3.0 The Need for Natural Resource Protection and Stormwater Management

3.1 Overview

As documented in Section 2.0, a variety of aquatic and terrestrial resources can be found within Georgia's 24-county coastal region. These valuable natural resources provide habitat, food and shelter for many important resident and migratory organisms and contribute greatly to the region's natural beauty, economic well-being and quality of life. They have also, at least in part, contributed to the significant population growth that has occurred within the region over the last four decades.

Between 1970 and 2000, the number of people living in Bryan, Bulloch, Camden, Chatham, Effingham, Glynn, Liberty, Long, McIntosh and Screven Counties (Figure 3.1) increased by nearly 62 percent (CQGRD, 2006). This population growth has continued over the last eight years and is not expected to stop anytime soon. Recent population projections (Table 3.1) have forecasted that the population of this 10-county study area will increase by an additional 32 percent by 2015 and an additional 51 percent by 2030 (CQGRD, 2006).

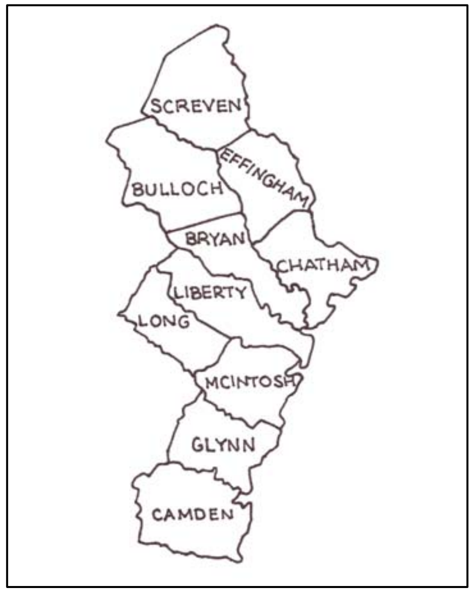

Figure 3.1: 10-County Population Study Area
(Source: Center for Watershed Protection)

Although the 10-county study area that was the focus of this particular population study is not synonymous with either the Coastal Nonpoint Source Management Area or Area of Special Interest (i.e., Bryan, Camden, Chatham, Effingham, Glynn, Liberty, Long and McIntosh Counties are part of the Coastal Nonpoint Source Management Area, Bulloch County is part of the Area of Special Interest and Screven County is not part of either the Coastal Nonpoint Source Management Area or Area of Special Interest), similar population growth can be expected to occur within these areas over the next two decades. This population growth will undoubtedly cause additional land development to occur throughout the 24-county coastal region.

Table 3.1: Projected Population Growth in the 10-County Population Study Area (Source: CQGRD, 2006)

County	Projected Population					
	2000	2010	2015	2020	2025	2030
Bryan	23,417	35,203	38,815	41,746	44,134	45,986
Bulloch	55,983	68,618	72,388	75,507	79,475	82,111
Camden	43,664	58,251	62,257	65,453	68,382	70,997
Chatham	232,048	262,138	275,057	286,869	297,352	307,472
Effingham	37,535	54,478	66,469	71,685	76,043	79,935
Glynn	67,568	81,368	87,118	92,121	96,581	100,483
Liberty	61,610	75,656	79,698	82,856	86,014	89,163
Long	10,304	15,537	17,705	19,568	21,163	22,607
McIntosh	10,847	14,262	15,751	16,939	17,918	18,626
Screven	15,375	20,058	22,070	23,872	25,398	26,779
Total	558,351	685,569	737,328	776,616	812,460	844,159

Although the land development process can help fuel economic growth, it can also have a wide range of unintended negative impacts on coastal Georgia's terrestrial and aquatic resources, as documented below. Without an effort to control and minimize these impacts, the anticipated population growth and associated land development activities have the potential to significantly impair the natural resources that contribute so greatly to the region's natural beauty, economic well-being and quality of life that, at least in part, make it such a desirable place to live.

3.2 Direct Impacts of Land Development

The land development process significantly alters the landscape by converting it from a natural state to a developed condition. During this process, clearing and grading are used to remove trees, shrubs and other vegetation, while cutting and filling are used to fill in natural drainage features and depressional areas to create clear and level building sites (Figure 3.2). These land disturbing activities can have direct negative impacts on both terrestrial and aquatic resources, often leading to the complete loss or destruction of these valuable resources.

