources and wildlife habitats. Does your town ask developers to propose open space or conservation subdivisions in key areas? If biodiversity doesn't move them, maybe the mounting list of studies showing the economic benefits of open space will!
- You can volunteer (or run) to serve on a land use board yourself, and have a direct hand in the decisions that shape the future of your town *(NEMO fact sheet #8)*.
- You can support wildlife conservation and habitat management programs in local schools.

CONCLUSION

Fragmentation impoverishes both the natural and human landscapes. Researchers still have much to learn about the effects of habitat fragmentation, but the basic concept is simple — a parking lot can't support a bobcat, nor can a suburban lawn accommodate grassland bird species. Whenever a streamside forest is replaced by manicured lawn, a wildlife corridor is severed and fish habitat is degraded. When forest understory plants are removed to create a park-like appearance, certain plant and animal species may lose their last foothold for miles around. When a large forest is fragmented into house lots, rare songbirds and other deep woods species lose another place to reproduce and thrive. And, as habitat goes, so does water quality and community character. As individuals and communities, we can help to reduce the impacts of fragmentation through a combination of planning, design, conservation, and management.

The Connecticut Forest Stewardship Program offers technical and financial assistance to private forest landowners in the planning and implementation of wildlife habitat enhancement and other forestland management activities. For information call 1-888-30WOODS or 1-860-345-4511. Or visit: http://www.canr.edu/ces/forest/

This fact sheet was written by Chester Arnold, UConn CES, Rosemary Monahan, EPA Region One, and Stephen Broderick, UConn CES. Printed March 1999.

NEMO is a project of the University of Connecticut's Cooperative Extension System, collaborating with the University of Connecticut Natural Resources Management and Engineering Department and the Connecticut Sea Grant College Program. Major funding provided by The Water Quality Program, USDA Cooperative State Research, Education and Extension Service.

3/99

University of Connecticut
Cooperative Extension System
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Kirklyn M. Kerr, Director, Cooperative Extension System, University of Connecticut, Storrs. The Connecticut Cooperative Extension System is an equal opportunity employer.

NEMO

NONPOINT EDUCATION
FOR MUNICIPAL OFFICIALS

TECHNICAL PAPER **NUMBER 5**

Parking Lots

By Jim Gibbons, *UConn Extension Land Use Educator, 1999*

Introduction

As more and more people own cars, more and more parking lots become necessary. Unfortunately, parking lots can adversely affect the environment as well as detract from "community character". Paved parking lots are typically designed to collect and concentrate large areas of storm water runoff, which can impact a receiving streams hydrography as well as water quality.

Paved parking lots can generate heat, raising the surrounding areas air temperature as well as the temperature of the first flush of storm water which can have significant ecological impacts. The City of Olympia Washington's Public Works Department found that parking lots account for 53% of imperviousness on a commercial site and 15% of multifamily sites. These figures are typical of most communities. Therefore careful attention to their design will go a long way toward protecting your community's water resources.

While eighty to ninety percent of all parking demands in America are met by surface parking, many view parking lots as necessary yet unattractive, even hostile places. While we need places to park cars, parking lots in summer can be flame-thrower hot and in winter, ice rink cold and slippery. Parking lots can be real or perceived danger zones, where drivers battle for choice parking spaces and pedestrians try to dodge kamikaze hits from myopic drivers. At night parking lots can become dark, desolate, Stephen King designed, landscapes harboring a rich assortment of imagined shadow lurking predators. Visually parking lots are often urban eyesores and broken tooth gaps in the Pepsodent smile of the urban streetscape.

In addition to their negative aesthetic characteristics, parking lots can also adversely impact the environment. For example, they act as heat islands greatly increasing summer temperatures. As car holding areas, they can transmit odors, noise, glare and a host of airborne pollutants. Paved parking lots seal the earth, preventing rainfall infiltration and ground water recharge. Impervious parking areas collect and convey storm water. As runoff traverses impenetrable asphalt or concrete, its' volume, velocity and pollutant loads increase, resulting in increased flooding, peak stream flows, stream channel erosion and polluted water resources.

As storm water quantity and quality is directly related to the amount of impervious cover on the landscape, water resources can be protected and enhanced by reducing impervious parking areas.

Local land use officials are charged with developing plans and regulations related to parking. This paper analyzes parking lot location, size, and design from a land planning perspective, emphasizing their potential adverse impact on water resources. Suggestions are offered as to how the imperviousness of these ubiquitous modern landscape features can be reduced.

Parking Lot Location

Parking lots are common in commercial, industrial and certain residential areas, such as apartment complexes. Often clustered in densely developed areas, parking lots may become part of a large network of interconnected impervious surfaces, collectively serving as polluted runoff storage and conveyance facilities. Parking lots may be proposed on or near fragile areas such as wetlands. Unless properly located and designed, parking lots can adversely impact water resources. Local officials should develop plans and adopt land use regulations that minimize or negate the potential environmental impacts of improperly sited impervious parking lots.

