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WATER SUPPLY NEEDS AND SOURCES ASSESSMENT ALTERNATIVE WATER SUPPLY STRATEGIES INVESTIGATION ARTIFICIAL RECHARGE OF THE FLORIDAN AQUIFER THROUGH DRAINAGE OR INJECTION WELLS IN ORANGE AND SEMINOLE COUNTIES

by

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EXECUTIVE SUMMARY

Drainage wells have been in use in Orange and Seminole counties since 1905. Their primary purpose is to provide surface drainage and to prevent flooding in closed surface basins. Most study area drainage wells provide either direct street and urban drainage or lake-level control. Drainage wells also provide important artificial recharge of the Upper Floridan aquifer.

In addition to drainage, several water resources management issues are important, such as the quantity and quality of aquifer recharge, the potential for aquifer contamination, and protection of the aquifer from brackish water intrusion. These issues are directly related to long-term water supply planning and development.

Drainage wells have benefits and associated risks. Given that the drainage benefits are well known, the focus of this investigation is on the following issues:

- Quantity and quality of surface water recharge
- Regulatory framework governing the construction and operation of drainage and injection wells
- Stormwater management and treatment options for improving the quality of the emplaced surface water
- The potential for increased artificial recharge using additional drainage or injection wells

These issues are important considerations in the comprehensive management of study area water resources.

SOURCES OF INFORMATION

This evaluation is based on an analysis of existing information. A literature review was conducted to develop an overall understanding of the use of drainage wells, both locally and nationally. Available local drainage well and water quality information were also compiled and used to develop quantitative estimates of current and potential future recharge.

Data of interest include drainage well characteristics, recharge water quality data, and watershed characteristics. Available data were assembled from a variety of sources, such as the U.S. Geological

Survey and local drainage well owners for the desired drainage well characteristics, existing literature and local municipal agencies for stormwater runoff and lake water quality characteristics, and available mapping for general characteristics of the major watersheds in Orange and Seminole counties.

ARTIFICIAL RECHARGE ESTIMATES

Currently known operational street and urban drainage wells serve approximately 5.1 square miles of highly developed urban area. These wells provide about 7.1 million gallons per day (mgd) of artificial recharge. Known operational lake-level control wells serve approximately 51.2 square miles of lake and tributary area and provide about 29.1 to 40.5 mgd of artificial recharge.

Total study area artificial recharge through the use of drainage wells is estimated to range from about 39.4 to 51.6 mgd. This estimate includes the above known operational wells, plus an allowance for additional wells that are likely to be operational. This estimate is in substantial agreement with recharge estimates developed in the past, which have generally ranged from 35 to 50 mgd.

Only about 5 percent of the total study area in Orange and Seminole counties is served by drainage wells. In addition, only about 13 percent of the 590 lakes located in Orange County are equipped with lake-level control wells. Therefore, the potential to increase artificial recharge using additional drainage or injection wells exists. However, it is likely that appropriate application would limit the volume of additional recharge to no more than about 10 percent of the areawide surface runoff, or about 66 mgd. This additional potential artificial recharge could more than double the recharge currently developed by study area drainage wells.

RECHARGE WATER QUALITY

Street, urban drainage, and lake-level control wells in operation today emplace stormwater and lake water contaminants into the aquifer. Lake water is of generally higher quality than direct urban runoff, and total coliform is the major constituent of concern. In lake water, primary drinking water standards, except for total coliform, are met in most circumstances.

In addition to total coliform, direct street runoff occasionally contains other constituents, including lead and cadmium, in excess of the primary Drinking Water Standards (DWSs). Because street runoff enters the well and aquifer directly and rapidly, the potential for aquifer contamination from accidental spills is much higher than for lake-level control wells.

In general, for all study area drainage wells, one or more primary DWSs are not met at the point of entry into the aquifer. It is likely that the total coliform DWS is always exceeded and has been for over 90 years. However, there is no documented evidence of significant aquifer contamination caused by recent drainage well operations in Orange or Seminole counties.

DRAINAGE WELL MANAGEMENT OPTIONS

Management of artificial recharge using drainage wells is governed by existing state and federal underground injection control programs. Application of existing drainage well regulations and policy result in a status quo situation. Existing wells are grandfathered under current law and policy, while new wells are nearly impossible to construct. Current regulations require that all primary and secondary drinking water standards be met before artificial recharge water can be emplaced in the aquifer. This criteria is nearly impossible and economically unfeasible to meet in urban drainage and lake-level control applications. Thus, the net effect of current policy is little or no improvement in aquifer recharge quantity or quality.

Current drainage well regulations and policy do not encourage comprehensive water resources management, which would include reducing the quantity of pollutants entering the Upper Floridan aquifer, increasing beneficial aquifer recharge, and providing cost-effective treatment of surface recharge waters.

Study area drainage wells provide important benefits, in addition to surface drainage. These include reduction of the hydrologic impact of water supply withdrawals, contribution to local springflow, and protection from potential saltwater intrusion. These benefits are not recognized under current drainage well regulations and policy.

There is no doubt that the existing artificial recharge provided by local drainage wells is hydrologically important. Previous studies have estimated that this existing recharge increases the Floridan aquifer potentiometric surface by as much as 4 feet on the average. As water supply demands increase in the future, this existing recharge will become increasingly important and alternatives to increase the existing recharge rate will need to be investigated and evaluated.

An alternative drainage well management approach that should be considered by water resources managers and regulatory agencies is based on net incremental improvements. The objective of this approach is to permit improvements that provide a net benefit to the aquifer. Benefits should be defined in terms of increased recharge without increasing aquifer pollutant loadings, or reduced existing pollutant loadings.

RECOMMENDATIONS

Drainage or artificial recharge injection wells should be recognized as a technology useful for total water resources management, including management of the Floridan aquifer and urban drainage and flood control. This technology has both advantages and disadvantages, and should be used when the advantages outweigh the disadvantages.

Existing regulations and policy should be revised to encourage net improvements in recharge water quality and increased recharge volume using drainage or injection wells. Net improvement would involve increased aquifer recharge or decreased aquifer pollutant loadings, or both. In this manner, incremental improvements, including artificial recharge, can be achieved even though all DWSs will not be met by the recharge water.

CONTENTS

CONTENTS (CONTINUED)

FIGURES

TABLES

INTRODUCTION

Public water supply within the St. Johns River Water Management District (SJRWMD) is generally provided by high quality ground water. Several characteristics of SJRWMD's ground water resources make potable ground water the supply source of choice. First, ground water is inherently reliable—an important attribute for public water supply. Second, treatment requirements and cost are often minimal because of the generally good quality of the raw ground water. Third, if the resource is developed and managed properly, the quality of the raw ground water remains stable.

To date, high quality, reliable, and inexpensive public water supplies have been developed within SJRWMD from ground water sources. However, the District is concerned that it may not be possible to meet future public water supply needs through the increased use of ground water resources without incurring unacceptable environmental impacts. Therefore, the District has initiated an investigation of the feasibility of several alternative water supply strategies.

PROJECT BACKGROUND

The District previously evaluated the potential impact of increased ground water withdrawal through the year 2010 (Vergara, 1994). The results of this evaluation indicated areas where water supply problems are critical or are expected to become critical. An increase in ground water withdrawals could adversely impact area water resources, affecting natural systems, ground water quality, and existing legal users. These areas of concern are known as the priority Water Resource Caution Areas.

For this reason, the District has undertaken a program to investigate the technical, environmental, and economic feasibility of alternative water supply strategies as a means of mitigating existing impacts and preventing projected adverse impacts. The program includes investigations conducted by District staff and several consultants, including CH2M HILL.

Figure 1 illustrates the water supply options being considered by SJRWMD. Major options include increased supply, reduced demand, and increased system storage to better manage existing supplies. For areas of critical concern, increased supply options could include

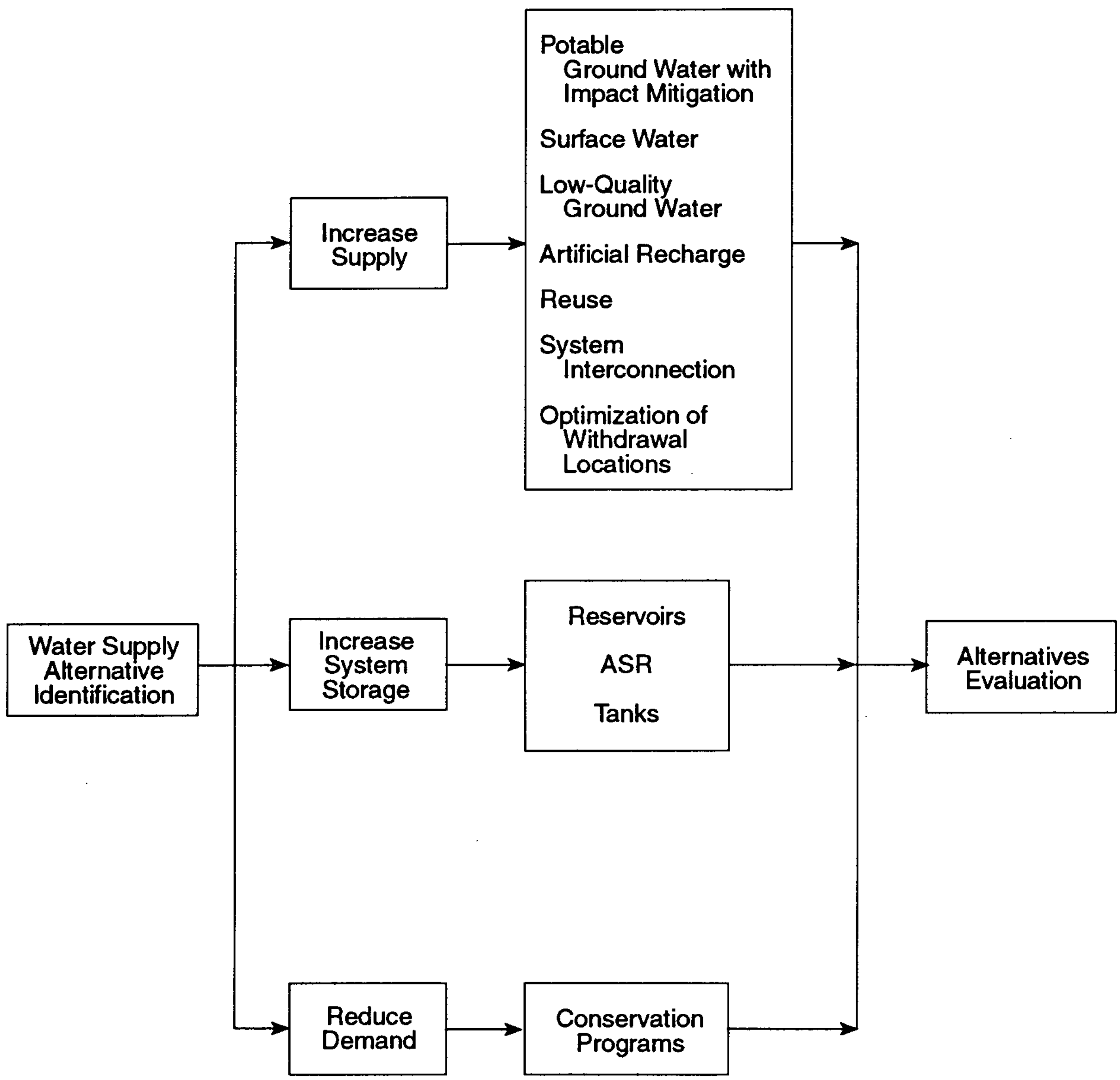

Figure 1. Water Supply Development Options for the SJRWMD.

developing one or more of the following potential water supply sources:

- Potable ground water, with mitigation of adverse impacts
- Surface water
- Brackish ground water
- Artificial recharge
- Reuse of reclaimed water
- Water supply systems interconnection
- Optimization of ground water withdrawal locations

Increased system storage could include the use of reservoirs, aquifer storage recovery (ASR) facilities, or ground storage tanks. Demand reduction may be achieved by implementing various water conservation initiatives. In many cases, a combination of increased supply, increased system storage, and demand reduction may provide the most environmentally acceptable, cost-effective future water supply systems.

This project is one of several tasks being performed by CH2M HILL pursuant to its contract with SJRWMD (Contract No. 95W166A) related to the alternative water supply strategy investigation. The investigation includes the evaluation of the following water supply sources or water management techniques, collectively referred to as *alternative water supply strategies*:

- Surface water supply development
- ASR
- Development of brackish ground water sources
- Mitigation and avoidance of the impacts associated with ground water withdrawal
- Artificial recharge using drainage or injection wells

PURPOSE AND SCOPE

This technical memorandum (TM) provides a preliminary investigation of artificial recharge using drainage or injection wells. The primary purpose of this investigation is to evaluate the feasibility of artificially recharging the Floridan aquifer system through drainage and injection wells in Orange and Seminole counties.

Drainage wells have been used in both these counties since early this century; however, this TM focuses on current practices, including state and federal regulations. Also in this TM, the quantity and quality of the recharge water emplaced in drainage wells is assessed, as is the potential for increasing both the quantity and quality of the recharged waters to enhance or preserve planning area water supplies. TM F.1.e also has the following specific objectives:

- Develop an estimate of the annual volume of surface water being recharged to the Floridan aquifer through drainage wells within the study area.
- Develop an estimate of the annual volume and location and distribution of additional surface water that could be recharged to the Floridan aquifer through new drainage and injection wells.
- Characterize the quality of the surface water entering drainage wells within the study area.
- Review state and federal regulations applicable to drainage and injection well construction and operation.
- Identify the treatment requirements associated with increasing the amount of surface water recharged to the Floridan aquifer through new drainage and injection wells.

DEFINITION OF DRAINAGE AND INJECTION WELLS

In the study area located within Orange and Seminole counties, drainage wells generally connect a surface water feature with the Upper Floridan aquifer. The primary purpose of the drainage wells is to provide surface drainage and prevent flooding in closed surface basins.

Drainage wells operate by gravity and are technically feasible in areas where the surface water elevation is greater than the potentiometric elevation of a transmissive receiving aquifer. These conditions exist throughout much of the developed portions of the study area, including Orlando. In areas where the aquifer potentiometric elevation is above ground surface, gravity drainage wells are technically infeasible. However, surface water could still be emplaced in the aquifer using an injection well, which relies on pumping to overcome the adverse head differential.

Drainage wells and injection wells differ in that injection wells require pumping, while drainage wells operate using gravity. Injection wells are not often used in surface water drainage applications because of the added expense of pumping facilities and the risk of failure associated with pump or power supply malfunctions.

Figure 2 (Bradner 1991), which is a generalized hydrogeologic section of the study area, illustrates the general geology of the Orlando area, including the Upper Floridan aquifer, the Lower Floridan aquifer, and the middle semi-confining unit. The figure also shows a lake with natural recharge to the Upper Floridan aquifer, and a drainage well that provides lake-level control and additional recharge of the Upper Floridan aquifer. Public water supply wells from both the upper and Lower Floridan aquifers are also illustrated in Figure 2.

The surface water source for a drainage well can be direct surface runoff, such as street or urban drainage, or indirect surface runoff, such as a lake, stormwater detention pond, or wetland outflow. By far, the most common existing drainage well applications within the study area are street drainage and lake-level control. Figure 3 (Dyer, Riddle, Mills, & Precourt 1984) illustrates a typical street or urban area drainage well installation with connecting inlets. In this application, surface runoff is discharged directly into the aquifer during and immediately after storm events.

Figure 4 (Mcbee 1985) illustrates a typical drainage well installed for the purpose of lake-level control. In this application, the lake must fill to the weir inlet elevation before water enters the drainage well.

DRAINAGE WELL ISSUES

Drainage wells in the study area are used to provide urban drainage and flood control, primarily within closed drainage basins. Therefore, drainage and flood control is, and always will be, a major issue for local drainage well owners and state and regional water resource managers.

However, other water resources management issues related to drainage wells are also important, such as the quantity and quality of aquifer recharge, the potential for aquifer contamination, and protection of the aquifer from brackish water upconing.

Drainage wells have benefits and associated risks. Given that the drainage benefits of drainage wells are well known, this investigation

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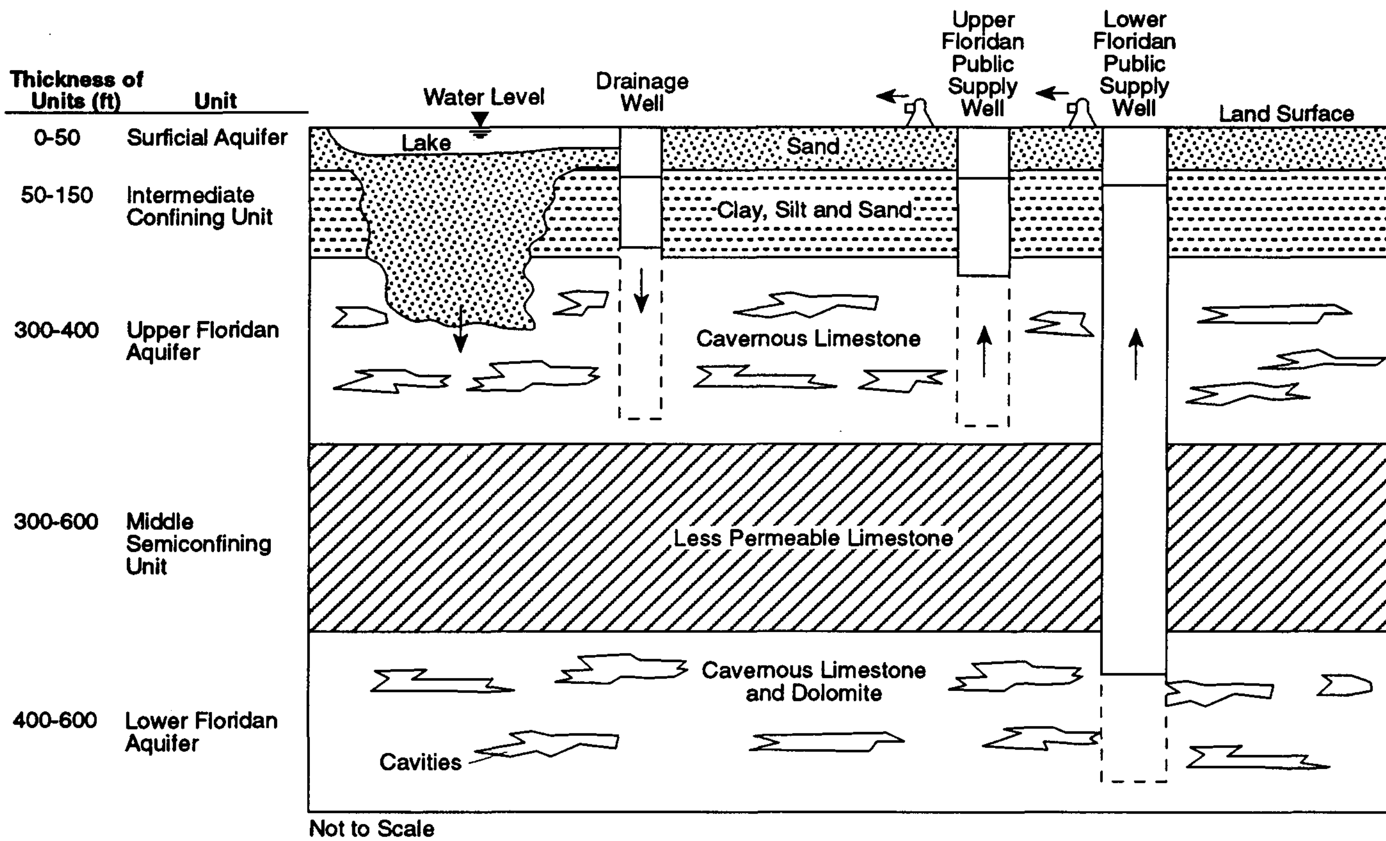

Figure 2. Generalized Hydrogeologic Section in the Orlando Area (After Bradner 1991).

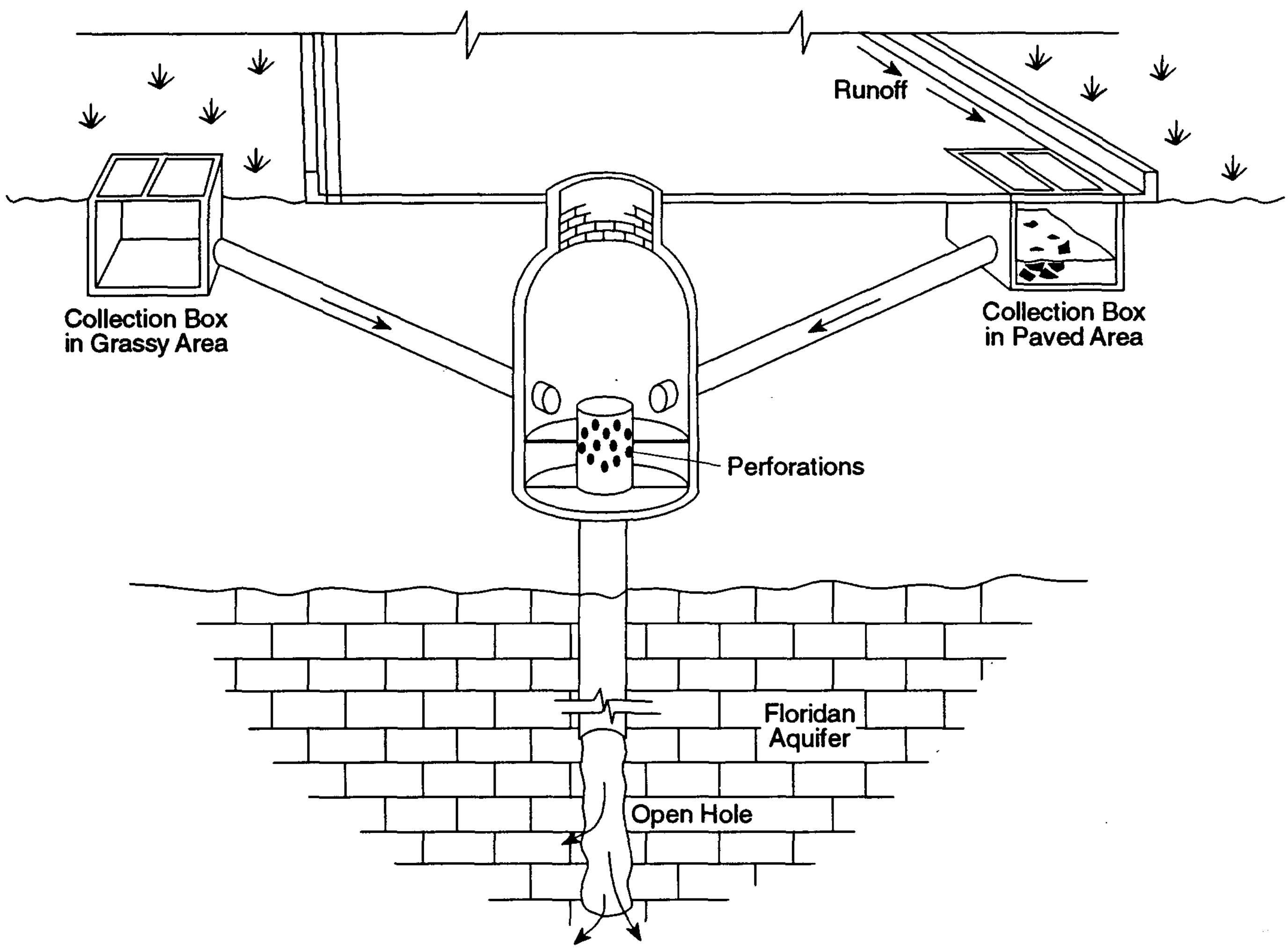

Figure 3. Storm Sewer Drainage Well with Connecting Inlets (After Dyer, Riddle, Mills & Precourt 1984).