Figure 3.2: Clear and Level Building Site
(Source: Atlanta Regional Commission, 2001)

Terrestrial resources are particularly vulnerable to the direct impacts of the land development process. For example, nearly 97 percent of all longleaf pine-wiregrass savannas (Section 2.3.9), which once covered approximately 90 million acres in the southeastern United States, have been lost or completely destroyed (WRD, 2005). Although fire suppression efforts have also contributed to the demise of this valuable terrestrial resource, many of these losses can be attributed to the land development process, which was used to convert these native forest communities into silvicultural, agricultural or urban land.

Wetlands are also particularly vulnerable to the direct impacts of the land development process. In fact, since 1780, more than 53 percent of all of the wetlands, both coastal and freshwater, that once existed in the contiguous U.S. have been lost to the direct impacts of the land development process (Wright et al., 2006, Dahl, 2006, Dahl, 2000, Dahl and Johnson, 2001, Dahl, 1990). In Chatham, Bryan, Liberty, McIntosh Counties alone, over 60,000 acres of forested wetlands have been converted to other land uses since 1974 (NARSAL, 2008). Although improved federal, state and local regulations have helped slow the rate of wetland loss over the last few decades, land development activities, such as filling, draining, dredging and impounding, continue to threaten the health of these and other important natural resources in coastal Georgia.

3.3 Indirect Impacts of Land Development

Any natural resources, and, in particular, any aquatic resources, that are not directly impacted by clearing, grading and other land disturbing activities, may still be negatively affected by the land development process. In converting the landscape from a natural state to a developed condition, the land development process fundamentally changes the characteristics of stormwater runoff. These changes, and the negative impacts that they can have on the aquatic resources of coastal Georgia, are described in more detail below.

3.3.1 Effects of Land Development on Stormwater Runoff

Additional information about the effects of the land development process on stormwater runoff, which includes changes in stormwater runoff quantity, quality and temperature, is provided below.

Effects of Land Development on Stormwater Quantity

Figure 3.3: Land Disturbing Activities Alter Site Hydrology
(Source: Center for Watershed Protection)

The effects of land development on stormwater quantity start the moment that the land development process begins. When a site is disturbed, its hydrology is fundamentally altered (Figure 3.3). Clearing removes the trees, shrubs and other vegetation that once reduced stormwater runoff volumes through the hydrologic processes of interception, evaporation and transpiration. Grading removes the native soils and natural depressional areas that once worked to retain rainfall and stormwater runoff on site. Compaction reduces the infiltration capacity of the underlying soils and increases the amount of rainfall that is converted to stormwater runoff. And, at the end of the process, the addition of roads, parking lots, rooftops and other impervious surfaces only works to further increase stormwater runoff volumes. In the end, much of the rainfall that was once retained on a development site, through the hydrologic processes of interception, evapotranspiration and infiltration, is now converted to stormwater runoff.