As a practical standard, parking should be located close to the building it serves. Parking is traditionally placed in the front yard of the building served, producing a common development pattern where blacktop replaces front yard landscaping. With front yard parking, side yard setbacks and controlled curb cuts are often forgotten. As a result, parking lots flow together onto the street forming massive asphalt sheets stretching door front to door front into what is commonly referred to as "strip commercial development." The macadamized landscape raincoats the earth allowing the preparation of a rich bouillabaisse of polluted runoff that is ultimately fed to unsuspecting rivers and streams.

Where parking lots are a requirement of commercial or industrial use, they should be placed at the rear of the building served. Rear parking reduces potential conflicts of cars crossing sidewalks at many points. The City of Fort Collins, Colorado in a effort to reduce the overall large scale of paved surfaces associated with big box retail development, requires that no more than 50 percent of the parking be located between the principle building and the primary abutting street. By distributing parking around a large building, walking distances from cars to the store are reduced.

Another way to reduce the amount of impervious parking exposed to rain, is to place parking underground, within the building it serves, or in multi-storied, shared parking garages.

NEMO Recommendations Regarding Parking Lot Location

- Plans of Conservation and Development should identify impervious surfaces, such as parking lots, as part of an existing land use inventory. The Plan should reference the potential and known adverse environmental impacts of impervious surfaces and recommend ways to reduce them.

- Plans of Conservation and Development should contain an "impervious cover build out analysis," showing the location and amount of imperviousness that will be generated if the community develops according to present zoning.

- Plans of Conservation and Development should make recommendations regarding the location, size, and design of future parking facilities emphasizing their potential environmental impact. Special attention should be paid to future policies regarding parking lots located near or draining to, watercourses and wetlands. The Plan should also address the issue of mass transit, garages versus surface parking, shared parking in mixed-use areas and porous versus impervious parking surfaces.

- Plans of Conservation and Development should recommend the use of porous surfaces on parking lots and other impervious surfaces as a way to improve storm water quality, control runoff volume and velocity and promote infiltration and groundwater recharge.

- Plans of Conservation and Development should review parking requirements found in local regulations and compare them to standards in other communities and national studies such as "The Parking Generation Manual," prepared by the Institute for Transportation Engineers, to determine if local standards are excessive.

- Plans of Conservation and Development should contain or recommend parking utilization studies, to see if required spaces are used. The common planning goal of "providing ample off-street parking" might be substituted with "adopting parking standards that meet actual demand."

- Communities, regions and watersheds should establish growth management policies that encourage growth in areas with infrastructure and conservation in areas deemed, unique or fragile. These policies should promote urban infilling and discourage suburban sprawl. The growth areas should contain mass transit and where feasible, require garages, shared parking or porous parking surfaces. Green areas designed to infiltrate runoff should be promoted in highly impervious urban areas.

- Communities should require rear yard parking while prohibiting parking in front and side yards. Rear yard parking prevents streetscape domination of door front to door front macadam flows. Also, consider requiring that structures be built at the street line to force rear yard parking.

- If front yard parking is permitted, limit parking and driveway coverage to no more than 50 percent of the front yard area. To avoid adjoining parking lots flowing together and eventually onto the street, maintain side yard setbacks and limit curb cuts and curb cut widths.

- To reduce the amount of impervious parking surface exposed to rain, require shared parking, parking be under or within the building served or within multi-storied parking garages.

Parking Lot Size

Few municipalities have developed formal parking policies. However, when parking regulations are reviewed two assumptions emerge:

1. Enough spaces will be supplied to meet the highest demand, and
2. Most drivers will park for free. Many planners feel these assumptions have produced too many large parking lots that accumulate and convey too much polluted runoff.

The number of off-street parking spaces and minimum parking space size required by zoning determines parking lot size. Typical zoning regulations produce surface parking that occupies 2 to 3 times more space than the floor area in the building served. A 1995 survey conducted by the city of Olympia, Washington found that over half of the city's commercial sites were devoted to parking and driveways. In her 1997 study entitled, "*The Bay Area's Love-Hate Relationship With The Motorcar*," Ellen Marie Miramontes estimates that between 30 and 40 percent of the land in a typical American downtown is consumed by parking spaces. Parking requirements for regional facilities such as shopping malls, airports and sport stadiums can generate parking lots that occupy 10 to 50 acres. Suburban shopping malls, multiplex theaters, "big box" stores and high rise apartments, are common modern land uses featuring large buildings surrounded by uninterrupted seas of asphalt or concrete parking.

Parking Spaces Required by Zoning

Research now shows that typical zoning regulations require more parking spaces than are actually utilized. For example, space utilization studies show that the common zoning standard of 4 parking spaces for every 1,000 square feet of gross floor area generates twice the number of parking spaces used. Most parking standards are based on peak hour traffic volumes or "peak hour, in peak season" demand, such as shopping during the weeks between Thanksgiving and Christmas. While the lots may be filled during this peak period, they are often greatly underutilized the rest of the year. As a case in point, from 1965 to 1981 shopping mall parking lots were designed for use at the 10th busiest hour of the year, using a standard of 6 spaces per 1,000-sq. ft. of retail space. In 1981 a study by the Council of Shopping Centers suggested shaving the standard to 4 spaces per 1,000-sq. ft. using the 20th busiest hour. Designing for the 20th busiest hour still leaves at least half of a shopping center's parking spaces vacant a minimum of 40 percent of the time. Similarly, large parking areas serving seasonal uses such as beaches, fairs, sporting events and festivals may be filled only a few days, remaining vacant the rest of the year.

