Stormwater•Aquifer Recharge Element

Data, Inventory & Analysis

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SUPPORT DOCUMENT

STORMWATER & AQUIFER RECHARGE ELEMENT
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STORMWATER ELEMENT SUPPORT DOCUMENT

1. INTRODUCTION

The primary purpose of the Stormwater Management and Aquifer Recharge Element is to review the City's stormwater management programs and policies, and to establish goals, objectives and policies to protect water quantity and water quality. The City has made a commitment to excellence in this area and is considered by many to be one of the most progressive public entities in the State relative to stormwater management.

The City of Orlando has approximately 120 lakes either partially or wholly within its boundaries. These lakes are the ultimate discharge point for approximately 90% of all stormwater runoff. Because these lakes are a vital amenity to the City residents, City officials have recognized the need to halt the water quality degradation process which urbanization has caused over time.

In earlier times, storm drainage was considered to have one function--to remove surface water as rapidly as possible, with little regard for water quality and land use impacts. The City has since broadened its stormwater management efforts into a multi-faceted program that considers not only flood control, but water quality enhancement, conservation and aquifer recharge. This has been accomplished by utilizing innovative approaches to design, construction, maintenance and funding of public stormwater management facilities, together with the strict regulation of private facilities.

In 1984, the City enacted a comprehensive set of stormwater regulations, the Orlando Urban Stormwater Management Manual (OUSWMM), which controlled the stormwater management for all new development. In 2003, the regulations were adopted into Chapter 7 of the City's Engineering Standards Manual (ESM) and OUSWMM regulations no longer exist.

In July 1989, the City implemented a stormwater utility, which bills all property owners based on the amount of runoff that is discharged from their property. The utility applies credits for properties that meet current ESM requirements and encourages retrofit for those who do not. The utility provides a guaranteed source of revenue that can only be spent for stormwater management purposes, thus assuring that the program may be perpetuated and enhanced.

The City has done considerable retrofitting of the stormwater management system since 1980, utilizing accepted Best Management Practices (BMP's) and pioneering the use of other innovative techniques for both flood control and water quality enhancement. Examples include aerators in lakes, screening devices at lake outfalls, sedimentation traps, exfiltration trenches, alum injection, wetlands, stormwater re-use, shoreline revegetation, filtration, lake drawdowns, aquatic weed control, and biological controls including triploid grass carp and alligator weed beetles. A large scale project utilizing a packed bed filter was previously completed. This project was funded through a Florida Department of Environmental Protection (FDEP) stormwater grant. The City also received research and development grants to monitor wetland treatment of stormwater at its Greenwood Urban Wetland and for the development of exfiltration systems data through a demonstration project. The City continues to pursue grant opportunities.

The City has upgraded its maintenance program through increased manpower and equipment levels, made possible by the creation of the Stormwater Utility. New facilities are designed for ease of maintenance and activities are being focused to minimize flooding and enhance water quality. In the area of flood control, lake level controls and interconnects are being installed to facilitate the creation of additional storage in advance of a severe storm. During normal conditions, excess water is transferred from one lake to another to help maintain lake levels in neighborhood environments. Emergency plans are in place in the event of a hurricane or severe storm, to help minimize flood damage.

Facilities are maintained at regular intervals. Trouble spots have been identified and receive increased preventive maintenance and/or immediate attention in the event of a significant rainfall. Street sweeping is done around lakes to help attenuate the pollutant loadings. The City has trained crews applying chemicals for aquatic weed control. It is the City's goal to reduce its dependence on chemicals and utilize natural processes as they are identified and refined.

The public's role in stormwater management is very important. Public education is practiced through flyers in the mail, brochures, and working with the public education system. Perhaps the most successful efforts are those accomplished through neighborhood meetings with lake resident groups. A dialog takes place between staff and the citizens where common problems are discussed and resolved with citizen participation in efforts such as "Lake Cleanup Days".

The City is very reliant on drainage wells for the ultimate disposal of stormwater. Many of these drainage wells are located in or adjacent to lakes. These wells provide lake level control by discharging overflow water into the aquifer at varying depths. A number of drainage wells receive runoff directly from City streets. The City recognizes the potential for groundwater contamination via the drainage wells and has completed a Drainage Well Monitoring Plan. This Plan was developed in conjunction with, and has been approved by, FDEP. In addition, the City is working with Orange County, FDEP, St. Johns River Water Management District (SJRWMD), and South Florida Water Management District (SFWMD) to identify drainage wells with a high risk for polluting the underlying groundwater. The City has committed funds to retrofit or replace those wells deemed a high risk.

Drainage wells have a potential for contaminating Orange County's groundwater and the potential for such contamination needs to be continually monitored. However, on the positive side, United States Geological Survey (USGS) studies have demonstrated that hundreds of millions of gallons of stormwater are recharging the underlying aquifers annually via drainage wells in Orange County. The City's goal is to maximize the benefits of flood control and aquifer recharge via drainage wells, but minimize the potential for aquifer contamination.

The City will continue to maintain a high-quality stormwater management program. The City's ESM provides reasonable assurance that new development will not adversely affect existing conditions, but pre-1984 construction has created many drainage systems which provide for no pollution abatement of stormwater runoff and there are still some occurrences of street and yard flooding, and even occasional structure flooding during very intense storms. Through its Stormwater Utility, the City will continue to correct the existing deficiencies. The approach will be multi-faceted with efforts aimed at both flood control and water quality enhancement. The City relies heavily on citizen input regarding the direction of its programs, be it system upgrading, retrofitting, or maintenance.

2. REGULATORY AND PROGRAM ASSESSMENT

2.A. FEDERAL LEGISLATION

Federal laws have been the primary force behind much of the state and local initiatives to protect the environment. Many laws have a direct impact on stormwater quantity and quality while others have an indirect impact.

The Water Pollution Control Act (Clean Water Act) was instrumental in the 1970's for implementing several programs to assess the environmental impacts from wastewater treatment (Section 201), and point and non-point sources (Section 208). The law also established objectives for water pollution abatement (Section 101) and standards for water quality of effluent discharge for sewage treatment plants (Section 301). Of primary importance was the establishment of the National Pollution Discharge Elimination System (NPDES) permit (Section 402) which requires permits for all discharges of polluted waters. In addition, it laid out dredge and fill and wetland responsibilities for the United States Environmental Protection Agency (EPA) and the Army Corps of Engineers (Section 404). The EPA developed the federal NPDES stormwater permitting program in two phases:

Phase I, promulgated in 1990, addresses the following sources:

- "Large" and "medium" municipal separate storm sewer systems (MS4's) located in incorporated places and counties with populations of 100,000 or more, and
- Eleven categories of industrial activity, one of which is large construction activity that disturbs five (5) or more acres of land.

Phase II, promulgated in 1999, addresses additional sources, including MS4's not regulated under Phase I, and small construction activity disturbing between one (1) and five (5) acres.

In October 2000, EPA authorized the FDEP to implement the NPDES stormwater permitting program in the State of Florida (in all areas except Indian Country lands). FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes. The NPDES stormwater program regulates point source discharges of stormwater into surface waters of the State of Florida from certain municipal, industrial and construction activities. As the NPDES stormwater permitting authority, FDEP is responsible for promulgating rules and issuing permits, managing and reviewing permit applications, and performing compliance and enforcement activities.

Section 303(d) of the Clean Water Act (CWA) requires states to submit lists of surface waters that do not meet applicable water quality standards (impaired waters) after implementation of technology-based effluent limitations, and establish Total Maximum Daily Loads (TMDL's) for these waters, on a prioritized schedule. TMDL's establish the maximum amount of a pollutant that a water body can assimilate without causing exceedances of water quality standards. As such, development of TMDL's is an important step toward restoring our waters to their designated uses. In order to achieve the water quality benefits intended by the CWA, it is critical that TMDL's, once developed, be implemented as soon as possible.

Implementation of TMDL's refers to any combination of regulatory, non-regulatory, or incentive-based actions that attain the necessary reduction in pollutant loading. Non-regulatory or incentive-based actions may include development and implementation of BMP's, pollution prevention activities, and habitat preservation or restoration. Regulatory actions may include issuance or revision of wastewater, stormwater, or environmental resource permits, to include permit conditions consistent with the TMDL. These permit conditions may be numeric effluent limitations or, for technology-based programs, requirements to use a combination of structural and non-structural BMP's needed to achieve the necessary pollutant load reduction.

The Safe Drinking Water Act, 1974 (as amended in 1986 and 1996) sets standards for drinking water quality. The law also sets out to protect potable water sources by implementing state wellhead protection programs and controlling underground injection of polluted waters. Additional protection of aquifers is accomplished through the "Sole Source Aquifer" designation.

The National Flood Insurance Program (NFIP), established with the passage of the National Flood Insurance Act of 1968, delimits areas of the 100 and 500 year floodplain. The program requires sound land use planning to minimize potential flood damage. The NFIP is a federal program enabling property owners in participating communities to purchase insurance as protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages.

The Solid Waste Disposal Act of 1965 was enacted to control the country's proliferating garbage problem and reduce the environmental impacts associated with landfills. This law was amended in 1976 by the Resource Conservation and Recovery Act and again in 1984 by the Hazardous and Solid Wastes Amendment Act. These acts broadened the original law's intent to control solid waste by including its impact on pollution control of surface and groundwater, through the restrictions placed upon leaking underground storage tanks (LUST) and hazardous waste disposal and air pollution.

The Comprehensive Environmental Response, Compensation and Liability Act of 1980, better known as the "Superfund Law," was enacted as an attempt to cleanup the country's legal and illegal landfills that threaten local water supplies. Two funds were created to clean the landfill site and properly dispose of the hazardous wastes. These were the Hazardous Substance Response Fund and the Post-Closure Response Fund.

The National Environmental Policy Act (NEPA) of 1970 requires a comprehensive environmental review of any project that receives federal financing. This law has little impact at the local level; however, it may apply in Orlando due to federal participation in the I-4 expansion, the commuter rail transit project, and the ongoing expansions of the Orlando International Airport.

Other federal laws that have an indirect effect on stormwater drainage are the Toxic Substance Control Act of 1976 and the Insecticide, Fungicide, and Rodenticide Act of 1972.

2.B. STATE LEGISLATION

<u>Florida Statutes</u>

The primary laws that regulate or impact drainage in Florida are contained in Chapters 163, 298, 373, 380, 387, and 403 of the Florida Statutes. Many are direct responses to the federal laws outlined in the previous section.

Chapter 163, Intergovernmental Programs; Local Government Comprehensive Planning Act requires each local government to adopt a comprehensive plan. This plan must contain required elements, studies, and surveys. A stormwater management and natural aquifer recharge element is one of the required elements.

Chapter 298, the Drainage and Water Control Act is the enabling legislation for the creation of the Water Management Districts (WMD's). The WMD's duties and powers are discussed below under the Florida Administrative Code section.

Chapter 373, the Florida Water Resources Act is an important piece of legislation. This act provides for the conservation, protection, and management of State waters. It provides the legislation for the creation of the FDEP, the WMD's, and pertinent county and municipal programs. In addition, Section 373.451, F.S. established the Surface Water Improvement and Management Act (SWIM). This legislation is involved in correcting surface water pollution problems. In addition it contains the State Water Resource Plan, provides for the Permitting of Consumptive Uses of Water, the Regulation of Wells, and the Management and Storage of Surface Waters.

Chapter 380, the Land and Water Management Act was enacted to establish land and water management policies, to guide and coordinate local decisions relating to growth and development. The law sets up areas of critical State concern, sets the policies and procedures for Developments of Regional Impacts (DRI's), the Florida Quality Developments Program, and the appeal procedure through the Florida Land and Water Adjudicatory Commission.

Chapter 387, the Pollution of Water Act restricts the disposal of surface water or sewage into underground waters of the State, as well as disposal of any deleterious substance into lakes, rivers, streams or ditches. The Act requires permits for disposal into underground waters and provides for penalties for non-compliance. Septic tanks are included under this Act.

Chapter 403, the Environmental Control Act is another important statute that has direct impact on stormwater management. Parts of this Act set water quality standards and policies for Pollution Control, Resource Recovery and Management, Environmental Regulation, Drinking Water, and Permitting Activities in Wetlands.

Florida Administrative Code

The Florida Administrative Codes (F.A.C.) are the implementing legislation to the Florida Statutes. These rules and regulations guide the local governments and private entities through the development process.

Chapter 9 contains the rules and regulations of the Department of Community Affairs (DCA). Of specific interest is Section 9J-2, which sets the rules and criteria for DRI's, and 9J-5, which sets the criteria for the local comprehensive plan review.

Chapter 10-D enables the county health departments to regulate septic tanks and private wells.

Chapter 62 is the most important of the F.A.C. as it relates to drainage and aquifer recharge. This chapter provides the rules and regulations of the FDEP and the WMD's. It gives the FDEP the power to invoke building moratoriums if wastewater plants are not operating efficiently. The legislation requires permits for stormwater management systems and for dredge and fill activities in any waters of the State, including wetlands. Section 62-302 sets surface water quality standards. Section 62-520 sets groundwater quality standards. Other sections of Chapter 62 require septic tank permits; regulate wastewater treatment permitting and monitoring; require permits for dredge, fill and stormwater; regulate water wells and underground injection control; and regulate hazardous waste.

Section 62-40 is the rule relating to the State Water Policy and the administration of the WMD's. The main duties of the WMD's are to approve stormwater management systems, issue consumptive use permits and to give technical assistance. Wetland jurisdictional claims are also a part of their duties in approving stormwater management plans. WMD boundaries are based on drainage basins. Orlando is located within two basins and therefore, depending on the location within the City, either the St. Johns River WMD or the South Florida WMD rules apply. Each District's rules are contained in Section 62-40 C and E, respectively. These rules contain the criteria by which the Districts regulate drainage in their basins.

2.C. OTHER GOVERNEMENT AGENCIES

Several other governmental agencies play a role in local stormwater management. The Florida Game and Freshwater Fish Commission is in charge of aquatic weed control. The East Central Florida Regional Planning Council (ECFRPC) is responsible for administering the 208 water quality programs, and acting as the lead review agency for DRI's. The Florida Department of Transportation (FDOT) requires drainage connection permits and standards for projects that connect drainage into FDOT rights-of-way.

Potentiometric Monitoring of the Floridan Aquifer. The USGS has a continuing program to monitor the potentiometric surface of the Floridan and surficial aquifers (ground water table), which has recently been delegated to the WMD's. This data is useful in determining the effects of rainfall and drought to water consumption. The Orlando Utilities Commission (OUC) monitors potable water wells for potentiometric surface levels, and drawdowns from pumping.

2.D. LOCAL REGULATIONS

Orange County

Because of the non-jurisdictional nature of natural resources, some of Orange County's ordinances impact the City in relation to stormwater. Chapter 15 of the Orange County Code of Ordinances created the County's Environmental Protection Commission. This Commission is responsible for protection of the environmental quality for air, water and land in the County. The County's Roads and Drainage Division has a Drainage Section whose primary responsibilities include the design, construction, maintenance and operation of stormwater control facilities. The County's stormwater management system consists of pump stations, open channels, canals, closed pipe systems, control structures, drainage wells, retention/detention ponds and drainage ditches.

The County maintains the primary control system, which consists of control structures, pumping stations, large canals and drainwells. This primary control system is not exclusive to the unincorporated areas of Orange County. It travels through several municipalities, including the City of Orlando. Orange County provides maintenance for the entire primary control system, regardless of the jurisdiction it is in.

City of Orlando

Growth Management Plan (GMP). The GMP is the policy document that gives the overall direction to the Land Development Code (LDC) and the ESM. The GMP addresses stormwater management in several elements. It provides policies to guide development within wetlands and floodplains, to control sediment and erosion, and to protect drinking water supplies. The Goals, Objectives and Policies of the Stormwater and Aquifer Recharge Element have been and will continue to be amended to ensure consistency with the LDC and ESM.

City Code, Part II.

Chapter 5: Code Enforcement Board. The Code Enforcement Board enforces City Codes pertaining to solid waste (Ch. 28), sewers (Ch. 30), minimum standards (Ch. 30A), stormwater utility (Ch. 31), and lakes (Ch. 35).

Chapter 28: Solid Waste. This Chapter contains several references for control of trash, weeds, and other debris. It also provides mechanisms for the City to enforce maintenance of private property, including stormwater facilities.

Chapter 30: Sewer Use and Rates. The primary purpose of this Chapter is to comply with the Clean Water Act. Its objectives are to prevent the introduction of pollutants that could contaminate surface or ground waters; to regulate private wastewater disposal systems; and to meet the NPDES permit requirements. The Chapter requires an industrial wastewater discharge permit, sludge management plans, and spill containment plans. In addition, it prohibits or limits the type of pollution and the connection of storm drainage to the sewer system, or the sewer system to the storm drainage system.

Chapter 31: Storm Water Utility. The purpose of this Chapter is to provide effective management and financing of stormwater systems; provide a mechanism for mitigating the damaging effects of uncontrolled and unplanned stormwater runoff; improve the public health, safety, and welfare; authorize the establishment and implementation of a master plan for storm drainage; establish reasonable stormwater service charges; and to encourage and facilitate urban water resource management technology. It also provides for inspection of private facilities, requires the stormwater design to include any off-site drainage and defines and prohibits the discharge of pollutants to lakes and stormwater systems.

Chapters 58 through 68: Land Development Code (LDC). These chapters implements the City's GMP. Reference to stormwater management and drainage can be found throughout the LDC. Various sections of the LDC are concerned with environmental protection and contain the most pertinent regulations. These involve floodplains, groundwater recharge, stormwater management, and surface water bodies and wetlands. Other parts require permits for development affecting floodplains and water bodies, and provide a process to review development for stormwater impacts.

<u>Orlando Urban Stormwater Management Manual (OUSWMM).</u> OUSWMM was the master drainage plan for the City of Orlando. The City Council adopted OUSWMM by resolution in 1984. The OUSWWM was divided into three parts.

1. The Inventory and Water Quality Analysis volume was a series of detailed maps and charts that showed the location, pipe size, and outfall by sub-basin throughout the City. Water quality data was graphically displayed for all lakes within the City.

2. Volume I contained the background information, specifically as it applied to Orlando including the purpose, objectives, and problems to be encountered. Information necessary to understand drainage includes rainfall and runoff characteristics of the area: distribution, intensity, and frequency of rainfall; pollutant loading; runoff design factors; and intensity-duration curves. Other necessary information includes metropolitan stormwater characteristics: geology; aquifer levels; soils; recharge areas; vegetation and land use; topography; and basin descriptions.

3. Volume II set procedures and minimum criteria for designing the stormwater system for new developments. This included submittal procedures and definition of the City-wide stormwater management system. The Hydrology of System Facilities section defined the hydrologic requirements for stormwater management systems that were intended to

provide guidelines to establish design storm conditions including, Level of Service (LOS). The Hydraulic Design Criteria section gave requirements for designing roadway drainage, storm sewer, culvert, open channel, outfall weir, bleeder, and filter designs. The Stormwater Pollution Abatement Design Criteria section was divided into four areas: Retention, Detention, Water Quality Monitoring, and Natural Depressed Areas. All projects were required to be designed to meet State water quality standards per Chapter 62.302, F.A.C. All projects were required to provide for pollution abatement using a two pond system. The Erosion and Sediment Control section required an erosion control plan with submittal of the final engineering plans. It required protection from cleared land and stockpiled material and required temporary and permanent seeding.