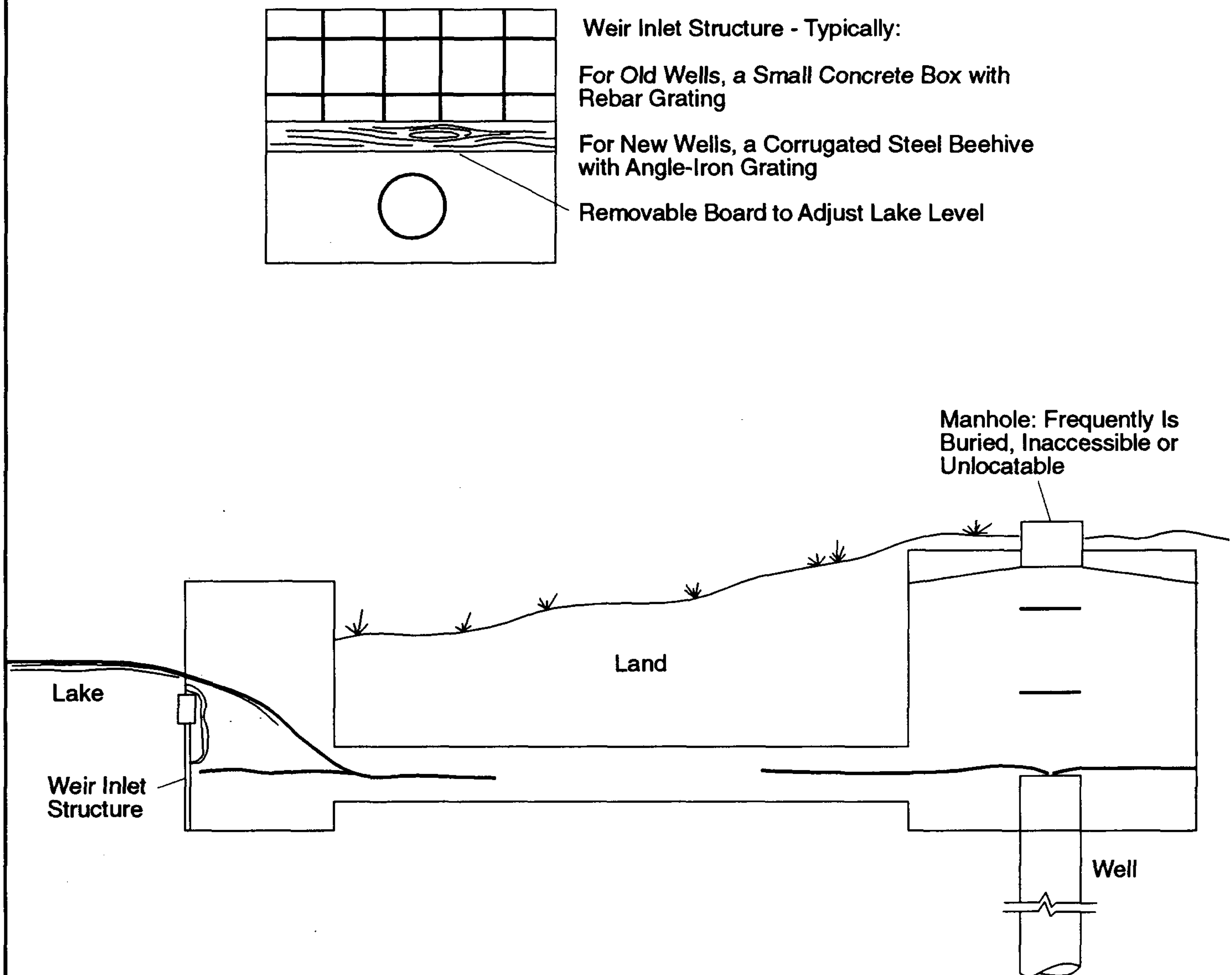

Figure 4. Typical Lake Control Drainage Well (After Mcbee 1985).

focuses on the quantity and quality of surface water recharge, the regulatory framework governing the construction and operation of drainage and injection wells, management and treatment options for improving the quality of the emplaced surface water, and the potential for increased artificial recharge using additional drainage or injection wells.

METHODS

This evaluation of artificial recharge using drainage and injection wells is based on the analysis of existing information. A literature review was conducted to develop an understanding of the use of drainage wells, both locally and nationally. Available local drainage well and water quality information were also compiled and used to develop quantitative estimates of current and potential future recharge.

LITERATURE REVIEW

An extensive literature review was conducted as part of this investigation. References of interest included publications on drainage wells, the geology and hydrology of Orange and Seminole counties, runoff water quality, lake water quality, stormwater treatment technologies, and regulations, including the Underground Injection Control (UIC) Program and recharge water quality criteria. All the literature included in the review is listed in the bibliography section of this TM. Where appropriate, specific references are cited in the text.

DATA SOURCES

Data of interest include drainage well characteristics, recharge water quality data, and watershed characteristics. Information on each data category is necessary to achieve the objectives of this investigation. Available data were assembled from a variety of sources, such as the U.S. Geological Survey (USGS) and local drainage well owners for the desired drainage well characteristics; existing literature and local municipal agencies for stormwater runoff and lake water quality characteristics; and available mapping, including the District's geographic information system (GIS) data base to obtain general characteristics of major Orange and Seminole county watersheds.

Drainage Well Data Base

Drainage well information of interest includes ownership, location, well size and depth, current operational status, recharge water source, tributary area characteristics, and flood elevations. Development of the drainage well data base involved a sequence of several steps. First, an overall inventory of drainage wells located in Orange and Seminole counties was obtained from USGS. The USGS inventory provided a listing of 398 drainage wells, with information on well location, ownership, and selected well characteristics.

This inventory was then used to formulate a request for additional or updated information from the major drainage well owners. The objective was to enhance the original USGS inventory using recent information compiled by municipal owners. Only data pertinent to the objectives of this investigation were requested. Once responses from the drainage well owners were received, the original USGS inventory was modified, resulting in the updated data base. This effort is described in greater detail in the subsection, Drainage Well Data Base, later in this TM.

Recharge Water Quality Data Base

Drainage well recharge water generally consists of two types: urban drainage, including direct street runoff, and lake water. The characteristics of urban drainage are well defined in the literature, and literature values were used to quantify direct urban runoff recharge water quality. Lake water is generally of better quality than direct urban runoff. Lake water characteristics were evaluated by analyzing ambient water quality monitoring data. These data were provided by the Orange County Environmental Protection Department.

Watershed Characteristics

Characteristics of the area tributary to existing drainage wells were requested as part of the drainage well data base development effort. Also, the general hydrologic characteristics of the major drainage basins in Orange and Seminole counties are important to establish total areawide runoff estimates. The basin-wide runoff estimates can be used to calculate the fraction of surface water resources being recharged by drainage wells and the potential for increasing recharge by major drainage basins. The hydrologic characteristics of interest in the major drainage basins include general land use and soil type, topography, and Floridan aquifer potentiometric surface. This information was extracted from existing mapping, including the District's GIS data base.

RECHARGE ESTIMATES

Recharge estimates are based on characteristics of the drainage well tributary area. Generally, two types of drainage wells are considered: street/urban drainage and lake-level control. Development of annual recharge estimates for street and urban drainage wells is relatively straightforward. These wells provide drainage for direct surface runoff, with the annual recharge volume equal to the annual runoff volume generated by the drainage well tributary area.

Lake recharge is more complex to estimate. Lake inflow may include surface runoff from the lake tributary area, overflow from upstream basins, direct rainfall on the lake surface, and, potentially, other sources of inflow, including irrigation water and septic seepage. Lake outflow may include lake evaporation, natural seepage or aquifer recharge through the lake bottom, and drainage well recharge and outflow to downstream basins. Each lake behaves in a unique manner, depending on the relative importance of each parameter in the water balance. Therefore, developing areawide lake drainage well recharge estimates on the basis of existing information is difficult and uncertain.

Bradner (1996) developed site-specific recharge estimates for selected drainage wells in Orange county, including several lake drainage systems. These estimates are used as much as possible to develop areawide estimates of lake recharge in this investigation.

REGULATORY REVIEW

Drainage wells are regulated by both federal and state agencies as part of the UIC Program. Under this program, drainage wells are considered Class V injection wells. Typically, Class V wells are used to inject nonhazardous fluids into or above underground sources of drinking water. Nationwide, there are approximately 170,000 inventoried Class V wells, consisting of more than 30 different types and including surface water drainage wells (Klemt 1987).

The laws and regulations governing the use and management of drainage wells are reviewed and summarized in this investigation.

LITERATURE REVIEW

An extensive review of the literature pertaining to drainage wells in the Orlando area has been prepared by Mcbee (1985). Mcbee presents an informative chronological discussion of all significant reports and investigations dealing with drainage wells in central Florida. A summary of the history of these drainage wells and the most significant literature is presented below. Mcbee's work is recommended to readers with additional interest in the history of drainage wells in central Florida.

Drainage wells provide an important water resources management option in Orange and Seminole counties. To fully understand the existing and potential future role of drainage wells in central Florida, knowledge of their development and usage and comparison of this information with a national perspective is necessary. The purpose of this literature review is to provide both a national overview and regional understanding.

NATIONAL OVERVIEW

Drainage wells are used in 38 states and are one subclass of Class V injection wells addressed in federal and state UIC programs. In the national UIC program, the following five classifications of wells are defined (Council and Fryberger, 1987).

- Class I wells inject hazardous and nonhazardous waste beneath the lowermost formation containing, within one-quarter mile, an underground source of drinking water (USDW).
- Class II wells are used in conjunction with oil and gas production, primarily to inject salt water.
- Class III wells are used in conjunction with the solution mining of minerals.
- Class IV wells inject hazardous or radioactive waste into or above a formation within one-quarter mile of a USDW.
- Class V wells include wells not included in the above four classes.

There are more than 30 subclasses of Class V wells identified in the national UIC program. Two subclasses, stormwater drainage wells (subclass 5D2) and special drainage wells (subclass 5G30), are of direct interest to this investigation. Stormwater drainage wells receive direct surface runoff from paved areas. Special drainage wells include drainage wells for landslide control, potable water tank overflow, swimming pool drainage, lake-level control, and municipal and construction dewatering.

Other Class V wells similar to the urban stormwater and lake-level control drainage wells used in Orange and Seminole counties include agricultural drainage wells (5A8), improved sinkholes (5D3), heat pump/air conditioning return flow (5A7), and artificial recharge wells (5R21).

According to Council and Fryberger (1987) there are an estimated 80,000 to 100,000 stormwater drainage wells located in 38 states, of which 1,539 were reported in the State of Florida. This means that half or more of the 170,000 existing Class V injection wells are stormwater drainage wells receiving inflow directly from paved surfaces.

There are only 1,557 special drainage wells reported nationally. Of these, 1,385 or 89 percent are reported in Florida. The large majority of these special drainage wells, particularly those located in Orange and Seminole counties, are probably lake-level control wells.

A third category of Class V wells that may be of interest is the aquifer recharge category. These wells are used to recharge depleted aquifers and may emplace recharge water from a variety of sources, including lakes, streams, reclaimed water, and water from other aquifers. Aquifer recharge wells are found in areas where ground water withdrawals for drinking water or irrigation exceed natural recharge. Nationally, 3,558 aquifer recharge wells are reported in 14 states, of which 349 are reported in Florida (Council and Fryberger, 1987). It would appear that the only difference between stormwater drainage wells, special drainage wells, and aquifer recharge wells is the purpose of the well and the degree of local water supply withdrawal.

In total, Council and Fryberger report 2,924 stormwater and special drainage wells in the state of Florida. In addition, 349 aquifer recharge wells are also reported, for a total of 3,273 drainage or recharge wells within the state. Most of these wells are located in south Florida, particularly in Dade County. Of the statewide total, approximately 400 wells, or about 12 percent, are located in Orange and Seminole counties.

In their investigation of drainage wells located within the state of Florida, Kimrey and Fayard (1984) report more than 5,000 drainage wells in Dade County, with approximately 2,000 additional drainage wells located in Broward County. The Kimrey and Fayard estimates result in a statewide total of about 7,600 drainage wells. Many of the Dade and Broward county drainage wells included in this total provide for swimming pool water disposal and air conditioning water disposal, not stormwater recharge. Also, recent practice limits stormwater drainage wells to portions of the Biscayne aquifer where chloride concentrations exceed 1,500 milligrams per liter (mg/L).

DRAINAGE WELLS IN ORANGE AND SEMINOLE COUNTIES

History and Current Use

Drainage wells have been used in central Florida for more than 90 years. The first recorded drainage well constructed in the Orlando area was a 2-inch-diameter test well constructed in 1905 in an attempt to correct a flooding problem induced by a clogged sinkhole (Mcbee 1985). This experimental well proved successful because of the significant hydraulic capacity of the highly transmissive Upper Floridan aquifer. Additional larger diameter drainage wells were then constructed. By 1906, six drainage wells 8 inches and 12 inches in diameter had been constructed.

During the hurricane periods of the 1920s, 1940s, and 1959 to 1961, many drainage wells were constructed to provide urban drainage and lake-level control. A chronology of the number of drainage wells in Orange and Seminole counties is presented in Table 1 (Mcbee 1985).

The topography of the Orlando area includes many closed hydrologic basins with no natural surface outflow. This condition, along with the naturally high transmissivity of the Floridan aquifer, made drainage wells an attractive option for addressing urban drainage and lake-level control. In many cases, no other practical options exist. Until the mid-1960s, when construction of drainage wells was halted because of concerns about aquifer contamination, they were the traditional solution to local drainage problems.

Unfortunately, during the first half of the century drainage wells were used for many purposes other than surface or lake water drainage. Gravity drainage wells were also used for waste disposal, including industrial and agricultural wastes and municipal wastewater. These

Table 1. Drainage Well Chronology for Orange and Seminole Counties, Florida.

Year	Number of Drainage Wells
1905	1 - test well
1906	6
1936	120
1943	200
1977	412
1996	398 (Current USGS Inventory)

practices resulted in the emplacement of highly polluted waters in the aquifer system, particularly the Upper Floridan. Historically, drainage wells in Orange and Seminole counties have been used for the following purposes.

- Urban stormwater drainage
- Lake-level control
- Wastewater disposal (septic tanks and cesspools)
- Industrial and agricultural waste disposal
- Air conditioning water disposal

In 1948, Telfair prepared a report for the Florida State Board of Health documenting aquifer pollution resulting from drainage wells in Suwannee and Orange counties. This report was probably the first investigation of the water quality impacts associated with drainage wells. The investigation was initiated because of suspected contamination of a water supply well in Live Oak, Florida, by a nearby drainage well. The work included a bacteriological survey of wells in both Live Oak and Orlando, and a tracer study of the Live Oak wells. Contamination of the Live Oak water supply well was confirmed. The source of the contamination included a stormwater drainage well, and a sewage drainage well was also suspected.

In the Orlando area, the presence of "gassing" wells was also documented by Telfair (1948). When under pressure, these wells produced methane gas, which is the end product of digestion of sewage and other organic waste introduced into the aquifer by waste drainage wells. From these investigations, Telfair recognized the importance of protecting underground waters from the unrestricted use of drainage wells. He recommended that sanitary sewage drainage wells no longer be used and that existing ones be plugged. He also recommended that stormwater drainage wells be used only as a last resort, and then only after pretreatment of the stormwater.

In the 1950s, the practice of using drainage wells for municipal sewage disposal decreased and was finally eliminated with the construction of the area's first municipal wastewater treatment plant. The use of drainage wells for industrial and agricultural waste disposal, notably the disposal of orange juice processing wastes, was also phased out through the 1960s and 1970s. There is at least one documented case of a lake-level control well contaminating nearby drinking water supply wells. This case of contamination occurred in 1961 and was reported by Lichtler et al. (1968). A drainage well located on Lake Pleasant in northwestern Orange County was suspected of causing pollution in nearby Upper Floridan aquifer water supply wells. Within a few hours after water was allowed to enter the drainage well, water from the supply wells in the area became polluted. Water from one supply well located 1,000 feet from the drainage well became muddy, high in bacteria, and had an unpleasant taste and odor. The pollution cleared up after the drainage well was shut down. Subsequent salt tracer tests confirmed the hydraulic connection between the lake-level control well and the Upper Floridan aquifer water supply wells.

In 1965, the Florida State Board of Health stopped granting permits for construction of new drainage wells. However, replacement of existing wells was allowed. In the 1970s, the state stopped granting permits for the construction of any drainage wells (Mcbee 1985). Thus, for the past 25 years or so, drainage well modifications or replacements have not been allowed, even if proposed replacements or modifications resulted in a net water resources management benefit, such as increased aquifer recharge or reduced pollutant loading to the aquifer.

The only known exception to this ban on replacement or repair of existing drainage wells in recent years is the Lake Tennessee project completed by the City of Orlando. A permit to repair an existing failed lake-level control well was obtained by the City after many years of effort.

Recent Reports and Investigations

Since the early 1970s, there have been several investigations dealing with various aspects of the drainage well issues in Orange and Seminole counties. Topics investigated have included aquifer contamination, aquifer recharge, and the potential impact on aquifers being recharged by drainage wells if the wells were plugged.

Lichtler (1972), in an appraisal of the water resources of east central Florida, noted that no appreciable cone of depression existed in the ground water potentiometric surface below Orlando. He reasoned that it was possible that the existing ground water withdrawals of 50 mgd were being balanced by drainage well recharge. The Lichtler analysis provides the first published estimate of the total average recharge provided by Orange county drainage wells.

Lichtler also noted that recharge water should be of at least as good a quality as that of the aquifer water to avoid contamination, given that the transmissive limestone aquifer would not provide much filtering. He suggested that holding basins and other pretreatment facilities be provided.

As part of 208 planning work for the East Central Florida Regional Planning Council, BC&E/CH2M HILL (1977) reported on the quality of water backpumped from two drainage wells. One drainage well, the Lake Sherwood well, was relatively inactive, having received no inflow for approximately 10 years. The other well, serving the Englewood Park residential area, regularly received lake water overflow. Approximately 45 parameters were sampled and compared to drinking water maximum contaminant levels (MCLs). All parameter concentrations, with the exception of iron and coliforms, were less than the MCL value by at least an order of magnitude.

In the case of the active Englewood Park well, fecal coliforms were 12 Most Probable Number (MPN)/100 millileters (ml) after 1 hour of pumping, and 9 MPN/100 ml after 6 hours of pumping. Total coliform counts were not reported.

Kimrey (1978) provides an appraisal of the geohydrologic aspects of Orlando area drainage wells. He notes that drainage wells generally recharge the Upper Floridan aquifer, while most major municipal water supply is obtained from the Lower Floridan. However, numerous small public and private water supplies are obtained from the Upper Floridan aquifer.

Quantitatively, drainage wells provide an effective method of artificial recharge. This source of additional recharge maintains higher potentiometric pressures, in spite of heavy Floridan withdrawals, and acts as a safeguard against saltwater encroachment.

Kimrey also noted that relatively few cases of severe pollution have resulted from the use of drainage wells. The reasons are unknown, but may involve several factors, including physical separation and upgradient location of the many water supply wells, attenuation of pollutants within the aquifer, and, possibly, that insufficient time has elapsed for the pollutants to travel from the recharge areas to the withdrawal areas.

Schiner and German (1983) investigated the effects of Orlando area drainage wells on water quality. As part of this investigation, 65 water supply wells and 21 drainage wells were sampled between September 1977 and June 1979. The results indicate that most constituent concentrations were slightly higher in water from drainage wells than in water from supply wells. This indicates a small, localized effect on aquifer water quality that can be attributed to drainage well recharge.

The most notable differences were in bacteria count and total nitrogen concentration. For drainage wells, the median values for nitrogen and total coliform were 1.0 mg/L and 39 MPN/100 ml, respectively. For water supply wells, the median values were 0.27 mg/L and 0 MPN/ 100 ml. In general, with the exception of fecal coliform, untreated water from drainage wells would, on the average, meet the MCLs established by the U.S. Environmental Protection Agency (EPA) and the Florida Department of Environmental Protection (FDEP).

Tibbals (1990) provides a detailed assessment of the hydrology of the Floridan aquifer system in east central Florida. As part of this work, an estimate of the quantity of recharge water provided by drainage wells in Orange and Seminole counties is reported. This estimate is based on a double mass curve analysis of rainfall and water well levels, as well as the history of water supply withdrawals. This analysis indicated that the drawdown effects of water supply withdrawals up to about 30 to 35 mgd appear to be offset or balanced by drainage well recharge. Thus, it can be concluded that the areawide recharge associated with drainage wells is also in the range of 30 to 35 mgd.

Tibbals also simulated the hydrologic impact of elimination of the aquifer recharge provided by drainage wells. The results of the simulation indicate that closure of all drainage wells would result in a 4-foot decline in the Upper Floridan aquifer potentiometric surface in the Orlando area. The declines would be regional. Potentiometric declines of more than 1 foot would extend from northern Osceola County to southern Seminole County.

Bradner (1991) compared the water quality of the Upper Floridan aquifer in the downtown Orlando area to the ground water quality found in other parts of Florida. The 6-square-mile downtown area considered has a high concentration of drainage wells. Other water quality data evaluated included data from an area in Orlando, but upgradient from the downtown area, and in the Ocala National Forest about 50 miles north of Orlando. This study found that calcium, potassium, sodium, chloride and ammonia are present in substantially higher concentrations in the downtown Orlando area than in ground water from the background areas.

Bradner (1996) estimated the annual average aquifer recharge of 18 selected drainage wells and the potential effects associated with closure of these wells. This work, which is of particular interest to this investigation, demonstrates the inherent difficulty in estimating recharge volumes from lake-level control wells because of the complex, unique hydrology of each individual lake system. The results do, however, provide a basis for estimating areawide drainage well recharge volumes.

Total average annual recharge through the 18 selected wells was estimated to be about 6 mgd. Extrapolation of the recharge estimates for the 18 selected wells to the same study area considered by Tibbals (1990) results in an areawide recharge estimate of about 40 mgd, compared with Tibbals' estimate of 30 to 35 mgd.

In addition, Bradner (1996) estimated that closure of the 18 selected drainage wells, which represent 6 mgd of recharge, would decrease the Upper Floridan aquifer potentiometric surface by a maximum value of approximately 1 foot.

DRAINAGE WELL DATA BASE

One objective of this investigation was to update and enhance the existing areawide drainage well data base. As a result of extensive previous study, the Orlando area office of the USGS currently maintains the most complete inventory of drainage wells in Orange and Seminole counties. The data base development procedure used in this investigation began with obtaining the USGS inventory, along with associated well location data, ownership information, and well characteristics. This inventory was used to formulate a request for additional or updated information, which was sent to the major drainage well owners. Once responses were received, the updated drainage well data base was constructed.

USGS DRAINAGE WELL INVENTORY

The USGS drainage well inventory provides a listing of 398 drainage wells. Of this total, 386 wells are located in Orange County and 12 wells are located in Seminole County. Most study area drainage wells are under public ownership. Table 2 summarizes the major public drainage well owners in the USGS inventory. As shown in Table 2, nearly three-fourths of the study area drainage wells are owned by either the City of Orlando or Orange County. The remaining 25 percent are scattered among a large number of owners.

Figure 5 illustrates the approximate distribution of drainage wells within the study area. The largest number and greatest concentration of drainage wells are located in and adjacent to the City of Orlando. A large number of drainage wells are located west of the Orlando urban area, but few wells are located to the east.