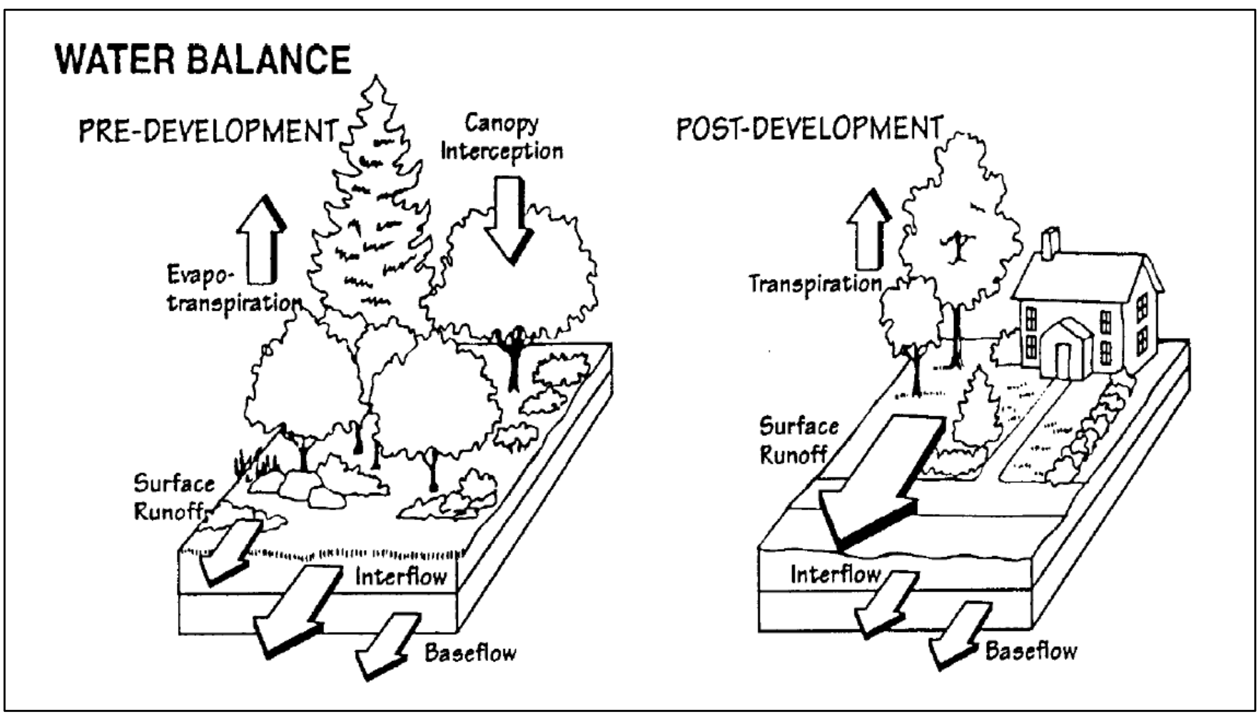

Figure 3.4: Changes in Site Hydrology Resulting from the Land Development Process
(Source: Schueler, 1987)

Previous studies (Pitt, 1994, Schueler, 1987) have shown that total stormwater runoff volumes can increase dramatically as a result of the land development process. Because more rainfall is converted to stormwater runoff on a development site, less rainfall becomes available to recharge groundwater aquifers and provide baseflow to aquatic resources, such as rivers, streams and wetlands, during dry weather (Figure 3.4).

The land development process not only increases stormwater runoff volumes and decreases groundwater recharge, but also dramatically increases the rate at which stormwater runoff is carried off the land. Impervious surfaces, such as roads, parking lots and rooftops, and compacted pervious surfaces, such as lawns, parks and athletic fields, increase stormwater runoff velocities and decrease the amount of time that it takes for stormwater runoff to reach both on-site and downstream aquatic resources. This effect is further exacerbated by drainage system improvements, such as curbs and gutters, storm drains and man-made ditches, that are designed to quickly convey stormwater runoff away from developed areas and into downstream aquatic resources. These increased stormwater runoff velocities lead to increased peak discharge rates, which can be two to five times higher on a developed site than on an undeveloped site (ARC, 2001).

Effects of Land Development on Stormwater Quality

The land development process not only affects stormwater quantity, but also stormwater quality. Pollutants, including sediment, trash and construction debris from cleared, graded and compacted development sites are picked up and washed into receiving streams and other aquatic resources during storm events. As the land development process proceeds, roads, parking lots, rooftops and other impervious surfaces replace the native soils and vegetation that once worked to reduce stormwater runoff volumes and pollutant loads through the processes of interception, evapotranspiration, filtration and infiltration. Pollutants that now accumulate on these impervious surfaces and on compacted pervious surfaces, such as lawns, parks and athletic fields, during dry weather are picked up and transported into receiving waters during rainfall events (Figure 3.5). In the end, greater amounts of stormwater pollution are generated and transported into on-site and downstream aquatic resources as a result of the land development process.

Figure 3.5: Pollutants that Accumulate on Impervious Surfaces are Transported Downstream During Storm Events
(Source: Atlanta Regional Commission, 2001)

Stormwater pollutants come from a variety of diffuse and scattered sources, many of which are a direct or indirect result of the land development process. These nonpoint source pollutants, which are the leading source of water quality degradation in the state of Georgia (ARC, 2001), and a number of other states across the country, include:

- Sediment: The sediment found in stormwater runoff is typically a result of land disturbing activities, atmospheric deposition or surface or streambank erosion. Sediment particles can adsorb other stormwater pollutants, such as nutrients, metals, hydrocarbons and pesticides, and transport them into receiving streams, wetlands and other aquatic resources.

- Nutrients: The nutrients found in stormwater runoff, which include nitrogen and phosphorus, are typically a result of fertilizer and detergent use, pet and animal waste, leaves, grass clippings, sanitary sewer overflows, septic system discharges and atmospheric deposition.