Engineering Standards Manual (ESM). In order to reduce confusion and duplication of regulatory requirements, in 2003 the City adopted a replacement to OUSWMM procedures and minimum criteria for designing stormwater systems, called the Engineering Standards Manual (ESM). The ESM sets forth engineering, design, development and material standards that align with more generally accepted standards found in St. Johns River Water Management District's (SJRWMD's) "Applicants Handbook" and South Florida Water Management District's (SFWMD'S) "Permit Information Manual". The Water Management District standards are referenced as minimum acceptable standards for environmental systems. What remains within the ESM are exceptions to FDOT, SJRWMD or SFWMD specifications or standards, not covered in those documents.

While the OUSWMM Inventory and Water Quality Analysis, together with Volume I of OUSWMM still exist, Volume II of OUSWMM has been incorporated into Chapter 7 of the City's Engineering Standards Manual. Level of Service for providing stormwater facilities was based on a reference to OUSWMM. However, with the switch from OUSWMM to the ESM, a "pre- and post-OUSWMM" level of service standard is confusing. Therefore, the LOS was changed to reflect the date that OUSWMM was adopted: 1984. Any facilities built prior to 1984 require a different level of service standard because they were built without stormwater management regulation. All facilities built after 1984 were required to meet OUSWMM and after 2003, the ESM. The City now references the standards as "pre-1984" or "post-1984".

Lake Enhancement Program. This is a multifaceted program to provide pollution control for runoff entering City lakes. End of pipe screening at stormwater outfalls is being phased out and replaced with high capacity inlet filters which have higher capture efficiency and are readily accessible for maintenance. Pollution control devices such as nutrient separating baffle boxes are also being installed at multiple sites in Orlando to capture sediments and gross solids. Source control includes an active illicit discharge program which enforces the City's ordinance prohibiting the discharge of any pollutant into the stormwater system. Public education programs to prevent pollution through education are administered by a Public Awareness Specialist position, which is dedicated to stormwater programs. Other lake enhancement programs include managing lakes to encourage the growth of native aquatic plants and the aggressive treatment of exotic species.

Drainage Well Enhancement Program. The impact to groundwater pollution from high risk drainwells is being studied to assess possible corrective sources. The program is designed to inventory all drainwells and to assess water quality of selected drainwells. Remedial measures are undertaken to address any pollution hazards.

Drainage Well Repair and Rehabilitation Program. Drainage wells are continuously inspected and repaired or rehabilitated, as necessary, to maximize their flood control capacities.

Street Sweeping Program. The City regularly sweeps streets to reduce sediment and trash loads into storm drains and lakes.

3. SURFACE WATER

3.A. RUNOFF

Surface runoff is the direct result of rainfall and is dependent upon the intensity, duration, and frequency of the storm event. Intensity is the amount (depth of rainfall measured in inches) that falls over a specified time or duration. The probability of the occurrence of a storm of a particular intensity and duration is called the frequency of the storm event and can be described as the 1, 5, 10, or 100 year storm. Figure S-1 shows the depth of rainfall for several storm frequency events at given storm durations. These figures are for rainfalls occurring at a single point and assume a uniform rainfall over the entire basin. This assumption holds because of the relatively small drainage basins in the Orlando area.

FIGURE S-1: DEPTH OF RAINFALL FOR LIKELY STORM EVENT FREQUENCIES, ACROSS VARIOUS DURATIONS

Frequency	30 min.	1 Hour	2 Hour	3 Hour	6 Hour	12 Hour	24 Hour
1 Year	1.50”	1.90”	2.30”	2.50”	2.80”	3.30”	3.80”
2 Year	1.75”	2.20”	2.70”	2.95”	3.35”	4.20”	4.70”
5 Year	2.10”	2.70”	3.20”	3.65”	4.30”	5.20”	6.25”
10 Year	2.45”	3.00”	3.75”	4.20”	5.20”	6.25”	7.48”
25 Year	2.80”	3.40”	4.25”	4.80”	5.95”	7.25”	8.60”
50 Year	3.00”	3.80”	4.70”	5.25”	6.60”	8.10”	8.95”
100 Year	3.20”	4.10”	5.10”	5.80”	7.30”	9.60”	10.40”

Source: City of Orlando, 1984.

Not all rainfall becomes surface runoff. The formation of runoff is a process that is affected by factors such as topography, soil, and land cover. Topography describes the slope, basin size and configuration, and depressional storage. Slope and basin factors will affect the velocity and time of accumulation of runoff. Depressional storage must be filled before excess rainfall will sheet flow into rivers, lakes and storm sewers as runoff. Soil affects runoff by determining the amount of rainfall that will infiltrate into the soil. Soils with low infiltration rates or that are highly compacted will not accept rainfall and will result in larger amounts of runoff. Soil moisture is also important in determining runoff. Soils that are saturated will not accept additional rainfall and runoff will occur sooner. High water tables are common in the Orlando area, and are a primary constraint to development. Land cover affects the amount of water that can infiltrate into the ground. Natural vegetation has less impervious surface than developed urban lands. Impervious surfaces such as parking lots and roofs contribute almost 100% of their intercepted rainfall as runoff. The Conservation Element contains figures showing Orlando's topography and soil associations.

The amount of runoff can be calculated for individual storm events by knowing the drainage basin area, the intensity and duration of the storm, topographic factors that affect time of concentration, and land use covers that affect infiltration or the runoff volume. Engineering formulas have been developed which relate these factors to approximate the volume of runoff that will result from development. The size of stormwater management systems can then be designed to handle the anticipated volume of runoff for selected storm frequencies and duration, generated by new development.

Problems with existing development can be analyzed by reversing this process. The capacity of existing canals and storm sewers can be calculated to ascertain the volume of water that can be safely conveyed. This volume can then be translated into a design storm. The ESM contains the necessary engineering standards and criteria to calculate runoff volumes and stormwater management system capacities.

3.B. SURFACE WATER MANAGEMENT SYSTEMS

Surface water management systems (SWMS) encompass a wide variety of functions. These functions can be grouped into 1) protection from land development, and 2) urban design and use considerations. Impacts from land development include flood protection, water quality protection, and erosion and sedimentation protection. Urban design and use considerations include visual amenities and multiple uses of drainage facilities to improve the livability of an area by providing recreation and open space opportunities. The goal of SWMS's is to make sure stormwater volumes, peak discharge rates and pollution loads leaving the site are no greater after development than before development.

Land development increases the peak runoff rate and the total runoff volume. This occurs because the amount of impervious surface is increased and the amount of depressional storage and infiltration is decreased. Natural ground cover and soil have the ability to store and detain specific volumes of rainfall. Increasing the impervious surface removes this natural storage and the rainfall drains much quicker and the volume, once stored in the soil and in depressions, is now contained in the runoff. The greatest impact will be felt by downstream property owners. Increased stream velocity and volume will cause erosion and flooding after smaller rain storms.

The loss of floodplain storage is another impact from development. As development increases in the floodplain, the area to store excess volumes of runoff is reduced. The results are higher flood elevations and faster flow velocities. A floodplain can be divided into the floodway and the floodway fringe. The floodway is essentially the channel of the watercourse. During periods of flooding, the floodway has the greatest depths and velocities. The floodway fringe is the area of inundation outside the floodway in which the excess stormwater runoff is stored. Floodplains also occur on lakes. The floodplain elevation will differ depending upon the storm event. As the volume of runoff increases, the flood elevations will also increase until the storage volume of the lake is consumed and flooding of roadways and/or property occurs.

Orlando and Orange County have felt the impacts from the loss of floodplain storage. Several downtown neighborhoods suffered severe flooding during the spring of 1987 when over 11" of rain fell in less than a month. Lakes Lucerne, Cherokee, Rabama and the Guernsey Park and College Park areas were especially affected. This situation was intensified because clogged drainwells added to the flooding problem. As a result of this flooding, roads remained flooded and were washed away. In 1987, homeowners sued Orange County for allowing development that caused flooding in their neighborhoods. Flood waters ruined their homes and incapacitated their septic tanks. Compensating storage is now required for any new development within the floodway fringe. This is accomplished by artificially lowering the groundwater table. Although this offsets the effects of natural storage loss, it usually is at the cost of wetland destruction, by direct removal and drainage of remaining wetlands. Nowhere in Orlando is the impact of development in the floodplain harder felt than in the Washington Shores and Carver Shores area. The entire area was built in a wetland without any compensating storage. The 100 year floodplain areas are shown in the Conservation Element. The City has completed the Lake Fran project to help address the flooding in these areas.

Increased maintenance costs of stormwater facilities are also a direct result of development. Development increases erosion by clearing of land and construction of ditches and canals for drainage. The increased erosion produces increases in sediment that fill existing drainage facilities. The increased sedimentation results in decreased capacity and blockages of the canals, ditches, lakes and piped facilities, requiring continual maintenance. The newly constructed drainage facilities require mowing and other maintenance.

Some stormwater systems will affect environmentally sensitive areas. Environmental losses are experienced through habitat loss from wetland destruction, overdrainage, and loss of aquifer recharge areas. Water quality of lakes, streams, wetlands, and aquifers are impacted through increased sedimentation and increased pollutant loads from street and parking lot runoff. Eutrophication is a natural process by which a water body changes to dry land. The normal time frame is in the order of tens of thousands of years for this to occur. However, the impacts from land development shorten this process to hundreds of years. Manifestations of "cultural" eutrophication include algal blooms, fish kills and noxious odors. The increase in impervious surfaces decreases the size of aquifer recharge areas that replenish the City's potable water source.

The development of stormwater facilities impacts more than the physical environment. The aesthetics of the development are affected through the use of urban design and the integration of the stormwater facility, to provide additional functions such as recreation, conservation and open space areas. Large developments in particular are better able to incorporate urban design into the project's overall design because of the large areas needed for stormwater facilities. These facilities are often large water bodies which can serve to enhance the development's overall appeal. However, locating facilities between buildings to offer "lakefront" views is not sufficient and the best designs provide enough room for passive use and natural features. This can be accomplished through the use of decreased slopes to make access easier, littoral zones to increase aesthetics and create wildlife habitat, and walkways and picnic areas to provide for passive recreation.

3.C. WATER QUALITY

Runoff in itself does not cause pollution of lakes, streams and aquifers. It is the water's ability to pick up and transport other substances that creates pollution. The type and amount of pollutants that contaminate stormwater depend on the source. Sources of pollutants are lawns, roadways and parking lots, effluent disposal, septic tanks, commercial and industrial discharges, landfills, illegal dumping, leaking underground storage tanks and spills.

Lawns contribute fertilizers, pesticides, sediment and organic matter such as leaves and grass clippings. The runoff will then travel down roadways picking up oil, grease, and heavy metals from automobiles. In the older sections of Orlando, it would then enter storm sewers and outfall directly into lakes, canals or drainwells. Commercial and industrial area contributions are from parking lots, residue from storage of chemicals, and residue and waste products of manufacturing, which drain into storm sewers.

Direct discharge of industrial and domestic wastes was once common to the area. As late as the 1960s, the City was discharging treated sewage through drainwells into the upper Floridan Aquifer. This has since stopped. The City of Orlando is permitted to surface discharge wastewater effluent into the Little Econlockhatchee River. The limit is 28 million gallons per day (MGD), but the City currently discharges only 6.8 MGD of effluent into the river. The majority of effluent is discharged by land applications consisting of filtration through he Orlando Easterly Wetlands, spray irrigation, and infiltration ponds.

Leaking underground storage tanks are primarily composed of underground gasoline tanks. They have the potential to seriously contaminate groundwater; therefore State law mandates the clean-up of these tanks. Spills from above-ground tanks can also cause problems. In July of 1987, liquid insecticide and dry fertilizer spilled over Interstate 4. At another time, a gasoline tanker spilled in the Downtown area, threatening to contaminate Orlando's Downtown lakes.

Septic tanks, both domestic and industrial, contribute to the pollution of surface waters. Septic tanks are often built in high water table areas, in floodplains, or left to deteriorate in the ground. Industrial septic tanks can handle the organic portions of the waste but these devices are not designed to break down the inorganic substances used in modern manufacturing. Drainage from legal and illegal landfills can also leach nutrients and hazardous wastes into the ground.

These pollutants increase in the natural eutrophication process by adding to the quantity og nutrients and sediments in surface waters. These in turn promote growth of algae, floating and submerged vegetation and the establishment of terrestrial plants upon newly made land. Hazardous waste can cause fish and plant kills. Over time, pollutants degrade the quality of lakes and streams to the point that their use for active and passive recreation is eliminated. Orlando's lakes are not used for potable water or industrial uses.

The natural environment has the ability to assimilate a certain amount of pollutants without long-term negative effects. This ability is called the carrying capacity of the system. Natural processes can reduce contaminant concentrations in surface water and groundwater, through dispersion and dilution of chemicals, precipitation, absorption and adsorption of suspended solids and heavy metals, and the natural die-off of bacteria.

Water, soil, bedrock and vegetation interact to reduce and incapacitate contaminants. Infiltration of contaminated runoff into the soil will filter sediments and adsorb nutrients and some heavy metals. Vegetation retards the overland flow and allows sediments to settle while permitting water to infiltrate into the soil, where plant roots can absorb the nutrients. The sedimentation process deposits nutrients and heavy metals into the muck layer of lakes, wetlands, and streams.

Once the process of cultural eutrophication begins, expensive long-term artificial maintenance programs must be administered. This can include a combination of periodic spraying with herbicides, flocculating agents (a method to remove particles from the water), aeration and mechanical removal of aquatic plants. The use of herbicides adds to the pollutants in the water system. Mechanical removal can stir up sediments, releasing nutrient and heavy metals into the water column. This also lowers the dissolved oxygen levels and increases the turbidity (relative cloudiness) of the water.

Water quality is difficult to assess, primarily because what constitutes good water quality is relative, depending upon the use of the water. Surface water used for drinking purposes would require better water quality than water used for recreation. In addition, the natural water quality of a lake may not meet with the human conception of good water quality. Water quality standards have been set based upon potable water needs and the biological, chemical, and physical properties of lakes. Orlando's surface waters are primarily lakes and are not used for potable water, therefore drinking water quality standards need not apply.

An often used lake assessment technique is the Trophic State Index (TSI). This index classifies lakes according to their primary productivity, or "fertility". The productivity of a lake in turn depends on nutrients received from drainage, its geologic age, and its depth. The biological productivity classifies lakes as Oligotrophic, Mesotrophic, or Eutrophic. Oligotrophic lakes are deep and have low primary productivity. Plants along the shore are scarce and algae density is low. Algae blooms are rare, since nutrients seldom accumulate sufficiently to produce a population eruption. In contrast, eutrophic lakes are generally shallower and have greater primary productivity. Vegetation along the shore is normally more abundant. Algae populations are denser and algae blooms are characteristic. Light penetration is low. Mesotrophic lakes are those classified between oligotrophic and eutrophic.

Lakes naturally evolve from an oligotrophic state to a eutrophic state. Nutrient loading controls the growth of phytoplankton that is the base of the food chain. This keeps successively higher levels of consumers in balance. Unlimited nutrient sources unbalance the normal succession of the aquatic food chain and results in algae blooms, fish kills and noxious odors.

The major aquatic plant nutrients are orthophosphates and inorganic nitrogen, in the form of nitrates and ammonia. Research has shown that phosphorus and nitrogen are the most important of the limiting factors, with some research pointing to phosphorus as the key nutrient. There are naturally occurring sources of these nutrients, however, the primary sources are man-made.

A number of attempts have been made by researchers to establish a trophic state criterion for lakes as a function of commonly measured water quality variables. The United States Environmental Protection Agency (EPA) has developed a TSI which estimates the trophic state of lakes based upon concentration of Chlorophyll A (which represents algae concentrations), total phosphorus concentration (nutrient concentrations) and Secchi disk depth (measured transparency in meters). Figure S-2 is a summary of how the EPA determines the trophic state of lakes.

FIGURE S-2: EPA TROPHIC STATE DELINEATION

Trophic State	Total Chlorophyll a (ug/l)	Phosphorus (ug/l)	Secchi Disk Depth (m)
Oligotrophic	7	10	3.7
Mesotrophic	7-12	10-20	2.0-3.7
Eutrophic	12	20	2.0

Source: City of Orlando, 1982.

While this method is sufficient in describing the trophic state of an individual lake, it does not allow the comparison of one lake to another. The Carlson TSI can be used to determine which lake is more polluted than another. Using the same parameters as EPA's TSI, Carlson used regression analysis to relate Secchi disk depth to total phosphorus concentration, to chlorophyl a concentration. He reasoned that a doubling of biomass levels, or a halving of Secchi disk depth corresponds to a change in trophic state. Carlson assigned a TSI scale of 0-100 to the three trophic variables, such that a change of 10 units in TSI corresponds to a halving of the Secchi disk depth and a change in trophic state. Figure S-3 contains the index values and variable relationships used by Carlson.

FIGURE S-3: CARLSON'S TROPHIC STATE INDEX

TSI	Secchi Disk (m)	Surface Phosphorus (ug/l)	Surface Chlorophyll a (ug/l)
0	64	0.75	0.04
10	32	1.5	0.12
20	16	3.0	0.34
30	8	6.0	0.94
40	4	12.0	2.60
50	2.0	24.0	6.40
60	1.0	48.0	20.00
70	0.5	96.0	56.00
80	0.25	192.0	154.00
90	0.12	384.0	427.00
100	0.062	768.0	1,183.00

Source: City of Orlando, 1982.

Carlson's TSI may be estimated from any one of the three parameters. The use of a scale effectively eliminates the subjective labeling of oligotrophic, mesotrophic, and eutrophic states and substitutes a scale easily interpreted by the layman. Florida lakes with a Carlson TSI greater than 60 are considered to be in the eutrophic range. In addition, an increase in TSI of 10 points indicates a doubling of eutrophication. In other words, one lake may be considered twice as eutrophic as another. The Bresonik TSI was calculated with Florida lake data and may be substituted for the Carlson TSI.

The following guide describes the probable condition of the state of Florida lakes at different trophic states:

TSI 30: The water will be clear, oxygen will be found in the hypolimnion (bottom layer of the lake)

TSI 40: Very good transparency, but anoxia (lack of oxygen) in hypolimnion possible

TSI 50: Decreased transparency, anoxic hypolimnion, macrophyte (aquatic plant) problems evident

TSI 60: Algal scums probable, heavy weed growth

TSI 70: Heavy scums prevalent throughout summer, decreased rooted weeds because the mass of algae reduces light penetration in the water

TSI 80: Algal scums, summer fish kills, few macrophytes

This model should not be used for muddy or colored waters. Most lakes in the southern U.S. have TSI values greater than 50 (Harper, Livingston, and Pearce, 1987).

Cultural eutrophication of a lake can be controlled, or its effects minimized, by reducing nutrient input. Nutrient loadings have been developed to evaluate the amount of lake fertilization allowable to control eutrophication. Figure S-4 gives the allowable nutrient loadings for nitrogen and phosphorus. This data was obtained by correlating annual phosphorus loadings, mean lake depths, and the degree of lake enrichment. Permissible loadings are defined as the maximum allowable for a lake to remain oligotrophic in the long term. Dangerous loadings are sufficiently great to cause a lake to become eutrophic.