INFORMATION REQUESTS

The USGS inventory was used to help formulate a request for additional information from major public drainage well owners. The USGS data were sorted by owner, and tables were prepared listing the known information for each inventoried well. These data included well location, expressed in terms of latitude and longitude; well owner; and certain well characteristics, including total depth, well diameter, and casing depth.

Table 2. Major Public Drainage Well Owners from the USGS Inventory (1975).

Owner	Number of Drainage Wells	Percentage of Drainage Wells	Cumulative Percentage of Drainage Wells
City of Orlando	186	46.7	46.7
Orange County	110	27.6	74.3
FDOT	13	3.3	77.6
City of Winter Park	8	2.0	79.6
Seminole County	3	0.8	80.4
City of Altamonte Springs	2	0.5	80.9
City of Apopka	2	0.5	81.4

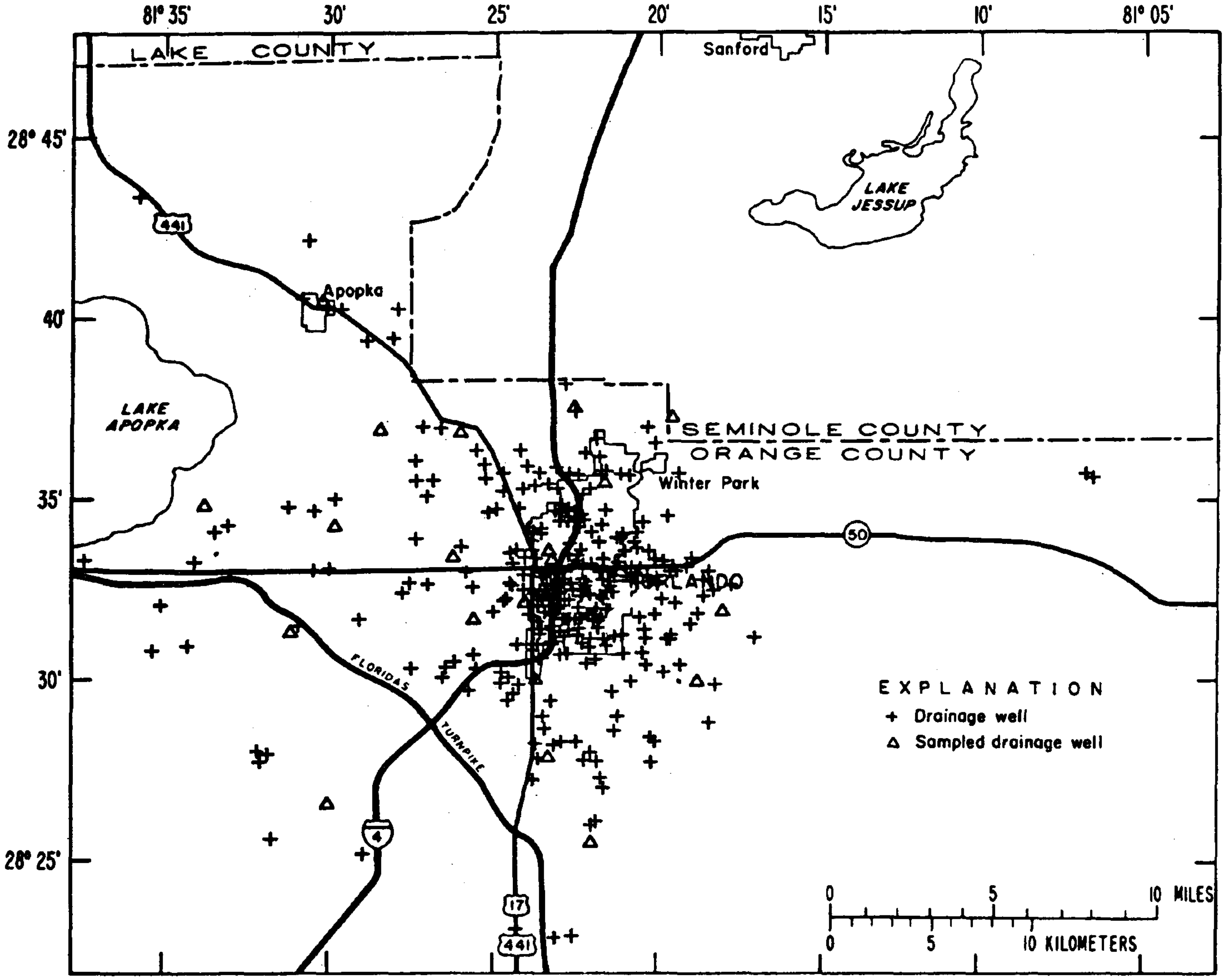

Figure 5. Approximate Distribution of Drainage Wells in the Study Area (After Schiner and German 1983).

A data request on SJRWMD letterhead, dated September 25, 1996, was mailed to the cities of Orlando, Winter Park, Altamonte Springs, Apopka, Ocoee, Maitland, and Casselberry; Orange and Seminole counties; and the Florida Department of Transportation (FDOT). The drainage well data requested are listed in Table 3. In the table, the USGS site ID is the USGS identification number, which was included with each request. This ID number includes well location, expressed as latitude and longitude. The SJRWMD sequence number is an identification number assigned by the District to each of the 398 drainage wells on the USGS inventory. Well depth, bottom of casing, and diameter of casing are data items appearing on the USGS inventory. These data were included with the owner-specific information request. The remainder of the data items listed in Table 3 is information requested from the owners.

In addition to the drainage well data, a request was made for available tributary area and water quality data that would help characterize the quantity and quality of the recharge water entering drainage wells. A meeting was held in the District's Orlando office on October 15, 1996, to discuss this information request with the drainage well owners and other interested parties, including FDEP, USGS, and the South Florida Water Management District.

Responses were received from Orange County and the Cities of Orlando, Ocoee, and Altamonte Springs. These four municipal drainage well owners account for over 75 percent of the drainage wells in Orange and Seminole counties.

Orange County has prepared individual reports on most of their drainage wells. These reports were made available and document well location, well characteristics and use, well status, and tributary area characteristics. A complete listing of drainage well latitude and longitude was also provided by the county. The individual drainage well reports also present estimated flood elevations with and without the drainage well in operation. The individual reports provided the primary source of information for Orange County's portion of the drainage well data base update. This information was supplemented as necessary by data presented in a summary report on drainage wells by the Orange County Stormwater Management Department (1992).

The Orange County Environmental Protection Department also provided valuable ambient lake water quality monitoring data. The data obtained represent current water quality conditions for lakes

Table 3. Definition of Requested Drainage Well Database Parameters.

Parameter	Definition
USGS Site ID	This drainage well identifier has been assigned by the USGS. In addition to providing a unique identification number, it also provides the well location expressed in latitude and longitude. The first six digits of the identifier provide the latitude in degrees, minutes, and seconds. Digits 8 through 13 provide the well longitude.
SJRWMD Sequence Number	An identification number assigned by SJRWMD.
Owner ID Number	Any unique identification number used by well owner for internal management purposes.
Status	Current status of drainage well. The following codes apply: A - active drainage well C - inactive capped well P - inactive plugged well I - inactive (reason unknown) U - status unknown
County	County in which well is located. The following codes apply: O - Orange County S - Seminole County
Well Altitude	Elevation of inlet to well, ft. msl. (This is the elevation at which surface water inflow begins)
Well Depth	Depth of the well, in feet, below land surface (bls)
Bottom of Casing	Depth to bottom of well casing, in feet bls.
Diameter of Casing	Diameter of well casing, in inches
Major Basin	Major drainage basin in which drainage well is located. The following codes apply: LA - Lake Apopka RC - Reedy Creek SC - Shingle Creek BC - Boggy Creek LH - Lake Hart LW - Little Wekiva River W - Wekiva River LJ - Lake Jesup HC - Howell Creek LE - Little Econlockhatchee River E - Econlockhatchee River

Table 3. Definition of Requested Drainage Well Database Parameters (Continued).

Parameter	Definition
Drainage Type	General type of drainage that the well receives as follows: S - direct street or roadway runoff L - lake outflow R - stormwater retention or wet pond outflow W - wetland outflow A - air conditioning/cooling water O - other miscellaneous - non surface waters
Tributary Area	Total area, in acres, which discharges to the drainage well
Lake/Pond Area	Lake or pond area, in acres, tributary to the drainage well, at normal pool elevation.
Overflow Elevation	Elevation at which surface water, originating in the drainage well basin, will overflow into the next downstream basin.
Flood Elevations	Flood elevations, in feet msl, if known. 10 yr. elev. with well 25 yr. elev. with well 100 yr. elev. with well 10 elev. without well 25 yr. elev. without well 100 yr. elev. without well

served by drainage wells and were provided in electronic spreadsheet format. Useful data for 28 ambient water quality monitoring stations from 17 different lakes served by drainage wells were provided by Orange county.

Extensive data related to the City of Orlando drainage wells are contained in the City's Drainage Well Protection Plan published in 1994. This report contains detailed information on drainage wells owned by the City of Orlando, including well location and characteristics, recharge water source (e.g., lakes, streets), and drainage area characteristics, including detailed land use maps and summaries for many wells.

The City of Orlando report did not contain drainage well locations expressed in terms of latitude and longitude. These coordinates are necessary to compare the City's drainage well inventory to the USGS inventory, which is fully defined on a latitude/longitude location system. To assist in this investigation, the City of Orlando computed the latitude and longitude of all known active drainage wells and provided this information to the project staff.

The City of Ocoee provided information on seven drainage wells, three of which were once owned by Orange County. A complete report was provided that summarized the most useful information, as well as additional details where available.

The City of Altamonte Springs owns two drainage wells, which provide the only flood control for the Lake Orienta Basin. Although few in number, the City of Altamonte Springs' drainage wells are important, given the large size, degree of development, and flood-prone nature of the Lake Orienta Basin.

DRAINAGE WELL DATA BASE SUMMARY

The procedure used to update the drainage well data base involved matching, where possible, wells on the USGS inventory with wells reported by the municipalities. Well location, in terms of latitude and longitude, provided the most important data relative to matching wells. In many cases, matches for exact location and well characteristics were identified. In cases where the location was a close match (within 2 seconds of latitude or longitude) and the well characteristics of well depth, well diameter, and casing depth matched, a match between the USGS inventory and the municipal data was assumed. In cases where a match to the original USGS inventory could not be made, a new entry for the municipal well was made in the data base.

There are 479 entries on the updated drainage well data base. However, this does not mean that there is an equal number of drainage wells in Orange and Seminole counties. It is likely that many wells appearing on the USGS inventory, but not matched with known municipal wells, no longer exist. Therefore, the number of active, operational drainage wells within the study area is still uncertain. There are at least 214 wells, which is the number currently identified by the four responding municipalities, and less than 464 wells, which is the total number of entries on the data base less the number of known plugged or capped wells.

Appendix A presents the current updated drainage well data base. The data appearing in Appendix A are sorted by owner and latitude and longitude, and the data base parameters are defined in Table 3. Entries with a USGS identification number appear on the original USGS inventory. Entries without a USGS identification number have been added to the data base.

Table 4 presents a summary of information obtained from the 4 major municipal drainage well owners who responded to the District's request for information. This table summarizes the number of wells used for lake-level control and street and urban drainage and the number of inactive (plugged or capped) wells.

Table 4. Summary of Status of Drainage Wells for Four Municipal Owners.

Owner	Number of Wells				
	Street or Urban Drainage	Lake-Level Control	Inactive (plugged or capped)	Status Unknown or Unlocated	Total
City of Orlando	80	52	37*	60*	229
Orange County	24	51	2	0	77
City of Ocoee	0	5	0	2	7
City of Altamonte Springs	0	2	0	0	2
Total	104	110	39	62	315

*These totals taken from the 1994 City of Orlando Drainage Well Protection Plan. Not all inactive or unlocated wells appear in the area-wide data base.

ARTIFICIAL RECHARGE QUANTITY

The quantity of artificial recharge occurring from drainage wells is estimated on an average annual basis. Estimates are prepared for two major categories of wells: street or urban drainage wells and lake-level control wells. In each case, an anticipated areawide recharge rate is computed and applied to the total area known to be served by each drainage well category. Adjustments are then applied to account for the recharge likely to be occurring from additional wells, whose status is currently unknown.

Additional artificial recharge could be achieved with the construction of new recharge wells. The potential for such additional recharge is also discussed in this section of the TM.

RECHARGE FROM STREET AND URBAN DRAINAGE WELLS

Computation of recharge from street and urban drainage wells is rather straightforward. The recharge resulting for these wells is approximately equal to the quantity of runoff generated by the drainage well tributary area. Therefore, if the tributary area, composite runoff coefficient, and average annual rainfall are known, recharge estimates can be computed easily.

In certain situations, a street basin may have more than one outlet. In such cases, only a portion of the annual runoff volume would become recharge. However, for the purpose of this areawide recharge estimate, it is assumed that the recharge volume is approximately equal to the annual runoff volume.

Rainfall in the Orlando area averages 50.88 inches per year (Jenab, et al. 1986). Typical composite runoff coefficients were computed for a sample of ten street and urban drainage areas served by drainage wells. Five wells owned by the City of Orlando and 5 wells owned by Orange County were evaluated. In each case, detailed land use information was available from existing data sources. Runoff coefficients for each land use type were established on the basis of values reported by Harper (1994).

Table 5 presents a summary of the individual street drainage well runoff coefficient estimates. For this typical sample, runoff coefficients ranged from 0.376 to 0.837. The average runoff coefficient for all ten sites is 0.578. Based on the average runoff coefficient, street drainage

Table 5. Runoff Coefficients for Selected Street Drainage Well Tributary Areas.

		Tributary Area by Land Use Category/Typical Runoff Coefficient*									
Well No.	Well Owner	Low-Density Residential 0.268	Single-Family 0.373	Multi-Family 0.675	Low-Intensity Commercial 0.837	High-Intensity Commercial 0.887	Industrial 0.793	Highway 0.783	Recreational/ Open Space 0.163	Total	Weighted Runoff Coefficient
11	City of Orlando				4.56					4.56	0.837
31	City of Orlando		0.24	4.73						4.97	0.660
58	City of Orlando				10.83					10.83	0.837
117	City of Orlando		2.30	7.23						9.53	0.602
137	City of Orlando		14.73		2.20					16.93	0.433
B64	Orange County			3.50	5.00	10.50			2.00	21.00	0.771
B85	Orange County		53.60				40.00		43.10	136.70	0.430
H37	Orange County		29.84			0.16				30.00	0.376
S74	Orange County					25.60			38.40	64.00	0.453
W40	Orange County		14.08			1.32			2.90	18.30	0.377
Total		0.00	114.79	15.46	22.58	37.58	40.00	0.00	86.40	316.81	
									Mean	31.68	0.578
									Std. Dev.	40.77	0.188
									Coeff. Var.	1.287	0.326
									Maximum	136.70	0.837
									Minimum	4.56	0.376

* Runoff Coefficients taken from Harper (1994).

well recharge will average approximately 29.41 inches per year, or 2,188 gallons per day per acre of tributary area served.

A total of 104 street or urban drainage wells serving a total of 3,242 acres (5.1 square miles)is reported in the updated drainage well data base. Table 6 summarizes the estimated areawide recharge obtained from these wells, based on the computed average recharge rate. A total of 7.09 mgd of recharge is estimated to occur from known street and urban drainage wells.

RECHARGE FROM LAKE-LEVEL CONTROL WELLS

Computing artificial recharge from lake-level control wells is significantly more complex than computing recharge from street drainage systems. This is because of the inherent complexity of individual lake drainage basin hydrology. In the case of street drainage, discussed previously, surface water enters the well directly and becomes recharge. In the case of a lake-level control well, various sources of inflow and outflow are possible.

Inflow sources to a lake include tributary area runoff and direct rainfall. Other sources may include inflow from upstream lakes, septic system seepage, irrigation water, and shallow ground water inflow.

There are also several potential lake water outflow paths. In all cases, water is lost through lake surface evaporation. Also, some water may outflow to the next downstream lake in an interconnected system, and water may also recharge the aquifer naturally through lake bottom seepage. Therefore, the quantity of lake water recharged through lake-level control wells depends on the hydrologic characteristics of the individual lake basin, as well as the relative elevation of the well intake structure within the lake stage regime.

Development of accurate, site-specific estimates of artificial recharge through lake-level control wells requires detailed hydrologic analysis of individual lake systems. Such an analysis was recently completed by Bradner (1996) for several lakes located in Orange County. Bradner used a variety of analysis techniques, depending on data availability, to establish drainage well recharge estimates for each lake. The results of Bradner's analysis are summarized in Table 7. The second column of Table 7, total basin yield, presents the total annual inflow volume available for potential recharge. This value of 24.24 inches per year is directly comparable to the street drainage basin yield of 29.41 inches per year. The lake drainage basins are generally larger and more

Table 6. Estimated Recharge through City of Orlando and Orange County Street or Urban Drainage Wells.

Owner	Number of Street or Urban Drainage Wells	Area Served (acres)	Total Recharge	
			acre feet/yr	mgd
City of Orlando	80	1,245	3,052	2.72
Orange County	24	1,996	4,893	4.37
Totals	104	3,242	7,945	7.09

Note: Orange County street drainage well No. W-46 is reported to serve a basin area of 2,842 acres. This area is not included in the above summary.

Table 7. Lake-Level Control Drainage Well Recharge Estimates from Bradner (1996).

Lake	Total Basin Yield in/yr	Surface Water Inflow (upstream) in/yr	Surface Water Outflow (downstream) in/yr	Drainage Well Recharge in/yr	Recharge as a Fraction of Basin Yield
Killarney	24.8	0.0	0.0	24.8	1.00
Little Lake Barton	32.3	16.1	0.0	48.4	1.50
Fairview	26.2	0.4	20.8	5.8	0.22
Little Lake Fairview	25.7	1.9	6.5	21.1	0.82
Mann	25.4	0.0	24.8	0.4	0.02
Buchanan	24.0	0.0	0.0	24.0	1.00
Nashville Avenue Retention Pond	24.0	0.0	0.0	24.0	1.00
Fair	20.0	0.0	14.9	5.1	0.26
Yucatan Drive Retention Pond	20.0	0.0	13.0	7.0	0.35
Eve	20.0	0.0	0.0	20.0	1.00
Average	24.24	1.84	8.00	18.06	0.72
Std Dev.	3.75	5.05	9.67	14.15	0.47
Coeff. Var.	0.155	2.742	1.208	0.783	0.663
Maximum	32.3	16.1	24.8	48.4	1.50
Minimum	20.0	0.0	0.0	0.4	0.02

diverse in land use than the street drainage basins, resulting in a lower overall unit water yield.

Adjustments were made for lake inflow and outflow to arrive at the net estimated artificial recharge for each lake system investigated by Bradner. These results are reported in column 5 of Table 7. The average drainage well recharge rate for the ten lakes evaluated by Bradner was estimated to be 18.06 inches per year, or 1,343 gallons per day per acre of total basin area.

Although the average drainage well recharge rate of 18.06 inches per year is a reasonable value, there is considerable variation in individual recharge rates. The observed range is from 0.4 to 48.4 inches per year. In addition, the tributary area weighted-average drainage well recharge rate differs considerably from the numeric average of the individual values. The area-weighted recharge rate is 12.19 inches per year. Because of this large variation and differences in computed mean values, a range of probable lake-level control well recharge is developed and reported in this TM.

These areawide values (12.19 and 18.06 inches per year) are applied to the updated drainage well data base totals to estimate the current quantity of artificial recharge from lake-level control wells in Orange and Seminole counties. Table 8 summarizes City of Orlando lakes served by drainage wells. Forty lakes served by 52 lake-level control wells have been identified. The total basin area served is 13,619 acres, or about 21.3 square miles.

Table 9 reports similar data for Orange County lakes. Forty-two lakes served by 51 wells have been identified. The total basin area is 15,482 acres, or about 24.2 square miles. Table 10 reports lake-level control well data for other municipalities, including the cities of Ocoee and Altamonte Springs. In total, 5 lakes, 7 wells, and 3,696 acres (5.8 square miles) of basin area are reported by these municipalities.

The estimated annual artificial recharge achieved by the study area lake-level control wells is summarized in Table 11 and is based on data reported in Tables 7 through 10. Total estimated annual artificial recharge for the 110 known active lake-level control wells ranges from 32,555 to 45,389 acre feet per year, or from about 29.1 to 40.5 mgd. This estimate represents the anticipated areawide recharge for the 32,797 acres (51.2 square miles) served by lake-level control wells.

Although the areawide artificial recharge estimates are based on a unit recharge rate of 12.19 to 18.06 inches per year, recharge rates for

Table 8. City of Orlando Lakes Served by Drainage Wells.

Lake Name	City Well No. (s)	Drainage Basin No.	Tributary Area (acres)	Total Basin Area (acres)	Lake Area (acres)
Adair	24	HB-27	228.3	256.6	28.2
Angel	122	SC-19	589.2	595.3	6.1
Arnold	105	LE-12	253.6	278.7	25.1
Barton	36	LE-8	637.8	792.6	154.8
Ben White Raceway	2	LW-1	--	--	--
Cay Dee	16	HB-34	98.8	110.3	11.5
Cherokee	93, 94, 95	LE-27	120.9	132.6	11.7
Cinca Lane and San Luis Dr.	110	LE-37	--	43.2	--
Concord	25	HB-26	297.6	363.5	66.0
Copeland	92	SC-29	43.0	60.0	17.0
Cypress St. ext.	81	SC-10	--	--	--
Davis	96	LE-26	102.5	121.2	18.8
Emerald	99	LE-22	25.7	27.5	1.9
Eola	50, 52, 53	HB-32	290.1	316.6	26.5
Gear	35	LE-6	41.9	50.9	9.0
Giles	106	LE-11	237.0	265.4	28.4
Greenwood	100, 102, 103, 104, 101	LE-14	557.0	560.3	3.3
Ivanhoe	19	HB-25	580.0	732.9	153.0
Lake of the Woods	86, 87, 88, 89	LE-32	176.4	181.3	4.9
Lancaster	98	LE-20	329.2	382.1	52.8
Lawne	22	LW-15	2,721.9	2,883.9	162.0
Lawsona	46	LE-24	82.6	91.6	9.0
Little Lake Fairview	142	LW-5	591.3	679.3	88.0
Lorna Doone	76	SC-13	153.1	167.6	14.4
Lucerne	90	LE-28	276.6	286.2	9.6
Lurna	119,120	LE-30	100.5	109.4	9.0
Monterey	111	LE-34	148.9	150.5	1.6
Olive	48	LE-25	88.9	91.9	3.0
Park Lake	29	HB-31	82.8	90.7	8.0
Porter	113	BC-8	341.1	364.3	23.2
Rabama	115	LE-38	179.9	187.0	7.2
Richmond	125	SC-9	123.1	160.3	37.2
Rowena	12	HB-21	804.6	874.9	70.3
Shenandoa Way	112	LE-1F	--	--	--
Spring Lake	23	HB-28	390.4	431.0	40.7
Sunset Lake	79	SC-17	119.8	148.8	29.0
Tennessee	158	BC-10	127.0	137.8	10.8
Teresa	34	HB-37	24.8	26.2	1.4
Underhill	38	LE-10	1,120.3	1,271.5	151.2
Wade	118	LE-19	191.4	194.8	3.4
Totals	52		12,277	13,619	1,298

Table 9. Orange County Lakes Served by Drainage Wells.