Zoning traditionally requires a "minimum" number of parking spaces, allowing developers to provide more spaces, if they wish. It is this, "bigger is better" approach that has resulted in excess parking, particularly at "big box retail" sites where developers routinely build more parking spaces than required by zoning. Olympia, Washington surveys showed most land uses had more parking than required by zoning and a majority of these parking stalls were not used. Rather than relying on open-ended minimum ratios, communities should consider median parking ratios that truly reflect parking needs. If minimum ratios are kept, they should be used in conjunction with maximum ratios so developers cannot build as many spaces as they wish.

Land use officials are recognizing their regulations may generate more parking spaces than are commonly used and are interested in revising them accordingly or placing caps on the number of parking spaces permitted in certain areas. For example, Boston and Portland have set limits on the number of parking spaces that can be built in their downtowns. Boston has already reached its cap of 35,500 spaces. San Francisco limits parking to no more than 7 percent of the floor area of the building it serves.

Some states, including Connecticut, allow planning and zoning commissions to request payment in lieu of constructing off street parking spaces, where the required spaces are felt to be unnecessary or they cannot be built due to poor site conditions. Fees are based on costs of installing the usually required parking space. Collected revenue is deposited into a fund dedicated to parking or other transportation facilities.

Most zoning regulations contain "maximum lot coverage" provisions meant to regulate the size and bulk of development. Many of these regulations define coverage as, "the area occupied by buildings." A more comprehensive definition of coverage includes all impervious surfaces, such as rooftops, roads, parking areas, patios, sidewalks and compacted earth. All of these areas can contribute to increased storm water runoff and other potential adverse environmental impacts.

Another way to obtain fewer and smaller parking lots is to encourage or require shared or joint parking. Shared parking reduces the parking area for mixed uses with non-competing hours of operation such as residential units above a store or the use of church parking lots by schools. Joint parking refers to two or more multi-tenant buildings using the same parking facilities.

Parking Space Size Required by Zoning

Traditionally communities require that each parking space have minimum dimensions. A minimum stall of 10' by 20' or 9' by 18' is common. The City of Olympia, Washington has calculated that during a two-year rain event (2.8 inches in 24 hours), approximately 38 cubic feet of runoff would be generated by a 9' by 18.5' parking stall. Over the last decade the average size of cars sold in the United States has in declined. In recognition of the popularity of smaller cars, many communities are downsizing required parking space size. Los Angeles for example, permits 8'4" by 18' parking stalls. In a 1982 survey of 900 local governments, the American Planning Association found 33% of the respondents had downsized the minimum parking space size required by zoning. According to the APA survey, small car stall widths ranged from 7'6" to 8'6" with lengths ranging from 14' to 19.' The most commonly used small car dimension was 7'. 6" in width by 15' in length.

Adherence to older parking space standards results in land unnecessarily being paved. Smaller parking stalls mean less impervious coverage for the same number of parking spaces. In a 100-space parking lot, using a 112.5-sq. ft. stall, as opposed to the older 200-sq. ft. standard will reduce the lot's total paved area by 8,750 sq. ft. Palo Alto, California requires that lots with over 150 spaces have a minimum of 20% of the spaces designed for small cars.

Parking Lot Drives, Curb Cuts and Stall Arrangements

In addition to parking space standards, parking lot driveways, curb cuts and parking space arrangement influence the amount of paved area associated with parking lots. A general planning standard is to minimize the number and size driveways and curb cuts associated with parking lots. Lengths and widths of parking lot driveways should be kept as short and narrow as possible. Driveway widths of 9' for single lane drives and 18' for double lanes are often adequate. In most instances, one curb cut will adequately serve a parking lot. Where curb cut standards are disregarded, parking areas and the street become one. Phoenix, Arizona stipulates that, with the exception of safety considerations, the location of driveway curb cuts for parking lots shall not cause the removal of existing mature landscaping.

There are four common angles used to design parking space arrangement, 90°, 60°, 45° and 30°. The angle used depends on the situation and the available space. 30° and 45° parking

are used when the parking area is narrow and reduced traffic aisle widths (13') are needed. However, both require a large amount of paved area per vehicle, approximately 252- sq. ft. per car. The 60° stall is commonly used due to the ease of entering and backing out of stalls and the relatively narrow (18') traffic aisle required. However the angle requires 217-sq. ft. gross area per car. The 90° parking uses only 171 -sq. ft. of pavement per vehicle, thus achieving the highest car capacity of the four different angles. Some planners feel the 90° stall is best used for all day parking as it presents some difficulty for entering stalls. However, most people are quite used to this arrangement as it is often used in retail areas.