The Trophic State Index permits the assessment and prioritization of lakes based upon water quality. The allowable nutrient loadings set definable limits to nutrient loadings, to correct or minimize the eutrophication process. The TSI's and nutrient loadings described above are not necessarily representative of Florida's lakes and runoff. Specific nutrient loading charts and the Brezonik TSI can be substituted for the previous charts because they are more specific to Florida's lakes. However, prior to taking corrective action, a quantitative survey of nutrient and other pollutant sources and a limnological study of impacted lakes are essential. This data can reveal the trophic state of a lake and determine whether the majority of nutrients and other pollutants are from point or non-point sources. Then corrective actions can be taken to improve surface water runoff.

FIGURE S-4: ALLOWABLE NITROGEN AND PHOSPHORUS LOADING LEVELS IN LAKES

Mean Depth (m)	Permissible Loading (g/m2 of surface area/yr)		Dangerous Loading (g/m2 of surface area/yr)	
	N	P	N	P
5	1.0	0.07	2.0	0.13
10	1.5	0.10	3.0	0.20
50	4.0	0.25	8.0	0.50
100	6.0	0.40	12.0	0.80
150	7.5	0.50	15.0	1.00
200	9.0	0.60	18.0	1.20

Source: Clark, Viessman, and Hammer, 1977.

3.D. IMPROVEMENTS TO SURFACE WATER RUNOFF

Improvements to surface water runoff must provide treatment, to control quantity and quality of stormwater. This is accomplished through Best Management Practices (BMP's). The primary BMP's used for stormwater management are: 1) infiltration through retention, and 2) detention. Stormwater detention is defined as temporarily storing water during and after storm events to prevent flooding and excess water being released to streams. Stormwater retention is a permanent storage mechanism that allows water to percolate into the ground over time. Use of these methods will reduce stormwater volumes, peak discharge rates and pollution loads.

Infiltration through retention is exemplified by swales, dry retention ponds, and underground percolation or French drains. Infiltrating stormwater back into the ground provides 100% treatment of stormwater and provides for groundwater recharge. These methods may only be used in areas with porous soils and where groundwater is well below the land. It has been shown that 90% of the stormwater pollutant loading is contained in the first 1/2 inch of runoff, and 97% of the pollutant loading is contained in the first 1 inch of runoff. In addition, 80% to 90% of all rain storms in the Central Florida area produce between 1/2 inch and 1 inch of rainfall. The use of wet retention defeats the purpose of infiltration to filter contaminants from the stormwater.

Swales must be completely vegetated to ensure they do not erode and to provide filtration and nutrient uptake. This method is often used in conjunction with storm sewers that transport excess runoff to detention areas for peak rate attenuation. Retention areas can be incorporated into the development's overall design to provide passive recreation, open space and landscaping. This reduces maintenance and raw land needs. Underground percolation systems can be used in urban areas where land is expensive, or already developed. Large perforated pipes are placed underground which allow stormwater to be stored and slowly flow out of the pipe into the ground. The City has successfully used this system in its Downtown area.

Detention facilities control peak discharge rates and can be used to provide stormwater treatment. These methods are best used where soil percolation is low, the water table is high and the terrain is flat. Three designs are most commonly used: detention with filtration, detention areas, and wetland systems.

Detention areas are usually wet and designed to form lakes that are integrated into the overall project as an amenity. Detention systems must include appropriate biological, chemical, and physical mechanisms to break down the pollutants in the stormwater. A perimeter swale and a littoral zone can be used in the design to prevent nuisance algae and aquatic plant growth. Prevailing winds, aerators or fountains should be used to help in aeration. Detention with filtration involves a detention area with a soil filter. These are high maintenance systems and only provide particulate pollutant removal (associated with sediment). This system is not recommended by FDEP.

Natural wetland systems and certain isolated wetlands can be used to effectively store stormwater and filter out pollutants. These are the natural functions of wetlands, however, the natural mechanisms must be protected to ensure that the carrying capacity of the system is not overcome by excess nutrient, heavy metals and sediment loadings. The use of a pre-treatment lake adjacent to the wetland can reduce sediment loads, remove oils and greases and attenuate stormwater volumes. Stormwater must be allowed to sheet flow through the wetland, to maximize the wetland's potential for treatment and attenuation. The major advantages of using wetlands for stormwater management are the reduced operation and maintenance needs, the preservation of wetlands, the restoration of drained wetlands and the use of uplands for development.

The "dual pond" system is the most effective stormwater method. The first flush of runoff is routed to a retention area where the most polluted stormwater is allowed to percolate into the ground under favorable conditions. The remaining flood volume is routed to a detention area and released at the pre-development peak discharge rate.

Other innovative BMP's include the use of grass swales with stormwater inlets, instead of using curb and gutter with inlets. A variation of this would use curb cuts to allow some of the stormwater to flow into adjacent grass areas. Turf block and porous concrete are technological innovations that have potential to reduce runoff. Larger scale methods include alum injection into lakes in order to increase adsorption of nutrients with storage in the bottom sediment and regional stormwater facilities that would handle the stormwater from the entire basin or several basins.

Stormwater facilities must be designed to include the increase in runoff volume from increases in impervious surfaces. Figure S-5 shows the assumed increase in runoff generation by increases in the percentage of impervious cover and increases in the percentage of storm sewers. The figure shows that increases in impervious surfaces and storm sewers increases runoff up to six times over natural ground cover.

FIGURE S-5: ASSUMED RUNOFF GENERATION INCREASES AS A RESULT OF INCREASES IN IMPERVIOUS SURFACES AND AREAS SERVED BY STORM SEWERS

	Assumed Runoff Generation (Increase in Mean Annual Flood)					
Percentage of	% of Area Served by Storm Sewers					
Impervious Cover	0	20	40	60	80	100
0-2 ½	[1.0]	1.1	1.1	1.1	1.1	1.1
2 ½/2-5	[1.1]	1.2	1.2	1.2	1.2	1.2
5-10	[1.2]	1.3	1.4	1.4	1.4	1.4
10-20	[1.3]	1.4	1.7	2.0	2.1	2.1
20-33	1.4	[1.8]	2.0	2.4	2.5	2.5
33-50	1.5	2.2	[2.4]	2.7	2.8	3.0
50-75	1.8	2.5	3.0	[3.8]	4.0	4.2
75-100	2.5	3.0	4.2	5.0	[5.4]	6.0

Note: Bracketed numbers indicate the mix of impermeable cover and storm sewer drainage area most common to that range of impervious surfaces.
Source: Tourbier, 1981.

Volume increases may have only limited impact to conveyance capacity during small storms of limited extent. They will have larger repercussions during larger, area-wide storms of longer duration. Landlocked drainage basins (those without connections to larger streams) are especially at risk. The City currently requires compensating storage for developments in floodplains.

BMP's can be used to increase the overall aesthetic and multi-use benefits of a development or area. The creation of lakes can be designed to provide public access and create visual amenities. This was the historical trend within the City for many years, until development began to face directly onto lake fronts, closing the lake to public use. Dry stormwater facilities can be used for non-structural recreation, such as recreation fields, or picnic areas and other passive recreational and open space uses. Wetlands and adjacent detention lakes can serve as wildlife sanctuaries and visual amenities, with limited use of boardwalks within wetlands.

Several strategies are available for waterfront property owners. These include shoreline (re)vegetation, swale and berm systems, on-site retention/detention, backyard design and landscaping. The use of lake water to irrigate would also reduce the amount of fertilizer needed for lawns.

Several methods are available to reduce pollutant loading, which are oriented to the individual property owner. Chemicals should be used only as needed and should not be disposed into sewer systems. Natural fertilizers and natural insect controls should be used. Storm drainage should be kept free of garbage, yard waste and other materials that will clog drains and increase nutrient and hazardous pollutant loadings.

The use of these BMP's can easily be incorporated into the design of new development. Retrofitting of existing developments is more difficult because of the limited undeveloped area and existing infrastructure.

Low Impact Development

Conventional stormwater management practices have some negative consequences that raise the need for a modified set of practices to better protect water resources from the nonpoint sources common in urban development. One approach is Low Impact Development (LID).

LID's basic principle is modeled after nature: manage rainfall at the source. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate and detain runoff close to its source. Techniques are based on the premise that stormwater management should not be seen as stormwater disposal. LID practices are typically designed according to the following principles: Retain, Detain, Recharge, Filter and Use.

LID reduces stormwater pollutant loads through site designs that reduce and disconnect impervious surfaces, restore the ability of soils to infiltrate stormwater, and incorporate small distributed landscape features that filter, detain or infiltrate stormwater. LID approaches can be applied to open space, rooftops, streetscapes, parking lots, sidewalks and medians. With proper planning and construction, LID can be implemented on a community-wide scale for new development, urban retrofits, or redevelopment/revitalization projects.

Examples of LID practices that can apply to new development and/or retrofit projects include low impact site preparations; green roofs; rainwater harvesting (cisterns and rain barrels); vegetated swales and bioswales; stormwater reuse as a source of irrigation water; building roads to cover less area; and the use of permeable concrete to allow water to reach the ground beneath the pavement.

By 2010, Florida may have a statewide set of new stormwater regulations to focus on Best Management Practices, in order to encourage prevention of runoff and improve the removal of nutrients. The City's ESM references WMD stormwater requirements. As these change to reflect LID practices, the City will be able to approve development consistent with the changes. Changes at the WMD level are needed because developers are resistant to implementing practices that require special WMD approval and/or are more expensive than the minimum requirements.

3.E. EXISTING SURFACE WATER MANAGEMENT SYSTEM

Conveyance Hierarchy

Runoff is transported through a system of conveyance facilities such as gutters, pipes, ditches and canals. They are connected in a hierarchal fashion to accommodate increasingly larger flows. The outfall of the conveyance facility is called "the receiving water". The conveyance system within the City of Orlando contains five levels, with two local governments having operational jurisdiction. The system contains Orange County's Primary Water Control System, and the City's Primary, Secondary, Tertiary and roadway conveyance facilities. The St. Johns River and the South Florida Water Management Districts oversee all water resource management within the City of Orlando.

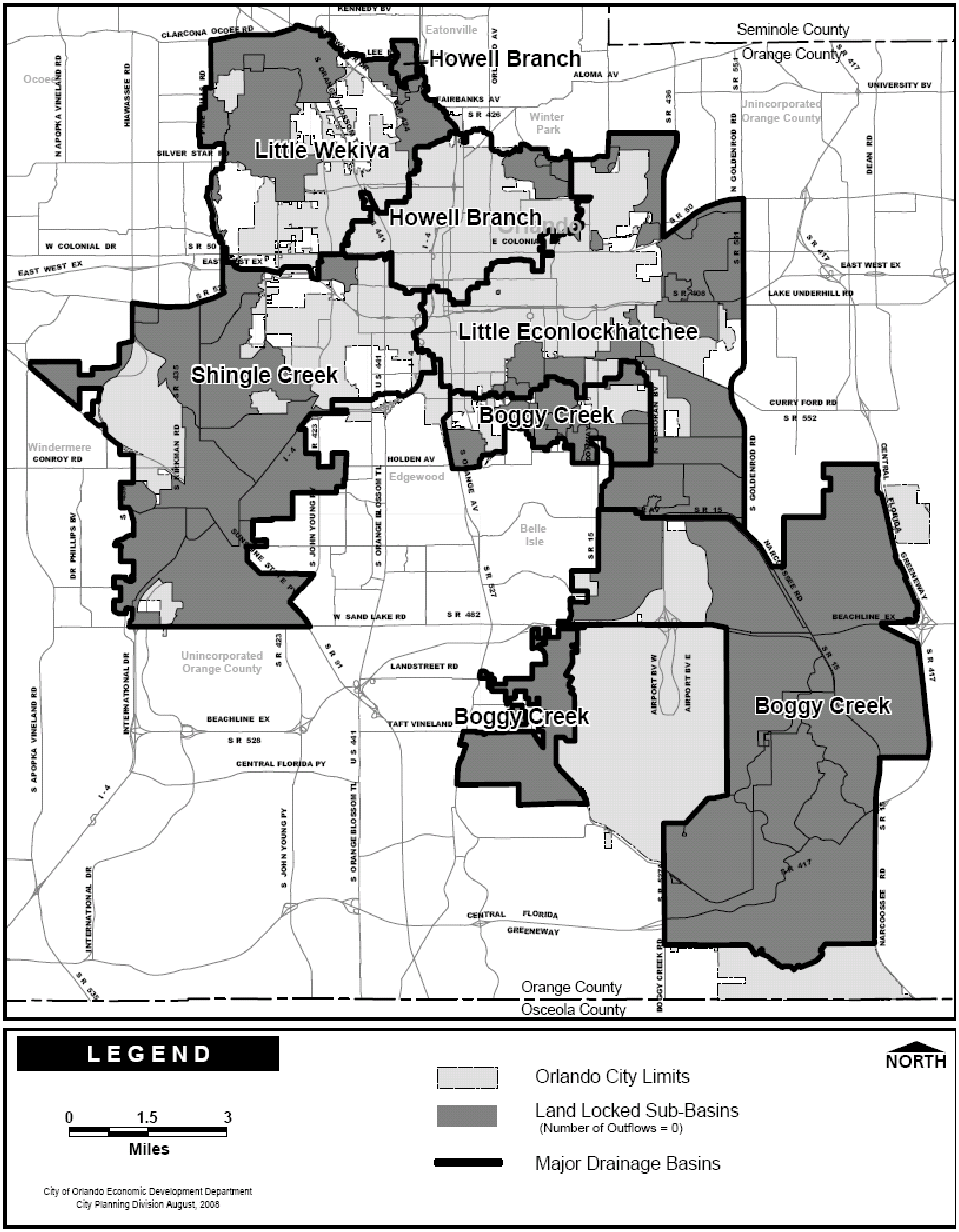
The Orange County Primary Water Control Board was created to delineate and manage the primary drainage system county-wide. This organization no longer exists, but the primary water control system is still maintained by the Orange County Roads and Drainage Division, Public Works Department. The Primary Water Control System encompasses lake interconnects, lake outfalls, and pumping stations designated by the Board, County-wide. Figure S-6 shows the major drainage basins within the City boundaries and landlocked sub-basin areas within these major drainage basins.

The County has control of some stormwater facilities contiguous to the City that can cause conflicts during peak runoff events. The County has the option of redirecting flows to alleviate County flooding, instead of City flooding. The same situation is possible for lake levels that determine the flood storage capacity. Intergovernmental coordination between the City and County should define acceptable stormwater drainage policies.

The City has operational responsibility for all other systems not under County or private ownership. The City stormwater system is divided into five categories:

1) Primary Conveyance Facilities, which are all other systems, outfalls and/or control structures in the City of Orlando, not maintained by Orange County,
2) Secondary Conveyance Facilities are all other systems in the City which drain an area greater than 10 acres,
3) Tertiary Conveyance Facilities are other systems which drain an area less than, or equal to 10 acres,
4) Roadway Conveyance Facilities consist of curb, gutter and inlets which are the beginning of the drainage process, and
5) Retention and Detention facilities, that act as the pollution abatement facilities.

Figure S-6 **Major Drainage Basins**



Surface receiving waters can be described as having a positive outfall, or being landlocked. Lakes and detention ponds that receive runoff, but allow excess volumes to flow into a canal or stream are examples of receiving waters with positive outfalls. Lakes, isolated wetlands and retention ponds which do not allow excess flows to leave, or outfalls to another system are considered landlocked and the final receiving water.

Groundwater is a third receiving water. The City of Orlando relies upon drainage wells to dispose of excess stormwater, especially in the older sections of the City. Many lakes and areas of the City would be flooded after minor storms, if not for drainage wells. Drainage wells will be discussed further in the Inventory and Groundwater sections of this Element.

Inventory

The physical stormwater system for the City contains collection, storage, disposal, and pollution control facilities. A complete description and location map of facilities is available through the City's GIS system and engineering records. Many of these facilities serve more than one of these functions.

Collection facilities include pipes, swales, inlets, ditches and canals. Collection and disposal is augmented by pumps and force mains. Design storms and capacities of collection facilities are known for some collection facilities built after 1984, when OUSWMM was adopted. Design storms and capacities are not known for development before 1984, with the exception of specific purpose designs that have been completed.

Storage facilities include retention and detention (holding) ponds, lakes and wetlands. There are approximately 100 holding ponds that are maintained by the City. The number of private facilities is somewhere between 500-1000. As part of the Stormwater Utility study, a total of 1,891 parcels were given credit against their utility fee because they were required to meet the water quality criteria in OUSWMM. It cannot be assumed that there are 1,891 stormwater facilities however, because many of theses parcels share the same facility. Of the approximately 120 lakes either partially or wholly within the City, the City maintains approximately 94 acres of shoreline and approximately 231 acres of open ditches, canals and swales. The location of lakes and wetlands can be found in the Conservation Element.

Disposal of stormwater is accomplished by streams, lakes, wetlands, and drainage wells. Many of the basins are landlocked and rely totally on lake storage augmented by drainage wells. Figures S-7A and S-7B show the approximate location of each drainage well in the City. The City has approximately 150 drainage wells. Drainage wells are involved with disposal throughout the City and are responsible for preventing flooding in roadways and property. Many areas around lakes near Downtown Orlando would be flooded if not for drainage wells. In addition, they recharge the Floridan Aquifer. Drainage wells also have negative aspects. The stormwater, which ends up in the upper Floridan Aquifer, contains all of the associated pollution from roadway and urban development. This pollution has the potential to contaminate the City's potable water source located in the lower Floridan Aquifer. This issue is addressed in the Groundwater section of this Element.

High capacity inlet filters have been installed to reduce some of the pollution potential of runoff to lakes and the aquifer. BMP's include screens, sediment traps, aerators and created wetlands. Natural wetlands are also an integral part of the City's overall stormwater management plan. Figure S-8 contains the lakes that are aerated.

Maintenance

All aspects of the stormwater management system require maintenance. The lack of proper maintenance of drainage facilities can increase pollutant loadings, reduce capacity, cause back-ups creating flooding and create visual and noxious odor nuisances. Responsibility for maintenance is not always clear. This can lead to unmaintained canals, ditches, swales and drainwells. Access is also a problem for proper maintenance. Often it is difficult to access canals and ditches because of existing development and inadequate rights of way.

Private facilities must also be properly maintained to provide the correct level of service. Often retention and detention ponds fill in with sediment. This reduces the capacity of the ponds and allows polluted water and greater volumes to discharge into other receiving waters. Unwanted plant growth often accompanies increased sedimentation that further reduces capacity. If plant growth is planned, it can be conducive to increased water quality. However, if uncontrolled and unmaintained, the plant growth's negative effects may outweigh the positive effects. The City currently inspects private drainage facilities to ensure that the facilities are operating as designed. These issues should be studied to alleviate undue flooding and water quality problems because of poor maintenance.