Lake Name	Orange County Well No. (s)	Drainage Basin No.	Tributary Area (acres)	Total Basin Area (acres)	Lake Area (acres)
Azalea	E-97	E	127.38	130.79	3.41
Bass	B-107	BC	--	315.6	--
Bear Head	B-87	BC	104.9	119.1	14.2
Bonnie Lou Dr. Retention	B-86	BC	36	40	4
Buchanan	S-76	SC	--	208.8	--
Carity	H-20	HC	450.39	494.39	44
Catherine	S-71,S-72, S-75	SC	531.82	602.32	70.5
Davis	W-18	W	33.46	34.76	1.3
Dover Oaks Retention	E-103	E	88.9	92.3	3.4
Eve	W-19	W	54.29	61	6.71
Fair	W-32	W	66.18	68.61	2.43
Fairview	W-38	W	2147	2548	401
Florence	W-44	W	378.85	487	108.15
Forest	E-93	E	64.65	69	4.35
George	B-112	BC	423.5	485	61.5
Holden	B-66, B-70	BC	--	979.33	--
Hourglass	E-101	E	265.2	278	12.8
Jessamine	B-77	BC	93.45	104	10.55
Killarney	H-34, H-35	HC	882	1119	237
LaGrange	B-110	BC	100.3	113.3	13
Lawne	W-47	W	22.25	23.82	1.57
Little Lake Barton	E-96	E	78	94	16
Little Lake Fairview	W-39	W	457.4	535	77.6
Mann	S-57, S-58	SC	1024	1260	236
Margaret	B-109	BC	93.6	104	10.4
Nashville Av. Retention	S-62, S-63	SC	42.22	42.89	0.67
Nina	W-17	W	49.1	51.4	2.3
Notasulga	S-54A	SC	107.05	110.34	3.29
Olivia	W-8, W-9	W	405	487.6	82.6
Page	W-12	W	237.29	262	24.71

Table 9. Orange County Lakes Served by Drainage Wells (Continued).

Lake Name	Orange County Well No. (s)	Drainage Basin No.	Tributary Area (acres)	Total Basin Area (acres)	Lake Area (acres)
Pinelock	B-67, B-69	BC	684	743	59
Retention	S-60	SC	93.7	96.4	2.7
Retention	W-12A	W	18.25	20	1.75
Retention	W-45	W	--	332.17	--
San Susan	W-51	W	122.95	139.39	16.44
Sherwood	W-50	W	1240	1359	119
Silver/Crystal	E-68	E	96	103	7
Spier	E-94	E	44	68	24
Stevens	B-108	BC	41.86	45.34	3.48
Swamp/Street	S-73	SC	--	42.76	--
Sybelia	H-21	HC	462.19	540.09	77.9
Tyner	B-79	BC	41	48	7
Yucatan Dr. Retention	E-98	E	--	623.83	--
Totals	51		11,208	15,482	1,772

Table 10. Other Lakes Served by Municipal Drainage Wells.

A) City of Ocoee

Lake Name	Well No.	Drainage Basin No.	Triburary Area (acres)	Total Basin Area (acres)	Lake Area (acres)
Johio	W-7*	LW	229	253	24
Spring	W-6*	LW	446	482	36
Stanley	W-22*	LW	197	232	35
Starke	2 wells -- unnumbered	LW	1,338	1,678	340
Totals	5		2,210	2,645	435

* Well identification numbers assigned by Orange County prior to transfer to the City of Ocoee.

B) City of Altamonte Springs

Lake Name	Well No.	Drainage Basin No.	Triburary Area (acres)	Total Basin Area (acres)	Lake Area (acres)
Orienta	421, 505	LW	916	1,051	135
Totals	2		916	1,051	135

Table 11. Estimated Recharge through Study Area Lake-Level control wells.

Owner	Number of Lake Level Control Wells	Total Basin Area (acres)	Total Recharge			
			acre feet/year		mgd	
			Low	High	Low	High
City of Orlando	52	13,619	13,835	20,497	12.35	18.30
Orange County	51	15,482	14,966	19,329	13.36	17.26
City of Ocoee	5	2,645	2,687	3,981	2.40	3.55
City of Altamonte Springs	2	1,051	1,068	1,582	0.95	1.41
Totals	110	32,797	32,555	45,389	29.06	40.52

individual lake-level control wells will vary significantly from these average values. For example, the reported range in lake-level control recharge rates from Table 7 is 0.4 to 48.4 inches per year. Accurate quantification of the recharge from an individual lake/watershed/drainage well system would require extensive, site-specific hydrologic analysis.

TOTAL EXISTING ARTIFICIAL RECHARGE

Table 12 presents an estimate of total existing recharge from drainage wells in Orange and Seminole counties. Included in these estimates are the known active street drainage wells and the known active lake-level control wells. The known active street drainage wells serve an area of approximately 5.1 square miles and recharge approximately 7.1 mgd. The known active lake-level control wells serve an area of approximately 51.2 square miles and recharge approximately 29.1 to 40.5 mgd. In aggregate, these wells serve approximately 56.3 square miles and recharge on the order of 36.2 to 47.6 mgd.

In some cases, street drainage wells are located within the watershed boundaries of lakes served by lake-level control wells. Adjustments were made to the lake basin area when street and urban drainage wells were known to be located within the lake basin. However, it is likely that a small amount of double counting exists in the street drainage and lake well area totals reported in Tables 6, 8, and 9. Therefore, the total effective lake well basin area of 51.2 square miles may be slightly overestimated. The uncertainty associated with the effective lake tributary area is, however, quite small when compared to the uncertainty associated with the average effective lake well recharge rate.

In addition, it is likely that additional wells serving additional tributary area are in operation. Table 12 provides an allowance for wells owned by FDOT and additional municipalities, including the cities of Winter Park, Apopka, and Maitland, and Seminole County. In the case of the FDOT wells, it was assumed that these wells were street drainage wells, so the average recharge rate for the known street drainage wells was applied. In the case of the other municipal wells, it was assumed that the additional wells are a mixture of lake-level control wells and street drainage wells, so the average recharge rate per active well was applied.

Table 12. Estimated Areawide Artificial Recharge through Drainage Wells in Orange and Seminole Counties.

Source	Number of Wells	Estimated Annual Recharge-Low (mgd)	Estimated Annual Recharge-High (mgd)
Known Wells			
Street/urban drainage	104	7.09	7.09
Lake-level control	110	29.06	40.52
Subtotals	214	36.15	47.61
FDOT wells	13	0.89	0.89
Other Municipal Wells	14	2.33	3.06
Estimated Areawide Totals	241	39.36	51.55

These adjustments result in a total estimated average areawide drainage well recharge rate in the range of 39.4 to 51.6 mgd, generated by a total tributary area of approximately 61.0 square miles. This estimate is in substantial agreement with estimates previously reported in the literature, which ranged from about 33 to 50 mgd. Drainage wells are obviously an important source of Upper Floridan aquifer recharge in Orange and Seminole counties.

POTENTIAL ADDITIONAL ARTIFICIAL RECHARGE FROM DRAINAGE AND INJECTION WELLS

Currently, drainage wells serve some of the most densely developed urban areas within Orange and Seminole counties. However, land area in the two-county study area totals approximately 1,165 square miles. Therefore, only about 5 percent of the total area currently contributes recharge to existing drainage wells. The potential exists to increase artificial recharge through additional drainage or injection wells, if increased recharge is desired.

Figure 6 illustrates the approximate boundaries of the major surface drainage basin in the study area. As can be seen from the figure, the Orlando urban area is located along a hydrologic divide. Surface runoff originating in the northern and eastern portions of the study area is tributary to the St. Johns River, by way of the Wekiva River and Econlockhatchee River basins. Surface runoff originating in the southern portions of the study area is tributary to the Kissimmee River through Reedy Creek, Shingle Creek, and the Boggy Creek drainage basins.

Land elevations in the western and central portions of the study area are higher than the Floridan aquifer potentiometric surface elevations. In these areas, natural recharge occurs and additional artificial recharge could be achieved by construction of new drainage wells.

Land elevations near the St. Johns River and the lower portions of the Wekiva and Econlockhatchee River basins are, in some areas, lower than the Floridan aquifer potentiometric elevations. In these areas, natural discharge may occur and artificial recharge can only be achieved by construction of pressure injection wells.

Surface water yields range from 5 to 6 inches per year in the Lake Apopka and upper Kissimmee River basins, up to 21 inches per year in

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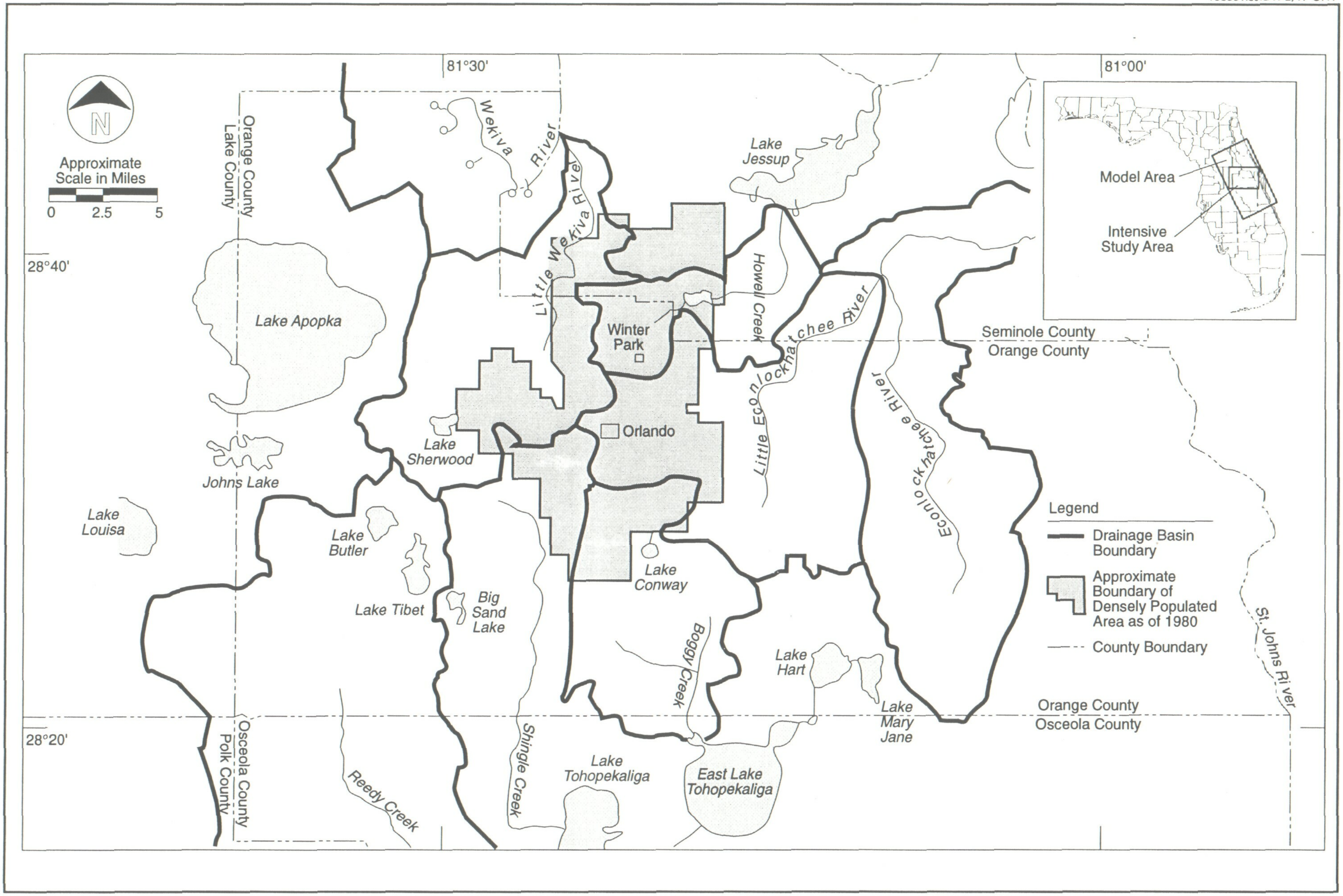

Figure 6. Major Drainage Basins in Orange and Seminole Counties (After Bradner 1996).

the Wekiva River basin (Bush and Johnson 1988). Surface water yield for the Econlockhatchee River basin is reported to be about 15 inches per year.

The Wekiva River receives significant portions of its flow from springs that discharge from the Floridan aquifer. The spring flow is included in the reported watershed yield of 21 inches per year. These springs receive much of their flow from adjacent upland Orlando urban area recharge, including recharge from existing drainage wells. Surface runoff from the Wekiva River watershed is probably on the order of 10 inches per year, considering the yield of adjacent watersheds.

Using the surface runoff unit yields by major basin and the land tributary area associated with each basin, an estimate of total study area surface water yield is developed (Table 13). Land area data are reported in Table 13 by major basins, county, and potential recharge type. The total land area of approximately 1,165 square miles generates approximately 656 mgd of surface runoff. Most of this runoff (53 percent) originates in areas where drainage wells are applicable. The remainder is generated by areas where pressure injection wells are applicable.

The potential to increase artificial recharge using additional drainage or injection wells exists. However, appropriate application would probably limit the volume of additional recharge to approximately 10 percent of the runoff generated, or about 66 mgd. Reduction of 10 percent or less in surface water flow should not adversely impact surface water systems, and an increase in recharge of this magnitude would more than double the current artificial recharge rate provided by existing drainage wells.

The most logical way to increase aquifer recharge would be to increase the use of lake-level control wells because lake water quality is superior to direct urban runoff water quality. Table 14 presents a summary of lakes and associated outlet controls for Orange County lakes. The information summarized in this table was compiled from the Orange County Lake Index (Orange County 1995) and lake-level control well information presented in Tables 8, 9, and 10.

Table 13. Estimated Surface Water Yield for Orange and Seminole Counties.

			Tributary Area (square miles)				Surface Water Yield (mgd)			
			Orange County		Seminole County		Orange County		Seminole County	
Basin Name	Basin Code	Unit Yield inches per year [a]	Recharge Area	Discharge Area	Recharge Area	Discharge Area	Recharge Area	Discharge Area	Recharge Area	Discharge Area
Lake Apopka	LA	5	84	0	0	0	20.0	0.0	0.0	0.0
Reedy Creek	RC	6	89	0	0	0	25.4	0.0	0.0	0.0
Shingle Creek	SC	6	79	0	0	0	22.6	0.0	0.0	0.0
Boggy Creek	BC	6	66	0	0	0	18.9	0.0	0.0	0.0
Lake Hart	LH	6	41	0	0	0	11.7	0.0	0.0	0.0
Little Wekiva River	LW	10	64	7	19	2	30.5	3.3	9.0	1.0
Wekiva River	W	10	32	21	5	3	15.2	10.0	2.4	1.4
Lake Jesup	LJ	16	0	0	51	119	0.0	0.0	38.8	90.6
Howell Creek	HC	16	9	2	25	6	6.9	1.5	19.0	4.6
Little Econlockhatchee River	LE	15	88	10	12	1	62.8	7.1	8.6	0.7
Econlockhatchee River	E	15	59	59	17	17	42.1	42.1	12.1	12.1
St. Johns River	SJ	16	0	152	0	26	0.0	115.8	0.0	19.8
Totals			611	251	129	174	256.1	179.9	90.0	130.3

[a] Based on basin runoff values reported by Bush and Johnston 1988.

Table 14. Summary of Lake Outlet or Lake-Level Controls in Orange County, Florida

Basin Name	Number of Lakes by Outlet or Control Type					Total Number of Lakes	Percentage of Lakes Served by Drainage Wells
	Drainage Wells	Pump Stations	Weir	Culvert	Other or Unknown		
Lake Apopka			5	2	70	77	0.0
Reedy Creek (including Cypress Creek)			3	3	69	75	0.0
Shingle Creek	4	1	4	3	44	56	7.1
Boggy Creek	16	1	5	2	22	46	34.8
Lake Hart			3		4	7	0.0
Little Wekiva River	10		5	6	19	40	25.0
Wekiva River	12	3		4	112	131	9.2
Howell Branch	15		7	5	29	56	26.8
Little Econlockhatchee River	20		4	1	51	76	26.3
Econlockhatchee River				5	18	23	0.0
St. Johns River					3	3	0.0
Totals	77	5	36	31	441	590	13.1

The total number of lakes in each major drainage basin is reported, along with the total number of lakes currently served by lake-level control wells. There are 590 lakes in Orange County and only about 13 percent are currently served by drainage wells. Thus, substantial opportunity exists to increase the number of lakes with operational lake-level control wells.

Figure 7 illustrates the distribution of lakes within Orange County. The total number of lakes and the number of lakes currently served by lake-level control wells are reported for each major drainage basin. As can be seen from this figure, the opportunity to increase aquifer recharge using additional lake-level control wells exists throughout the county. Additional recharge wells could be located to minimize net aquifer drawdown and the potential for saltwater intrusion or to maximize net benefits to springflows, or all of these.

Surface runoff rates will increase as land area develops. An appropriate use of drainage well technology may be to help offset the adverse hydrologic effects of urbanization by emplacing a volume of water equivalent to the increased runoff in the aquifer. In this manner, the surface hydrologic budget is preserved and the increased surface water yield generated by urbanization (a negative impact) is used to help offset the aquifer drawdowns associated with increased potable water use (a positive impact).

Such applications would be combined with other urban stormwater management goals, providing multi-purpose water resources management. A recent project that combines many of these attributes is the Greenwood Urban Wetland constructed in the 1980s (Palmer and Hunt 1988).

The Greenwood Urban Wetland was built primarily to alleviate flooding in an urban drainage basin located in the City of Orlando. The wetland provides pretreatment of stormwater prior to entering existing drainage wells. The pretreatment system was designed to maximize recharge water detention time, and the entire system was integrated into an urban park. This project could serve as a good model for comprehensive water resources management in the study area. New projects similar to the Greenwood Urban Wetland and with new drainage wells could provide many benefits, including increased treatment and aquifer recharge.

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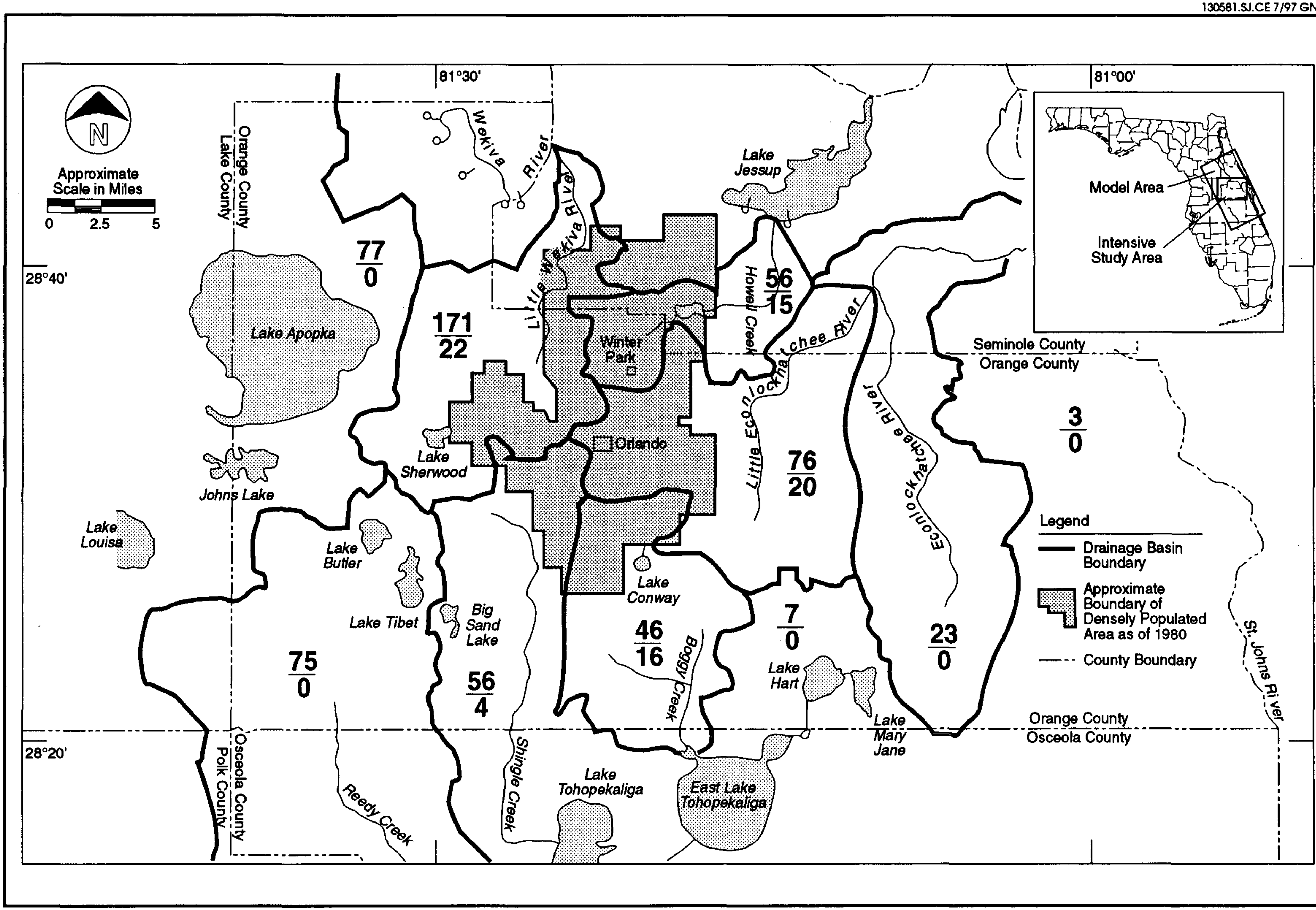

Figure 7. Distribution of Lakes in Orange County by Major Drainage Basin.

LEGEND

77 Total Lakes

0 Lakes Served by Drainage Wells

RECHARGE WATER QUALITY

The quality of the recharge water currently being emplaced by drainage wells in Orange and Seminole counties is variable. In general, it is of two types, direct urban runoff and lake or stormwater retention pond outflow. The discharge of highly polluted waters, such as septic system discharge and citrus wastes, no longer occurs.

In this section of the TM, the water quality characteristics of the recharge water are summarized and compared to the primary drinking water standards to identify constituents of concern.

URBAN RUNOFF CHARACTERISTICS

Most of the water entering the study area street or urban drainage wells is direct urban runoff. For the most part, the characteristics of urban runoff are well known. Table 15 presents a summary of typical constituent concentrations for runoff in central and south Florida (Harper 1994). The constituents of greatest concern for urban stormwater management planning include nutrients, BOD, and heavy metals, as listed in Table 15. Unfortunately, these are not necessarily the constituents of greatest concern in water supply applications. In fact, the only parameter reported in Table 15 that is also included in the primary drinking water standards is lead. The drinking water MCL of 0.015 mg/L for lead is exceeded by all values reported in Table 15, including surface runoff from open space and wetlands.

Table 16 presents a summary of stormwater characteristics measured prior to entering selected drainage wells in the study area. These data were collected as part of the East Central Florida 208 planning study conducted during the late 1970s (BC&E/CH2M HILL, 1977). The 16 parameters reported in Table 16 are all included in the primary drinking water standards. Water quality from both a retention pond (Englewood Park drainage well) and from direct urban runoff (Plaza Court drainage well) are reported. The lead concentrations observed in the retention pond water and direct urban runoff exceed the drinking water standards for both. However, lead concentrations from the retention pond were an order-of-magnitude lower than concentrations observed in the direct urban runoff. These data tend to indicate that stormwater retention is an effective treatment technology for removal of lead from stormwater.

Table 15. Summary of Literature-Based Runoff Concentrations for Selected Land Use Categories in Central and South Florida (After Harper 1994).