- Bacteria: The bacteria and other pathogenic organisms found in stormwater runoff, whose concentrations routinely exceed public health standards for contact recreation, are typically a result of pet and animal waste, sanitary sewer overflows and septic system discharges.

- Organic Matter: The organic matter found in stormwater runoff is typically a result of leaves, grass clippings, pet and animal waste, sanitary sewer overflows and septic system discharges.

- Metals: The heavy metals, such as lead, zinc, copper and cadmium, found in stormwater runoff are typically a result of atmospheric deposition, vehicle wear and commercial, industrial and hazardous waste sites.

- Hydrocarbons: The hydrocarbons found in stormwater runoff are typically a result of vehicle wear, chemical spills, restaurant grease traps and the improper disposal of waste oil and grease.

- Pesticides: The insecticides, herbicides and other pesticides found in stormwater runoff are typically a result of lawn care and maintenance activities, chemical spills and atmospheric deposition.

- Trash and Debris: Considerable quantities of trash and debris typically accumulate on impervious surfaces and get picked up and transported into receiving waters by stormwater runoff. This trash and debris can accumulate in the stormwater conveyance system, causing clogging and other maintenance problems, and in downstream aquatic resources.

As documented below in Section 3.3.2, these pollutants can have a number of negative impacts on the aquatic resources of coastal Georgia, including reduced water quality, reduced dissolved oxygen levels, increased primary productivity (e.g., eutrophication, algal blooms), sediment contamination, shellfish bed contamination and closure, degradation of habitat and a general decline in wildlife abundance and diversity.

Effects of Land Development on Stormwater Temperature

The land development process not only affects stormwater quantity and quality, but also affects stormwater temperature. Impervious surfaces, such as rooftops, roads and parking lots, tend to retain heat when exposed to sunlight. As stormwater runoff moves over these impervious surfaces, it increases in temperature. As documented below in Section 3.3.2, when this "heated" stormwater runoff is conveyed into a river, stream, wetland or other aquatic resource, it can decrease the amount of dissolved oxygen contained within the water column, which reduces the amount of oxygen that is available to aquatic organisms.

3.3.2 Effects of Land Development on Aquatic Resources

The changes in stormwater runoff resulting from the land development process can have a wide range of negative impacts on coastal Georgia's valuable aquatic resources. Additional information about these impacts is provided below.

3.3.2.1 Effects of Land Development on Freshwater Resources

The indirect impacts that the land development process can have on the freshwater resources of coastal Georgia, which include rivers, streams and freshwater wetlands, are documented below.

Rivers and Streams

The changes in stormwater quantity, quality and temperature resulting from the land development process can have a number of negative impacts on coastal Georgia's freshwater rivers and streams. These impacts, which have been well documented by the Center for Watershed Protection (CWP, 2003), include:

- Increased Channel Forming Events: The increased stormwater runoff rates and volumes resulting from the land development process cause an increase in the frequency and duration of channel forming bankfull and near bankfull events (Figure 3.6). These channel forming events create streambank erosion and stream channel enlargement.

Figure 3.6: Bankfull Event
(Source: Atlanta Regional Commission, 2001)

- Increased Flooding: The increased stormwater runoff rates and volumes resulting from the land development process also cause an increase in the frequency, duration and severity of overbank and extreme flooding events (Figure 3.7). These flooding events can cause property damage and endanger public health and safety.

Figure 3.7: Overbank Flooding Event
(Source: Center for Watershed Protection)

- Decreased Baseflow: The increased stormwater runoff volumes resulting from the land development process reduce the amount of rainfall available to recharge shallow groundwater aquifers and feed freshwater rivers and streams during dry weather.

- Stream Channel Enlargement: Stream channels enlarge (Figure 3.8) in order to accommodate the increased peak discharges resulting from the land development process. A stream channel may become much wider and deeper in order to accommodate the increased stormwater runoff rates and volumes resulting from the land development process.

- Loss of Riparian Vegetation: As streambanks are gradually undercut, scoured and eroded away, the roots of trees and other plants that are found along the stream corridor may become exposed. Consequently, a significant amount of riparian vegetation may be undercut, uprooted and conveyed downstream during storm events (Figure 3.8).