Figure S-7A **Drainage Wells - Northwest Quad**

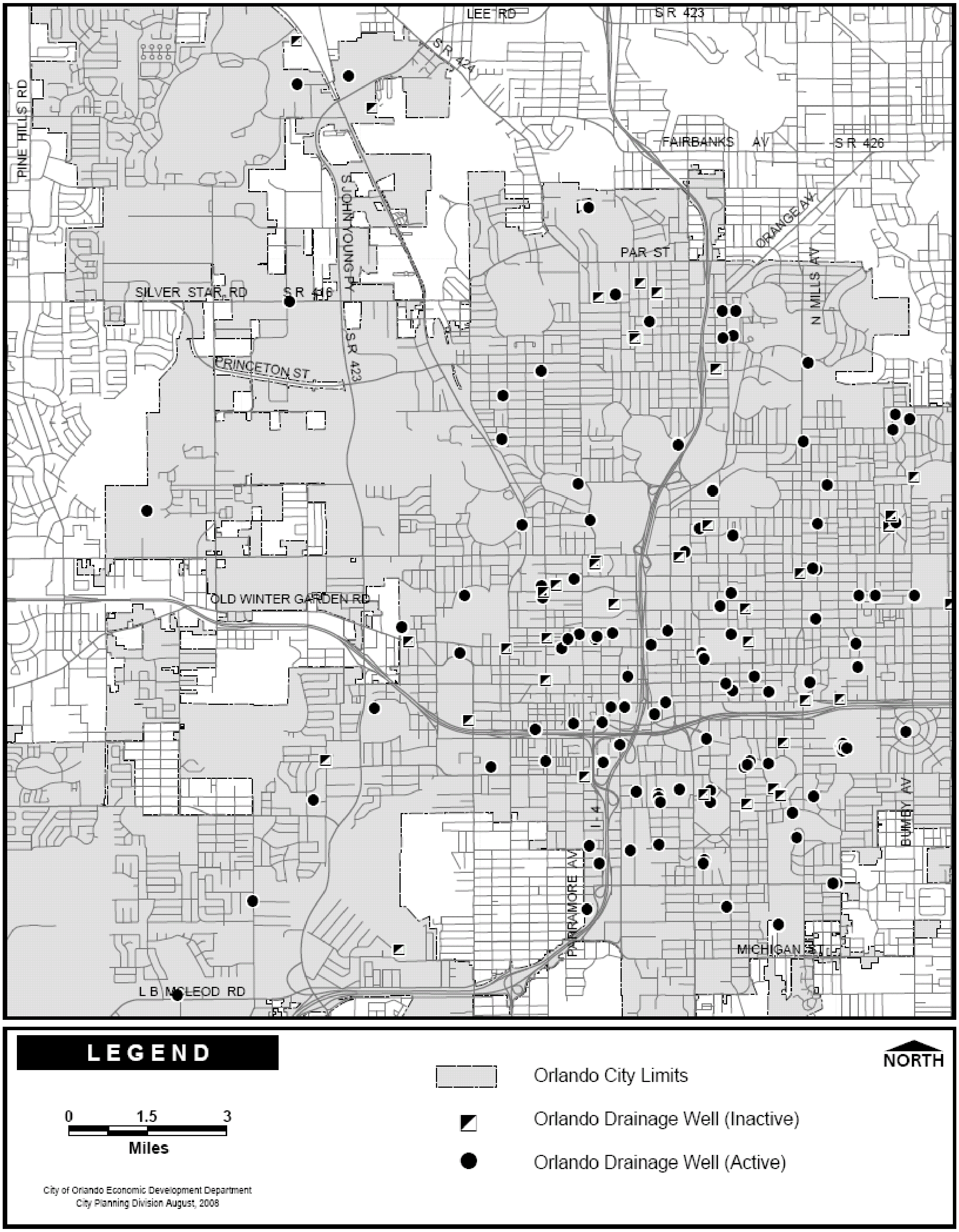
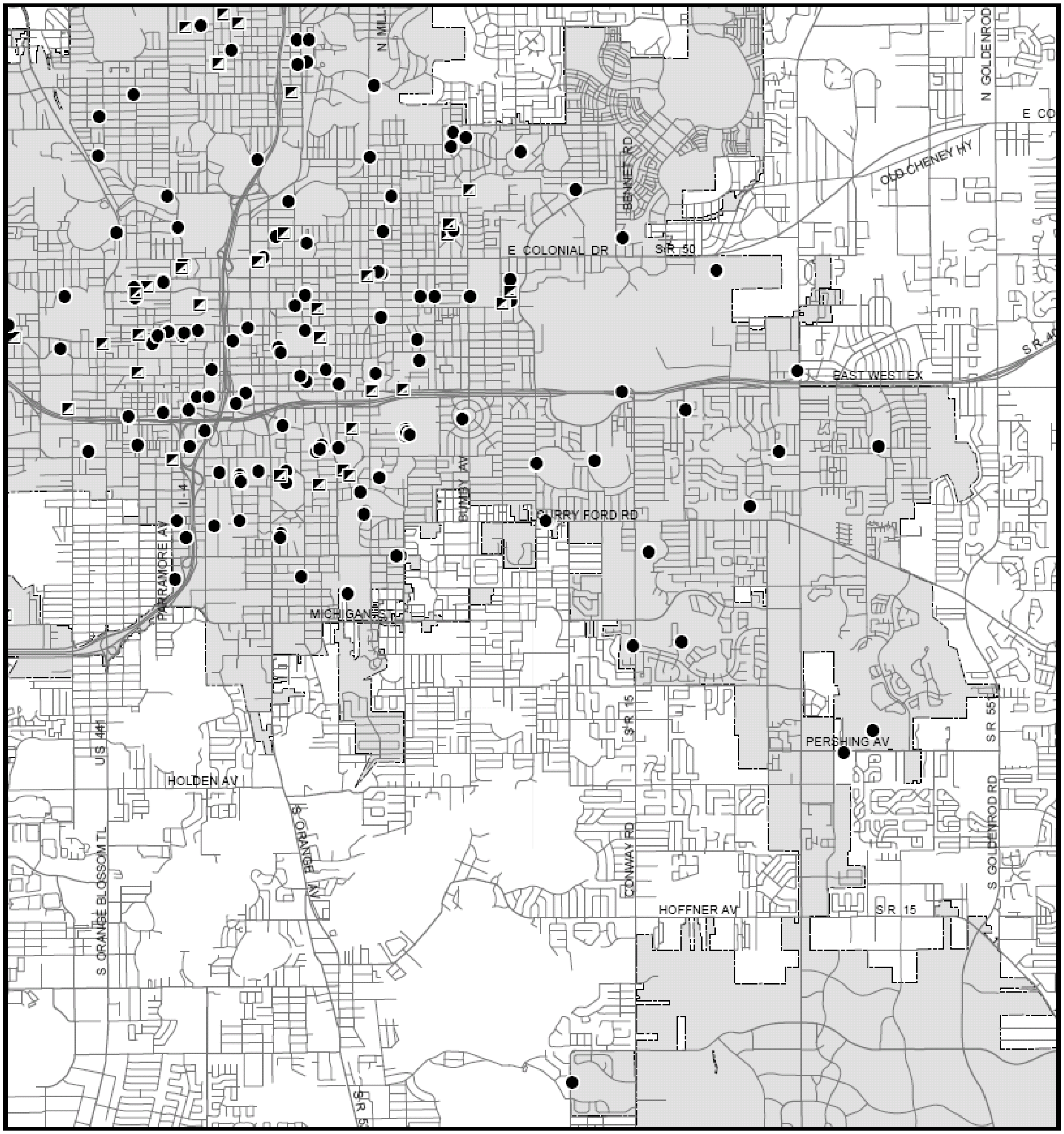


Figure S-7B

Drainage Wells - Northeast Quad



LEGEND

0 1.5 3
Miles

Orlando City Limits
Orlando Drainage Well (Inactive)
Orlando Drainage Well (Active)

NORTH

City of Orlando Economic Development Department
City Planning Division August, 2008

FIGURE S-8: CITY AERATED LAKES

Arnold	Concord	Ivanhoe - West and Middle Lobe
Beardall	Emerald	Fredrica
Lorna Doone	Cay Dee	Park
Lancaster	Richmond	Rowena
Winyah	Beauty	Greenwood
Theresa	Eola	Sandy
Walker	Lurna	Lucerne - East and West Lobe
Como	Lawsona	Olive
Santiago	Hoperita Basin	

Source: City of Orlando, 1998.

General Description of Local Surface Water System

The City of Orlando is uniquely situated at the divide of two major river basins: the St. Johns River and the Kissimmee River. Orlando's position at the basin divide is unique because the City does not accept runoff from any other municipality, or local government. However, this places a special burden upon the City to keep runoff from polluting waters of other jurisdictions.

Figure S-9 shows the five drainage basins within the City. Each basin is divided into sub-basins and assigned numbers corresponding to the OUSWMM classification. Each sub-basin can be further divided into sub-systems that correspond to individual storm sewer outfalls. Figure S-10 shows the service area of the basins contained within OUSWMM.

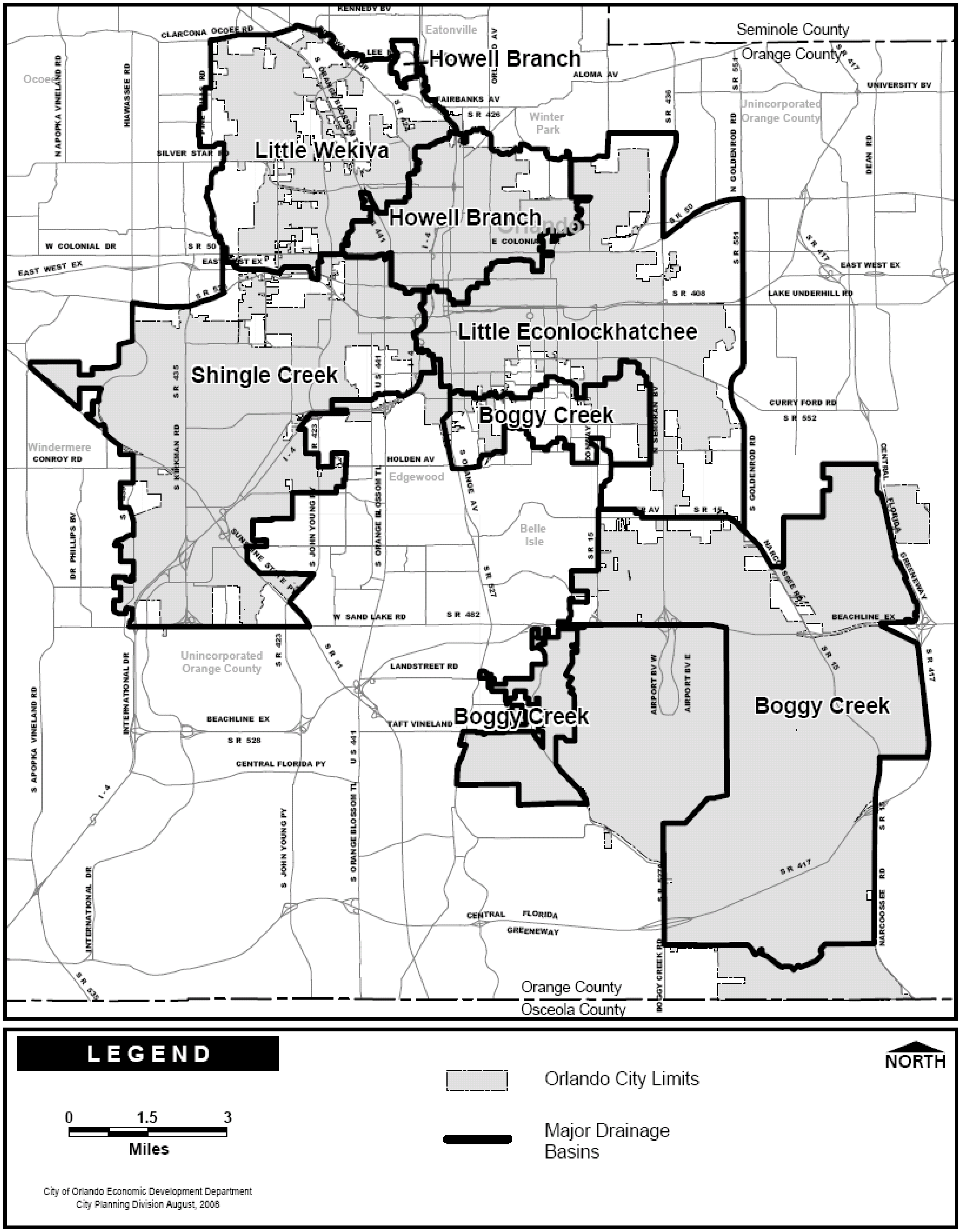
FIGURE S-9: BASINS AND SUB-BASINS WITHIN THE CITY OF ORLANDO

Basin	Sub-Basins	Total Acres
Boggy Creek	27	25,192[1]
Shingle Creek	24	13,439
Howell Branch	18	4,894
Little Econ.	42	8,255
Little Wekiva	13	5,654
Total:	124	57,434

Source: OUSWMM and Engineering/Streets and Drainage Division

[1]Includes the International Airport

Figure S-10 Major Drainage Basins



The drainage boundaries have been adjusted to accommodate changes in drainage patterns due to development. Land within the large landlocked area in the center of the City (see Figure S-6) was assigned to basins according to flow direction, in the event that this landlocked basin were to fill up. Figure S-11 gives the land use by drainage basin within the City of Orlando.

Kissimmee River Sub-Basins

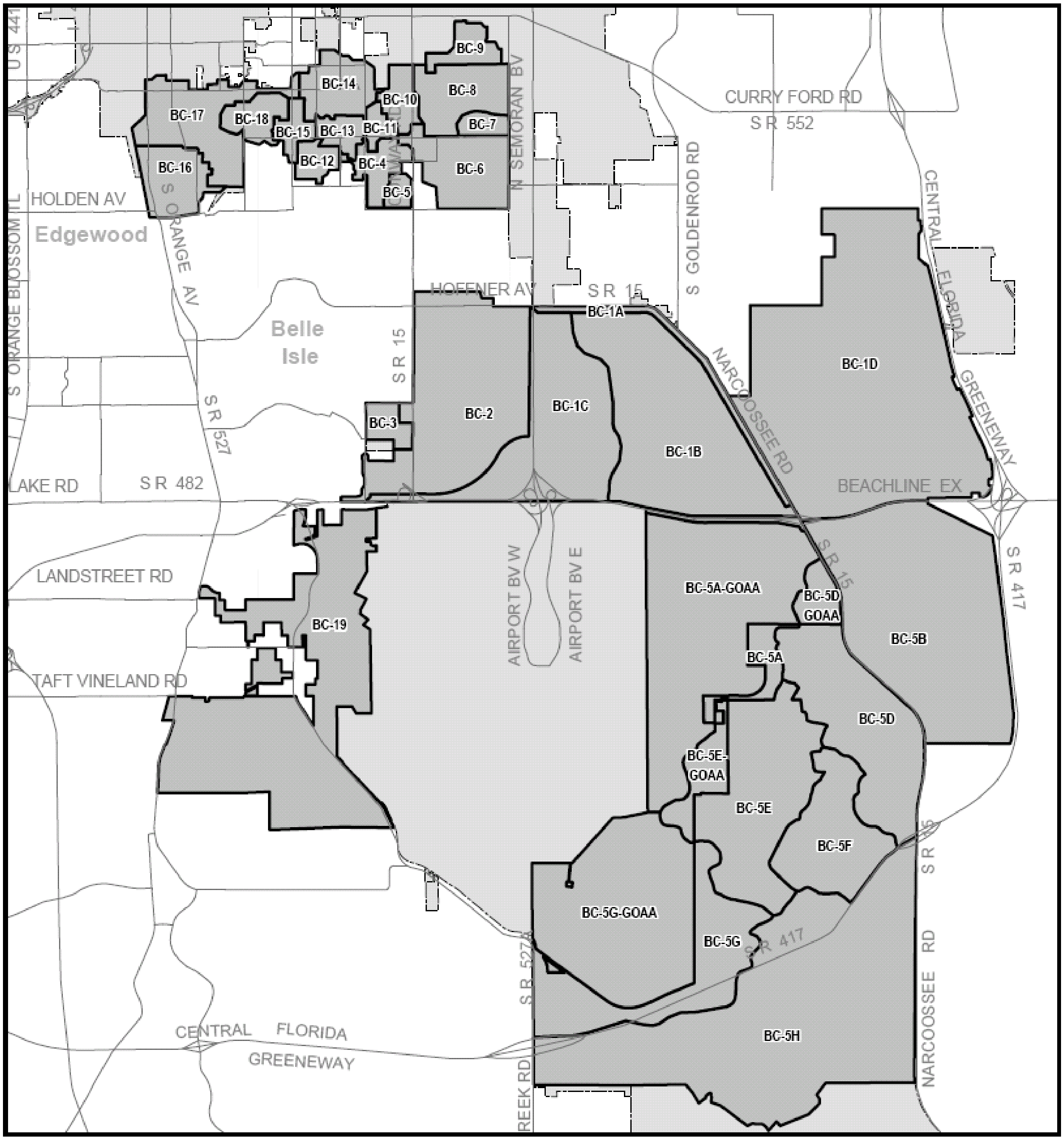
The Boggy Creek Drainage Basin and its sub-basins are shown in Figure S-12. This basin occupies the southeastern portion of the study area. Generally, this basin is divided into two distinct areas, the first being those sub-basins that have positive outfalls into the main channel of Boggy Creek and the second being a series of landlocked lakes in the northern portion of the basin. The main channel of Boggy Creek originates at the discharge from Lake Mare Prairie and the watershed originates from the Conway Channel lakes. The main channel runs south under the Beachline Expressway, around the Orlando International Airport on the east and continues south into undeveloped Osceola County and into East Lake Tohopekaliga, which forms the headwaters to the Kissimmee River. That portion of the basin within the study area is characterized by numerous lakes of various sizes, surrounded by gently rolling terrain. Ground surface within the study area ranges in elevation from 90 feet to 80 feet where the creek leaves the study area. Land use data for the Boggy Creek basin has been divided into two sections. The first section contains only land that was considered in the original OUSWMM study. The second section contains information on land uses within the International Airport and annexed land south of the Beachline Expressway.

The Shingle Creek Drainage Basin and its sub-basins are shown in Figure S-13. This basin occupies the southwest portion of the OUSWMM study area and primarily consists of a large artificial canal system, reaching from Old Winter Garden Road on the north to Clear Lake and Lake Mann on the east. This canal system bisects the drainage basin running from the north to the south and intercepts the storm water overflow from 18 lake sub-basins. Shingle Creek generally slopes from north to south with ground surface elevations varying from 80 feet to 95 feet in the upper reaches of the basin. The basin contains sandy soils in broad flatwoods, wetlands, some large upland lakes and lowland grassy sloughs. The natural surface drainage in these areas is not well established and depends on the artificial canal system within the basin for flood protection. This basin is rapidly developing.