NEMO Recommendations Regarding Parking Lot Size

- All parking areas, other than those associated with single family detached residential units, should require special permits and be subject to site plan review.

- To reduce the size of parking spaces, review existing zoning regulations pertaining to parking space size and compare them to national standards. For example, do your regulations reflect the trend to smaller sized cars and do they provide variations in space requirements for compact versus full size cars?

- Where necessary revise land use regulations to define "Maximum lot coverage," by all impervious surfaces, not just building size and bulk.

- To reduce parking lot size, conduct random utilization studies of existing parking lots to determine if required spaces are being utilized. Revise your regulations based on survey results.

- To provide fewer parking spaces, allow median or maximum, rather than "minimum" number of spaces required by zoning.

- To provide fewer spaces, ask for fees in lieu of required spaces in areas where the required spaces are not needed or because of site limitations, they cannot be built. Fees should be deposited in a fund dedicated to improving transit and parking facilities.

- To provide fewer spaces, allow reductions of parking requirements if developers provide transportation alternatives, such as ridesharing, transit pass subsidies and employee busing.

- To provide fewer and smaller lots, encourage the use of shared parking, especially in mixed-use areas.

- To reduce or avoid large impervious areas, require that parking in areas generating large individual or collective parking lots, such as central business districts, malls, universities, hospitals, theaters and sports arenas provide underground, 1st floor or muti-story garage parking.

- To reduce the adverse impacts of large impervious parking surfaces, revise local zoning regulations to encourage or require that parking lots have porous rather than impervious surfaces. Porous surfaces may be required for the entire lot or in certain areas such as the parking stalls, pedestrian walkways, landscaped areas and overflow parking. Porous surfaces such as crush stone, paver stone, grass and porous asphalt mixtures should be considered.
- Set limits on the number of permitted parking spaces in certain areas, such as downtowns. Encourage several smaller parking lots accommodating no more than 20 to 25 cars, rather than fewer, larger facilities.

- In areas served by mass transit, provide incentives for its use, while making surface parking difficult.

- Require grass or other porous parking surfaces at seasonal sites such as beaches, parks, stadiums and fairs.

- Where possible encourage the used of 90° angle parking as it is the arrangement that uses the least amount of pavement per vehicle.

- Minimize the number and size of parking lot curb cuts and driveways.

Parking Lot Design

After a community reviews its' plans and regulations regarding the location and size of parking lots, it should look at parking lot design. Planners have long suggested that sections of parking lots be landscaped to keep vehicles cool in summer, improve the lot's appearance and function and to break up the flow of storm water. Perimeter landscaping can screen the lot from public view, while interior landscaping can break up large expanses of asphalt, promote driver and pedestrian safety and help define different lot areas, such as long-term versus visitor parking.

In addition to their positive contributions to parking lot appearance and safety, landscaped areas can help moderate dust, wind, heat, noise, glare and air pollution. They can also abate water pollution by reducing the volume and velocity of runoff flowing over large paved areas. Landscaped areas can be sunk below grade and designed to serve as drainage or bio-retention filters to receive runoff from adjacent paved areas.

Some communities require landscaping in all parking lots while others require it in minimum sized lots, expressed either in total area or number of parking spaces. For example, a five or six car lot is a common minimum size for required landscaping.

Suggested minimum areas of parking lots to be landscaped range from 5 to 25% of the total paved area. A 1964 planning advisory service report entitled, "parking lot aesthetics" recommends a minimum of 10% of a parking lot's total area be landscaped. This percentage is the minimum standard used by most planners, engineers and landscape architects. Anything

less than 10% is felt to not provide enough area for effective landscaping.

Regulations should encourage the use of existing vegetation in both perimeter and interior landscaped areas. Preserving existing vegetation is an excellent way to minimize site disturbance and maintain existing drainage patterns. Austin, Texas requires that for development along county roads, at least forty percent of the site remain in an undisturbed, natural state and 100' vegetative buffers be maintained or provided. In some instances it may be necessary to supplement existing vegetation with additional plantings to effectively shade or screen the parking lot.

Definitions of landscaping found in zoning regulations vary tremendously. Some regulations include hard, man-made or artificial materials such as: fences, wood or masonry walls, fountains, pools, screens and sculpture. Other regulations limit the definition of landscaping to natural vegetation, including turf, shrubs, trees, flowers, hedges and earthen mounds or berms. However, most regulations permit combinations of materials. For example, sand, stone and decorative mulches are commonly permitted as groundcovers, while plants, hedges and vines are often planted next to wood or masonry walls.

Parking lot landscaped areas have often been used as snow dumps. Ideally, trucks should remove snow from the lot. Where this is not feasible, snow-piling sites should be provided in locations other than parking stalls, sidewalks and landscaped areas.

There are two parking lot areas where landscaping may be required, perimeter and interior spaces.

1. Perimeter Landscaped Areas

Parking lot perimeter landscaped areas include screens and buffers located: between the lot and street, between the lot and adjacent uses and, the entrance to the parking lot.