Figure 3.8: Stream Channel Enlargement and Loss of Riparian Vegetation
(Source: Center for Watershed Protection)

- Degradation of Habitat: The increased stormwater runoff rates and volumes resulting from the land development process scour stream beds and wash away valuable aquatic habitat. The increased sediment loads that result from land disturbing activities, as well as from surface and streambank erosion, can also degrade aquatic habitat, filling in streambeds and destroying the important pool-riffle structure found in many undisturbed freshwater rivers and streams.

- Increased Temperatures: The increased stormwater runoff temperatures resulting from the land development process can raise the temperature of the water found within freshwater rivers and streams. Since some aquatic organisms can survive only within a specific temperature range (e.g., trout, stoneflies), increased river and stream temperatures can lead to an overall decline in wildlife abundance and diversity.

- Degradation of Water Quality: The increased stormwater pollutant loads resulting from the land development process reduce the overall water quality of freshwater rivers and streams. This water quality degradation negatively impacts many of the ecological functions that these important natural resources provide.

- Reduced Dissolved Oxygen Levels: The increased amounts of organic matter found in urban stormwater runoff, and the increased stormwater runoff temperatures that result from the land development process, reduce the amount of dissolved oxygen found in freshwater rivers and streams. If the amount of dissolved oxygen found in the water column gets low enough, fish kills (Figure 3.9) and the loss of other aquatic organisms can result. Low dissolved oxygen levels can also force the release of harmful pollutants such as metals, nutrients, hydrocarbons and pesticides that have accumulated within the sediments found at the bottom of freshwater rivers and streams.

Figure 3.9: Fish Kill of Atlantic Menhaden
(Source: Guadagnoli et al., 2005)

- Decline in Wildlife Abundance and Diversity: When the increased stormwater runoff rates, volumes and pollutant loads resulting from the land development process degrade habitat and water quality, the abundance and diversity of aquatic organisms found in freshwater rivers and streams may be significantly reduced. Sensitive "keystone" organisms that require high quality habitat may become stressed and be gradually replaced by organisms that are more tolerant of the degraded conditions.

- Reduced Recreational Value: The increased trash, debris and pollutant loads found in urban stormwater runoff can accumulate in freshwater rivers and streams and detract from their natural beauty and recreational value.

Freshwater Wetlands

The changes in stormwater quantity and quality resulting from the land development process can have a number of negative impacts on coastal Georgia's freshwater wetlands. These impacts, which have been well documented by the Center for Watershed Protection (Wright et al., 2006), include:

- Increased Ponding: The increased stormwater runoff rates and volumes resulting from the land development process can cause increased ponding within freshwater wetlands. This increased ponding can stress native wetland plant communities (Figure 3.10), particularly if the wetlands did not previously receive large inputs of stormwater runoff.

Figure 3.10: Increased Ponding in a Freshwater Wetland
(Source: Center for Watershed Protection)

- Increased Water Level Fluctuations: The increased stormwater runoff rates and volumes resulting from the land development process can cause increased water level fluctuations in freshwater wetlands. These increased water level fluctuations can stress native wetland plant communities and lead to a decline in plant and wildlife abundance and diversity.

Figure 3.11: Excessive Sediment Accumulation in a Freshwater Wetland
(Source: Center for Watershed Protection)

- Decreased Baseflow: The increased stormwater runoff volumes resulting from the land development process reduce the amount of rainfall available to recharge shallow groundwater aquifers and provide a steady supply of baseflow to freshwater wetlands.

- Degradation of Habitat: The increased ponding and water level fluctuations, and decreased baseflow, resulting from the land development process can stress native wetland plant communities and degrade the habitat value of freshwater wetlands. The increased sediment loads resulting from the land disturbing activities, as well as from surface and streambank erosion, can also degrade the habitat value of wetlands by filling them in (Figure 3.11).

- Degradation of Water Quality: The increased stormwater pollutant loads resulting from the land development process reduce the overall water quality of freshwater wetlands. This water quality degradation negatively impacts many of the ecological functions that these important natural resources provide.

- Increased Primary Productivity: The increased nutrient loads found in urban stormwater runoff unnaturally increases the primary productivity of freshwater wetlands, promoting algal growth and forcing the native wetland plant community to compete for available nutrients (Figure 3.12). The competition can stress native wetland plant communities and lead to an overall decline in plant and wildlife abundance and diversity.