FIGURE S-11: LAND USE BY DRAINAGE BASIN

		LAND USE									
Basin	***Basin Area***	***Agricul-ture***	***High Intensity Commercial***	***Low Intensity Commercial***	***Industrial***	***Multi-Family Residential***	***Single Family Residential***	***Other***	***Total Land Use Areas***	***Total Hydro Areas***	***Basin Area minus Total Land Use Area***
Boggy Creek	25,192	9,782	530	1,404	539	501	1,179	4,479	18,414	2,326	6,778
Howell Branch	4,894	0	182	1,258	93	247	1,547	218	3,545	583	1,349
Little Econ.	8,255	3.5	310	2,389	74	705	1,989	978	6,448	800	1,807
Little Wekiva	5,654	0	264	1,164	866	407	1,053	1,029	4,783	594	871
Shingle Creek	13,439	3.42	967	3,301	794	1,684	1,746	2,194	10,689	1,512	2,750
TOTAL	**57,434**	**9,789**	**2,253**	**9,516**	**2,366**	**3,544**	**7,514**	**8,898**	**43,879**	**5,815**	**13,555**

Figure S-12 Boggy Creek Sub Basins



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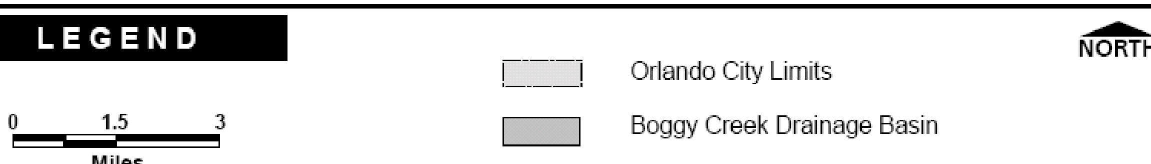


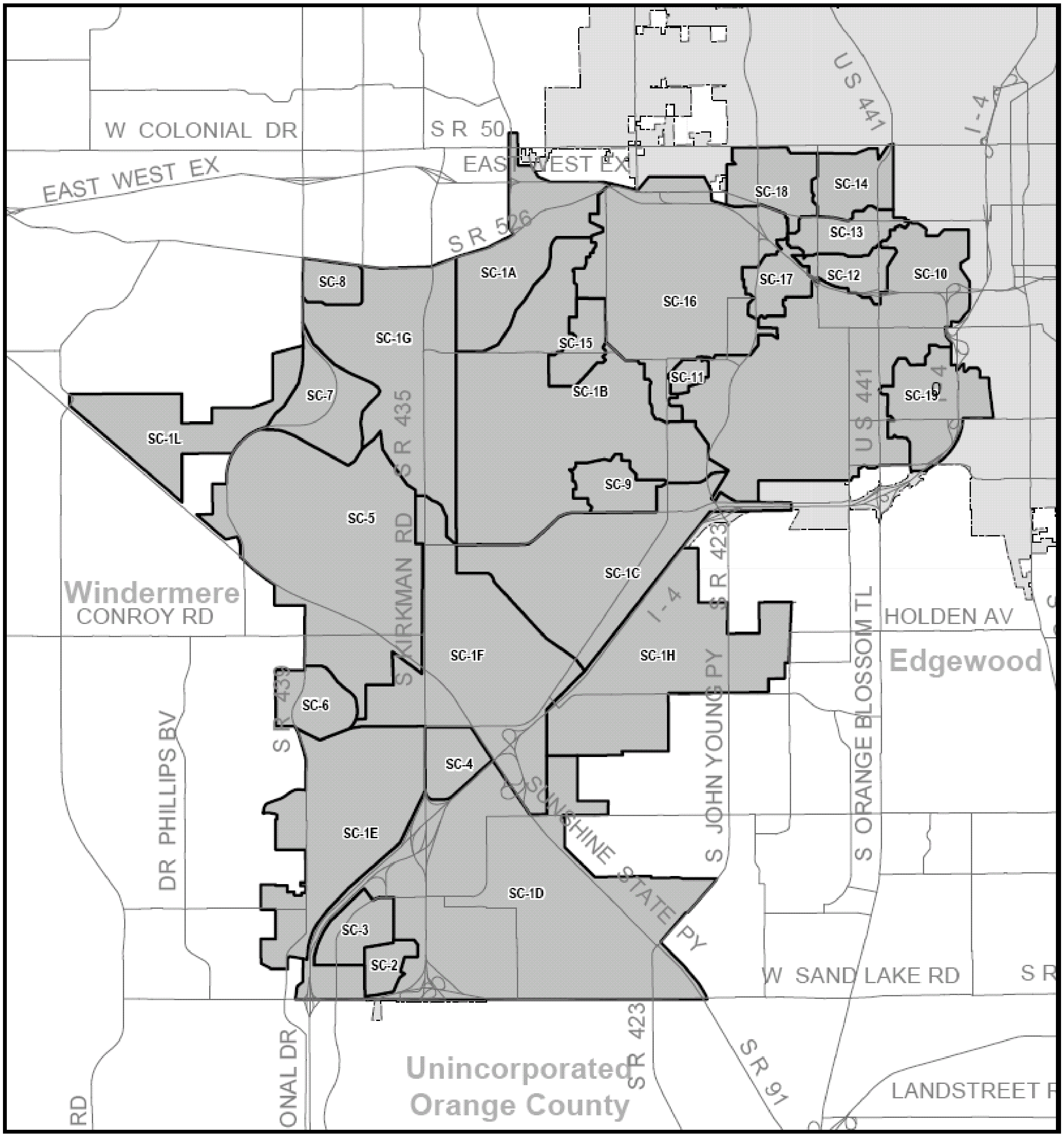
Orlando City Limits

Boggy Creek Drainage Basin

Sub Basin Boundary

City of Orlando Economic Development Department
City Planning Division August, 2008

Figure S-13 **Shingle Creek Sub Basins**



LEGEND

0 1.5 3
Miles

Orlando City Limits

Shingle Creek Drainage Basin

Sub Basin Boundary

NORTH

City of Orlando Economic Development Department
City Planning Division August, 2008

The Howell Branch Drainage Basin and its sub-basins are shown in Figure S-14. This basin is generally divided into two distinct areas. The southern, upstream portion consists of landlocked sub-basins and lakes. The northern, downstream portion consists of lake sub-basins that are interconnected and flow into Howell Creek. This basin drains much of Downtown Orlando and the older residential neighborhoods. Stormwater from this basin enters the Winter Park chain of lakes. Because of the potential impact downstream to an existing urbanized area, these lakes deserve extra consideration.

The Little Econlockhatchee River Drainage Basin and its sub-basins are shown in Figure S-15. This basin is located within the central and eastern portions of the City. There are four principal legs of the Little Econ. These have been labeled the Lake Baldwin Outfall System, Canal E-9 Outfall for Lake Barton, the Azalea Park Outfall, and the Conway Manor Outfall Canal System. A large number of lakes within the western portion of the basin are landlocked and are controlled through the use of drainwells. The landlocked basins contain primarily residential land uses. The Little Econ basin contains several large projects that were annexed into the City in 1998. The Vista East area, like the Southeast Orlando Sector Plan area to the south, has not yet been analyzed and incorporated into the OUSWMM.

The Little Wekiva River Drainage Basin and its sub-basins are shown in Figure S-16. This basin occupies the northwest portion of the City and primarily consists of a chain of lakes, starting with Lake Lawne on the south and Little Lake Fairview on the east, that are interconnected and form the headwaters of the Little Wekiva River. The River leaves the City north of Lake Orlando and continues into Seminole County, to a confluence with the Big Wekiva River. Natural drainage is poor due to the lack of natural surface drainage ways. Many artificial channels have been constructed to provide improved outfall drainage from the intensely developed areas in the southern and eastern portions of the basin.

During the 2004 Regular Session, the Florida Legislature passed the Wekiva Parkway and Protection Act (WPPA). Section 369.319 and 369.321 F.S. requires each local government within the Wekiva Study Area to develop a master stormwater plan and amend the appropriate elements of the Growth Management Plan, including the Capital Improvements Element, to ensure implementation of the master stormwater management plan.

In November 2005, the Wekiva Parkway and Protection Act Master Stormwater Management Plan Support Document, prepared by CDM for St. Johns River Water Management District, provided master stormwater management plan recommendations, together with a recommended schedule for the local governments located within the Wekiva Study Area. The Master Stormwater Management Plan (MSMP) was developed to satisfy the requirements of Section 369.319 F.S. of the Wekiva Parkway and Protection Act.

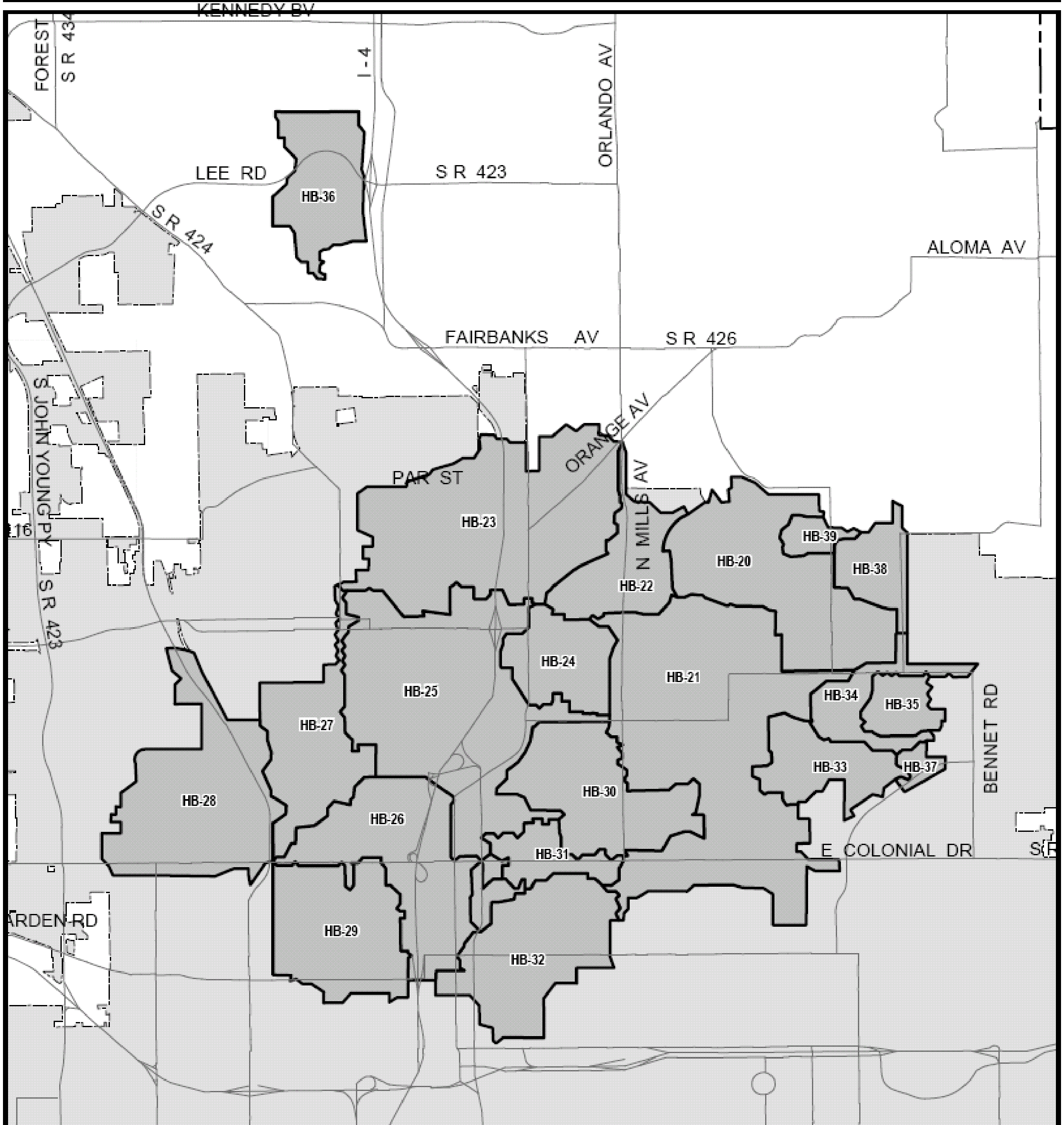
In association with St. Johns River Water Management District, the City of Orlando, Orange County, Seminole County and the City of Altamonte Springs also participated in the Little Wekiva River Watershed Management Plan (WMP), being an independent study by CDM, dated November 1995, to address the Wekiva stormwater issues specific to the participating local governments. The WMP was initially developed prior to and was independent of the MSMP.

Although the WMP had been underway prior to the adoption of legislation, the recommendations contained within the WMP are consistent with the goals of the WPPA.

The requirement to develop a master stormwater management plan for the Wekiva Study Area is met through the MSMP. The City was required to amend the goals, objectives and policies for the Stormwater and Aquifer Recharge section within the Growth Management Plan, to cover those recommendations within the MSMP not previously included in the City's Growth Management Plan. The amendments were approved by City Council in 2008. The boundary of the Wekiva Study area contained within the City's jurisdiction is shown in GMP Conservation Element Figure C-3.

A more detailed description of the basins and the associated sub-basins is contained in Volume I of the OUSWMM. As indicated above, the City limits have expanded since the completion of OUSWMM. In addition to the Southeast Orlando and Vista East areas, the original OUSWMM analysis did not include other areas such as the International Airport, Tradeport, the Navy Annex, the Airport Industrial Park of Orlando and other new developments. Portions of Shingle Creek were also not included. OUSWMM has been incorporated into Chapter 7 of the ESM and includes these areas in order to maintain a current inventory and description of surface drainage in Orlando. This is needed to facilitate master drainage planning in Orlando.

Figure S-14 Howell Branch Sub Basins



LEGEND

0 1.5 3
Miles

Orlando City Limits

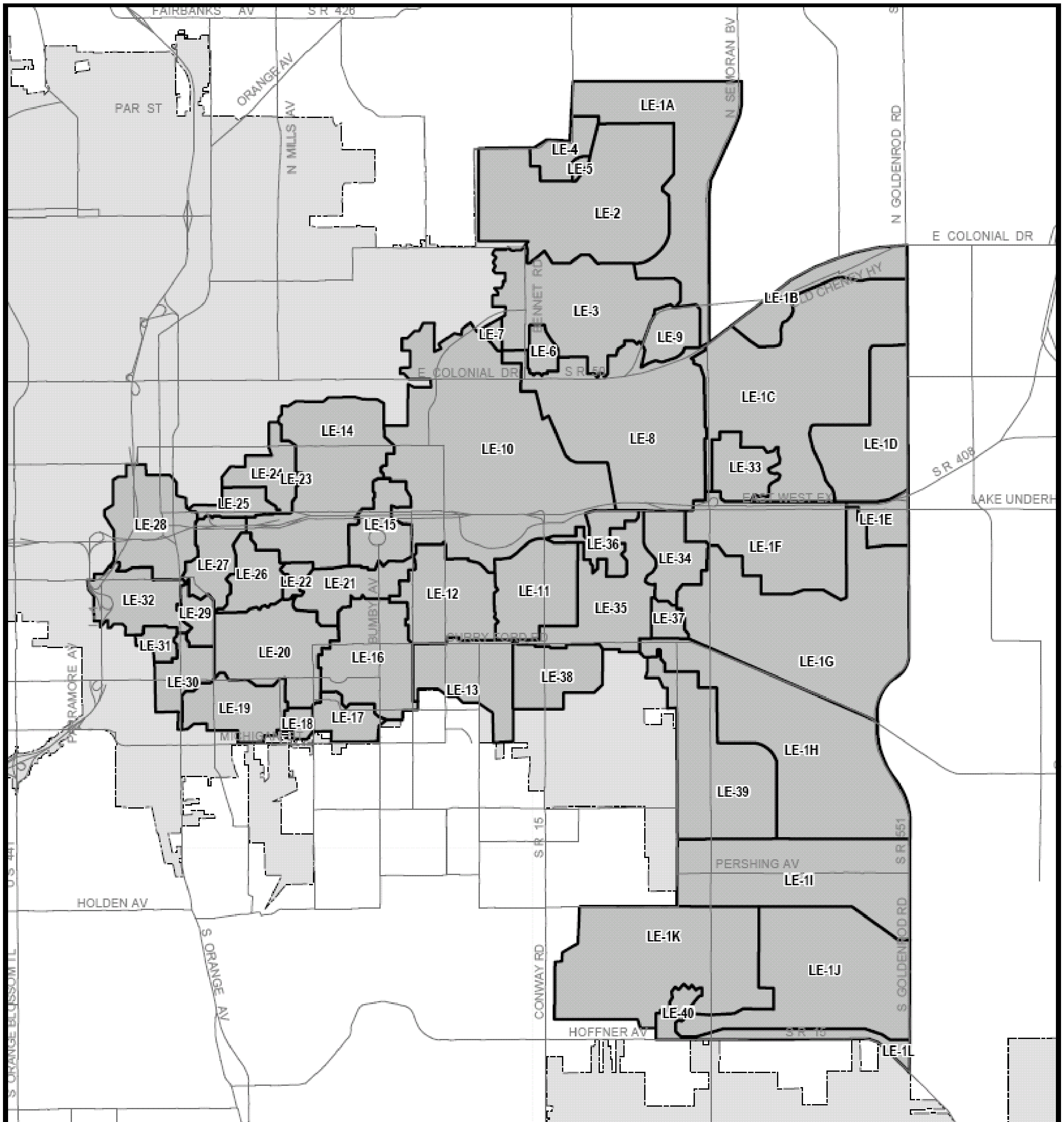
Howell Branch Drainage Basin

Sub Basin Boundary

NORTH

City of Orlando Economic Development Department
City Planning Division August, 2008