Perimeter landscaped areas rely on the height, width, type, and density of landscape materials to screen or separate parking from adjacent land uses. Screens such as berms, fences, walls, evergreen plantings and hedges, are commonly placed along the street front and side yards. Screens separating parking lots from residential uses might be 8 to 10 feet high to provide privacy to dwellings on the first and second floors. Vehicle heights vary, but common ranges are from 4 to 8 feet tall. Walls or plant materials meant to screen parked cars from the sidewalk or adjacent uses, should use vehicle height as a design standard. Screens separating parking lots from streets might be limited to heights of 2 Whatever landscape design is chosen, regulations should contain provisions requiring continuous maintenance.

Porous Parking Surfaces

Another feature to consider when designing parking lots, is the use of porous surface materials such as grass, crushed stone, porous asphalt and concrete mixtures and blocks or brick laid in sand. The porous surfaces can cover the entire lot, or certain areas, such as parking stalls. Porous surfaces should be designed to encourage the direct infiltration and cleansing of storm water, thus reducing the adverse environmental impacts of large impervious parking areas. The Town of West Hartford, Connecticut required the developer of a major regional shopping mall to install a large "overflow parking area," surfaced entirely of grass. The parking area surrounding Miami's Orange Bowl is also grassed. Both sites underlay the grass surface with sub-bases designed for infiltration and plastic grid systems to hold topsoil and grass and distribute vehicle weight.

As a minimum, communities should require that landscaped buffers and islands be designed as porous infiltration areas. Some communities require that pedestrian walkways be porous, while others require that everything other than the traffic lanes have pervious surfaces.

NEMO Recommendations Regarding Parking Lot Design

- The zoning regulation's "statement of intent" should describe why landscaping is required in parking areas. In addition to landscaping's role of improving lot appearance and safety, mention its' value regarding water quality protection and storm water management.

- Regulations lacking parking lot landscape standards should be revised to include them.
- Where feasible, porous parking surfaces should be used in place of impervious materials.

- Where feasible existing grades and vegetation should be retained and used for naturalistic landscaping of parking lots.

- Any paved parking areas should drain to on-site vegetative filter strips and any landscaped areas built above grade should have curb, berm or wall breaks to allow runoff inflow.

- Perimeter and interior landscaped areas should be designed as bio-retention filters or vegetated filter strips capable of cleansing and infiltrating storm water runoff. To be effective filters, the landscaped areas should be built below grade and planted with vegetation that is heat and salt tolerant and has filtration capabilities.

- Allow flexibility in landscape design. Buffer and screen width and height will vary based on adjacent uses and the landscape materials proposed to screen or buffer those uses from the parking lot.

- Require that a minimum percentage of the parking lot's landscaped area be devoted to interior landscaping.
- Adjacent parking lots should be separated with landscaped filter strips to break up large impervious areas and to filter runoff from these areas.
- Regularly sweep and vacuum impervious parking areas to remove pollutants.
- Where feasible, retrofit existing impervious parking lots with porous surfaces.

Contact Information
University of Connecticut, CES
Box 70, 1066 Saybrook Road
Haddam, CT 06438
Phone: (860) 345-4511
Email: nemo@canr.uconn.edu
Web Address: nemo.uconn.edu

University of Connecticut
COOPERATIVE EXTENSION SYSTEM

NEMO is an educational project of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land use Education And Research (CLEAR). For more information about CLEAR, visit www.clear.uconn.edu. The Connecticut Cooperative Extension System is an equal opportunity employer.

NEMO

NONPOINT EDUCATION
FOR MUNICIPAL OFFICIALS

TECHNICAL PAPER NUMBER 6

Driveways

By Jim Gibbons, *UConn Extension Land Use Educator, 1999*
Updated by Michael Dietz, CT NEMO Stormwater Specialist, 2006

Purpose

The purpose of this paper is to provide information on driveways, including methods to reduce their contribution to stormwater pollution. An engineer or contractor should be consulted if more detailed driveway installation specifications are desired. More specific information related to regulations and planning for commission members or town personnel can be found in Technical Paper #1 of this series.

Introduction

Driveways are vehicle access ways between a street and abutting property, and are sometimes used as emergency access ways. In low-density residential areas, driveways are often single lane paved areas connecting a carport, garage or off-street parking area to a street. In high-density residential, commercial and industrial areas, driveways lead to off-street parking or loading areas.

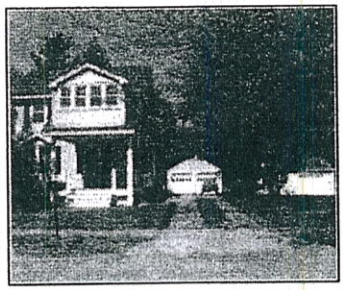
While often viewed as a necessary component of the automobile transport network, driveways contribute to the overall imperviousness of a watershed. As a significant component of a community's impervious surface coverage and a recognized generator of polluted runoff, communities should be concerned about the effect of impervious driveways on local waterways. The increase in impervious coverage associated with driveways can result in increased runoff during storm events, and less local groundwater recharge. The driveway essentially connects the impervious areas on individual lots to the local stormwater system.