Figure 3.12: Increased Productivity in a Freshwater Wetland
(Source: Center for Watershed Protection)

- Sediment Contamination: The metals, hydrocarbons and pesticides found in urban stormwater runoff can become attached to the surface of sediment particles and accumulate within freshwater wetlands. This accumulation can cause sediment contamination and expose aquatic and terrestrial organisms alike to the harmful effects of these pollutants.

Figure 3.13: Trash and Debris Reduce the Aesthetic Value of Freshwater Wetlands
(Source: Center for Watershed Protection)

- Decline in Wildlife Abundance and Diversity: When the increased stormwater runoff rates, volumes and pollutant loads resulting from the land development degrade habitat and water quality, the abundance and diversity of plants, animals and other organisms found in freshwater wetlands may be significantly reduced. In these situations, native wetland plant communities tend to be replaced by invasive species, and sensitive macroinvertibrate, amphibian, reptile and bird populations become stressed and gradually replaced by populations that are more tolerant of the degraded conditions. This can result in the local extinction of native aquatic and terrestrial organisms.

- Reduced Aesthetic Value: The increased trash, debris and pollutant loads found in urban stormwater runoff can accumulate in freshwater wetlands, detracting from their natural beauty and aesthetic value (Figure 3.13).

3.3.2.2 Effects of Land Development on Estuarine Resources

The indirect impacts that the land development process can have on Georgia's estuarine resources, which include tidal rivers, sounds, tidal creeks, coastal marshlands and tidal flats are documented below. Although these impacts are primarily a result of the increased pollutant loads contained in post-construction stormwater runoff, increased stormwater runoff rates and volumes can also have a number of negative impacts on the region's vital estuarine resources.

- <u>Increased Salinity Fluctuations</u>: The increased stormwater runoff rates and volumes resulting from the land development process cause increased salinity fluctuations within estuarine resources (Holland et al., 2004, Dustan, 2004, Lerberg et al., 2000). The increased salinity fluctuations can negatively affect the health of shrimp (Figure 3.14), crabs and other important aquatic organisms (Vernberg et al., 1996) and lead to an overall decline in wildlife abundance and diversity (Callaway and Zedler, 1998).

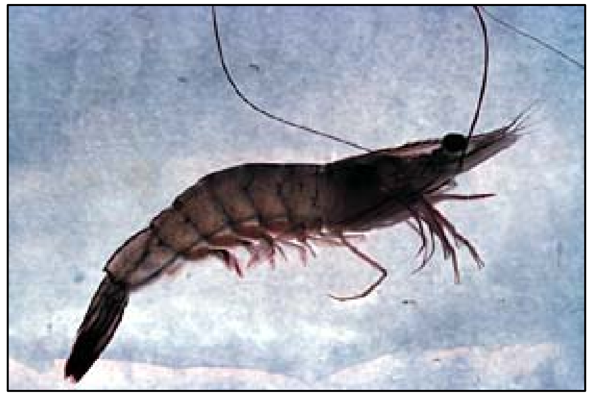

Figure 3.14: Salinity Fluctuations Can Negatively Affect the Health of Shrimp and Other Aquatic Organisms
(Source: National Oceanic and Atmospheric Administration)

- <u>Decreased Baseflow</u>: The increased stormwater runoff volumes resulting from the land development process tend to reduce the amount of rainfall available to recharge shallow groundwater aquifers and provide a steady supply of baseflow to estuarine resources, such as tidal creeks and coastal marshlands.

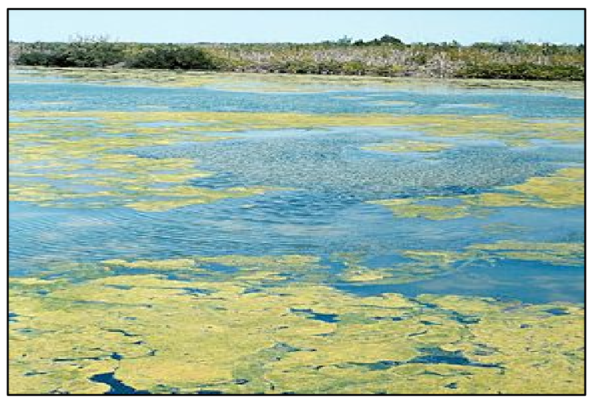

Figure 3.15: Algal Bloom
(Source: St. Johns River, FL Water Management District)

- <u>Degradation of Habitat</u>: The increased salinity fluctuations and decreased baseflow resulting from the land development process can degrade the overall habitat value of estuarine resources (Mallin and Lewitus, 2004). The increased sediment loads resulting from land development activities, as well as from surface and streambank erosion, can also degrade the value of the habitat provided by these important natural resources.