Land Use Category	Typical Runoff Concentration (mg/L)							Percent Impervious (%)	Runoff Coefficient
	Total N	Ortho-P	Total P	BOD	TSS	Total Zn	Total Pb		
1. Low-Density Residential[a]	1.77	0.077	0.177	4.4	19.1	0.032	0.037	14.7	0.268
2. Single-Family	2.29	0.15	0.30	7.4	27.0	0.057	0.048	27.8	0.373
3. Multi-Family	2.42	0.27	0.49	11.0	71.7	0.055	0.087	67.0	0.675
4. Low-Intensity Commercial	1.18	0.03	0.15	8.2	81.0	0.111	0.136	91.0	0.837
5. High-Intensity Commercial	2.83	0.33	0.43	17.2	94.3	0.170	0.214	97.5	0.887
6. Industrial	1.79	0.13	0.31	9.6	93.9	0.122	0.202	86.8	0.793
7. Highway	2.08	0.14	0.34	5.6	50.3	0.134	0.189	85.0	0.783
8. Agricultural									
a. Pasture	2.48	0.349	0.476	5.1	94.3	--	--	0.00	0.355
b. Citrus	2.05	0.088	0.14	2.55	16.3	--	--	0.00	0.282
c. Row Crops	2.68	0.398	0.562	--	--	--	--	0.00	0.204
d. General Agriculture	2.32	0.227	0.344	3.8	55.3	--	--	0.00	0.304
9. Recreational/Open Space	1.25	0.004	0.053	1.45	11.1	0.006[b]	0.025[b]	1.50	0.163
10. Mining	1.18	0.07[c]	0.15	9.6[d]	93.9[d]	0.122[d]	0.202[d]	23.0	0.361
11. Wetland	1.60	0.13	0.19	4.63	10.2	0.006	0.025	0.00	0.225
12. Open Water/Lake	1.25	0.05[c]	0.11	1.6	3.1	0.028	0.025[b]	100	0.500

[a] Average of single-family and recreational/open space loading rates.
[b] Runoff concentrations assumed equal to wetland values for these parameters.
[c] *Orthophosphorus concentrations assumed to equal 50% of average total phosphorus.*
[d] Runoff concentrations assumed equal to industrial values for these parameters.

Table 16. Characteristics of Stormwater Discharging to the Englewood Park and Plaza Court Drainage Wells (from BC&E/CH2M HILL 1977).

Parameter	Units	Englewood Park (Retention Pond)		Plaza Court (Direct Urban Runoff)	
		Average	Maximum	Average	Maximum
Arsenic	mg/L	<0.006	<0.008	<0.007	<0.008
Barium	mg/L	<0.03	<0.04	<0.03	<0.04
Cadmium	mg/L	<0.002	0.003	<0.003	<0.004
Chromium	mg/L	<0.004	<0.005	0.009	0.011
Fluoride	mg/L	0.085	0.090	0.045	0.050
Lead	mg/L	<0.028	0.037	0.345	0.520
Nitrate	mg/L	0.03	0.03	0.75	1.39
Selenium	mg/L	<0.004	<0.004	<0.004	<0.004
Sodium	mg/L	7.8	8.2	3.3	4.9
Heptachlor	µg/L	<0.01		<0.01	
Heptachlor Epoxide	µg/L	<0.01		<0.03	
Lindane	µg/L	<0.01		2.6	
Endrin	µg/L	<0.01		<0.06	
Methoxychlor	µg/L	<0.50		<0.2	
Chlordane	µg/L	<0.05		<0.5	
Toxaphene	µg/L	<0.50		<3.0	

The only other exceedance observed was lidane in the direct urban runoff. The remaining 14 parameter were all well within the primary drinking water MCL values.

Stormwater runoff coliform data are relatively scarce. However the data available indicate that coliform concentrations in direct urban runoff are highly variable and extremely large relative to a drinking water standard of 4 MPN/100 ml. For example, average fecal coliform concentrations in urban stormwater runoff measured in Atlanta, Georgia, ranged from 2,100 MPN/100 ml to 11,000 MPN/100 ml (Lager et. al. 1977). Measurements in Tulsa, Oklahoma, ranged from 10 MPN/100 ml at an airport site, to 18,000 MPN/100 ml at an industrial site. Runoff from a typical residential area in Tulsa measured 3,300 MPN/100 ml (Lager et. al. 1977). Because the concentrations above are fecal coliform measurements, total coliform concentrations would be even larger. Typically, total coliform concentrations in urban runoff are on the order of 1,000 to 10,000 MPN/100 ml.

The fate and transport of bacteria and other microorganisms within the Floridan aquifer is largely unknown. Parameters such as die-off rates have not been investigated. It is known, however, that limestone aquifers, including the Floridan aquifer, are highly variable, with large and small cavities and channels interconnected both horizontally and vertically (Lichter et al. 1968). Therefore, the potential exists for relatively rapid movement within the aquifer. Attenuation mechanisms, including natural filtration, die-off, and dilution, will reduce bacteria concentrations associated with the recharge water. The effectiveness of these mechanisms should be investigated.

LAKE WATER CHARACTERISTICS

Lake water quality data provided by Orange County were analyzed to establish current lake water recharge characteristics. All data analyzed were collected in the 1990s and, therefore, represent current conditions. In addition, only lakes currently served by lake-level control wells were considered. The parameters considered were selected because they are associated with general lake health (5-day biochemical oxygen demand [BOD_5], total phosphorus, and total suspended solids [TSS]), or they are included in the primary drinking water standards.

The results of this analysis by lake and sampling station are reported in Tables 17 and 18. Table 17 reports the mean value observed at each sampling station, and Table 18 reports maximum observations. These

Table 17. Lake Water Quality Data -- Summary of Mean Values with Comparison to Drinking Waters MCLs.

Lake Name	Orange County Station	Total Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	BOD_5 mg/L	Total P mg/L	Nitrates (NO_3) mg/L	Nitrites (NO_2) mg/L	TSS mg/L	Sodium (NA) mg/L	Lead (PB) µg/L	Cadmiun (CD) µg/L	Nickel (NI) µg/L	Chromium (CR) µg/L	Mercury (HG) µg/L	Selenium (SE) µg/L	Arsenic (AS) µg/L
Barber (George)	BC2	80	45	2.16	0.018	0.120	0.003	3.0	6.77	5.63	5.93	21.1	8.14	0.10	10.0	3.4
Bass	BC3	146	70	3.63	0.012	0.037	0.121	5.8	16.44	4.58	0.78	22.8	1.72	0.10	3.0	4.3
Bearhead	BC4	159	40	2.77	0.036	0.048	0.011	4.3	- -	3.82	0.25	20.0	5.00	0.10	- -	2.5
Buchannon	SC3	- -	- -	1.83	0.048	0.061	0.005	5.0	- -	2.50	0.81	- -	5.00	0.10	- -	2.5
Catherine																
-- northeast lobe	SC29	- -	- -	3.32	0.045	0.043	0.003	4.4	- -	3.18	- -	- -	- -	- -	- -	- -
-- mid	SC6	100	- -	4.29	0.043	0.033	0.003	4.1	- -	3.18	- -	- -	- -	- -	- -	- -
-- south lobe	SC28	82	- -	4.89	0.065	0.029	0.004	4.7	- -	3.08	- -	- -	- -	0.17	- -	2.5
Concord	HB7	302	311	2.95	0.047	0.049	0.005	7.5	- -	- -	- -	- -	- -	- -	- -	- -
Conway																
-- northeast	BC6	45	18	1.70	0.015	0.015	0.003	1.9	18.51	2.12	0.47	22.4	0.94	0.10	6.4	3.8
-- northwest	BC7	24	5	1.48	0.013	0.014	0.003	2.0	18.98	2.26	0.48	19.3	0.92	0.10	2.5	4.1
-- mid lobe	BC8	51	34	1.54	0.010	0.015	0.003	2.5	22.30	2.58	0.51	21.2	0.88	0.10	6.0	3.7
-- south lobe	BC9	11	3	1.46	0.011	0.012	0.003	2.0	21.39	2.51	0.47	21.1	0.85	0.14	5.3	4.1
Fairview																
-- north lobe	LW28	159	142	2.19	0.022	0.010	0.003	4.4	10.28	2.19	0.44	23.0	1.48	0.10	2.5	3.2
-- south lobe	LW29	180	82	2.96	0.043	0.017	0.004	6.8	9.92	4.97	0.49	23.3	1.19	0.10	2.5	2.5
Holden																
-- north	BC14N	300	106	3.94	0.265	0.013	0.005	10.3	13.69	2.48	0.39	20.0	1.99	0.10	2.5	3.4
-- south	BC14S	148	79	3.93	0.046	0.015	0.005	9.7	15.60	2.64	0.41	20.0	2.19	0.10	0.0	6.8
Jassamine	BC17	39	23	2.20	0.018	0.019	0.003	4.1	13.21	3.65	0.72	24.4	1.79	0.10	7.4	0.0
-- west	BC17W	--	--	1.98	0.021	0.025	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
-- north east	BC17NE	--	--	2.97	0.017	0.041	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Killarney	HB21	477	385	2.66	0.029	0.013	0.004	5.3	9.37	2.49	0.45	22.6	1.63	0.10	2.5	2.5
Lawne																
-- north	LW10N	234	84	3.87	0.131	0.032	0.006	11.1	10.34	2.52	0.46	22.1	1.13	0.10	3.1	2.5
-- mid	LW10M	273	142	3.66	0.098	0.099	0.007	- -	- -	3.13	- -	- -	- -	- -	- -	- -
-- south	LW10S	194	68	4.11	0.124	0.024	0.006	8.8	10.28	2.35	0.41	22.0	1.08	0.10	2.5	3.3
Little Fairview	LW11	322	161	2.89	0.031	0.010	0.003	5.9	- -	4.00	- -	- -	- -	- -	- -	- -
Lorna Doone	SC11	415	135	3.31	0.045	0.015	0.007	5.5	4.61	2.85	0.55	22.7	1.72	0.10	2.5	2.5
Olivia	BW45	55	- -	3.15	0.074	0.018	0.008	4.7	- -	5.12	- -	- -	- -	- -	- -	- -
Pinelock	BC22	210	81	3.01	0.031	0.055	0.005	4.8	11.31	2.73	0.50	23.8	2.01	- -	- -	3.0
Sherwood	BW54	173	- -	3.08	0.033	0.039	0.004	- -	- -	3.23	- -	- -	- -	- -	- -	- -
Overall Mean -- all Lakes		174	101	2.93	0.050	0.033	0.01	5.3	13.31	3.19	0.81	21.9	2.20	0.11	3.9	3.2
Std. Dev.		125	97	0.92	0.053	0.026	0.02	2.6	5.15	0.98	1.29	1.5	1.92	0.02	2.6	1.3
Coeff. of Variation		0.715	0.965	0.315	1.062	0.797	2.525	0.477	0.387	0.308	1.594	0.067	0.872	0.173	0.657	0.404
Maximum		477	385	4.89	0.27	0.120	0.12	11.1	22.30	5.63	5.93	24.4	8.14	0.17	10.0	6.8
Minimum		11	3	1.46	0.010	0.010	0.00	1.9	4.61	2.12	0.25	19.3	0.85	0.10	0.0	0.0
MCL		4	na	na	na	10	1	na	160	15	5	100	100	2	50	50

Table 18. Lake Water Quality Data -- Summary of Maximum Values with Comparison to Drinking Water MCLs.

Lake Name	Orange County Station	Total Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	BOD_5 mg/L	Total P mg/L	Nitrates (NO_3) mg/L	Nitrites (NO_2) mg/L	TSS mg/L	Sodium (NA) mg/L	Lead (PB) µg/L	Cadmiun (CD) µg/L	Nickel (NI) µg/L	Chromium (CR) µg/L	Mercury (HG) µg/L	Selenium (SE) µg/L	Arsenic (AS) µg/L
Barber (George)	BC2	550	500	9.60	0.049	1.000	0.010	9.0	13.78	46.00	32.00	50.0	55.00	0.10	34.0	6.00
Bass	BC3	640	490	10.80	0.036	0.112	0.360	27.0	20.30	11.40	2.50	40.0	5.00	0.10	5.0	7.00
Bearhead	BC4	640	62	4.20	0.056	0.170	0.053	8.0	- -	12.60	- -	20.0	- -	- -	- -	- -
Buchannon	SC3	- -	- -	2.80	0.129	0.180	0.010	7.0	- -	2.50	2.50	- -	5.00	0.10	- -	2.50
Catherine																
-- northeast lobe	SC29	- -	- -	6.30	0.058	0.250	0.008	10.0	- -	7.20	- -	- -	- -	- -	- -	- -
-- mid	SC6	156	- -	15.60	0.051	0.210	0.008	9.0	- -	7.20	- -	- -	- -	- -	- -	- -
-- south lobe	SC28	92	- -	20.40	0.177	0.160	0.008	6.0	- -	6.90	- -	- -	- -	- -	- -	2.50
Concord	HB7	540	890	4.10	0.064	0.170	0.010	17.0	- -	- -	- -	- -	- -	- -	- -	- -
Conway																
-- northeast	BC6	266	162	6.40	0.036	0.166	0.007	8.0	23.20	8.30	2.50	50.0	5.00	0.10	36.0	7.00
-- northwest	BC7	180	64	6.50	0.040	0.137	0.018	10.0	32.20	8.40	2.50	20.0	5.00	0.10	2.5	7.00
-- mid lobe	BC8	280	254	5.90	0.030	0.100	0.007	7.0	44.70	10.10	2.50	50.0	5.00	0.10	36.0	6.00
-- south lobe	BC9	90	38	6.30	0.040	0.088	0.011	6.0	41.04	10.60	2.50	50.0	5.00	0.50	35.0	7.00
Fairview																
-- north lobe	LW28	760	570	3.80	0.037	0.040	0.009	10.0	11.84	4.80	2.50	50.0	5.00	0.10	2.5	6.00
-- south lobe	LW29	1,280	510	6.20	0.069	0.080	0.010	17.0	11.46	26.10	2.50	50.0	5.00	0.10	2.5	2.50
Holden																
-- north	BC14N	1,240	260	6.80	6.000	0.089	0.012	18.0	15.28	6.20	1.10	20.0	5.00	0.10	2.5	7.00
-- south	BC14S	440	176	5.90	0.096	0.075	0.011	17.0	17.64	5.90	1.00	20.0	5.00	0.10	- -	17.00
Jassamine	BC17	290	356	4.10	0.030	0.100	0.007	12.0	15.90	14.80	2.50	50.0	5.00	0.10	22.0	- -
-- west	BC17W	- -	- -	3.00	0.048	0.075	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
-- north east	BC17NE	- -	- -	4.20	0.035	0.078	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Killarney	HB21	845	710	4.60	0.061	0.060	0.020	16.0	10.93	12.70	2.50	46.0	5.00	0.10	2.5	2.50
Lawne																
-- north	LW10N	2,280	1,420	12.00	0.211	0.560	0.012	29.0	12.66	7.20	2.50	50.0	5.00	0.10	7.0	2.50
-- mid	LW10M	870	280	7.10	0.175	0.550	0.011	0.0	- -	6.50	- -	- -	- -	- -	- -	- -
-- south	LW10S	1,200	350	10.20	0.187	0.600	0.015	23.0	12.70	6.60	2.50	50.0	5.00	0.10	2.5	7.00
Little Fairview	LW11	720	240	5.00	0.051	0.040	0.006	11.0	- -	6.00	- -	- -	- -	- -	- -	- -
Lorna Doone	SC11	2,200	660	6.30	0.079	0.070	0.053	12.0	5.48	8.20	2.50	50.0	5.00	0.10	2.5	2.50
Olivia	BW45	92	- -	6.00	0.112	0.090	0.042	13.0	- -	9.70	- -	- -	- -	- -	- -	0.00
Pinelock	BC22	830	264	6.20	0.187	0.380	0.014	12.0	12.51	13.80	2.50	50.0	5.00	- -	- -	5.00
Sherwood	BW54	410	- -	6.60	0.053	0.150	0.009	- -	- -	7.40	- -	- -	- -	- -	- -	- -
Mean (of maximums)		704	413	7.03	0.293	0.206	0.029	12.6	18.85	10.68	4.06	42.12	7.94	0.13	13.75	5.39
Std. Dev.		594	330	3.86	1.120	0.220	0.069	6.7	11.17	8.66	7.21	12.89	12.13	0.10	15.01	3.68
Coeff. of Variation		0.844	0.799	0.549	3.825	1.067	2.417	0.535	0.592	0.811	1.775	0.306	1.527	0.800	1.091	0.684
Maximum		2,280	1,420	20	6	1	0.360	29.0	44.70	46.00	32.00	50.0	55.00	0.50	36.00	17.00
Minimum		90	38	3	0	0	0.006	0.0	5.48	2.50	1.00	20.0	5.00	0.10	2.50	0.00
MCL		4	na	na	na	10	1	na	160	15	5	100	100	2	50	50

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values are summarized for all sampling stations. Summary statistics include the mean, standard deviation, maximum value, and minimum value. When applicable, the current primary drinking water MCL value is also reported.

As can be seen from Table 17 the only primary drinking water standard exceeded by all the lakes is fecal coliform. The average observed value is 174 MPN/100 ml, and the drinking water MCL is 4 MPN/100 ml. The only other constituent exceeded at any lake is cadmium, and only one sampling station among the 25 exceeded this standard.

Lead is well within the MCL value for all the lakes. This may indicate that adequate treatment is being provided by these natural systems or that lead is declining in the environment, or both of these conditions. In recent years, lead has decreased in the environment as unleaded gasoline has replaced leaded gasoline and residual lead has been washed from land surfaces.

Considering worst-case conditions, which would be the maximum of all observations at all 28 lake sampling stations shown in Table 18, only total coliform, lead, and cadmium limits were exceeded. The MCL for lead was exceeded at two stations and the MCL for cadmium was exceeded at one station.

POLLUTANT LOADING CONSIDERATIONS

Annual pollutant loads emplaced in the aquifer by drainage well recharge are equal to the average constituent concentrations multiplied by the annual recharge volume. Fortunately, approximately 85 percent of the total recharge volume is higher quality lake water, and only 15 percent is lower quality direct urban runoff. However, in many cases, it is likely that the lower volume street and urban drainage accounts for the majority of the pollutants.

For example, if total colifom concentration in direct urban runoff is 10 times greater than lake water concentrations (a reasonable ratio), then more than 63 percent of the total colifom entering the aquifer will be associated with the street drainage recharge.

Based on the information above, it can be concluded that lake water is of generally higher quality than direct urban runoff, and total coliform is the major constituent of concern. With lake water, other primary drinking water standards are met in the vast majority of circumstances. In addition, because street runoff enters the well and aquifer directly and rapidly, the potential for aquifer contamination from accidental spills is much higher than for lake-level control wells. Thus, recharge of lake water is preferable to recharge of direct urban runoff.

REGULATORY FRAMEWORK

The Safe Drinking Water Act of 1974 directed EPA to promulgate an UIC program. The federal UIC program is contained in 40 Code of Federal Regulations (CFR), Parts 144, 145, 146, and 147, which are summarized below:

- Part 144 establishes the minimum UIC program requirements.
- Part 145 specifies EPA procedures for approval, revision, or withdrawal of state UIC programs.
- Part 146 establishes technical criteria and standards for both state and federal programs.
- Part 147 provides for state administration of UIC programs promulgated in accordance with federal UIC requirements. Authorization for Florida's UIC program is contained in Subpart K of 40 CFR, Part 147.

An outline of these regulations is provided in Appendix B.

Florida's UIC program was approved by EPA and became effective on March 9, 1983. The program is administered by FDEP.

FLORIDA RULES

The primary Florida rules pertaining to underground injection control are contained in Chapter 62-528 FAC, The UIC Program. Florida's program closely follows federal rules. The 1995 amendments to the state's program were largely driven by allegations that Florida's rules were less stringent than the federal rules.

Chapters 62-520 FAC, Groundwater Classes, Standards and Exemptions, and 62-522 FAC, Groundwater Permitting and Monitoring Requirements, contain additional technical requirements for the operation and monitoring of Class V wells. Administrative, legal, and technical issues associated with injection wells are contained in a number of other state and federal regulations, rules, and statutes. An annotated listing of pertinent rules is provided in Appendix C.

REGULATION OF AQUIFER RECHARGE WELLS

Aquifer recharge wells are regulated as Class V wells. The Class V category includes all wells that introduce non-hazardous fluids into or above an aquifer designated as a USDW. Florida regulations differentiate 22 groups and subgroups of Class V wells on the basis of intended use and source and the quality of the injected water. Subgroups of Class V wells pertinent or potentially pertinent to artificial recharge of freshwater aquifers in SJRWMD are as follows:

- Group 2a. Recharge wells used to replenish, augment, or store water in an aquifer
- Group 2b. Saltwater intrusion barrier wells
- Group 2c. Subsidence control wells, which are used to reduce or eliminate subsidence associated with the overdraft of freshwater
- Group 6. Stormwater wells and lake-level control wells used to drain surface waters into a subsurface formation (drainage wells)
- Group 7. ASR wells

REGULATORY STATUS OF EXISTING FACILITIES

Drainage wells have been used for lake-level control and stormwater management in Orange and Seminole counties for more than 90 years (Schiner and German 1983). The existing drainage well facilities (those constructed prior to March 1983) "existed before Primacy" and are, for the most part, used in place. However, it is virtually impossible, under the current interpretation of the regulations governing Class V wells, to obtain a permit for a new Class V, Group 6, well. Even the ability to obtain construction permits to repair or modify existing facilities is uncertain because the permitting process could trigger a requirement that the injected water meet primary and secondary drinking water standards. It is unlikely that recharged surface waters could meet these criteria without undergoing extensive physical and chemical treatment prior to injection.

The only known drainage well reconstruction permit issued in recent years was for the Lake Tennessee well. The reconstruction permit was obtained by the City of Orlando.

REGULATORY ISSUES

Federal regulations pursuant to the 1974 Safe Drinking Water Act (SDWA) do not address the potential beneficial effects of drainage wells and other subclasses of Class V wells.

The failure of the regulations to anticipate potential beneficial uses and to focus only on the risks has resulted in interpretations that severely constrain opportunities for using drainage wells and related subclasses of Class V wells in an integrated water management strategy. The focus of the problem is found in the interpretation of 40 CFR Part 144.12(a):

"No owner or operator shall construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR Part 142 or may otherwise adversely affect the health of persons. The applicant for a permit shall have the burden of showing that the requirements of this paragraph are met."

The meaning of this requirement, as currently interpreted by EPA and FDEP, is that the injected water must meet drinking water standards prior to injection. No zone of mixing (zone of discharge) is allowed under Florida rules (62-522.300[2][a] FAC) for direct discharge to groundwater. The rules do provide for a zone of discharge for indirect discharges, such as percolation ponds and land application.

The national primary drinking water standard regulation in 40 CFR Part 142, referenced in subparagraph (a) above. Part 142.2 provides the following definitions:

- *National primary drinking water regulations* means any primary drinking water regulation contained in Part 141 of this chapter. (Part 141 provides maximum contaminant levels.)
- *Maximum contaminant level* means the maximum permissible levels of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system, except in the case of turbidity, where the maximum permissible level is measured at the point of entry into the distribution system.

The language of 144.12 suggests a prohibition on contamination of a USDW that results in an exceedance of an MCL after the raw water has been treated and distributed in a potable water system. The plain language of these regulations seems to prohibit contaminating a drinking water aquifer with pollutants that cannot be readily removed (economically and in a technically feasible manner) at a WTP before distribution to consumers. CFR Part 144.12 was promulgated pursuant to the 1974 SDWA, 42 USCA Section 300h, et seq., which states:

"Underground injection endangers drinking water sources if such injection may result in the presence in underground water which supplies or can reasonably be expected to supply any public water system of any contaminant, and if the presence of such contaminant may result in such system's not complying with any national primary drinking water regulation or may otherwise adversely affect the health of persons."