Research shows that driveways are also a hot spot for the accumulation and conveyance of non-point source pollutants. In Wisconsin, driveways were found to be a significant source of phosphorus loads in stormwater (Bannerman, *et al.*, 1993). Driveways, as pollution generators, are strongly influenced by the emissions, leaks and deteriorating metal parts from the cars using them. In addition, driveways are used as work and play areas. Activities such as washing, repairing and maintaining vehicles and equipment often take place on the driveway. When used as the work area for changing the family car's oil or washing grass off the lawnmower, inevitable spills and deposits are stored on the driveway's surface and washed by the next rainfall to receiving roads, curbs and catch basins. When gutters and down spouts are directed to driveways, the volume, velocity and pollutant load of driveway runoff increases.

Driveway Design

Driveway design can range from the minimum needed for practical and safe use to a maximum assuring ease of driving and parking. Many communities, as part of their subdivision and zoning regulations, establish minimum driveway design requirements. If a proposed lot cannot be served by a driveway meeting adopted standards, it will not be approved. Most regulations address driveway location, grading, erosion control, drainage and construction details.

As a general rule, driveways should be designed to be as narrow, short and few as possible to reduce overall impervious coverage. The common driveway types are single slab, made of asphalt or concrete, and ribbon, made of two parallel strips of pavement with grass or stone in between. The single slab is more common as ribbon drives are deemed impractical where the driveway is long or curved.



Ribbon driveway

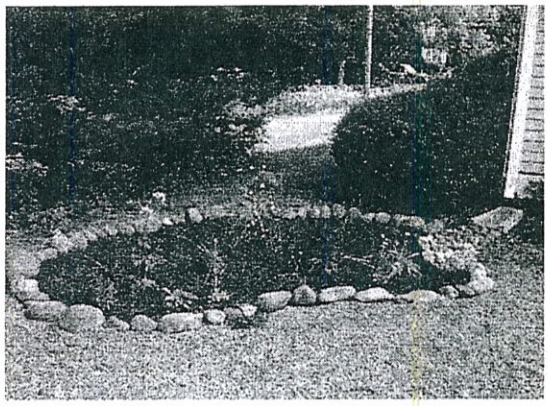
soil/grass or gravel, crushed stone, pervious asphalt and pervious concrete. The key to the use of pervious driveway surfaces is the installation of a sub-base specifically designed to promote infiltration. The companies that offer the alternative surfaces often have a technical specification for bedding materials and sub-base preparation. Crushed stone is a pervious alternative, but when used without a structure, it tends to migrate with car traffic and winter maintenance. There are some newer products on the market that can bind crushed stone, making it a more durable surface while still allowing for infiltration. Pervious asphalt is just a different mix, with a higher proportion of large aggregate than typical asphalt. Pervious concrete also has a different mix than traditional concrete, and the application technique is much different. All of these alternatives have been successfully been used in both warm and cold climates, although some may be more appropriate for certain sites.

If impervious driveway surfaces must be installed, they should be crowned and pitched to direct runoff flow to adjacent pervious areas such as grass, vegetated swales or filter strips. Roof runoff should not flow over driveways but be directed to grass, dry wells or gardens designed as rain gardens. Some infiltration could also be achieved by installing a pervious driveway surface where the driveway intersects the road.

Towns may also provide some regulation related to stormwater from driveways. For example, Andover, Connecticut stipulates that driveways be designed to prevent runoff from entering public rights-of-way by installing privately owned and maintained drainage diversion swales, retention areas, or dry wells. Before a certificate of occupancy is issued, a deed stipulation, approved by the Town Attorney, must be filed in the land records clearly establishing land owner responsibility to maintain the driveway related swale, retention facility or dry well.

NEMO Recommendations Regarding Driveways

- Do not allow roof gutters and downspouts to drain over impervious driveways.
- Use various driveway designs, including ribbon drives that contain less impervious surface than the more common full width, single slab, drive.
- Make single lane straight drives 8' or 9' wide and double lane drives to be 18', if regulations permit.
- Use pervious driveway surfaces to reduce runoff and pollution. Concrete paver blocks and grids, pervious asphalt or concrete, plastic grid structures with grass or crushed stone, and plain crushed stone are all viable options. When installing one of these alternatives, make sure that the contractor is aware of the design and installation differences, and has experience installing alternative materials.
- Where pervious driveway surfaces are used, insure that a proper sub-base is installed that is capable of infiltrating and cleansing stormwater.
- Where impervious driveway surfaces are installed, make sure that they are crowned and pitched to direct runoff to adjacent pervious areas.
- Where impervious driveway surfaces are installed, disrupt their connection to roads, curbs and catch basins with pervious materials in the area where the drive intersects the road.



Roof runoff should be directed to pervious vegetated areas, such as this rain garden.

References

Bannerman, R. T., Owens, D. W., Dodds, R. B., and Hornewer, N. J. 1993. Sources of pollutants in Wisconsin stormwater. *Water Science and Technology.* Vol. 28(3-5), pp. 241-259.