Figure S-15 Little Econlockhatchee Sub Basins



LEGEND

0 1.5 3
Miles

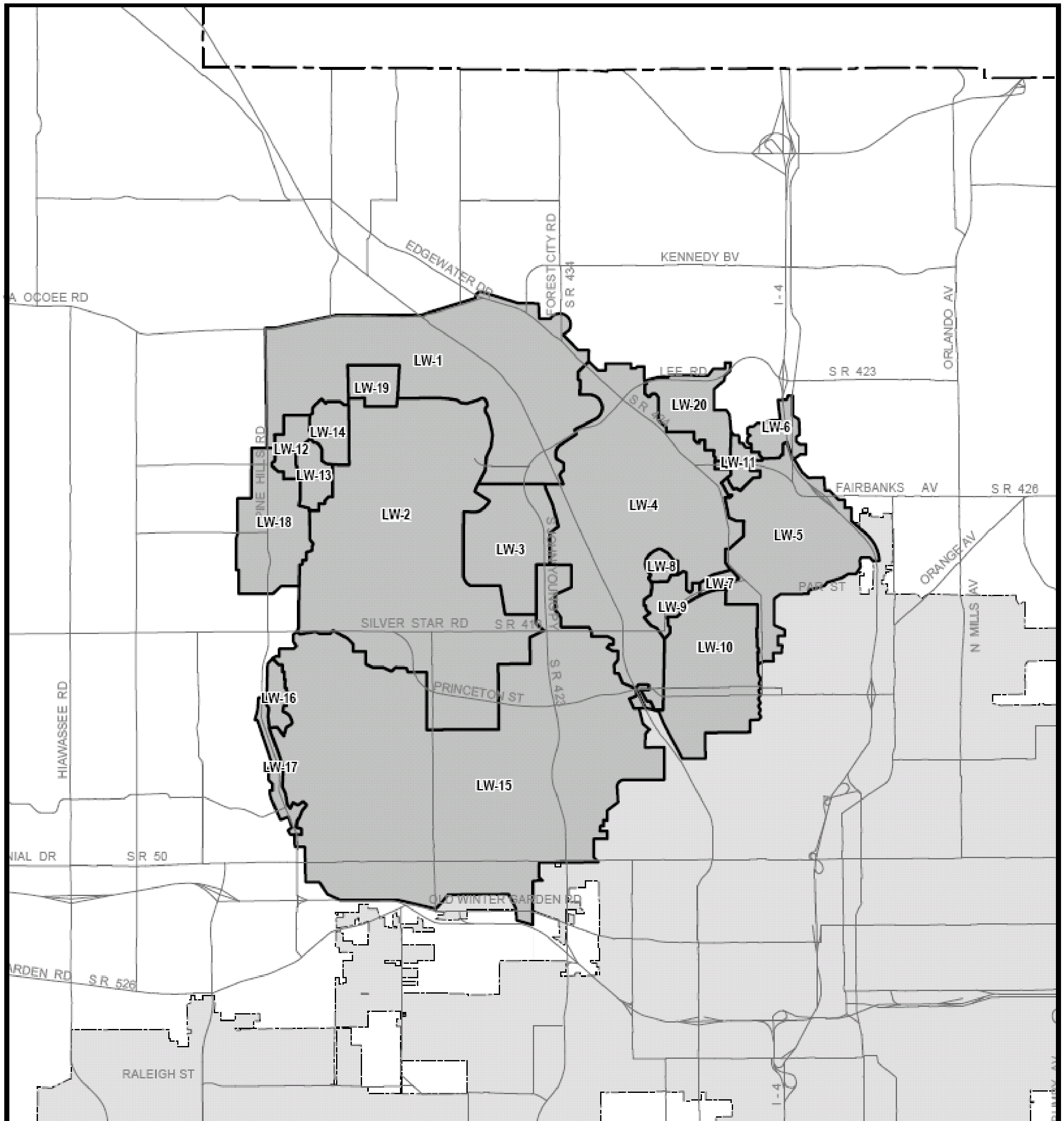
Orlando City Limits

Little Econlockhatchee Drainage Basin

Sub Basin Boundary

City of Orlando Economic Development Department
City Planning Division August, 2008

Figure S-16 Little Wekiva Sub Basins



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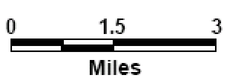


Orlando City Limits

Little Wekiva Drainage Basin

Sub Basin Boundary

City of Orlando Economic Development Department
City Planning Division August, 2008

4. EXISTING LEVEL OF SERVICE

Level of Service (LOS) is defined as the capacity per unit of demand for a public facility, usually expressed in terms of per capita per day, or land use unit per day. This LOS is an indicator of the extent or degree of service provided by a stormwater facility. It is difficult to express a stormwater LOS in meaningful terms as a per capita or land use unit per day LOS. A stormwater LOS is best described in terms of the physical characteristics of the system. The physical characteristics must address the needs for capacity and performance criteria for water quality and flood control, for new and existing systems. Additional criteria are that the LOS must not conflict with requirements of the Water Management Districts and the FDEP; they must allow for traffic movement; be cost effective; and maintain the relationship with the environment.

A capacity LOS can be expressed as the design storm condition. This will require the selection of a storm frequency, duration and the antecedent soil condition for conveyance and storage facilities. A performance or water quality treatment LOS should establish specific pollutant load reduction goals, requiring treatment of runoff volumes, or reduction in the total runoff volume. The LOS must consider the impacts from both new and existing development.

4.A. LEVEL OF SERVICE STANDARDS

Pre-1984 LOS

The City has been developed under two different stormwater LOS: development before the implementation of OUSWMM in 1984; and development after the implementation of OUSWMM. The majority of the City was developed prior to OUSWMM. Existing storm sewer LOS are not known because of the lack of design criteria in the City prior to 1984. As a condition of the City's National Pollution Discharge Elimination System Permit (NPDES) from the U.S. EPA, the City will update its inventory of storm sewer facilities. The capital improvement projects list will then be revised to reflect any deficiencies determined in the NPDES study. In prioritizing facilities for improvements, a number of criteria should be considered, such as the number of people affected, improvement to water quality, coordination with other capital infrastructure projects, reduction in maintenance and available funding.

Post-1984 LOS

The introduction of OUSWMM in 1984 placed many standards on the design of stormwater systems. The LOS standards for OUSWMM contained quantity and quality criteria that contained storm frequencies and durations relating to conveyance and roadway facilities. Design criteria and regulations pertaining to stormwater management within the City of Orlando can now be found in the ESM. The following design criteria are to be used as the City's post-1984 LOS:

Facility	LOS
City Primary	Design Storm: 25 year / 24 hour Max Flood Stage: 100 yr / 3 day below floor elevations

	Max Hydraulic Grade Line (HGL): at gutter elevation for 25 year / 6 hour storm
City Secondary	Design Storm: 10 year / 6 hour Max HGL: 1' below gutter elevation Check Storm: 25 year/ 6 hour Max HGL: at gutter elevation
City Tertiary	Design Storm: 10 yr / 6 hour Max HGL: 1' below gutter elevation Check Storm: 25 yr / 6 hour Max. HGL: at gutter elevation
Arterial Road	Roadway Section and Inlet Design: 10 year/6 hour storm Minimum 2' between seasonal high water table and bottom of base course.
Collector Road	Roadway Section and Inlet Design: 5 year / 6 hour storm Minimum 1' between seasonal high water table and bottom of base course.
Minor Road	Roadway Section and Inlet Design: 3 year / 6 hour storm Minimum 1' between seasonal high water table and bottom of base course.
Travel Lane Spread	12 feet for all roads; roads with parking lane, width measured from face of curb to centerline outermost travel lane; clearance between design water surface and top of curb - 1".
Maximum Run Distance	400 feet to first inlet
Retention Ponds	Per Water Management District criteria.
Detention Ponds	Per Water Management District criteria.
Detention Ponds (landlocked basins)	Per Water Management District criteria.
Floodprone Areas	Development allowed in 100 year floodplain with compensatory storage loss for floodplain and no development in the floodway.

These LOS and the other design criteria primarily address the rates of discharge rather than the issue of volume increases and their impact to existing stormwater facility capacities. There are two concerns with the volume issue: 1) the impact to conveyance capacities and lake storage within the City, and 2) the impact to conveyance capacities and lake storage outside the City.

Fully developed basins may or may not be of concern. This would depend upon the existing LOS for that basin and the occurrence of flooding. Landlocked basins are susceptible to flooding, especially if the lake level is controlled by drainage wells. Reliance on drainage wells may not be acceptable because of the possibility of blockage or failure. As discussed earlier, this can lead to severe flooding during minor storms. Landlocked basins should be studied as to flood elevations at a specific storm design, without drainage wells, to ascertain what will be at risk and if this is acceptable. LOS for basins with positive outfalls must also be ascertained in regard to acceptable flooding protection.

Additional volumes will impact downstream users. This is especially true of undeveloped land within the City that drains into developed areas, such as Winter Park, south Orange County and northern Osceola County, together with other developed portions of Orlando. This will be of special concern to Boggy Creek and Shingle Creek. Capacities of these major surface drainage features must be assessed, as well as the appropriate secondary facilities. This is addressed in the Intergovernmental Coordination Element.

4.B. NEEDS ASSESSMENT

The purpose of a Needs Assessment analysis is to determine the capital improvement projects needed to maintain the adopted LOS and the costs of those projects to the year 2028. This assessment will first select a feasible and practical pre-1984 LOS that will be used to identify existing deficiencies in flood and water quality protection of the pre-1984 stormwater system. Any development built after the adoption of OUSWMM is considered to meet the post-1984 LOS for flood and water quality protection.

The pre-1984 standards should be based upon the physical impact of stormwater upon the populace and the land. Environmental concerns must also be addressed in the pre-1984 LOS standard. The lack of pollution abatement facilities and the interconnection of surface waters to groundwaters make environmental impacts an important consideration. These impacts, according to priority, are: 1) immediate health and safety issues, 2) property damage, 3) environmental contamination, and 4) inconvenience to travel. However, a lack of design information prior to 1984 on stormwater facilities necessitates the City taking a different interim approach.

A water quality LOS for pre-1984 systems is complicated by the dependence of drain wells for flood control in most of the older (and some of the post-1984) sections of the City. In addition, post-1984 pollution abatement facilities may continue to add to the contamination of the City's surface waters and groundwaters, through inefficient designs and lack of maintenance.

Existing flooding areas have been delineated by the City's Engineering Division based upon the prioritization system employed by the Division. Figure S-17 lists the projects, locations, and cost for each. The majority of projects are capital improvements. However, many are environmental, or repair and replacement projects, with many projects having dual functions. Figure S-18 shows the anticipated capital projects from 2013 - 2018. Additional water quality projects may be identified as TSI trends for City lakes are determined.

Revenue Analysis

Prior to the implementation of the Stormwater Utility Enterprise Fund in fiscal year 1990, stormwater management was funded by the general fund. All maintenance, repair, replacement and new construction of stormwater management systems have been funded by the stormwater utility since that time. The fee is applied City-wide based upon the amount of impervious surface on each parcel.

Figure S-19 shows the projected stormwater revenue to the year 2030. Capital expenditures are based upon the projects from Figure S-17, that are funded by the stormwater utility. Total revenues were projected using growth trends for development and annexations; operation and maintenance; and overhead components. Capital improvement revenue projections were determined by subtracting projected operation and maintenance and overhead components from projected gross revenue. The capital improvement revenue figures for fiscal year 2009 through fiscal year 2013 were set by the Public Works Department in the fiscal year 2008 Capital Improvements Program. The capital expenditure 20-year needs were calculated by subtracting projected capital improvement revenue from the known total estimated capital costs of $103,195,565. Under this scenario, anticipated stormwater management improvements will not be completed until 2025.

FIGURE S-17: CITY OF ORLANDO 2007-2012 CAPITAL IMPROVEMENT PROGRAM

Project Name	Project ID #	Funding Source	Project Priority	2007-2012 Funding	Projected Operating Cost Impact
Al Coith/Euclid/Gore Drainage Improvements	06-721-006	Stormwater Utility Fee	Critical Deficiency	650,000	
Albert Shores Storm Drainage Improvements	04-719-006	Stormwater Utility Fee	Existing Deficiency	1,250,000	
Drainage Well Enhancement	89-722-072	Stormwater Utility Fee	Existing Deficiency	1,600,000	
Lake Enhancement Improvements	83-722-029	Stormwater Utility Fee	Existing Deficiency	2,000,000	$3,000
Little Lake Fairview Stormwater Treatment System	95-721-010	Stormwater Utility Fee	Existing Deficiency	400,000	
Maury Rd./Edgewater Dr. Drainage	96-721-008	Stormwater Utility Fee	Existing Deficiency	1,000,000	
Par Street Drainage Improvements	04-719-028	Stormwater Utility Fee	Existing Deficiency	400,000	
System Repair	83-722-022	Stormwater	Repair/ Replacement	2,350,000	$2,000

Project Name	Project ID #	Funding Source	Project Priority	2007-2012 Funding	Projected Operating Cost Impact
and Rehabilitation		Utility Fee			
Lucerne-Cherokee-Davis-Lancaster Interconnection	04-719-027	Stormwater Utility Fee	Existing Deficiency	915,532	

FIGURE S-18: CITY OF ORLANDO 2013-2018 CAPITAL IMPROVEMENTS

Name of Project	2013	2014	2015	2016	2017	2018
Caravan Court Drainage	$300,000				$300,000	
Drainage Well Enhancement	$400,000	$300,000	$300,000	$300,000		
Drainage Well Repair & Rehab	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Emergency Spill Clean-up	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Flood Studies	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Kaley St/Eola Dr Drainage Imp	$350,000					
Lake Davis/Lake Greenwood	$780,000					
Lake Enhancement Imp	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Lake Hiawassee Outfall		$1,605,519				
Lake Lancaster/Lk Hourglass			$700,000			
Lake Olive/Lake Lawsona	$250,000					
Park Lake Outfall	$500,000	$500,000				
Parramore North Pond		$500,000	$500,000	$500,000		
Parramore South Pond		$500,000	$500,000	$500,000		
Rapid Response Construction	$500,000	$250,000	$350,000	$350,000	$350,000	$350,000
Sandbar Removal	$200,000	$500,000	$500,000	$500,000	$500,000	$500,000
Stormwater Monitoring	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
SW System Construction	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
SW System Evaluation	$600,000	$300,000	$300,000	$300,000	$300,000	$300,000
System Repair & Rehab	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
TMDL Implementation	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Underdrain Construction	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Total Project Costs	**$8,627,656**	**$7,938,179**	**$7,494,211**	**$7,000,000**	**$6,430,000**	**$3,700,000**

FIGURE S-19: CITY OF ORLANDO STORMWATER AND CAPITAL EXPENDITURE PROJECTIONS

Year	Total Revenue	CIP Revenue[1]	Possible Future Projects	20 Year CIP Needs
2009	$22,291,204	$8,817,613	$0	$103,195,565
2010	$22,737,028	$8,353,974	$0	$94,377,952
2011	$23,191,769	$8,173,870	$0	$86,023,978
2012	$23,655,604	$7,972,361	$0	$77,850,108
2013	$24,128,716	$7,748,006	$0	$69,877,747
2014	$24,611,290	$7,498,302	$0	$62,129,741
2015	$25,103,516	$7,222,314	$0	$54,631,439
2016	$25,605,587	$6,918,232	$0	$47,409,125
2017	$26,117,698	$6,584,113	$0	$40,490,893
2018	$26,640,052	$6,217,869	$0	$33,906,780
2019	$27,172,853	$5,817,253	$0	$27,688,911
2020	$27,716,310	$5,379,845	$0	$21,871,658
2021	$28,270,637	$4,903,032	$0	$16,491,813
2022	$28,836,049	$4,383,995	$0	$11,588,781
2023	$29,412,770	$3,819,686	$0	$7,204,786
2024	$30,001,026	$3,206,801	$0	$3,385,100
2025	$30,601,046	$2,541,761	$2,363,462	$178,299
2026	$31,213,067	$1,820,679	$4,184,141	$0
2027	$31,837,328	$1,039,328	$5,223,469	$0
2028	$32,474,075	$193,104	$5,416,573	$0
2029	$33,123,557	$0	$4,693,563	$0
2030	$33,786,028	$0	$2,979,066	$0

1. Based on the stormwater utility revenue model.

2. After 2025, the CIP needs will be met and future revenues will go to additional capital needs.

3. 20-year CIP needs calculated by subtracting capital improvement revenues from total projected costs.

4. For 2029-2030, projected revenues are expected to be devoted entirely to operating expenses. If additional revenue sources are identified, a portion will be allocated to CIP projects.

5. PERFORMANCE ASSESSMENT

The Engineering/Streets and Stormwater Drainage Division is responsible for the majority of the maintenance operations and capital improvements within the City's stormwater system. This is carried out through five sections within the Division. The Division's main policy is protection through preventive maintenance. The City has full-time permanent crews to keep storm sewers and ditches clear and maintained.

Flooding is prevented and reduced because of regular high pressure cleaning of the storm sewers from blockage, due to debris or sediment build-up. Inlets, catch basins, well grades, and all other PCDs are also regularly maintained. Open ditches and City shorelines are also mowed, cleared and shaped on a regular basis. Street repairs help the overall stormwater system by maintaining inlets and catch basins, elevations and curb replacement. This assures that the upper reaches of the drainage system are functioning properly. Lake levels are also maintained to maximize storage capacity during the rainy season and reduce drought during the dry season.

Water quality is maintained through several programs. Street cleaning keeps debris from clogging the storm sewers and drain wells or polluting lakes. The City has approximately 979 lane miles of streets to maintain. This translates into over 1,958 curb miles since there are two or more curbs per street to clean. In FY 2007, the Division cleaned 18,513 curb miles of streets. The amount of debris and sediment collected was 26,500 cubic yards.

Lake water quality is maintained and monitored through the Lake Enhancement Program, in the Streets and Stormwater Division. The main impetus of the Lake Enhancement program is pollution prevention and habitat management.

The Stormwater Utility has increased performance of the stormwater system by implementing programs such as water quality monitoring, private and public stormwater pond inspections, increased maintenance and increased data gathering and evaluation.

The general conditions and life expectancy of the stormwater system is difficult to assess. The majority of storm sewer pipes were installed in the last 50 years. In the older sections of the City, some of the systems are 70 to 90 years old. The vast majority of the pipes were made of reinforced concrete, which had a design life of 50 years. However, many of the older pipes are in good condition while newer pipes may be in need of repair or replacement due to improper installation, or corrosion from the high water table. The City regularly funds repair and replacement capital improvement projects to maintain its facilities. Cost-effectiveness is maximized by coordinating with other departments' construction activities, such as Wastewater and Transportation. The City is committed to a continual repair and replacement program for all storm sewers.

The natural environment is impacted from runoff by pollution loading into surface waters and groundwater together with increases in sediment load. The receiving points will be lakes, streams and drainage wells. Surface runoff will pick up oils, fertilizers, soil and other pollutants and transport them to the City's lakes and drainage wells, or downstream to be added to other sources of pollution. Accidental spills of hazardous materials also jeopardize our water resources.

As stated earlier, runoff can also impact lakes and the Floridan Aquifer from discharge of drainwells. The City has implemented several innovative solutions. Examples are the underground exfiltration systems used in the Downtown area that use drainage pipes as the retention area. In some locations, the City created wetlands to remove nutrients before entering drainwells and lakes, such as Lake Greenwood. Planting shoreline vegetation is another example of the City's innovative approach. Expansion of these projects is however constrained by available land and limited funding.

New development must meet the flooding and pollution abatement requirements of the ESM in order not to exacerbate the existing problems. Existing stormwater system problems prior to 1984 are difficult to alleviate. Alleviation of these problems would include inter-basin removal of surface drainage from landlocked basins, consolidation of drainage pipes into lakes and locating sites for drainage facilities in completely developed areas. A more complete analysis of this issue is described in the Groundwater section of this Element.

6. GROUNDWATER AND AQUIFER RECHARGE

Groundwater is the primary source of drinking water for the Orlando area. In addition, most non-potable demands such as irrigation and industrial uses utilize groundwater. Groundwater is also the receiving body for much of the surface runoff, through drain wells. The injection of runoff controls flooding, but also introduces contaminants that may pollute Orlando's drinking supply. The availability of an abundant and pure water source is paramount to the future of Orlando and the surrounding area. In order to protect this resource, the geological and hydrological processes must be understood.