- <u>Degradation of Water Quality</u>: The increased stormwater pollutant loads resulting from the land development process reduce the overall water quality of estuarine resources. This water quality degradation negatively impacts many of the ecological functions that these important natural resources provide.

- <u>Increased Primary Productivity</u>: The increased nutrient loads found in urban stormwater runoff increases the primary productivity of estuarine resources, creating eutrophic conditions and promoting algal growth, which leads to the production of algal blooms (Mallin and Lewitus, 2004, Howarth et al., 2000) (Figure 3.15). Algal blooms prevent sunlight from penetrating the water column and can lead to the degradation or complete loss of submerged or partially-submerged aquatic vegetation (Howarth et al., 2000).

- Reduced Dissolved Oxygen Levels: The increased amounts of organic matter found in urban stormwater runoff, and the increased primary productivity resulting from the land development process, reduce the amount of dissolved oxygen found in estuarine resources (Dustan, 2004, Mallin et al., 2006). If the amount of dissolved oxygen found in the water column becomes low enough, hypoxic or anoxic conditions can result, which can lead to fish kills and the loss of other aquatic organisms. Low dissolved oxygen levels can also force the release of harmful pollutants, such as metals, nutrients, hydrocarbons and pesticides, that have accumulated within the sediments found at the bottom of estuarine resources.

- Shellfish Harvesting Area Contamination and Closure: The increased bacteria loads found in urban stormwater runoff can cause the contamination and closure of shellfish harvesting areas (Mallin and Lewitus, 2004, Mallin et al., 2001, Mallin et al., 2000), preventing the harvest and consumption of shellfish from these areas (Figure 3.16). The contamination of shellfish harvesting areas decreases the amount of commercial and recreational shellfishing that can occur in estuarine waters.

Figure 3.16: Shellfish Bed Contamination and Closure
(Source: Atlanta Regional Commission, 2001)

- Sediment Contamination: The metals, hydrocarbons and pesticides found in urban stormwater runoff can become attached to the surface of sediment particles and accumulate within estuarine resources. This accumulation can cause sediment contamination (Mallin and Lewitus, 2004, Van Dolah et al., 2004, Paul et al., 2002, Sanger et al., 1999a, Sanger et al., 1999b) and expose both aquatic and terrestrial organisms, including humans, to the harmful effects of these pollutants.

- Decline in Wildlife Abundance and Diversity: When the increased stormwater runoff rates, volumes and pollutant loads resulting from the land development process degrade habitat and water quality, the abundance and diversity of plants, animals and other organisms found in estuarine resources, such as tidal rivers, sounds, tidal creeks, coastal marshlands and tidal flats, may be significantly reduced (Bilkovic et al., 2006, Mallin and Lewitus, 2004).

- Reduced Recreational Value: The increased trash, debris and pollutant loads found in urban stormwater runoff can accumulate in estuarine resources and detract from their natural beauty and recreational value.

3.3.2.3 Effects of Land Development on Marine Resources

The primary indirect impact that the land development process can have upon Georgia's marine resources, which include near coastal waters and beaches, is beach contamination (Figure 3.17). The bacteria and other pathogenic organisms found in urban stormwater runoff, whose concentrations routinely exceed public health standards for contact recreation, pose significant threats to public health and safety. Contact with waters that have high levels of bacteria and other pathogenic organisms can cause a number of illnesses, including respiratory and gastrointestinal illnesses and infections (Mallin, 2006, Haile et al., 1999). Because of the threat to public health and safety, the contamination of near coastal waters in coastal Georgia can, and often does, lead to the issuance of beach advisories (NRDC, 2006).

Figure 3.17: Beach Contamination
(Source: Elizabeth Cheney)

3.3.2.4 Effects of Land Development on Groundwater Resources

The indirect impacts that the land development process can have on the groundwater resources of coastal Georgia, which include groundwater aquifers, are primarily a result of the changes in stormwater quantity that result from the process. These impacts include:

- Decreased Groundwater Recharge: The increased stormwater runoff volumes resulting from the land development process reduce the amount of rainfall available to recharge shallow groundwater aquifers, which normally provide a steady supply of baseflow to rivers, streams and other aquatic resources. Without this valuable baseflow, the hydrology of these vital aquatic resources may be altered, which can stress native wetland plant communities and lead to an overall decline in plant and wildlife abundance and diversity. Decreased groundwater recharge can also reduce the amount of rainfall available to recharge the deeper, confined aquifers that serve as the principal source of potable water for coastal Georgia.