This language seems even more focused on preventing the contamination of aquifers with pollutants that will cause finished water in a public water supply system, not a raw water source, to violate primary standards.

The insistence of EPA and FDEP that recharge water be treated to drinking water standards before recharge is the main issue inhibiting the use of Class V injection wells for aquifer recharge and other beneficial uses. Under these standards, recharging aquifers containing Class I or Class II groundwater with water not meeting drinking water standards is prohibited, even if recharge is necessary to maintain the aquifer as a viable drinking water source. The main concern is the presence of heavy metals, oil, grease, and bacteriological contaminants that are perceived as being hazardous. State and federal regulators insist that, notwithstanding the plain language of the SDWA and the regulations, these risks demand their interpretation of Section 144.12, which requires that injection water meet drinking water standards.

AQUIFER EXEMPTION

This interpretation of the rules would require obtaining an aquifer exemption whenever a proposed recharge source fails to meet drinking water standards. Exempted aquifers excluded from the procedures and technical requirements for aquifer exemptions are contained in Chapters 62-528 FAC and 62-520.520. The exemption provided under 62-520.520 applies only to the exemption from secondary standards. An exemption covering primary standards requires approval of the EPA administrator (a major exemption) or the EPA regional administrator (a minor exemption).

The viability of any regulatory action, particularly in Florida, that would exempt an aquifer from water quality protection is questionable. Notwithstanding the technical merits of such an action, it is unlikely that current public opinion would support such an exemption. However, no alternative permitting mechanism exists in the federal UIC regulations. Because Florida's UIC regulations closely follow the wording of EPA's regulations, the only regulatory options presently available in the state involve either an aquifer exemption or a water quality exemption. EPA is in the process of developing national Class V rules. At present, regulation of existing drainage wells and related recharge wells in Florida is essentially on a well-by-well basis.

ARTIFICIAL RECHARGE MANAGEMENT OPTIONS

The management of artificial recharge by using drainage wells in Orange and Seminole counties is largely governed by existing UIC regulations, as discussed previously. In this section, implications of the current approach, including the feasibility and cost associated with compliance, are discussed, as is an alternative approach for improving existing conditions.

CURRENT APPROACH

The current regulatory approach to drainage well management effectively prohibits constructing new drainage wells or modifying existing wells. The objective of the current approach is to protect the Floridan aquifer from contamination by prohibiting the introduction of water than does not fully meet all DWSs.

Theoretically, new artificial recharge wells could be constructed if they met all DWSs, including the total coliform MCL of 4 MPN/100 ml. However, fully meeting this criterion is beyond the limits of any passive surface water treatment techniques, such as retention ponds, wet ponds, or wetlands treatment systems. It is likely that the best water quality obtainable using natural or passive treatment systems is currently being obtained by area lakes. These lakes produce an average total coliform concentration of 174 MPN/100 ml (101 MPN/100 ml for fecal coliform). These levels meet Class I surface water standards and are considered safe for body contact recreation and raw surface water supply.

The primary rationale for the restrictive coliform criteria for potential ground water supplies is that many individual water supply wells provide drinking water for direct consumption without disinfection. Surface waters are not distributed without treatment, including disinfection. However, whether or not it is necessary to fully meet the drinking water standard at the point of entry into the aquifer is open to debate. The Orange County Health Department reports that contamination of drinking water wells occurs from time to time (Fuchs, K. pers. com., 1997), but the source of contamination is largely unknown and undocumented. Potential sources of drinking water contamination include poor water well construction and the presence of septic system leachate, as well as surface water recharge. No doubt, die-off of coliform and other microorganisms will occur once the recharge water enters the aquifer. In addition, further attenuation will be achieved by natural filtration and dilution. However, little is known about the ultimate fate of microorganisms in the Upper Floridan aquifer.

Treatment Requirements and Costs

To fully meet DWSs at the point of entry into the recharge well would require physical or chemical disinfection of the recharge water. Camp Dresser and McKee (CDM) (1994) evaluated the technical and economic feasibility of disinfecting Lake Tennessee recharge water for the City of Orlando. Three disinfection technologies were evaluated: chlorination, ozonation, and ultraviolet (UV) radiation. Issues considered included disinfection effectiveness, costs, practicality, and potential adverse environmental effects.

Chlorination is currently the most widely used disinfection technique in conventional water and wastewater applications, and chlorine systems are generally reliable. However, chlorine gas is highly toxic and extremely hazardous. Chlorine may also react with other constituents in lake recharge water and form undesirable chlorinated hydrocarbons, which could then be introduced into the aquifer.

Ozone is also a very effective disinfection agent; however, it is unstable and must be generated onsite. Like all chemical disinfectants, it is toxic and potentially hazardous. It is also relatively expensive and energy intensive. However, ozone will not produce unwanted chlorinated hydrocarbons.

UV light is a physical disinfecting technique that is inherently safer than chemical disinfectants, such as chlorine or ozone. UV light does not form undesirable disinfectant by-products; however, it is only effective with clear feed water. The presence of color or turbidity will interfere with light penetration and, therefore, the effectiveness of disinfection.

Camp, Dresser and McKee (1994) prepared construction cost estimates for disinfection of the 8-inch Lake Tennessee drainage well inflow. Costs were prepared for a 1-cubic-feet-per-second (cfs) to a 10-cfs system to identify probable costs. Construction costs for gaseous chlorination systems ranged from $75,000 to $300,000. Ozonation construction costs ranged from $250,000 to $2,000,000, and the UV system ranged from $125,000 to $260,000. Considering the overall characteristics of each alternative disinfection technique and the range of construction costs reported above, it would appear that UV disinfection is the most attractive option. Gaseous chlorine would be hazardous at remote, unattended locations and could introduce harmful pollutants into the aquifer. Ozone is also hazardous and expensive. UV is the least hazardous and most feasible for remote, unattended locations.

The maximum hydraulic capacity of the Lake Tennessee drainage well was estimated to be about 7 cfs (CDM, 1994). If 7 cfs is used as the disinfection facility design capacity, the anticipated construction cost would be about $230,000. Total capital cost would be approximately 45 percent greater, or $333,000. Operation and maintenance cost estimates are not currently available and would need to be established during a pilot or research study. Clearly, the capital cost of retrofitting all lake-level control wells to provide disinfection would be substantial. Using a unit cost of $333,000 per well and 110 known active lake-level control wells, the areawide total capital cost would be about $37 million.

Providing disinfection facilities at street drainage wells would be much more difficult than at lake-level control wells. Street drainage wells tend to be located in highly developed downtown areas below streets and sidewalks. Also, the flow rate and water quality arriving at street drainage wells are more variable than lake-level control applications. Therefore, construction for disinfection facilities would be difficult and disinfection effectiveness would be reduced.

Implications of Current Approach

There are several implications associated with continued use of the current drainage well management approach. First, because no new recharge wells can be constructed, no additional artificial recharge will be obtained. Thus, additional hydrologic benefits, including reduced aquifer drawdown, potentially increased spring flow, and added protection against saltwater upconing, are unrealized.

Second, since upgrades or significant changes in the existing drainage well configuration are difficult to achieve, direct urban runoff continues to be emplaced in the aquifer. The permitting of new drainage wells, as in the case of the Lake Tennessee well reconstruction, is extremely difficult; therefore, existing systems tend to remain in place, even if improvements could be realized by construction of a new well. A new well that replaces an existing street drainage well and also provides passive stormwater treatment, such as a wet pond, would result in lower overall pollutant loads to the aquifer. However, because conventional stormwater treatment systems cannot fully meet all primary DWSs, these systems cannot be permitted under current regulations. This situation encourages the status quo and discourages incremental improvements.

Under the current regulatory approach, the only practical way aquifer pollutant loads can be reduced is to eliminate active drainage wells. This approach reduces aquifer recharge and can lead to environmentally costly surface water management practices, including construction of disruptive conveyance and pumping facilities and interbasin transfers of surface waters.

INCREMENTAL IMPROVEMENT APPROACH

An alternative drainage well management approach that should be considered by water resources managers and regulatory agencies is based on net incremental improvements. The objective of this approach is to permit projects that provide a net benefit to the aquifer without inducing other undesirable impacts. Benefits should be defined in terms of increased recharge without increasing aquifer pollutant loadings, or in reduced existing pollutant loadings.

Using this approach, rerouting street drainage to a lake would be encouraged. To provide the same level of flood protection, a new lake-level control well would be permitted and constructed to replace the abandoned street drainage well. Although all DWSs will not be met by the lake water, the rerouted recharge water would be better quality than current street drainage water. Thus, pollutant loads to the aquifer would be reduced and a net benefit realized.

When adding new tributary area to a lake, care must be taken not to adversely impact the lake. In particular, nutrient loadings should not be increased to the point where algae blooms or other detrimental impacts occur. The total water resources system must be considered and, if necessary, stormwater treatment facilities included in the rerouting plans.

In another situation, it may be possible to increase flood protection and recharge quantity by lowering the inflow elevation of an existing lake-level control well. This action should be permittable if enough additional treatment is provided to reduce pollutant concentrations such that total loads are not increased. In this case, the benefits of increased flood protection and increased aquifer recharge are realized, without increasing aquifer pollutant loads.

CONCLUSIONS

SUMMARY

Drainage wells have been used in Orange and Seminole counties to provide land drainage and flood control since 1905. The topography of this region includes many closed hydrologic basins, with no natural surface outflow. This condition, along with the naturally high transmissivity of the Floridan aquifer, made drainage wells an attractive option for addressing urban drainage and lake-level control. In many cases, no other practical option exists. Until the mid-1960s, when construction of drainage wells was halted because of concerns about aquifer contamination, drainage wells were the traditional solution to local drainage problems. Currently, there are on the order of 400 drainage wells located in Orange and Seminole counties, with most wells located within or near the City of Orlando.

Nationally, there are approximately 80,000 to 100,000 stormwater drainage wells located in 38 states. In Florida, there may be as many as 7,600 drainage wells, most of which are located in Dade and Broward counties. A large number of these wells are swimming pool drainage wells and not stormwater recharge wells.

The drainage wells in Orange and Seminole counties provide several important water resources management functions. The primary function is flood control and drainage, especially within closed urban basins. Drainage is the original reason for their construction, and drainage continues to be an important benefit.

In addition, existing drainage wells provide significant artificial recharge of the Upper Floridan aquifer. Based on the analysis presented in this TM, the total average annual artificial recharge rate provided by study area drainage wells is approximately 54 mgd. This estimate is somewhat greater than previous estimates, which have ranged from about 35 to 50 mgd.

The artificial recharge provided by the drainage wells is quantitatively important to study area water resources. This recharge source helps minimize potentiometric surface declines resulting from water supply withdrawal. That is, without this source of recharge water, aquifer drawdowns would be greater, local springflows would likely be reduced, and the potential for salt water upwelling would increase. These are important water resources management benefits.

Technically, existing Floridan aquifer artificial recharge rates and associated water resources benefits could be increased substantially by constructing appropriate additional recharge wells.

However, drainage well technology can be misused and has been misused in the past. Beginning in the early part of this century and extending into the early 1950s, drainage wells were used to dispose of raw or partially treated domestic wastewater. In addition, some drainage wells were used to dispose of industrial process water and agricultural wastes. These practices have been eliminated.

Street, urban drainage, and lake-level control wells in operation today emplace stormwater and lake water contaminants in the aquifer. In general, one or more primary DWSs are not met at the point of entry into the aquifer. It is likely that the total coliform DWS is always exceeded and has been exceeded for more than 90 years. However, there is no evidence of significant aquifer contamination associated with existing operational drainage wells in Orange or Seminole counties.

The potential for local aquifer contamination exists. Street drainage wells provide a direct conduit to the aquifer for untreated urban runoff and accidental spills that occur in the future.

Existing drainage well regulations and policy result in a status quo situation. Existing wells are grandfathered under current law and policy, and new wells are nearly impossible to construct. Current regulations require that all primary and secondary drinking water standards be met before artificial recharge water can be emplaced in the aquifer. This criteria is nearly impossible and economically unfeasible to meet in urban drainage and lake-level control applications. Thus, the net effect of this policy is little or no improvement in aquifer recharge quantity or quality.

Existing drainage well regulations and policy do not encourage total water resources management, which would include reducing the quantity of pollutants entering the Upper Floridan aquifer, increasing beneficial aquifer recharge, and providing cost-effective treatment of surface recharge waters.

RECOMMENDATIONS

Drainage or artificial recharge injection wells should be recognized as a useful technology for total water resources management, including overall protection of the Floridan aquifer and urban drainage and flood control. This technology has both advantages and disadvantages, and should be used when the advantages outweigh the disadvantages.

Existing regulations and policy should be revised to encourage net improvements in recharge water quality and increased recharge volume using drainage or injection wells. Net improvement should be defined as increased aquifer recharge or decreased aquifer pollutant loadings, or both. In this manner, incremental improvements relative to existing conditions can be achieved even though all the DWSs are not met by the recharge water.

For example, where possible, direct street drainage wells should be replaced with new wells that incorporate standard accepted stormwater treatment systems, such as wet ponds. Such action could substantially decrease current pollutant loads to the aquifer. A net improvement would occur, even though all the DWSs would not be met by applying standard stormwater treatment. Projects that both increase recharge and decrease pollutant loads should be encouraged.

Consideration should also be given to supporting a number of research or demonstration projects to obtain a better understanding of the risks associated with direct artificial recharge of surface waters. One such area of research deals with the fate of coliform and other bacteria in the aquifer. This project would involve constructing observation wells near an existing drainage well. Measuring bacteria concentrations in the recharge water and nearby aquifer would provide insight into the survival rate of these aerobic bacteria in the underground environment. The results of this effort would help quantify the compatibility of surface water recharge wells and individual supply wells.

Another area of interest is the ability of passive stormwater treatment techniques to reduce pollutants of interest, including bacteria from entering the aquifer. Most stormwater treatment research has been focused on constituents of concern to surface water environments, such as suspended solids, BOD, and nutrients. Little emphasis has been placed on bacteria removal.

In combination, these areas of research would provide a foundation for determining the efficacy of the current DWS criteria as applied to recharge water, as well as the effectiveness of passive stormwater treatment techniques relative to parameters of interest for aquifer protection.

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Appendix A
Drainage Well Data Base

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	Flood Elevation -- ft. msl 10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
282938081242901	28 29 38	81 24 29	34		--		O		466	--	--											
283043081264301	28 30 43	81 26 43	60		--		O		164	--	12											
283059081342401	28 30 59	81 34 24	70		--		O		--	--	12											
283218081214402	28 32 18	81 21 44	159		--		O		863	--	8											
283218081214403	28 32 18	81 21 44	161		--		O		645	--	--											
283321081231801	28 33 21	81 23 18	263		--		O		471	--	--											
284543081174001	28 45 43	81 17 40	398		A B PETERSON		S		369	118	10											
283052081235201	28 30 52	81 23 52	67		A T CONTELLA		O		250	150	4											
282929081244201	28 29 29	81 24 42	31		AGNES DOUGHERTY		O		368	--	12											
282938081242901	28 29 38	81 24 29	33		AGNES DOUGHERTY		O		466	92	6											
282748081201701	28 27 48	81 20 17	12		ALBERT BASLER		O		235	--	8											
283855081223501	28 38 55	81 22 35	393	421	ALTAMONTE SPRINGS	A	S	61.00	320	260	10-12	LW	L	1051	135	100	65		67	65		67
283858081223001	28 38 58	81 22 30	394	505	ALTAMONTE SPRINGS	A	S	61.60	200	120	8	LW	L	1051	135	100	65		67	65		67
284215081305001	28 42 15	81 30 50	385		BAXTER LONG		O		318	71	8											
283321081195601	28 33 21	81 19 56	261		C A KUHR		O		350	194	8											
283759081193501	28 37 59	81 19 35	391		C H GALLOWAY		S		260	66	8											
283312081210301	28 33 12	81 21 03	252		C W JAMERSON		O		349	261	6											
283051081352801	28 30 51	81 35 28	66		CHARLOTTE ROPER		O		293	--	8											
283142081352501	28 31 42	81 35 25	109		CHARLOTTE ROPER		O		400	--	--											
283204081351401	28 32 04	81 35 14	143		CHARLOTTE ROPER		O		--	--	8											
284025081301701	28 40 25	81 30 17	381		CITY OF APOPKA		O		423	124	12											
284032081302401	28 40 32	81 30 24	382		CITY OF APOPKA		O		315	94	12											
283729081223801	28 37 29	81 22 38	374		CITY OF MAITLAN		O		403	117	20											
283412081322901	28 34 12	81 32 29	302		CITY OF OCOEE	A	O	97.68	350	150	12	LW	L	1678	340		100.51	100.78	101.19			
	28 34 14	81 32 29			CITY OF OCOEE	A	O	97.06	350	150	8	LW	L	1678	340		100.51	100.78	101.19			
283443081303401	28 34 40	81 30 34	326	W7	CITY OF OCOEE	A	O	112.09	440	205	12	LW	L	253	24	125	116.86	117.21	117.91	117.12	117.5	118.22
283448081312201	28 34 52	81 31 21	333	W6	CITY OF OCOEE	A	O	112.12	450	250	12	LW	L	482	36	130	114.39	114.85	115.75	114.44	114.91	115.82
283504081295902	28 35 03	81 29 58	337	W22	CITY OF OCOEE	A	O	79.85	375	150	18	LW	L	232	35	86.65	82.7	83.47	84.92	83.1	83.9	85.5
	28 35 14	81 32 58			CITY OF OCOEE	U	O					LA										
	28 35 48	81 33 04			CITY OF OCOEE	U	O					LA										
	28 29 58	81 18 23		127	CITY OF ORLANDO	A	O			137	12	LE	S									
	28 30 06	81 18 05		128	CITY OF ORLANDO	A	O				8	LE	S									
283035081260301	28 30 34	81 26 04	56	125	CITY OF ORLANDO	A	O		--	--	--	SC	L	160.32	37.22							
283028081192301	28 30 35	81 19 32	52	B113	CITY OF ORLANDO	A	O		452	161	8	BC	L	240		107.5	103.69	103.97	104.48	103.87	104.15	104.64
	28 30 41	81 19 31		113	CITY OF ORLANDO	A	O					BC	L	364.3	23.2							
	28 30 41	81 19 54		158	CITY OF ORLANDO	A	O				12	BC	L	137.8	10.8							
	28 30 50	81 24 35		123	CITY OF ORLANDO	P	O				18	SC										
283058081220701	28 30 58	81 22 07	68		CITY OF ORLANDO		O		487	171	20											
	28 30 60	81 21 58		118	CITY OF ORLANDO	A	O		487	171	20	LE	L	194.8	3.4							
	28 31 05	81 23 18		122	CITY OF ORLANDO	A	O				20	SC	L	595.3	6.1							
283105081222201	28 31 06	81 22 22	76	137	CITY OF ORLANDO	A	O		483	153	10	LE	S	16.93								
	28 31 08	81 25 34		124	CITY OF ORLANDO	A	O					SC	S									
283111081221101	28 31 11	81 22 11	78		CITY OF ORLANDO		O		--	--	--											
283113081225601	28 31 13	81 22 56	84		CITY OF ORLANDO		O		623	87	12											
283112081213801	28 31 14	81 21 37	80	116	CITY OF ORLANDO	A	O	83.42	706	245	16	LE	S	10.3								
283112081214201	28 31 14	81 21 39	81	117	CITY OF ORLANDO	A	O	83.42	524	394	10	LE	S	9.5								
283116081231001	28 31 16	81 23 10	88		CITY OF ORLANDO		O		202	160	6											
283113081194701	28 31 17	81 19 46	83	115	CITY OF ORLANDO	A	O		436	220	20	LE	L	187.04	7.17							
283118081222801	28 31 21	81 22 32	90	120	CITY OF ORLANDO	A	O	87.47	435	114	12	LE	L	109.42	8.96							
	28 31 22	81 23 14		121	CITY OF ORLANDO	A	O		513	110	12	SC	S	20.9								
	28 31 23	81 22 31		119	CITY OF ORLANDO	A	O	85.81	444	141	20	LE	L	109.4	9							
283125081230101	28 31 26	81 23 01	94	85	CITY OF ORLANDO	A	O	102.12	228	146	12	SC	S	33.2								
283126081231901	28 31 26	81 23 19	95		CITY OF ORLANDO		O		452	210	20											
283127081233601	28 31 27	81 23 36	99		CITY OF ORLANDO		O		--	--	6											
283127081225001	28 31 28	81 22 49	98	149	CITY OF ORLANDO	A	O		431	120	12	LE	S									
	28 31 28	81 23 18		83	CITY OF ORLANDO	A	O	94.80	452	210	12	SC	S									
283127081203002	28 31 29	81 20 31	97	108	CITY OF ORLANDO	A	O	103.94	--	--	8	LE	S									
283127081203001	28 31 29	81 20 32	96	107	CITY OF ORLANDO	A	O	104.51	--	211	18	LE	S									
283129081222801	28 31 29	81 22 28	100		CITY OF ORLANDO		O		444	141	20											