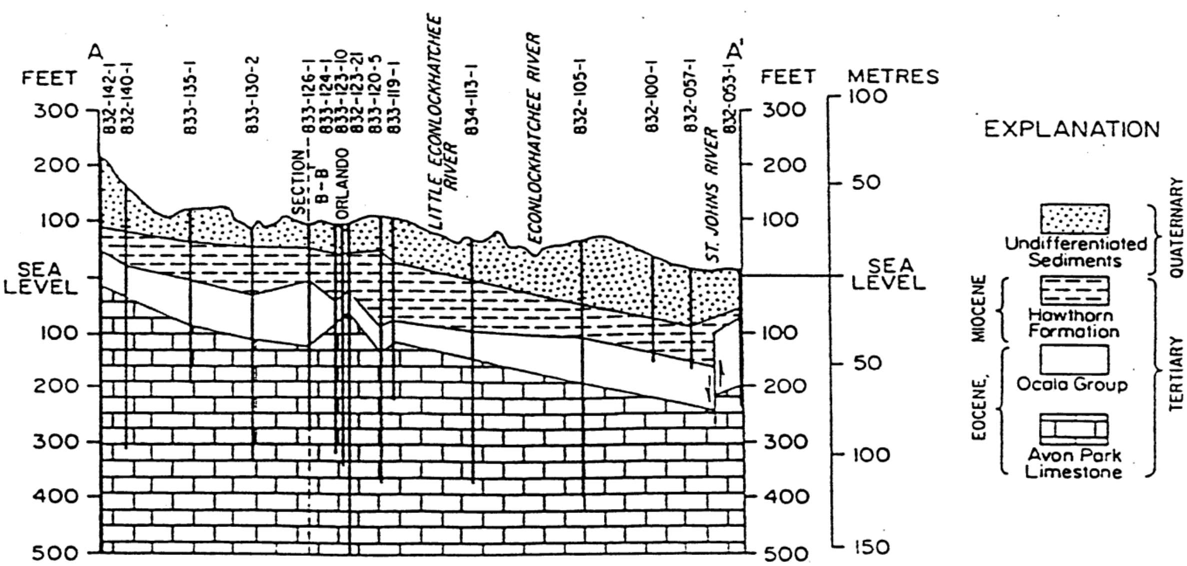
6.A. GEOLOGY

The rock formations below the land surface dictate the availability of water, both in quantity and ease of withdrawal. The depositional process is important in determining the water bearing capacity of the rock. Orlando is generally underlain by undifferentiated sediments of sand with varying amounts of clay and shell. These were deposited by wind and wave action when the ocean level was much higher. These initial deposits are underlain by marine limestone, dolomite, shale and anhydrite to depths of approximately 6,500 feet. The upper 2,000 feet of the geological structure are the most important to area groundwater because of the freshwater-salt water interface. These deposits contain the Floridan aquifer that consists of the Ocala, Avon Park and Lake City formations. These are sedimentary formations deposited with the rise and fall of the ocean. Figures S-20 and S-21 present geologic cross sections of Orange County with associated water bearing characteristics of each formation.

The Floridan aquifer is overlain by a rather impervious layer of quartz sand, silt, clay, phosphatic limestone and sandstone. This layer has been termed the Hawthorne formation and tends to retard the vertical movement of water between the water table aquifer and the underlying Floridan systems. Formations that tend to inhibit or retard the vertical movement of water are called aquicludes or aquitards. The Hawthorne formation is thickest in the southeast portion of Orange County at approximately 300 feet, and thinnest in the northwest portion at approximately 50 feet. It is also important to note that the slope of the Hawthorne Formation is from west to east.

The intergranular pore space of sand and rock generally dictates the volume of water available. This is especially true in the unconsolidated surficial deposits. However, the intergranular pore space of limestone is generally zero because of the cemented nature of the rock. The capacity of limestone to store and yield water is due to karst processes that dissolve the limestone into a large interconnected network of channels and cavities. The creation of underground channels and cavities is similar to sinkhole formation. Sinkholes are formed by the solution of soluble, limestone rock by acidic water in the Hawthorne formation. The process is controlled by the circulation of water that is controlled by the rate of recharge, the rate of groundwater flow, and the changes in water table fluctuations. Sinkholes are most likely to form in areas of active groundwater recharge because the dissolving action of water is greatest as it first enters the ground. Karst processes are responsible for most of Orlando's lakes. The creation of sinkholes and other karst features create direct linkages between the surficial and confined aquifers. Filtration of pollutants is reduced because the filtering function of the overlying soil and rock is by-passed. In addition, the fissures and cavities can substantially change the localized flow patterns of the groundwater.

FIGURE S-20: GEOLOGIC CROSS SECTION OF ORANGE COUNTY



Source: USGS WRI 76-65

Source: Lichtler and Hughes, 1976.

6.B. AQUIFER SYSTEMS

If a groundwater body provides a good supply of water to wells, the soil or rock that contains the water is called an aquifer. Generally, an aquifer has three characteristics. It must have a fairly large volume in relation to the amounts that are being removed; its porosity should be moderate to high; and it should allow easy movement of water towards a well.

When groundwater is in direct vertical contact with the atmosphere through open pores of the aquifer, the aquifer is said to be unconfined (surficial) and the top of the groundwater is the water table. If the aquifer is overlain by an impervious layer, the aquifer is said to be confined.

It is saturated throughout its thickness and does not have a free water surface. Groundwater in a confined aquifer is under positive pressure, greater than atmospheric pressure.

This pressure is measured as the head or piezometric pressure and is the height to which water will rise in a pipe.

The collective height created by the piezometric pressure is called the piezometric surface. The pressure is created by recharge at a higher elevation than the strata confining the aquifer.

The geologic stratum through which water cannot move except at negligible rates is called an aquiclude. Some stratum allows more water than others but still retard the movement of water. These layers are called aquitards. Figure S-22 represents a generalized aquifer system with an unconfined and confined aquifer.

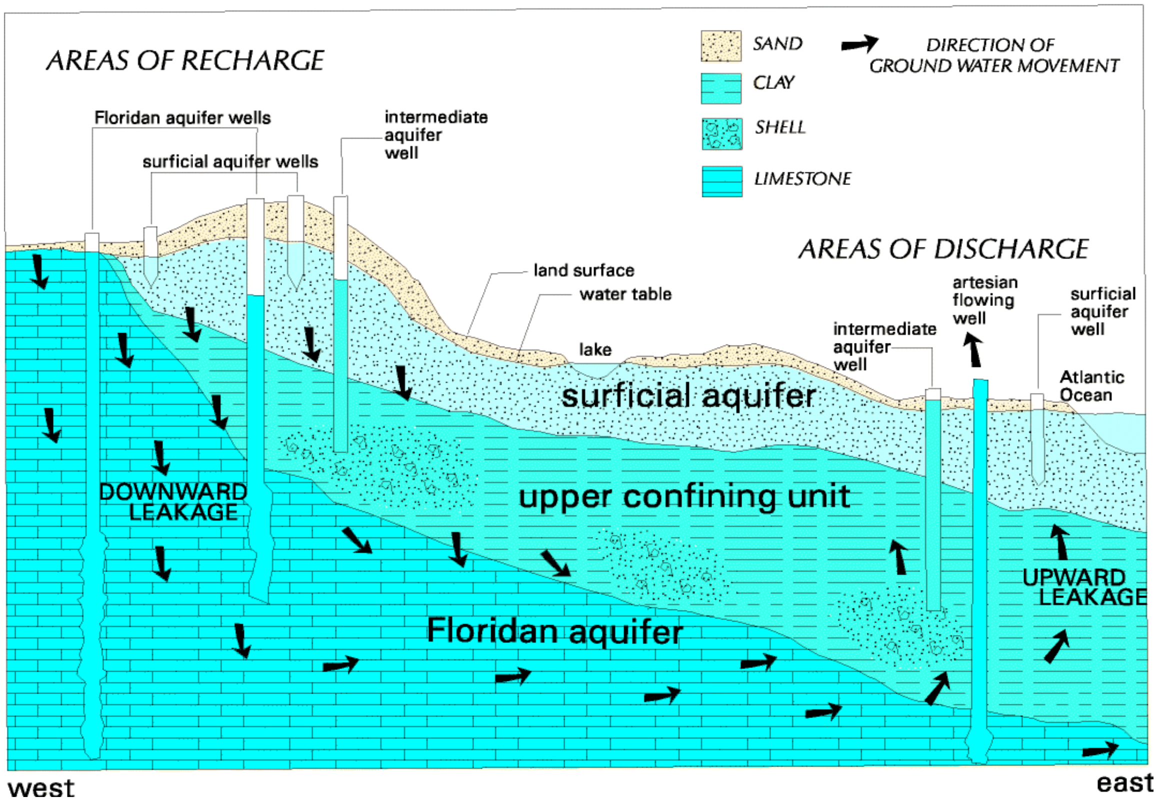
The aquifer system beneath Orlando is comprised of the unconfined surficial aquifer and the Floridan aquifer. The Floridan aquifer is composed of the Upper and the Lower aquifers. There also exists an intermediate aquifer, but it is of little consequence and will not be discussed.

FIGURE S-21: WATER BEARING CHARACTERISTICS

Aquifer/Formation	Rock Series	Thickness (in feet)	Description of Materials	Water Bearing Properties	Water Level
Surficial Aquifer Undifferentiated, non-artesian	Holocene to Pliocene	0-200	Mostly quartz sand with varying amounts of clay and shell	Varies widely in quantity and quality of water produced	0-20 feet below land surface
Hawthorn Formation Semi-permeable with some secondary artesian aquifers	Miocene	0-200	Gray-green, clayey, quartz sand and silt; phosphatic sand; lower section mostly buff, impure phosphatic limestone	Generally impermeable except for limestone, shell or gravel beds	Not applicable
Upper Florida Aquifer Avon Park Limestone Formation	Eocene	0-125	Cream to tan, fine, soft to medium hard, granular, porous, sometimes dolomitic limestone.	Moderately high transmissivity	Not applicable
Upper Florida Aquifer Avon Park Limestone Formation	Eocene	400-600	Upper section mostly cream to tan, granular, porous limestone. Lower section mostly dense, hard, brown crystalline dolomite	Overall transmissivity very high. Contains many interconnected solution cavities	Range in OUC wells from 40 to 43 feet MSL in 1989
Lower Floridan Aquifer Lake City Limestone Formation	Eocene	Over 700, total unknown	Dark brown crystalline layers of dolomite alternating with chalky fossiliferious layers of limestone	Similar to Avon Park Limestone	Not applicable

Source: Schiner and German, 1982.

FIGURE S-22: GENERALIZED AQUIFER SYSTEM



Source: SJRWMD, 1999.

The Unconfined Aquifer is composed of quartz sand with clay, hardpan and shell to a depth of 0' to 150'. The water table levels range from 0' to 20' below land surface except below sandhills in the western part of Orange County, where it may be deeper. Annual fluctuations range between 5' and 20'. In areas where the water table is at, or near the ground-level, flooding can easily occur. The water table reacts quickly to rainfall and drought. Recharge is from rainfall, upward leakage from confined aquifers, seepage from surficial waters and artificial recharge from irrigation and septic tanks. Discharge is through evapotranspiration, seepage from surface waters, pumpage and downward leakage. Evapotranspiration through the root zone of plants is appreciable. Wells yield between 5 and 10 gallons per minute (gpm) with maximum yields of 30 gpm. The surficial aquifer plays an important role in purifying surface water that percolates downward and recharges the lower aquifers. Surface runoff accumulates contaminants from roads, lawns and other land uses. Generally, the water contains high levels of iron and color.

The Floridan Aquifer is composed of the Upper and Lower zones. The upper zone is between 150' and 600' below land surface. The lower zone is between 1,100' and 1,500' below land surface. Both zones are composed of hard brown dolomitic limestone, or dolomite and relatively soft cream limestone. These limestones correspond to the Avon Park, Lake City, Ocala, Suwannee, Tampa and permeable parts of the Hawthorne formations. Figure S-20 shows the geologic structure of the aquifer. An outcrop of the upper zone generally occurs in a 50 mile wide band along the western gulf coast from Wakulla County to Hillsborough County.

The lithologic and hydrologic character of the Floridan aquifer is not uniform horizontally or vertically because of karst processes, bedding planes and fracture lines. Freshwater is available to approximately 2,000 feet below Orlando. The relative thickness of the freshwater aquifer generally declines to the east, until it reaches the St. Johns River. Groundwater flow is generally to the northeast, with piezometric highs in the Green Swamp area near the four corners of Orange, Osceola, Lake and Polk counties. Flow rates are measured in inches per year.

Average yields from wells vary between 1,000 gpm to 5,000 gpm, with drawdowns of 10' to 25' for 20" to 24" wells. Approximately 75% of all public supply wells are in the upper zone. The Orlando Utilities Commission and Winter Park are the primary users of the lower zone.

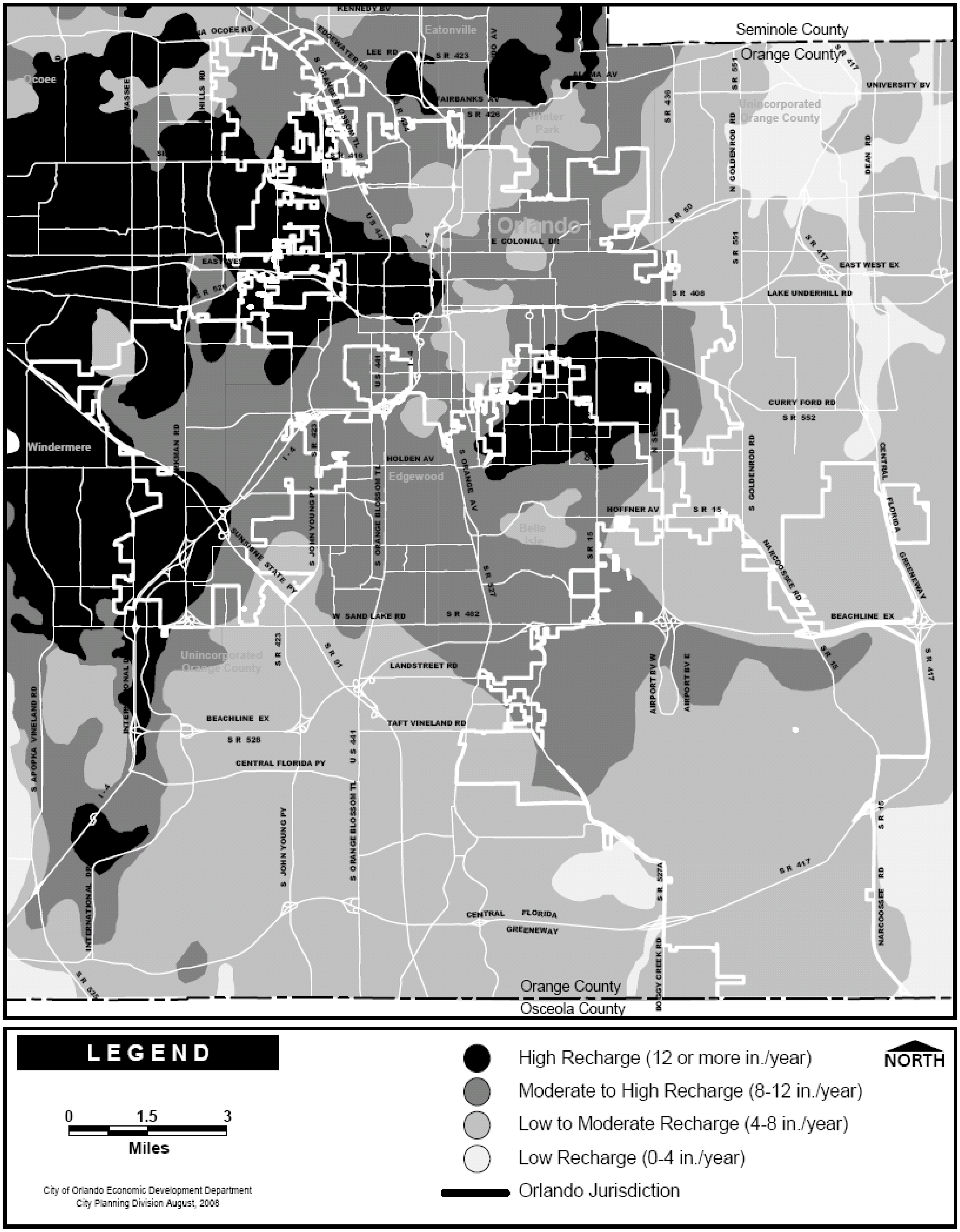
6.C. AQUIFER RECHARGE

To protect the future water supplies of the area, knowledge of recharge processes and recharge areas is necessary if development in Orange County is to be maintained. It has been estimated that of the 52" of annual rainfall in Orange County only 10% infiltrates into the ground. This amount equals approximately 210 million gallons per day (MGD) at an annual rate of 2" to 10" per year, depending upon soil conditions (Phelps, 1984). Figure S-23 represents recharge areas in the Orlando area.

Three factors are needed to ascertain the recharge potential of an area. The first is the altitude and configuration of the piezometric surface of the Floridan aquifer. This will indicate the direction of groundwater flow because water moves from areas of high to low piezometric surface. The second is the direction and magnitude of the hydraulic gradient between the water table and the piezometric surface. For recharge to occur, the upper Floridan aquifer must be lower than the water table. For recharge to the lower Floridan aquifer to occur, the piezometric surface of the upper Floridan must be higher than the lower Floridan. Depending on the levels of each aquifer, there will result either an upward or downward hydraulic gradient. The third factor is the thickness and permeability of the confining beds.

The permeability of the confining beds is referred to as the leakage coefficient and is a measure of the ability of the confining beds to transmit water to the main producing zone. There are two primary confining beds within the local aquifer system. The first is from 0' to 200' thick and is the most impermeable. The second is 600' to 1,100' below land surface and divides the two zones of the Floridan aquifer. This aquitard is semi-permeable and contains some water bearing layers that would be considered acceptable aquifers in many parts of the country (Lichtler, 1972).

Figure S-23 Aquifer Recharge Areas



Other factors that affect recharge are evapotranspiration, land use, soil, topography and drainwells. Drainwells are an important factor because surface water is directly injected into the upper Floridan aquifer, bypassing the filtrating capacity of the surficial and upper Floridan deposits. It has been estimated that 40% of the total aquifer recharge in the Orlando core area is from drainage wells (Schiner and German, 1982). Drainwells are responsible for the high recharge area delineation within the Orlando area. Recharge by drainwells produces local piezometric highs, which can offset local piezometric lows due to pumping.

Discharge is by groundwater outflow into Seminole and Brevard Counties; upward leakage into the St. Johns River, Wekiva and Rock Spring marshes; pumpage; and spring outflow. Under pre-development conditions (before drainwells and pumping), 28% of the total natural discharge from the Floridan Aquifer in Central Florida was by upward leakage and 69% was by springs (Phelps, 1984). Equilibrium was maintained between the two processes that maintained the hydraulic gradients. However, this equilibrium is constantly being unbalanced by new development, reducing the available recharge areas and increasing withdrawal by pumping. Thus, the level of the piezometric surface and the interrelationship of all three aquifers levels are important considerations in the management of Orlando's water resources.

<u>Piezometric Surfaces</u> are the best and easiest means of monitoring the impact of man and nature on the aquifers. Fluctuations in surface levels have a direct relation to the capacity of the aquifer, although the exact volume is not known. However, an overall trend indicates a lowering of the piezometric surface since 1945. There are statewide declines in the piezometric surface, although small, due to the results of rainfall shortages and increased demand in groundwater supplies (Barr, 1987).