Contact Information
University of Connecticut, CES
Box 70, 1066 Saybrook Road
Haddam, CT 06438
Phone: (860) 345-4511
Email: nemo@canr.uconn.edu
Web Address: nemo.uconn.edu

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational project of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land use Education And Research (CLEAR). For more information about CLEAR, visit www.clear.uconn.edu. The Connecticut Cooperative Extension System is an equal opportunity employer.

NEMO

NONPOINT EDUCATION
FOR MUNICIPAL OFFICIALS

TECHNICAL PAPER NUMBER 7

Sidewalks

By Jim Gibbons, UConn Extension Land Use Educator, 1999

Introduction

Sidewalks are a common feature in most communities. In addition to providing a pedestrian network, sidewalks serve as meeting places for friends and neighbors; play areas for children, retail display areas and settings for special events. As sidewalk surfaces need to be stable, firm, smooth and slip resistant, they are often constructed of continuous swaths of impervious materials, such as asphalt or concrete. While their imperviousness can have adverse impacts on water resources, the fact that sidewalks are not used by large gas driven vehicles and often drain to landscaped areas, means they usually generate less contaminants than streets, parking lots and driveways.

Sidewalk Systems

If people are to choose walking over driving, the walking experience must be pleasant, safe and efficient. To this end, the sidewalk system should be structurally and visually continuous.

Sidewalks must flow together forming an unbroken coordinated network. The only instances where a break or gap in the sidewalk system is acceptable, is when the dead-end walk is scheduled to connect with a planned walk in the near future or the sidewalk serves a special land use area, such as a central business district.

The sidewalk system should present a continuous visual edge of building facades, trees, public spaces, lawns and open space. Where sidewalks cross streets, the continuity of the walk should be preserved by a change of the texture or color of the street pavement. In commercial areas, buildings often constitute one edge of the sidewalk while a landscaped border often forms the other edge.

Sidewalk Location

Many communities require all new developments be served with sidewalks, even where they will not connect to existing walks. As few communities have prepared comprehensive sidewalk plans, they do not know if the new sidewalks will ever join with others in a logical pattern.

Sidewalks should only be required where there are enough people to use them, where they link homes with schools, commercial centers, community facilities, jobs and mass transit stops or where they serve a well defined, high use area such as a downtown. In low-density residential areas, the walking distance to schools is often so great that school buses are used. There may be no need for sidewalks in these low-density areas. The road edge, particularly those designed as filter strips, can serve as a walkway.

Some communities only require sidewalks next to streets with traffic flows greater than 200 average daily trips. A report entitled, "Public Improvement Specifications," prepared by the Northeastern Connecticut Regional Planning Agency, recommends sidewalks be provided on one side of the street, only in areas where there is residential development of 3 or more dwelling units per acre, commercial uses, or public buildings within 1500 feet. Guilford, Connecticut may require sidewalks where they are deemed necessary for public safety and one of the following conditions exist: lots with an area of 10,000 sq. ft. or less, roads classified as collectors, (road extends to an existing road which has sidewalks), within 1,000 sq. ft. of a school, public facility, park or playground where pedestrian easements are provided, and cul-de-sac residential roads where children must walk to school bus stops.

Public sidewalks should always be placed within the public right-of-way while private sidewalks should be placed on private land. Some communities require that all sidewalks be located along private property lines or one foot from the right-of-way line. Placing sidewalks at the maximum practical distance from the curb provides pedestrians with: safety from street traffic, reduced conflict with trash and plowed snow stored in the border and protection from being splashed by passing vehicles.

While most sidewalks are located along front yards and streets, some are located within the lot, such as pedestrian walkways at shopping plazas and malls, while others are placed along the rear lot lines, often designed as multi-purpose trails.

Sidewalk Width

Many communities have one standard design for all sidewalks. In some communities sidewalk width depends upon road width. As is true with road width, sidewalk width should be in direct proportion to the projected volume of users, with attention given to those with special needs.

Anton Nelessen in his book, "Visions For A New American Dream," presents a sliding scale of sidewalk widths based on the number of people who might travel it walking side-by-side. Nelessen recommends a width of three feet for a single pedestrian 5'6" for two people walking side by side, 7'6" for three, 9'6" for four, 11'6" for five and 13' walks to be used by six people walking abreast.

DeChiara and Koppleman in their "Time Saver Standards for Site Planning," recommend a minimum sidewalk width of 4' with 6' preferred for moderate two-way traffic and handicapped accessibility. Walks should be uninterrupted by any grade changes, blending to a common level with building entrances, driveways, parking lots, curbs and other walks. Changes in grade from street to sidewalk and sidewalk to building entrance create the most problems for wheelchair users, so care should be taken to install curb ramps in these locations.

The "Americans with Disabilities Act," suggest 36" wide sidewalks to allow passage of one wheelchair and 60" for two wheelchairs. The minimum width for a person walking past a person in a wheelchair is 44."