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283130081215501	28 31 31	81 21 54	101	98	CITY OF ORLANDO	A	O		199	130	12	LE	L	382.1	52.84							
283136081190401	28 31 35	81 19 00	104	110	CITY OF ORLANDO	A	O		459	211	18	LE	L	43.187								
283135081232001	28 31 35	81 23 20	103		CITY OF ORLANDO		O		513	110	10											
283140081215701	28 31 40	81 21 55	105	97	CITY OF ORLANDO	A	O	67.91	--	--	12	LE	S	329.238								
283140081234301	28 31 40	81 23 43	106		CITY OF ORLANDO		O		460	145	12											
283144081220101	28 31 44	81 22 01	111		CITY OF ORLANDO		O		416	387	12											
283143081223001	28 31 44	81 22 29	110	92	CITY OF ORLANDO	A	O	78.96	316	257	10	SC	L	60	17							
283144081225001	28 31 44	81 22 49	113	88	CITY OF ORLANDO	A	O		896	--	10	LE	L	181.3	4.9							
283145081223301	28 31 45	81 22 33	115		CITY OF ORLANDO		O		397	90	12											
283144081224901	28 31 45	81 22 50	112	87	CITY OF ORLANDO	A	O		617	--	20	LE	L	181.3	4.9							
283147081214701	28 31 46	81 21 47	119	99	CITY OF ORLANDO	A	O		428	315	12	LE	L	22.904	1.86							
283146081224901	28 31 46	81 22 49	117		CITY OF ORLANDO		O		353	253	10											
	28 31 47	81 22 50		86	CITY OF ORLANDO	A	O		276		10	LE	L	181.3	4.9							
283142081225901	28 31 47	81 22 59	107	84	CITY OF ORLANDO	A	O		484	171	12	LE	S	6.3								
283146081223001	28 31 48	81 22 29	116	91	CITY OF ORLANDO	A	O	71.62	730	120	18	LE	S	12.9								
283147081224301	28 31 48	81 22 41	120	89	CITY OF ORLANDO	A	O		607	138	20	LE	L	181.3	4.9							
283150081232001	28 31 50	81 23 20	121		CITY OF ORLANDO		O		300	158	12											
283147081203601	28 31 51	81 20 36	118	105	CITY OF ORLANDO	A	O	93.35	464	196	20	LE	L	278.68	25.13							
283151081235801	28 31 51	81 23 58	122		CITY OF ORLANDO		O		--	--	10											
283153081200801	28 31 53	81 20 10	124	106	CITY OF ORLANDO	A	O	98.27	466	216	20	LE	L	265.39	28.41							
283154081220701	28 31 54	81 22 07	127		CITY OF ORLANDO		O		668	77	12											
283155081231301	28 31 55	81 23 13	128		CITY OF ORLANDO		O		507	132	12											
	28 31 56	81 18 47		111	CITY OF ORLANDO	A	O	100.08	470	134	18	LE	L	150.029	1.6							
283153081221501	28 31 56	81 22 15	125	93	CITY OF ORLANDO	A	O		345	83	10	LE	L	132.58	11.71							
283152081235801	28 31 56	81 23 58	123	81	CITY OF ORLANDO	A	O		--	--	10	SC	L									
283157081215801	28 31 57	81 21 58	131		CITY OF ORLANDO		O		335	115	12											
	28 31 57	81 22 14		95	CITY OF ORLANDO	A	O		96	93	12	LE	L	132.58	11.71							
283158081220201	28 31 58	81 22 02	134		CITY OF ORLANDO		O		342	121	12											
	28 31 58	81 22 05		96	CITY OF ORLANDO	A	O		435	78	12	LE	L	121.2	18.8							
	28 31 58	81 22 13		94	CITY OF ORLANDO	A	O		112	88	12	LE	L	132.58	11.71							
283155081231302	28 31 58	81 23 12	129	154	CITY OF ORLANDO	A	O		437	132	6	SC	S									
283157081233501	28 31 58	81 23 36	132	82	CITY OF ORLANDO	A	O	97.70	411	--	10	SC	S	21.2								
	28 31 58	81 25 05		80	CITY OF ORLANDO	A	O				8	SC	S	27.1								
	28 31 59	81 18 02		112	CITY OF ORLANDO	A	O				18	LE	L									
283201081213401	28 32 01	81 21 34	135		CITY OF ORLANDO		O		863	50	12											
283201081213802	28 32 01	81 21 38	138		CITY OF ORLANDO		O		140	55	12											
	28 32 02	81 21 35		101	CITY OF ORLANDO	A	O	60.65	123	62	12	LE	L	560.27	3.31							
283201081213402	28 32 03	81 21 33	136	104	CITY OF ORLANDO	A	O		230	62	12	LE	L	560.27	3.31							
283203081215901	28 32 03	81 21 59	140		CITY OF ORLANDO		O		392	--	12											
283201081213801	28 32 04	81 21 34	137	103	CITY OF ORLANDO	A	O		139	62	12	LE	L	560.27	3.31							
	28 32 04	81 21 36		100	CITY OF ORLANDO	A	O	81.08	487	82	12	LE	L	560.27	3.31							
283204081230701	28 32 04	81 23 07	142	135	CITY OF ORLANDO	A	O		447	128	12	LE	S	6.2								
283201081213803	28 32 05	81 21 35	139	102	CITY OF ORLANDO	A	O	60.45	82	50	12	LE	L	560.27	3.31							
283204081223201	28 32 06	81 22 30	141	90	CITY OF ORLANDO	A	O		532	329	20	LE	L	286.22	9.64							
283207081234301	28 32 07	81 23 43	145		CITY OF ORLANDO		O		444	188	20											
283207081234601	28 32 07	81 23 46	146		CITY OF ORLANDO		O		448	191	20											
283208081232101	28 32 08	81 23 21	147		CITY OF ORLANDO		O		217	--	12											
283207081234101	28 32 09	81 23 40	144	75	CITY OF ORLANDO	A	O	93.37	378	113	12	SC	S									
283210081232401	28 32 11	81 23 24	149	66	CITY OF ORLANDO	A	O		438	196	20	SC	S	22.6								
283211081241001	28 32 11	81 24 10	151		CITY OF ORLANDO		O		150	76	12											
283209081231401	28 32 12	81 23 13	148	65	CITY OF ORLANDO	A	O		758	138	12	SC	S	10.8								
	28 32 13	81 19 29		109	CITY OF ORLANDO	A	O	111.23			12	LE	S	35.4								
283217081225501	28 32 15	81 22 51	154	56	CITY OF ORLANDO	A	O		432	--	6	LE	S	7.4								
283216081230201	28 32 16	81 23 02	152	145	CITY OF ORLANDO	A	O		186	99	12	LE	S									
283217081231001	28 32 17	81 23 09	155	64	CITY OF ORLANDO	A	O		566	167	12	LE	S									
283217081232101	28 32 17	81 23 21	156		CITY OF ORLANDO		O		197	137	12											
283216081244501	28 32 17	81 24 45	153	79	CITY OF ORLANDO	A	O		213	80	12	SC	L	148.84	29.01							
283218081214201	28 32 18	81 21 42	157		CITY OF ORLANDO		O		865	408	8											
283218081214401	28 32 18	81 21 44	158		CITY OF ORLANDO		O		700	--	--											
283218081214403	28 32 18	81 21 44	160		CITY OF ORLANDO		O		645	--	8											
283218081224801	28 32 19	81 22 47	162	55	CITY OF ORLANDO	A	O		--	--	10	LE	S	6.6								

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283219081195701	28 32 20	81 19 58	163	38	CITY OF ORLANDO	A	O	93.81	399	270	20	LE	L	1271.53	151.24							
	28 32 20	81 21 36		44	CITY OF ORLANDO	C	O				10	LE										
283219081215001	28 32 20	81 21 50	164	45	CITY OF ORLANDO	A	O		884	316	10	LE	S	2.267								
283220081225501	28 32 20	81 22 55	165		CITY OF ORLANDO		O		450	--	12											
283223081220501	28 32 23	81 22 05	166	48	CITY OF ORLANDO	A	O		503	377	20	LE	L	91.9	2.99							
283223081233801	28 32 23	81 23 38	167		CITY OF ORLANDO		O		--	--	6											
283224081221901	28 32 24	81 22 20	168	49	CITY OF ORLANDO	A	O		437	--	6	HC	S	7.2								
283224081232201	28 32 24	81 23 22	170		CITY OF ORLANDO		O		170	--	6											
283224081222301	28 32 26	81 22 22	169	54	CITY OF ORLANDO	A	O	88.09	--	--	12	HC	S	6.8								
283227081184001	28 32 27	81 18 40	173	37	CITY OF ORLANDO	A	O		448	132	20	LE	S									
283226081214801	28 32 27	81 21 48	172	46	CITY OF ORLANDO	A	O		611	174	20	LE	L	91.6	8.96							
283227081221201	28 32 27	81 22 12	174		CITY OF ORLANDO		O		483	417	12											
283225081233601	28 32 27	81 23 36	171	74	CITY OF ORLANDO	P	O		425	170	8	SC										
283227081230301	28 32 28	81 23 02	175	63	CITY OF ORLANDO	A	O		483	142	12	LE	S	17.2								
	28 32 29	81 22 11		136	CITY OF ORLANDO	A	O	73.92	484	417	8	LE	S	18.1								
283230081235201	28 32 30	81 23 52	177		CITY OF ORLANDO		O		205	86	8											
283233081212901	28 32 32	81 21 29	181	43	CITY OF ORLANDO	A	O	74.75	349	80	12	LE	S									
283232081241201	28 32 32	81 24 12	180		CITY OF ORLANDO		O		382	92	12											
283233081213101	28 32 33	81 21 31	182		CITY OF ORLANDO		O		349	--	--											
283236081225601	28 32 36	81 22 56	186		CITY OF ORLANDO		O		926	--	12											
283237081223201	28 32 37	81 22 32	187	53	CITY OF ORLANDO	A	O		156	94	12	HC	L	316.58	26.47							
	28 32 37	81 24 10		76	CITY OF ORLANDO	A	O		200	92	12	SC	L	167.6	14.4							
	28 32 38	81 23 51		78	CITY OF ORLANDO	P	O		348	90	12	SC										
283237081232901	28 32 39	81 23 29	188	70	CITY OF ORLANDO	A	O		487	153	12	HC	S	5.8								
283240081221401	28 32 40	81 22 14	190		CITY OF ORLANDO		O		448	104	12											
283242081225601	28 32 40	81 22 53	199		CITY OF ORLANDO		O		584	200	12											
283240081230701	28 32 40	81 23 07	191		CITY OF ORLANDO		O		--	--	20											
283240081232801	28 32 40	81 23 28	193		CITY OF ORLANDO		O		--	--	6											
283240081243101	28 32 40	81 24 31	194		CITY OF ORLANDO		O		195	76	12											
283241081213201	28 32 41	81 21 30	195	42	CITY OF ORLANDO	A	O		500	436	20	LE	S									
283241081221501	28 32 41	81 22 15	196	50	CITY OF ORLANDO	A	O	87.75	172	104	12	HC	L	316.58	26.47							
283242081200601	28 32 42	81 20 06	198		CITY OF ORLANDO		O		559	30.2	12											
283242081225602	28 32 42	81 22 56	200	57	CITY OF ORLANDO	A	O		503	200	12	HC	S	5.7								
283235081231501	28 32 42	81 23 16	185	114	CITY OF ORLANDO	A	O		401	180	10	HC	S	3								
283240081232301	28 32 42	81 23 27	192	69	CITY OF ORLANDO	A	O		460	197	20	HC	S	3.4								
283242081233201	28 32 42	81 23 32	201		CITY OF ORLANDO		O		408	109	12											
283241081231501	28 32 43	81 23 15	197	67	CITY OF ORLANDO	A	O		287	175	6	HC	S	4.1								
283243081222301	28 32 44	81 22 20	204	52	CITY OF ORLANDO	A	O		468	218	20	HC	L	316.58	26.47							
	28 32 44	81 23 09		62	CITY OF ORLANDO	A	O	98.54	192	120	6	HC	S	3.3								
283244081232001	28 32 44	81 23 22	207	68	CITY OF ORLANDO	A	O	101.60	202	136	12	HC	S	4.5								
283245081224601	28 32 45	81 22 46	210	58	CITY OF ORLANDO	A	O		470	194	12	HC	S	10.825								
283244081243501	28 32 46	81 24 34	208	134	CITY OF ORLANDO	A	O		479	280	20	SC	S									
283247081200801	28 32 47	81 20 08	211		CITY OF ORLANDO		O		518	238	12											
283247081202201	28 32 47	81 20 22	212		CITY OF ORLANDO		O		688	--	20											
283247081225601	28 32 47	81 22 56	213		CITY OF ORLANDO		O		254	150	20											
283249081205201	28 32 49	81 20 52	215		CITY OF ORLANDO		O		372	--	12											
283248081214601	28 32 49	81 21 46	214	47	CITY OF ORLANDO	A	O	93.51	231	132	12	LE	S	6.1								
283251081184001	28 32 51	81 18 40	216		CITY OF ORLANDO		O		448	132	20											
283251081225501	28 32 51	81 22 55	217		CITY OF ORLANDO		O		196	110	12											
283253081222501	28 32 53	81 22 25	219	138	CITY OF ORLANDO	A	O		750	215	12	HC	S	3.1								
283255081201601	28 32 55	81 20 16	220		CITY OF ORLANDO		O		449	205	12											
283244081204301	28 32 56	81 20 48	206	40	CITY OF ORLANDO	A	O		1049	192	12	LE	S									
283256081233701	28 32 56	81 23 37	221		CITY OF ORLANDO		O		389	102	8											
283256081234001	28 32 56	81 23 40	222		CITY OF ORLANDO		O		507	131	12											
	28 32 57	81 23 37		126	CITY OF ORLANDO	A	O		490	164	12	HC	S	7.8								
283258081240901	28 32 57	81 24 08	228	77	CITY OF ORLANDO	A	O		669	141	20	SC	S	10.4								
283258081202101	28 32 58	81 20 21	226		CITY OF ORLANDO		O		312	142	12											
283258081204701	28 32 58	81 20 47	227		CITY OF ORLANDO		O		350	--	12											
	28 32 58	81 21 06		41	CITY OF ORLANDO	A	O		696	405	18	LE	S	1.8								
283257081212301	28 32 58	81 21 22	224	129	CITY OF ORLANDO	A	O	91.82	528	222	18	LE	S	3.8								
283257081213001	28 32 58	81 21 29	225	130	CITY OF ORLANDO	A	O		594	288	20	LE	S	5.1								

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Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
	28 32 58	81 22 20		51	CITY OF ORLANDO	A	O					HC	S	3.3								
	28 32 59	81 20 48		143	CITY OF ORLANDO	P	O		828	180	6	LE										
283300081233701	28 33 00	81 23 37	229		CITY OF ORLANDO		O		460	194	20											
283301081233201	28 33 01	81 23 31	230	72	CITY OF ORLANDO	P	O	95.99	--	--	6	HC										
	28 33 01	81 23 37		73	CITY OF ORLANDO	A	O		460	194	20	HC	S	9.3								
283302081204201	28 33 02	81 20 42	231		CITY OF ORLANDO		O		512	160	10											
283303081193201	28 33 03	81 19 32	233		CITY OF ORLANDO		O		500	280	12											
283303081194001	28 33 03	81 19 40	234		CITY OF ORLANDO		O		481	150	18											
283303081225301	28 33 03	81 22 53	235		CITY OF ORLANDO		O		460	142	8											
283303081232301	28 33 03	81 23 24	236	71	CITY OF ORLANDO	A	O	91.43	418	163	12	HC	S	1.2								
	28 33 04	81 20 48		39	CITY OF ORLANDO	A	O				16	LE	S									
283304081214701	28 33 04	81 21 47	238		CITY OF ORLANDO		O		550	258	20											
283304081215301	28 33 04	81 21 53	239		CITY OF ORLANDO		O		--	--	12											
	28 33 07	81 21 46		148	CITY OF ORLANDO	A	O		603		20	HC	S	12.2								
	28 33 08	81 19 15		36	CITY OF ORLANDO	A	O	92.40		378	12	LE	L	792.6	154.8							
283307081214701	28 33 08	81 21 47	242	146	CITY OF ORLANDO	A	O		500	--	10	HC	S	9.6								
283307081231501	28 33 08	81 23 16	243	61	CITY OF ORLANDO	P	O	90.61	--	--	8	HC										
283310081211801	28 33 10	81 21 18	249		CITY OF ORLANDO		O		260	--	12											
283309081231401	28 33 10	81 23 15	245	60	CITY OF ORLANDO	P	O	89.95	--	--	8	HC										
283311081224001	28 33 11	81 22 42	251	59	CITY OF ORLANDO	P	O		424	--	12	HC										
	28 33 13	81 22 39		28	CITY OF ORLANDO	A	O		425		10	HC	S	7.6								
283313081224001	28 33 13	81 22 40	253		CITY OF ORLANDO		O		130	--	6											
283314081222201	28 33 14	81 22 22	254		CITY OF ORLANDO		O		--	--	8											
283317081220801	28 33 17	81 22 08	255		CITY OF ORLANDO		O		539	117	10											
	28 33 19	81 22 20		29	CITY OF ORLANDO	A	O				12	HC	L	90.7	8							
283320081211801	28 33 20	81 21 18	259		CITY OF ORLANDO		O		493	124	6											
	28 33 21	81 19 58		35	CITY OF ORLANDO	A	O		213	186	8	LE	L	50.9	9							
283317081223301	28 33 21	81 22 33	256	27	CITY OF ORLANDO	A	O		154	121	12	HC	S	8.8								
283322081211601	28 33 22	81 21 16	265	32	CITY OF ORLANDO	P	O		232	124	8	HC	P									
283322081223001	28 33 22	81 22 30	266		CITY OF ORLANDO		O		--	--	6											
283325081214301	28 33 23	81 21 46	267	31	CITY OF ORLANDO	A	O		219	124	12	HC	S	5								
	28 33 23	81 23 45		23	CITY OF ORLANDO	A	O		456	137	18	HC	L	431	40.7							
283322081211401	28 33 24	81 21 14	264	33	CITY OF ORLANDO	A	O		557	273	20	HC	S	5.9								
283321081231801	28 33 25	81 23 18	262	25	CITY OF ORLANDO	A	O		471	288	20	HC	L	363.51	65.95							
283327081201201	28 33 27	81 20 12	270		CITY OF ORLANDO		O		431	183	10											
283326081262101	28 33 27	81 26 17	269	22	CITY OF ORLANDO	A	O	88.44	329	90	18	LW	L	2883.86	162.01							
283329081225001	28 33 29	81 22 50	273		CITY OF ORLANDO		O		582	208	12											
283332081224901	28 33 32	81 22 49	275		CITY OF ORLANDO		O		384	208	12											
283333081225001	28 33 33	81 22 50	276		CITY OF ORLANDO		O		410	--	10											
	28 33 35	81 22 28		26	CITY OF ORLANDO	A	O		695	451	20	HC	S	0.8								
	28 33 37	81 21 42		30	CITY OF ORLANDO	A	O		313	113	12	HC	S	34.9								
283337081232301	28 33 37	81 23 23	278	24	CITY OF ORLANDO	A	O		228	142	20	HC	L	256.57	28.25							
283337081242601	28 33 37	81 24 26	279		CITY OF ORLANDO		O		405	142	6											
283338081222701	28 33 38	81 22 27	280		CITY OF ORLANDO		O		603	75	6											
283339081210601	28 33 39	81 21 06	282		CITY OF ORLANDO		O		502	167	12											
283339081202101	28 33 40	81 20 19	281	34	CITY OF ORLANDO	A	O		464	205	12	HC	L	26.17	1.41							
283340081222501	28 33 40	81 22 25	283		CITY OF ORLANDO		O		550	75	6											
283351081224701	28 33 51	81 22 47	287		CITY OF ORLANDO		O		415	--	--											
	28 33 52	81 22 42		19	CITY OF ORLANDO	A	O	78.63	582	208	12	HC	L	732.9	153							
283350081215201	28 33 53	81 21 51	286	18	CITY OF ORLANDO	A	O		469	126	12	HC	S	3.5								
283354081235401	28 33 53	81 23 54	289	20	CITY OF ORLANDO	P	O		606	202	20	LW	S	45.4								
283353081204801	28 33 55	81 20 44	288	16	CITY OF ORLANDO	A	O		478	157	18	HC	L	110.32	11.54							
283356081211501	28 33 57	81 21 14	290	17	CITY OF ORLANDO	A	O		524	265	12	HC	S	15.3								
283358081211501	28 33 58	81 21 15	291		CITY OF ORLANDO		O		573	265	12											
283402081211001	28 34 01	81 21 08	293	132	CITY OF ORLANDO	A	O	97.58	273	249	12	HC	S	6.3								
283402081211501	28 34 03	81 21 14	294	15	CITY OF ORLANDO	A	O		487	285	12	HC	S	3								
283408081233701	28 34 08	81 23 37	298		CITY OF ORLANDO		O		454	292	10											
283408081235301	28 34 08	81 23 54	299	150	CITY OF ORLANDO	A	O		--	--	10	LW	S	50.6								
283410081220601	28 34 10	81 22 06	301		CITY OF ORLANDO		O		433	385	8											
283415081235201	28 34 15	81 23 52	304		CITY OF ORLANDO		O		405	120	12											
283418081222801	28 34 18	81 22 28	307		CITY OF ORLANDO		O		414	158	10											

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283415081233801	28 34 18	81 23 38	303	21	CITY OF ORLANDO	A	O		407	183	12	LW	S	43.21								
283421081214701	28 34 21	81 21 47	310		CITY OF ORLANDO		O		596	385	8											
283421081214901	28 34 21	81 21 49	311	12	CITY OF ORLANDO	A	O	69.07	578	119	12	HC	L	874.9	70.28							
283428081224901	28 34 28	81 22 49	313		CITY OF ORLANDO		O		500	250	20											
283428081225201	28 34 28	81 22 52	314		CITY OF ORLANDO		O		--	265	20											
283430081222401	28 34 30	81 22 24	316	10	CITY OF ORLANDO	A	O		495	155	12	HC	S	8.3								
	28 34 31	81 22 20		9	CITY OF ORLANDO	A	O					HC	S	9.3								
283431081223501	28 34 31	81 22 35	317		CITY OF ORLANDO		O		431	158	12											
283435081222001	28 34 35	81 22 20	320		CITY OF ORLANDO		O		408	124	12											
	28 34 35	81 22 54		7	CITY OF ORLANDO	A	O	90.25			10	HC	S	13.4								
283429081221901	28 34 39	81 22 19	315	11	CITY OF ORLANDO	A	O		451	170	20	HC	S	4.5								
283439081222301	28 34 39	81 22 24	322	8	CITY OF ORLANDO	A	O	91.43	409	130	12	HC	S	8.1								
283441081251501	28 34 42	81 25 14	325	W43	CITY OF ORLANDO	A	O	94.36	199	100	10	W	S	131.11		95.4	98.37	98.69	99.15	98.6	98.96	99.33
	28 34 42	81 25 20		4	CITY OF ORLANDO	A	O		400		12	LW	S									
	28 34 44	81 23 15		5	CITY OF ORLANDO	P	O		33		6	HC										
283445081223801	28 34 45	81 22 38	327		CITY OF ORLANDO		O		439	346	20											
283445081225201	28 34 45	81 22 52	328		CITY OF ORLANDO		O		439	390	10											
283441081230801	28 34 45	81 23 08	324	6	CITY OF ORLANDO	A	O	89.07	456	156	18	HC	S	6.4								
283445081250101	28 34 45	81 25 01	329	W41	CITY OF ORLANDO	A	O	93.58	416	150	12	W	S	131.11		95.4	98.37	98.69	99.15	98.6	98.96	99.33
283446081225901	28 34 46	81 22 59	330		CITY OF ORLANDO		O		418	185	20											
283449081230301	28 34 49	81 23 03	334		CITY OF ORLANDO		O		203	100	12											
	28 35 16	81 23 19		142	CITY OF ORLANDO	A	O		390	243	18	LW	L	679.3	88							
283545081244901	28 35 45	81 24 49	351		CITY OF ORLANDO		O		721	130	12											
	28 35 51	81 24 47		3	CITY OF ORLANDO	P	O		721	130	12	LW										
	28 36 03	81 24 56		2	CITY OF ORLANDO	A	O				12	LW	L									
	28 36 15	81 25 17		1	CITY OF ORLANDO	A	O		142	100	6	LW	S	5.6								
				13	CITY OF ORLANDO	P	O	101.12	461	115	12	HC										
				14	CITY OF ORLANDO	P	O		408		12	HC										
				131	CITY OF ORLANDO	P	O		372		12	LE										
				133	CITY OF ORLANDO	C	O	99.78	508	132	12	SC										
				139	CITY OF ORLANDO	C	O		418	185	20	HC										
				140	CITY OF ORLANDO	C	O				12	LE										
				141	CITY OF ORLANDO	P	O				6	HC										
				144	CITY OF ORLANDO	P	O	94.31	355		10	SC										
				147	CITY OF ORLANDO	C	O	90.84	414	390	10	HC										
				151	CITY OF ORLANDO	P	O		161		10	HC										
				152	CITY OF ORLANDO	P	O		397	90	12	LE										
				153	CITY OF ORLANDO	C	O		502	167	12	HC										
				155	CITY OF ORLANDO	P	O		548		6	HC										
				156	CITY OF ORLANDO	P	O		414	158	10	HC										
				157	CITY OF ORLANDO	P	O		55		12	LE										
				159	CITY OF ORLANDO	P	O		501		12	HC										
				160	CITY OF ORLANDO	C	O		158	158	12	SC										
				161	CITY OF ORLANDO	P	O		405		20	HC										
				162	CITY OF ORLANDO	C	O		174		12	HC										
				163	CITY OF ORLANDO	P	O		811		12	LE										
				164	CITY OF ORLANDO	P	O		416		8	LE										
				165	CITY OF ORLANDO	P	O				6	HC										
				166	CITY OF ORLANDO	C	O				12	HC										
				167	CITY OF ORLANDO	P	O				12	HC										
				168	CITY OF ORLANDO	C	O		164	76	12	SC										
283455081230301	28 34 55	81 23 03	336		DUBSDREAD CLUB		O		--	--	--											
283103081231701	28 31 03	81 23 17	75		FLA DEPT TRANS		O		500	149	20											
283105081232101	28 31 05	81 23 21	77		FLA DEPT TRANS		O		450	200	20											
283257081210701	28 32 57	81 21 07	223		FLA DEPT TRANS		O		696	405	20											
283310081203801	28 33 10	81 20 38	246		FLA DEPT TRANS		O		620	354	12											
283310081204001	28 33 10	81 20 40	247		FLA DEPT TRANS		O		550	386	12											
283310081205401	28 33 10	81 20 54	248		FLA DEPT TRANS		O		530	263	12											
283326081234601	28 33 26	81 23 46	268		FLA DEPT TRANS		O		456	137	18											
283529081232801	28 35 29	81 23 28	344		FLA DEPT TRANS		O		396	243	18											
283553081214701	28 35 53	81 21 47	360		FLA DEPT TRANS		O		380	100	8											