Before urban and agricultural influences, the Floridan aquifer was in equilibrium: recharge equaled discharge. The average slope of the piezometric surface adjusted to the average recharge and average discharge. Water pumping, however, created a new discharge, which must be balanced by a reduction in natural discharge, or an increase in recharge, or a combination of the two to reach a new equilibrium. To reduce the natural discharge, the slope of the piezometric 1987 surface (hydraulic gradient) between the pumped area and the natural discharge area must be reduced so that less water flows to the discharge point. Drainage wells created new recharges that required additional balancing in the equilibrium. Lowering of the average piezometric surface is necessary if water removed from the aquifer is greater than the amount recharged.

When the piezometric surface in recharge areas is lowered, the hydraulic gradient between the water table becomes greater and recharge is increased, thereby salvaging water, which would normally flow off in streams or lost to evapotranspiration. However, increases to impervious land surfaces increase surface runoff and increased recharge may be lost or negligible. Drainage wells are used to offset this loss and explain the high recharge rate for the developed areas within Orlando. If pumping rates are stabilized, the piezometric surface will stabilize at a new equilibrium slope. A continual increase in pumping will result in a continual lowering of the average piezometric surface level (Lichtler, 1972).

The interrelationship between aquifers and surface waters is important in determining the recharge potential and the potential for contamination of the potable water supply. The magnitude of the hydraulic gradient determines the direction and rate of leakage between confined and unconfined aquifers and the quality of water entering the lower Floridan. Therefore, an understanding of the interrelationship of Orlando's aquifers with surface waters is necessary.

Lake level rises are caused by direct interception of rainfall, surface water inflow and groundwater inflow from surficial aquifers and upward leakage from confined aquifers. Declines are caused by evaporation, transpiration, positive surface outfalls and leakage at the lake bottoms. The magnitude of surface water fluctuations varies with storm events, size and slope of the basin and the permeability of the soil. The magnitude of groundwater fluctuations vary with differences in the lake levels and the aquifer levels and the hydraulic conductivity of the intervening soil and rock formations.

Studies have been conducted by USGS to evaluate the interrelationship between the aquifers in the Orlando area. These studies assumed that if the aquifers and the individual zones in the Floridan aquifer were separate, water levels would respond differently to hydrologic changes such as rainfall and pumping. Study results indicated that the hydraulic gradient between the water table level and the lake level increased during wet weather and the hydraulic gradient between lake levels and the confined aquifer decreased during wet weather. Thus, a direct link between lakes and the upper Floridan exists (Lichtler and Hughes, 1976).

Another study drilled a test well into the upper Floridan at Lake Adair, adjacent to an existing lower Floridan well. The upper zone well was cased to the top of the aquifer at 105' and bottomed to the top of the hard dolomite impermeable layer at 400'. The deep well was cased to 601' and bottomed at 1,281'. Both zones reacted rapidly to local rainfall. The magnitude and rate of change indicated that the zones were somewhat separated, but that all available evidence indicates that given time and pressure head differences, water would move from any part of the aquifer to any other part, carrying with it any soluble, long enduring pollutants it might contain. If heavy pumping creates a deep, permanent cone of depression in the lower zone and pollutants such as hard detergents are present in the upper zone, the pollutant will tend to migrate to the lower zone (Lichtler, 1972). A study by Schiner and German indicated that a natural downward hydraulic gradient from the upper zone is recharging the lower zone (1982).

Water Quality of the Floridan aquifer is more easily obtained where the water producing formations are higher in altitude and in, or near the recharge area. Geology is the major factor in determining the natural background water quality. Chemical quality varies laterally and with depth. As water percolates through the soil and rock layers, it dissolves the limestone and other mineral and organic constituents. Mineralization generally increases with depth and lateral movement to the east. The Upper zone has greater mineral water quality than the Lower zone. In Orange County, the chemical quality is generally good with < 150 mg/l of dissolved solids. Hydrogen sulfide is also present in the Floridan aquifer, but is readily removed. Salt concentrations also increase to the east because the freshwater lens approaches the surface near the St. Johns River.

The background water quality has been affected by the introduction of man-made pollutants. These include pesticides, herbicides, fertilizers, industrial and manufacturing wastes, road pollutants, which include heavy metals, grease and oil, and leachate from septic tanks and solid waste facilities. Gasoline from leaking underground storage tanks is also causing a significant pollution threat. The USGS has reported a toluene plume in the upper Floridan covering most of Downtown Orlando from an abandoned coal gasification plant. The contaminant was placed directly into the Upper zone through a drain well. Although the USGS reported that the Lower zone quality is not at risk, the above discussion shows that the concern for damage to the Lower zone is justified because of the leaky nature of the aquitard and the unpredictable direction of groundwater flow through the karst features. The nature and extent of drainage wells should be examined to understand the impact drainage wells have on the water quality of the aquifer.

6.D. DRAIN WELL POLLUTION

The earliest documentation of drainage wells in Orlando was at Lake Greenwood in 1904. The sinkhole became clogged and a considerable area in Southeast Orlando was flooded by heavy rains. Four wells were drilled and by 1907 the water level was almost back to normal. Drainage wells were then commonly used for drainage problems throughout the Orlando area. Their uses were expanded to drain land, control lake levels, drain wetlands and highways and to dispose of industrial, septic and municipal wastewater effluents.

Today, new drain wells are not allowed but the existing 250+ drain wells in the Orange County area are used for lake level control and to dispose of urban stormwater runoff. Approximately 50% dispose of street and impervious surface runoff, 35% control lake levels and the remaining dispose of cooling and air conditioning water. Ninety percent of the drainage wells in Orange County inject into the Upper Floridan Aquifer (100’-600’) and the remaining 10% inject into the Lower Floridan Aquifer. The filtering ability of the overburden is by-passed and the potential for concentrated quantities of contaminates is increased through drainage wells, especially those in the Lower Floridan.

An additional benefit of drainage wells is the compensation for heavy withdrawals from the Upper and Lower Floridan aquifers that maintains piezometric pressures and retards salt water intrusion. Data suggests that the high transmissivity of the aquifer will allow as much water to be accepted by gravity injection. Drainage well acceptance rates vary, depending upon the size and head pressure. Average rates range between 3,400 gpm to 9,500 gpm. Recharge from drainage wells is estimated at approximately 50 MGD because no appreciable cone of depression has formed due to withdrawals in the Orlando area (Schiner and German, 1982). Forty percent of the total aquifer recharge in Orange County is from drainage wells. However, the occurrence of drought conditions will unbalance the recharge - discharge relation.

The primary negative aspect of drainage wells is the potential for groundwater contamination. Under natural conditions, groundwater moves very slowly. However, when natural conditions are altered, as when a drain well builds a mound of water and pumping creates a cone of depression, the gradient between the two wells is steepened so that water moves rapidly from drainage well to supply well (Lichtler, 1972). Major factors which control the rate of water movement from drainage wells to supply wells include: distance between wells; rate of flow down the drainage well; pumpage rate of the supply well; relative depth intervals of the open hole parts of the two wells; permeability of the material between the wells; and relative orientation of the two wells.

Contamination from drain wells was documented as early as 1948 in a study of coliform contamination of a Live Oak, Florida supply well (Kimrey and Fayard, 1984). Another test done in 1961 indicated that contamination of supply wells by a salt test could occur within two to 18 hours.

A study by Schiner and German indicated that pollutants found in drainage wells were below State water quality standards (1982). In addition, the quality of supply well water was not appreciably affected by the proximity to drainage wells. Although contaminants were below water quality standards, it is important to consider that some contamination of the Lower aquifer existed. Six drainage wells and two supply wells were found to contain pesticides. The fact that pesticides, detergents and fecal bacterial contamination were found in supply wells must not go unnoticed.

Protection from further contamination must be implemented. Lower aquifer concentrations may be due to dilution by lakes and/or attenuation in the Upper aquifer. Localized water quality variation can also be explained by the number of drainage wells upgradient that are hydrologically connected, the variable nature of runoff (some wells receive runoff frequently, others seldom), types of land use, variations in hydraulic properties of the aquifer affecting rate and direction of flow and natural water quality of the aquifer.

In addition, many of the drainage wells are abandoned, or their locations are not known. Most of these wells were poorly constructed, badly cased, or have deteriorated over the years. This allows contaminated surficial aquifer water to drain to lower aquifers via the old well. Sand can also run into the drainage wells causing surface subsidence.

The City has taken the initial steps in studying the impact of drainage wells on the aquifer. In 1985, the City completed the “Drain Well Monitoring Plan”. The main purpose of this Plan was to address water quality entering drainage wells. The Plan classified drainage wells based upon lake pretreatment, no pretreatment, proximity to supply wells and land use. The City is continuing the water quality monitoring of selected drainage wells. In addition, the City in conjunction with Orange County, the Water Management Districts and the USGS initiated the “Drain Well Task Force”. The purpose of this task force was to study all drainage wells for impact to the aquifer and to suggest strategies for the most equitable remedial actions that would enhance groundwater quality, while protecting land uses from flooding. The task force is however no longer in existence. Instead, informal discussions between the agencies continue.

7. GROUNDWATER MANAGEMENT SYSTEM

A groundwater management system's purpose is to determine safe yields by controlling excessive withdrawals, and to reduce contamination. Since Orlando and the majority of Florida obtains potable water from the ground, it is important to have a sound groundwater management strategy. Unlike surface water, groundwater cannot be seen or smelled and therefore it is easy to overlook the need to protect the area's groundwater resources.

The interconnectedness of surface and ground waters is an important concept in the management of ground and surface waters. Water is stored in the ground until it resurfaces through seeps, lakes, rivers, springs and wells. The storage time varies from years to thousands of years, but eventually returns to participate in the earth's hydrologic cycle. The surface water will eventually evaporate and return to the surface as rainfall, where some will infiltrate back into the aquifer, or produce runoff to repeat the cycle. As with surface water, development has the ability to impact and alter natural processes affecting groundwater.

7.A. IMPACT OF LAND DEVELOPMENT

Urbanization has greatly influenced the amount of aquifer recharge in the Orlando area. Development increases the amount of impervious surface and alters the natural drainage patterns. This decreases the amount of water that can infiltrate into the ground and actually removes water from the area through improved surface drainage. On the other hand, Orlando uses drainage wells to inject water directly into the upper Floridan aquifer. It has been estimated that drainwells are responsible for the high recharge classification for the Downtown area and for 40% of all recharge in Orange County. Recharge is also accomplished through the disposal of reclaimed wastewater. The Conserv II project is a joint venture between the City and Orange County. Approximately 44 MGD of advanced treated wastewater is disposed to the west of Orlando in the prime aquifer recharge areas. Additional recharge, by using wastewater effluent may be a possible solution to postpone the adverse impact of excessive withdrawals of the aquifer.

Aquifer levels are further impacted by water withdrawals for domestic, industrial, agricultural and recreational uses. In many areas of the country, withdrawals of groundwater exceed the recharge rate because of excessive withdrawals. The capacity of the Floridan aquifer has not been established. The surface level of the aquifer is monitored by the Orlando Utilities Commission (OUC) to ascertain the impacts of withdrawal on the aquifer level. This is an indirect measure of the capacity of the aquifer. Rainfall is also monitored, as this directly affects the recharge.

As of 2008, the OUC had a Consumptive Use Permit (CUP) allowing the withdrawal of up to 101.4 million gallons per day (MGD) from the aquifer for potable uses. The OUC service area encompasses approximately 200 square miles and includes the City of Orlando, Edgewood, Belle Isle and portions of Unincorporated Orange County, with a total service population of approximately 400,000 residents. OUC's current demand is less than the CUP allocation. The average daily demand is projected to increase to 131.6 MGD by the year 2023; however the

2013 CUP withdrawl limit will not be increased in future years, even if demand increases. Many other jurisdictions also depend upon the aquifer for drinking water and the total impact from the cumulative withdrawals is not known. However, when the projected demand for water exceeds recharge, the aquifer storage capacity is reduced and impacts will be increased. These impacts may not be immediately felt by Orlando. Impacts will be felt first by eastern communities manifested by salty wells. Salt water intrusion has been reported in Christmas and Mims, Florida.

Individual land uses increase the potential for groundwater contamination. All developed land uses create pollution, but not to the same extent. Residential land uses provide fertilizer and organic compounds to runoff. Commercial land uses increase the concentration of oil, greases and heavy metals because of parking lot runoff. Industrial and manufacturing land uses can create a myriad of hazardous wastes, which if not properly disposed, can create substantial pollution problems. Those land uses located within the high recharge area have a greater chance of polluting the aquifer than those located in low recharge or discharge areas. Land uses near or within the same drainage basin as lakes and drainage wells also have high potential for contamination. Although those drainage basins that discharge into lakes can use the lakes for dilution, this has detrimental impacts to the surface water body. Major transportation corridors, such as Interstate highways and railroads, should be of major concern. Large amounts of hazardous materials travel though Orlando on a daily basis. A chemical spill containing Diazinon and Diurban closed I-4 for over two hours in 1983. The spill required 15 firefighters with oxygen tanks and masks to contain the chemical (Sentinel Star, 1987). Fuel spills are also frequent occurrences on roadways and development sites.

Water conservation and reuse can be an effective method in reducing the impact of land development. Improving water efficiency and reducing demand will reduce the amount of withdrawal from the aquifer. This will prolong the detrimental impacts of excessive water withdrawals. The Potable Water Element covers water conservation in more detail.

7.B. IMPROVEMENTS TO GROUNDWATER RECHARGE

Groundwater can be improved by concentrating on three areas: control of surface water runoff; potable water well head protection; and drainage wells. The City has established a Stormwater Utility to provide a constant and consistent source of funds for surface water improvement and maintenance. The ESM requires that the first flush of runoff be retained. This requirement enhances recharge potential and prevents contaminants from entering lakes and drainage wells. Pollutants that affect health include nitrates, sodium, and coliform bacteria. Significant reductions in phosphorus and nitrogen loading can be achieved through retrofitting of existing stormwater systems with retention ponds. Retention ponds would also act as barriers to heavy metal and hazardous material spills. Surface waters and groundwater should display better water quality as a result of such retrofitting.

Supply wells need added protection from possible contamination because of the localized piezometric head reductions. This creates downward hydraulic gradients conducive to transporting contaminated water to the aquifer. The complex nature of the Floridan aquifer system reduces the probability of this occurring. Construction of supply wells is similar to that of drainage wells and they are prone to deterioration. Seepage into the well from the surficial and upper Floridan can introduce contaminants without having to infiltrate into the lower aquifer. OUC wells are usually located within the water plant compound that offers two or three hundred foot buffers to other land uses. This is not necessarily the case in the older plants, especially Highland Avenue. The cone of depression has been estimated to be within a 500' radius of the well, more for multiple wells, although total impact from pumping can be detected for several miles. Land uses should be examined within a 1,000' diameter to minimize the chances of accidental contamination. OUC has an ongoing program to inspect supply well casings with TV cameras, to insure integrity of the casings.

The Safe Drinking Water Act requires EPA to develop and publish regulations on minimum requirements to prevent underground injection that may endanger underground sources of drinking water. FDEP has been delegated the State lead agency in the administration of this act in Florida. Chapter 62, F.A.C., contains the State's responses to the Federal Act. These rules set water quality standards for the design and installation of wells. The City has established a continuous program for taking corrective action to close some wells, re-route stormwater into existing conveyance systems, or pre-treat runoff going into drainage wells found to be indispensable in stormwater management. Remedial action should be implemented on a priority basis. Factors to be considered in the prioritization of drainage wells should include penetration into the Lower Floridan aquifer; location in relation to supply wells; the percentage of basins accepting road drainage; use for lake level control; hydraulic gradients; and land uses within drainage basins.

7.C. SAFE YIELD

The safe yield of an aquifer can be developed to indicate the volume of water that can be pumped without the creation of serious water problems. The determination of a sustained aquifer yield is dependent upon the volume of water that can be feasibly extracted from the hydrologic cycle.

A reliable estimate can be accomplished through a water budget analysis. Water budgets or balances are useful in computing:

1) Seasonal and geographical irrigation demand;

2) Soil moisture stresses under which vegetation can survive;

3) Prediction of stream flow and water table elevation; and

4) The economic and ecological feasibility of various schemes for using or manipulating land and water resources (Dunne and Leopold, 1978). Water budgets are good only for long term calculations because of the seasonal variation in rainfall.

Two assumptions are necessary in the determination of a water budget. The first is that all water losses must equal the amount of water that enters the aquifer through recharge or subsurface inflow. Second, that the increased water use or other losses must in the long run be offset by increased recharge or increased inflow. Failure to balance the water budget will result in a loss of storage and pressure which must be equaled somewhere in the system, usually by saltwater intrusion. Consumptive losses are accumulated downgradient and effect a permanent decrease in the dependable water supply (Clark, Veissman, and Hammer, 1977).

A water budget for a localized groundwater flow can be computed using the following formula:

Recharge + Groundwater Inflow = Discharge + Groundwater Outflow + Well Withdrawal

It can be assumed that when well withdrawals equal or exceed recharge, piezometric surface decreases will result. Inflow has been estimated to account for approximately 9% (Lichtler, 1972) of the total recharge and although this percentage is a large amount of water, it is not significant in augmenting water supplies. Since the water balance assumes that recharge must equal discharge, groundwater outflow and other discharges will further reduce the component of recharge that is available for consumptive uses. In addition, urban activities that divert water from recharging the aquifer further reduce the availability of water.

The Floridan aquifer has a large storage capacity although the exact volume is not known. The impact of water withdrawal has shown a long term trend of aquifer level reductions in the Orange County area. Although impacts are not affecting Orlando water users, their demands, when combined with other aquifer users create effects that are being felt downgradient, manifested as salt water intrusion, increased sinkhole activity and reduced spring flow. Orlando has a responsibility to reduce its impacts to the aquifer and to those communities that are affected, just as Orlando has a responsibility to reduce surface water impacts.

Comparison of the estimated recharge to anticipated water demands can result in projection of when water withdrawals will exceed recharge and create a negative draft upon the Floridan Aquifer. The Potable Water Element presents the projected water demand for the major water utilities in Orange County. Agricultural consumption hastens the depletion and once the effective recharge of the aquifer is consumed, demand along with natural discharge, will consume the storage capacity of the aquifer. This will result in larger downward hydraulic gradients carrying contaminants and possible salt water intrusion from deep salt water sources in the Orlando area. Long term declines in the potentiometric surface have been shown to be already occurring.

The foregoing analysis outlines the impacts of continued growth in Orlando and the Central Florida area on local water resources. Orlando is in a position to take positive action to alleviate and forestall impacts from depletion of water resources. Water conservation methods should be employed to increase the efficiency of water use, reduce water demand, increase recharge and improve water quality. Several alternatives to meet these ends have been outlined in this Element and the Wastewater and Potable Water Elements. Reclaimed water from the wastewater system should be expanded to increase aquifer recharge and reduce withdrawals.

Surface water quality should be improved and direct contamination of groundwaters eliminated, as much as possible. Individual consumption should be reduced by using water-efficient appliances. By making intelligent, long range decisions on the efficient use of Orlando's water resources, the City of Orlando may not be faced with the need for emergency actions.

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