In the Design Guide for Rural Roads," prepared by the Dutchess Land Conservancy, Inc., sidewalk width varies based on the size and use of the lot it abuts. For residential uses, the Conservancy recommends 3' sidewalks for 1-acre lots, 4' for half-acre development and 5' walks for homes on quarter acre sites. Sidewalk widths are broader in retail areas with the sidewalk extending from the edge of the street curb to the edge of the building. A minimum width of 6' is suggested for commercial areas with widths of 10' to 16' preferred to provide space for trees, lights, outside displays and benches.

Sidewalk Border Strips

Pedestrians feel safer on sidewalks that are separated from traffic by some kind of visual or physical barrier. A lane of parallel parking at the road's edge can create such a barrier. Landscaped borders separate sidewalks from curbs and street traffic. Borders of grass, trees, brick or paver stone can range from four to twenty five feet wide, depending on the street and sidewalk traffic. The heavier the traffic, the wider the strip. Border strips are commonly used to store garbage cans and trash waiting to be picked up. Borders are also used to store snow plowed and removed from the paved street.

In residential areas landscaped planting strips usually separate walks and road, while lawns, hedges or fences define the other edge. To reduce the adverse impacts of impervious sidewalk surfaces, the sidewalk should be graded to drain to border strips and adjacent lawns designed as filter strips capable of receiving, cleansing and infiltrating sidewalk runoff.

Sidewalk Length

Zoning regulations have a direct impact on the length of sidewalks associated with various land uses. Most zoning regulations contain front yard setback requirements. If, for instance, zoning required a 50' front yard setback for residential uses in 1-acre zones, the chances are very high that 50' sidewalks will connect front doors to the street.

Zoning also establishes minimum lot sizes that also influence sidewalk length. For example, a typical 1-acre lot measures 200' by 200'. If sidewalks are required, they will be at least 200' long. If 4' wide sidewalks are constructed in the front yard and along the l-acre lot described above, 1000 square feet of impervious surface will be generated.

Sidewalk Surface Materials

The sidewalk surface should be stable and relatively smooth yet not slippery, so as to provide proper traction. Sidewalks should have grades of 3 percent or less; however grades of up to 5 percent are permissible in short lengths. Maximum grade standards are particularly important in areas subject to icing. Minimum lateral drainage grades of ⅛ to ¼ inch per foot are suggested where impervious surface materials are used.

Many sidewalks are constructed of concrete which has the ability of being brushed, textured, scored, inlaid or stamped to provide textural variety and improve pedestrian safety. The Town of Durham, Connecticut stipulates that when sidewalks are installed in front of commercial properties, places of assembly or other places, which generate large amounts of pedestrian traffic, they shall be constructed of 5" cement concrete slab on an 8" gravel base. In all other areas requiring sidewalks, they shall be constructed of 2 ½" bituminous concrete on an 8" gravel base.

Many planners feel a varied sidewalk texture enhances the walking experience, as pedestrians tend to pay attention to the ground in front of them. Many sidewalks are blacktop or macadam, a material that not only repels water but also generally offers little textural variety. Alternative sidewalk surfaces such as brick and paver stone offer a variety of shapes, sizes and colors and can be laid with spaces between the stone permitting storm water infiltration. Asphalt can be mixed with large aggregate, creating voids that increase the sidewalk's porosity. Concrete or plastic grids filled with crushed stone or topsoil and grass can also be used to construct porous sidewalks.

NEMO Recommendations Regarding Sidewalks

- Local land use regulations should require sidewalks only where they will connect to existing walks or in areas designated in the comprehensive sidewalk plan.

- The plan of conservation and development should include a comprehensive sidewalk plan showing areas served by existing sidewalks and areas where sidewalks will be needed.
- In most low density residential areas sidewalks are not needed. Where they are deemed necessary, use roadside bio-retention swales as sidewalks rather than impervious surfaced walks.
- Where sidewalks are required, construct them of porous materials.
- Where impervious sidewalks are deemed necessary, construct them on only one side of residential streets.
- Sidewalk width should vary based on the number of pedestrians projected to use it, as opposed to a "one design fits all occasions," approaches.
- For most low and medium density residential areas, sidewalks of only 3' or 4' width are usually adequate.
- Where impervious sidewalks are installed crown them and have them drain to adjacent lawns or planted boarder strips designed to accept and filter runoff from the walk.
- Review your zoning regulations for required minimum lot width and front yard setbacks as these provisions directly impact sidewalk lengths.
- In residential areas, use the lip of driveways as the front yard sidewalk rather than building two separate impervious areas.

Contact Information
University of Connecticut, CES
Box 70, 1066 Saybrook Road
Haddam, CT 06438
Phone: (860) 345-4511
Email: nemo@canr.uconn.edu
Web Address: nemo.uconn.edu

University of Connecticut
COOPERATIVE EXTENSION SYSTEM

NEMO is an educational project of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land use Education And Research (CLEAR). For more information about CLEAR, visit www.clear.uconn.edu. The Connecticut Cooperative Extension System is an equal opportunity employer.