  Figure 3.18 identifies the areas that are known to provide groundwater recharge to Georgia's confined groundwater aquifer systems. Although there are a number of these recharge areas located within the Coastal Nonpoint Source Management Area and Area of Special Interest, none of them provides recharge to the Floridan aquifer system, which supplies most of the region's potable water (Section 2.2.4.1). Instead, many of them provide groundwater recharge to the shallower Brunswick and unconfined surficial aquifer systems.

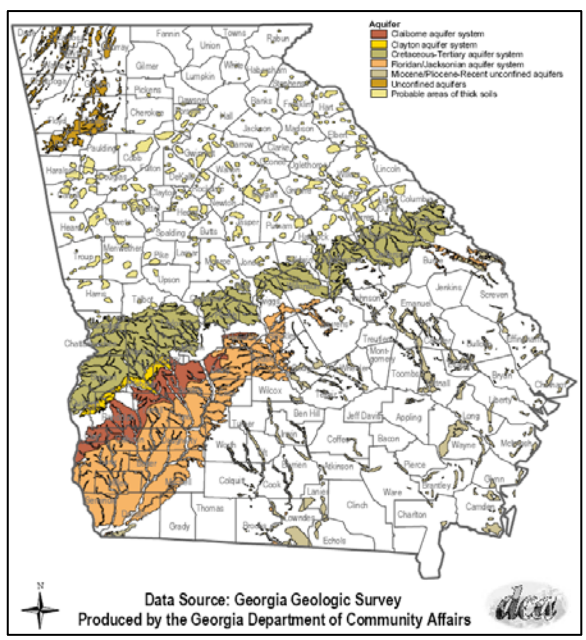

Figure 3.18: Known Confined Groundwater Aquifer Recharge Areas
(Source: Georgia Department of Community Affairs)

- Groundwater Drawdown: In recent years, population growth and the associated land development activities have increased water demand, which has increased the amount of water withdrawn from coastal

Georgia's groundwater aquifers. The increased withdrawal has caused an overall drawdown of these groundwater aquifers and has formed a cone of depression in the Upper Floridan aquifer beneath Savannah, Georgia. This cone of depression has reversed the gradient in the aquifer and has caused the lateral encroachment of seawater into the aquifer near Hilton Head Island, South Carolina and the vertical intrusion of seawater into the aquifer near Brunswick, Georgia (USGS, 2001).

3.4 Addressing the Impacts with Natural Resource Protection and Stormwater Management

As documented above, the land development process can have both direct and indirect impacts on coastal Georgia's terrestrial and aquatic resources. The remainder of this Coastal Stormwater Supplement (CSS) provides information about an integrated, green infrastructure-based approach to natural resource protection, stormwater management and site design that can be used to control and minimize these impacts. It provides Georgia's coastal communities with a wealth of information that they can use to ensure that the anticipated population growth and associated land development activities do not significantly impair the natural resources that contribute so greatly to the region's natural beauty, economic well-being and quality of life.

The integrated approach to natural resource protection, stormwater management and site design presented in this CSS involves:

- Identifying the valuable natural resources found on a development site prior to the start of any land disturbing activities
- Protecting these valuable natural resources from the direct impacts of the land development process through the use of better site planning techniques
- Limiting land disturbance and the amount of impervious and disturbed pervious cover created on development sites through the use of better site design techniques
- *Reducing* post-construction stormwater runoff rates and volumes, through the use of better site planning and design techniques and low impact development practices, to:
    - Help maintain pre-development site hydrology
    - Help prevent downstream water quality degradation
    - Help prevent downstream flooding and erosion
- *Managing* post-construction stormwater runoff rates, through the use of stormwater management practices, to:
    - Help prevent downstream water quality degradation
    - Help prevent downstream flooding and erosion

The remainder of this CSS provides information about implementing this approach, beginning with a comprehensive set of post-construction stormwater management and site planning and design criteria that can be applied to new development and redevelopment activities occurring within the Coastal Nonpoint Source Management Area and Area of Special Interest.

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