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Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283643081215701	28 36 43	81 21 57	370		FLA DEPT TRANS		O		977	--	--											
284019081294901	28 40 19	81 29 49	379		FLA DEPT TRANS		O		400	125	12											
284038081310101	28 40 38	81 31 01	383		FLA DEPT TRANS		O		430	131	12											
284325081360101	28 43 25	81 36 01	386		FLA DEPT TRANS		O		370	282	6											
283243081230701	28 32 43	81 23 07	205		FLA PUB SER CO		O		192	120	6											
284008081260001	28 40 08	81 26 00	396		FOREST LK ACAD		S		116	--	10											
282819081234801	28 28 19	81 23 48	21		FRANK H WISE		O		206	112	4											
283305081183101	28 33 05	81 18 31	240		GOOD SHEPERD CH		O		486	200	8											
283407081333701	28 34 07	81 33 37	297		H C TILDEN		O		500	--	16											
283116081204501	28 31 16	81 20 45	86		H S SYMONDS		O		350	--	8											
283830081230101	28 38 30	81 23 01	392		HANS SCHWEIZER		S		182	162	10											
282956081242001	28 29 56	81 24 20	38		HOEQUIST FIELD		O		--	--	6											
282830081201601	28 28 30	81 20 16	25		HOWARD PARTIN		O		185	--	8											
282539081315001	28 25 39	81 31 50	4		I S PRESCOTT		O		432	107	6											
282311081241901	28 23 11	81 24 19	1		IRLO BRONSON		O		300	--	10											
282820081223301	28 28 20	81 22 33	22		J A RIVIERE		O		220	124	6											
283909081260901	28 39 09	81 26 09	395		JESS WILLIAMS		S		170	73	6											
282803081220401	28 28 03	81 22 04	18		JOHN KEENE		O		285	56	6											
283317081243001	28 33 17	81 24 30	257		K-MART		O		230	92	4											
283007081263901	28 30 07	81 26 39	44		L B MCLEOD		O		450	125	12											
283022081273501	28 30 22	81 27 35	49		L B MCLEOD		O		450	--	12											
283024081263501	28 30 24	81 26 35	51		L B MCLEOD		O		450	125	12											
283034081261701	28 30 34	81 26 17	55		L R MCLEOD		O		--	125	12											
284015081221301	28 40 15	81 22 13	397		L T BRYAN		S		70	--	--											
283113081194001	28 31 13	81 19 40	82		LYSINDA GROVES		O		--	--	6											
283317081341601	28 33 17	81 34 16	258		MC MILLIAN BROS		O		--	--	8											
282636081300801	28 26 36	81 30 08	7		MINUTE MAID CO		O		364	116	12											
282839081212201	28 28 39	81 21 22	26		MR CRITTENDEN		O		--	--	8											
283142081291301	28 31 42	81 29 13	108		MRS DOWDA		O		185	--	12											
283418081240101	28 34 18	81 24 01	308		NELLIE B FORBES		O		387	80	8											
283520081241501	28 35 20	81 24 15	340		NYDEGGER CO		O		260	60	12											
282534081220601	28 25 34	81 22 07	3	B90	ORANGE COUNTY	A	O		455	202	12	BC	S	71.49		86.5	89.73	89.99	90.52	89.96	90.17	90.77
282608081215701	28 26 08	81 21 56	6	B89	ORANGE COUNTY	A	O	91.28	180	150	6	BC	S	65.5		96.4	96.59	96.6	96.63	96.59	96.6	96.63
282704081214301	28 27 04	81 21 43	8	B87	ORANGE COUNTY	A	O	90.82	455	383	8	BC	L	119.1	14.2	96.7	92.4	92.9	93.59	92.71	93.1	93.73
282749081215201	28 27 50	81 21 52	13	B86	ORANGE COUNTY	A	O	92.00	350	150	8	BC	R	40	4	98.6	96.09	96.41	97.01	96.45	96.8	97.23
282753081234501	28 27 53	81 23 45	16		ORANGE COUNTY		O		375	271	6											
282753081232501	28 27 55	81 23 23	15	B84	ORANGE COUNTY	A	O	94.87	457	99	12	BC	S	6.13		96.5	95.99	96.18	96.54	97.03	97.19	97.47
282750081221801	28 27 57	81 22 17	14	B85	ORANGE COUNTY	A	O	93.11	165	146	12	BC	S	136.7		100.3	99.46	99.68	100.04	100	100.08	100.23
282819081231301	28 28 19	81 23 13	20		ORANGE COUNTY		O		--	--	10											
282820081230101	28 28 20	81 23 01	23		ORANGE COUNTY		O		160	123	8											
282822081201101	28 28 22	81 20 11	24		ORANGE COUNTY		O		158	150	12											
282842081233001	28 28 51	81 23 30	27	B79	ORANGE COUNTY	A	O	91.18	350	150	6	BC	L	48	7	90.4	93.72	94.01	94.48	93.77	94.06	94.54
282853081182701	28 28 53	81 18 27	28		ORANGE COUNTY		O		--	--	10											
282903081211501	28 29 03	81 21 15	29		ORANGE COUNTY		O		158	150	12											
282904081233302	28 29 04	81 23 31	30	B77	ORANGE COUNTY	A	O	92.34	350	150	8	BC	L	104	10.55	89.94	93.83	94.08	94.54	93.86	94.11	94.57
	28 29 41	81 24 32		S76	ORANGE COUNTY	A	O		350		6	SC	L	208.8		87.45	93.74	94	94.47	93.75	94	94.48
282943081212901	28 29 44	81 21 29	35	B108	ORANGE COUNTY	A	O	91.31	420	249	12	BC	L	45.34	3.48	97	93.91	94.51	95.64	95.1	95.82	97.02
282945081255001	28 29 47	81 25 47	36	S73	ORANGE COUNTY	A	O	95.82	417	211	12	SC	W	42.76		96	94.88	95.08	95.36	95.28	95.46	95.8
	28 29 51	81 18 52		B112	ORANGE COUNTY	A	O	96.95	422	137	10	BC	L	485	61.5	100.18	98.87	99.23	99.89	98.9	99.27	99.95
282955081181801	28 29 55	81 18 18	37		ORANGE COUNTY		O		422	137	12											
282957081244801	28 29 57	81 24 48	39		ORANGE COUNTY		O		--	--	8											
283001081185301	28 30 01	81 18 53	40		ORANGE COUNTY		O		345	149	12											
283001081205201	28 30 02	81 20 50	41	B109	ORANGE COUNTY	A	O	84.39	350	150	18	BC	L	104	10.4	93	87.21	87.79	88.86	88.15	88.85	90.07
283002081234701	28 30 02	81 23 46	42	B70	ORANGE COUNTY	A	O		600	110	16	BC	L	979.33		99.2	92.08	92.3	92.71	92.11	92.34	92.75
283007081244001	28 30 03	81 24 42	43	S75	ORANGE COUNTY	A	O		350	150	8	SC	L	602.32	70.5	92	92.85	93.2	93.78	92.98	93.31	93.92
283011081243601	28 30 11	81 24 32	45	S71	ORANGE COUNTY	A	O	89.41	350	150	8	SC	L	602.32	70.5	92	92.85	93.2	93.78	92.98	93.31	93.92
283016081245001	28 30 16	81 24 50	46	S72	ORANGE COUNTY	A	O		777	263	14	SC	L	602.32	70.5	92	92.85	93.2	93.78	92.98	93.31	93.92
283017081195201	28 30 17	81 19 52	47		ORANGE COUNTY		O		427	169	8											
283019081253501	28 30 19	81 25 33	48	S74	ORANGE COUNTY	A	O	92.47	463	105	12	SC	S	64		94	95.25	95.49	95.71	95.65	95.89	96.25
	28 30 22	81 19 52		B111	ORANGE COUNTY	A	O	101.27	427	169	8	BC	S	21.8		113?	103.09	103.11	103.14	103.1	103.12	103.15
283030081221502	28 30 28	81 22 15	54	B69	ORANGE COUNTY	A	O	92.09	350	150	24	BC	L	743	59	103.4	95.94	96.64	97.84	96.23	96.94	98.13

File: DWDB4.XLS

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283028081202501	28 30 30	81 20 24	53	B110	ORANGE COUNTY	A	O	93.09	350	150	8	BC	L	113.3	13	99	95.95	96.31	96.97	96.18	96.54	97.1
283036081215801	28 30 36	81 21 58	57	B67	ORANGE COUNTY	A	O	92.51	350	150	12	BC	L	743	59	103.4	95.94	96.64	97.84	96.23	96.94	98.13
283038081234301	28 30 38	81 23 43	59		ORANGE COUNTY		O		--	--	18											
	28 30 39	81 23 40		B65	ORANGE COUNTY	A	O		400	108	8	BC	S	12		105.6	105.64	105.76	106	106.04	106.22	106.53
283038081233501	28 30 40	81 23 35	58	B64	ORANGE COUNTY	A	O	102.56	400	108	8	BC	S	21		105.6	105.57	105.7	105.96	105.85	106.01	106.31
283045081230501	28 30 46	81 23 05	62	B66	ORANGE COUNTY	A	O		350		12	BC	L	979.33		99.2	92.08	92.3	92.72	92.11	92.34	92.75
283047081210701	28 30 47	81 21 07	64		ORANGE COUNTY		O		--	--	--											
283050081202901	28 30 51	81 20 28	65	B107	ORANGE COUNTY	A	O	94.09	400	250	15	BC	L	315.6		100	96.96	97.61	98.97	97.3	98.03	99.55
283059081213701	28 30 59	81 21 36	69	E68	ORANGE COUNTY	A	O	92.34	412	212	12	E	R	103	7	97.15	94.9	95.22	95.37	95.14	95.28	95.4
283101081235501	28 31 01	81 23 54	71	S62	ORANGE COUNTY	A	O	90.73	350	150	12	SC	R	42.89	0.67	95	103	103.44	104.22	104.33	104.85	105.81
283102081231901	28 31 02	81 23 19	73		ORANGE COUNTY		O		--	--	8											
283102081234701	28 31 02	81 23 47	74	S61	ORANGE COUNTY	A	O	99.96	350	150	10	SC	S	31.84		106	107.21	107.28	107.41	107.32	107.39	107.51
283101081235601	28 31 02	81 23 57	72	S63	ORANGE COUNTY	A	O		350	--	8	SC	R	42.89	0.67	95	103	103.44	104.22	104.33	104.85	105.81
	28 31 06	81 22 21		E119	ORANGE COUNTY	A	O	95.63			12	E	S	41.45		95.94	101.14	101.27	101.53	101.16	101.31	101.58
283112081202601	28 31 13	81 20 25	79	E103	ORANGE COUNTY	A	O		350	150	10	E	R	92.3	3.4	112.3	112.67	112.93	113.45	112.85	113.1	113.58
283116081212301	28 31 17	81 21 23	87	E101	ORANGE COUNTY	A	O	85.95	400	214	12	E	L	278	12.8	91.9	90.77	91.66	92.2	91.37	92	92.25
283119081194101	28 31 19	81 19 41	91		ORANGE COUNTY		O		421	162	8											
283120081234201	28 31 20	81 23 42	92	S60	ORANGE COUNTY	A	O	94.35	--	--	8	SC	R	96.4	2.7	106	102.23	103.04	103.39	102.84	103.18	103.57
283118081210801	28 31 21	81 21 06	89	E102	ORANGE COUNTY	A	O	93.47	435	113	12	E	S	278		99.1	99.02	99.1	99.62	99.57	99.94	100.3
283121081311601	28 31 21	81 31 16	93		ORANGE COUNTY		O		498	344	12											
283116081170701	28 31 23	81 17 02	85	E104	ORANGE COUNTY	A	O	83.02	442	198	18	E	S	875		77	88.13	88.32	88.84	88.14	88.34	88.87
	28 31 26	81 20 29		E118	ORANGE COUNTY	A	O	104.12			8	E	S	7.22		110.4	110.22	110.32	110.48	110.71	110.81	111.01
	28 31 29	81 20 31		E117	ORANGE COUNTY	A	O	104.57			18	E	S	7.22		110.4	110.22	110.32	110.48	110.71	110.81	111.01
	28 31 31	81 31 21		W8	ORANGE COUNTY	A	O	93.20	402	338	12	W	L	487.6	82.6	98.9	95.53	95.91	96.6	95.7	96.07	96.8
283133081310301	28 31 33	81 31 03	102	W9	ORANGE COUNTY	A	O		300	121	12	W	L	487.6	82.6	98.9	95.53	95.91	96.6	95.7	96.07	96.8
283144081254201	28 31 47	81 25 42	114	S57	ORANGE COUNTY	A	O		398	140	16	SC	L	1260	236	91	93.55	93.86	94.4	93.6	93.92	94.46
283154081184901	28 31 54	81 18 49	126		ORANGE COUNTY		O		470	134	20											
283157081180401	28 31 57	81 18 04	130		ORANGE COUNTY		O		466	128	18											
283157081250601	28 31 58	81 25 05	133	S58	ORANGE COUNTY	A	O	93.13	141	74	8	SC	L	1260	236	91	93.55	93.86	94.4	93.6	93.92	94.46
283211081193101	28 32 11	81 19 31	150		ORANGE COUNTY		O		--	--	10											
283227081275301	28 32 28	81 27 53	176	W51	ORANGE COUNTY	A	O	110.06	412	140	8	W	L	139.39	16.44	124	112.16	112.57	113.32	112.27	112.69	113.44
283232081224001	28 32 32	81 22 40	179		ORANGE COUNTY		O		468	178	12											
283232081182201	28 32 34	81 18 19	178	E97	ORANGE COUNTY	A	O		350	--	20	E	L	130.79	3.41	97.3	97.13	97.2	97.33	97.2	97.28	97.41
283240081175201	28 32 41	81 17 50	189	E98	ORANGE COUNTY	A	O	84.18	350	150	18	E	R	623.83		85.2	92.86	93.06	93.34	92.88	93.07	93.36
283242081270702	28 32 42	81 27 07	203		ORANGE COUNTY		O		430	140	26											
283251081271501	28 32 51	81 27 15	218		ORANGE COUNTY		O		--	94	18											
283244081274201	28 32 52	81 27 33	209	S52	ORANGE COUNTY	A	O	95.57	425	204	12	SC	S	95.5	2.36	108.74	105.6	106.67	108.13	107.29	108.13	108.97
283302081245801	28 33 02	81 24 57	232	S54A	ORANGE COUNTY	A	O	91.23	183	--	12	SC	L	110.34	3.29	101.1	97.86	98.15	98.68	98.24	98.55	99.04
283303081255801	28 33 03	81 25 58	237		ORANGE COUNTY		O		--	--	12											
283306081303202	28 33 06	81 30 32	241		ORANGE COUNTY		O		430	207	18											
	28 33 07	81 35 21		A1	ORANGE COUNTY	A	O		350		12	LA	S	16.67		119.9	117.72	118.05	118.18	118.19	118.31	118.55
283307081300801	28 33 08	81 30 08	244	W50	ORANGE COUNTY	A	O		450	118	24	W	L	1359	119	120	79	79.31	79.92	79.01	79.32	79.94
283311081191201	28 33 11	81 19 12	250		ORANGE COUNTY		O		378	--	12											
283328081190101	28 33 28	81 19 01	272		ORANGE COUNTY		O		--	--	10											
	28 33 30	81 18 56		E96	ORANGE COUNTY	A	O	91.15	350	150	12	E	L	94	16	97	95.14	95.5	96.03	95.42	95.7	96.22
283344081260501	28 33 44	81 26 04	285	W46	ORANGE COUNTY	A	O		383	100	24	W	S	2842		87.5	90.04	90.27	90.72	90.04	90.27	90.72
283334081243501	28 33 54	81 24 44	277	W47	ORANGE COUNTY	A	O	91.41	685	--	14	W	R	23.82	1.57	93.36	93.88	93.97	94.17	94	94.11	94.35
283358081272901	28 33 59	81 27 29	292	W45	ORANGE COUNTY	A	O		350	--	18	W	R	332.17		85	83.06	83.61	83.82	83.63	83.75	83.9
283406081210801	28 34 06	81 21 08	296		ORANGE COUNTY		O		--	--	6											
283410081204701	28 34 08	81 20 51	300	H95	ORANGE COUNTY	A	O		437	247	10	HC	S	3.96		106	105.15	105.25	105.47	105.8	106.01	106.05
283416081295901	28 34 16	81 29 59	305		ORANGE COUNTY		O		454	194	16											
	28 34 16	81 30 01		W44	ORANGE COUNTY	A	O	77.98	450	60	15	W	L	487	108.15	84	79.32	79.55	80	79.43	79.67	80.13
283417081331401	28 34 17	81 33 14	306		ORANGE COUNTY		O		500	--	8											
283419081340301	28 34 19	81 34 03	309		ORANGE COUNTY		O		--	--	--											
283426081203101	28 34 29	81 20 32	312	E93	ORANGE COUNTY	A	O	102.34	425	113	12	E	L	69	4.35	112	107.07	107.7	108.79	108.03	108.69	109.82
283434081241901	28 34 36	81 24 17	319	W42	ORANGE COUNTY	A	O	95.63	350	150	10	W	S	18.88		99.7	100.13	100.28	100.57	100.26	100.43	100.75
283436081194501	28 34 37	81 19 45	321	E94	ORANGE COUNTY	A	O	91.52	350	150	18	E	L	68	24	99.4	92.84	93.01	93.34	92.97	93.16	93.51
283439081272102	28 34 39	81 27 21	323		ORANGE COUNTY		O		375	200	12											
283447081241701	28 34 48	81 24 16	332	W40	ORANGE COUNTY	A	O	93.97	400	134	12	W	S	18.3		99.7	98.35	98.56	99	99.11	99.29	99.64
283449081335601	28 34 50	81 33 55	335	A4	ORANGE COUNTY	A	O	106.52	350	150	8	LA	S	37.68		106.6	107.99	108.13	108.39	108.14	108.29	108.56
283508081270801	28 35 08	81 27 08	338		ORANGE COUNTY		O		341	135	12											

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283514081222301	28 35 15	81 22 23	339	H37	ORANGE COUNTY	A	O	85.96	350	150	12	HC	S	30		93.4	93.47	93.56	93.73	93.52	93.62	93.79
283522081221001	28 35 22	81 22 10	342		ORANGE COUNTY		O		--	--	12											
283521081231101	28 35 27	81 23 31	341	W39	ORANGE COUNTY	A	O		450	128	12	W	L	535	77.6	84.14	90.92	91.26	91.87	90.98	91.32	91.94
283528081235201	28 35 27	81 23 50	343	W38	ORANGE COUNTY	A	O		745	176	18	W	L	2548	401	88	90.06	90.37	90.94	90.07	90.37	90.96
283532081273401	28 35 32	81 27 34	346		ORANGE COUNTY		O		341	135	12											
283535081265901	28 35 35	81 26 59	347		ORANGE COUNTY		O		325	200	12											
283540081252301	28 35 40	81 25 23	348		ORANGE COUNTY		O		--	--	12											
283546081223201	28 35 49	81 22 31	352	H34	ORANGE COUNTY	A	O	81.65	390	181	18	HC	L	1118.99	237	82.5	83.93	84.12	84.48	83.98	84.18	84.54
283548081224601	28 35 50	81 22 45	356	H35	ORANGE COUNTY	A	O	81.77	400	200	18	HC	L	1118.99	237	82.5	83.93	84.12	84.48	83.98	84.18	84.54
283557081231301	28 35 57	81 23 13	361		ORANGE COUNTY		O		376	178	12											
283559081240601	28 35 59	81 24 06	362		ORANGE COUNTY		O		--	--	10											
	28 35 60	81 24 01		W31	ORANGE COUNTY	A	O	83.70	350	150	24	W	S	120.5		91	90.26	90.95	91.09	91.08	91.1	91.19
	28 36 01	81 23 14		W32	ORANGE COUNTY	A	O	94.02			12	W	L	68.61	2.43	97.2	97.07	97.27	97.67	97.07	97.27	97.68
283602081252201	28 36 02	81 25 22	363		ORANGE COUNTY		O		142	--	6											
283608081273101	28 36 08	81 27 31	364		ORANGE COUNTY		O		341	130	12											
283624081253801	28 36 24	81 25 38	366		ORANGE COUNTY		O		--	--	13											
283626081241701	28 36 27	81 24 14	367	W30	ORANGE COUNTY	A	O		350	--	10	W	S	15.64		94.5	95.48	95.8	96.1	95.76	96.03	96.18
283654081260801	28 36 54	81 26 07	371	W18	ORANGE COUNTY	A	O	74.23	450	250	18	W	L	34.76	1.3	90	77.46	78.11	79.25	79.57	80.44	81.87
	28 36 54	81 28 33		W14	ORANGE COUNTY	P	O	NA	387	147	20	W	L	NA	NA	NA	NA	NA	NA	NA	NA	NA
283702081264601	28 37 04	81 26 46	372	W17	ORANGE COUNTY	A	O		682	216	12	W	R	51.4	2.3	75.29	69.75	70.69	72.66	71.3	73	76.3
	28 37 06	81 20 24		H91	ORANGE COUNTY	I	O	NA	121		4	HC	L	21.09		81.6	76.45	77.39	79.01	76.76	77.72	79.35
283706081271801	28 37 06	81 27 18	373		ORANGE COUNTY		O		380	100	20											
283735081224001	28 37 36	81 22 30	375	H21	ORANGE COUNTY	A	O	72.42	388	110	12	HC	L	540.09	77.9	86.7	74.45	74.86	75.6	74.54	74.95	75.7
283743081253201	28 37 44	81 25 31	376	W19	ORANGE COUNTY	A	O	81.39	350	150	10	W	L	61	6.71	80.8	82.53	82.79	83.27	82.72	82.99	83.47
283816081225502	28 38 17	81 22 55	377	H20	ORANGE COUNTY	A	O	66.95	385	251	12	HC	L	494.39	44	90.2	68.88	69.16	69.69	68.95	69.24	69.79
	28 38 39	81 27 52		W12A	ORANGE COUNTY	A	O	125.32	350	150	10	W	R	20	1.75	131.68	130.14	130.43	130.98	130.96	131.14	131.39
283927081290201	28 39 27	81 29 02	378		ORANGE COUNTY		O		324	88	18											
	28 39 33	81 28 17		W12	ORANGE COUNTY	A	O	80.56	350	178	18	W	L	262	24.71	89.34	80.66	80.86	81.2	80.67	80.9	81.32
284020081280601	28 40 20	81 28 06	380		ORANGE COUNTY		O		400	200	12											
				W29	ORANGE COUNTY	P	O		350		12	W										
282716081235101	28 27 16	81 23 51	9		ORLANDIA CORP		O		420	151	12											
283327081241001	28 33 27	81 24 10	271		ORLANDO C CLUB		O		375	172	12											
283340081235601	28 33 40	81 23 56	284		ORLANDO C CLUB		O		--	--	6											
283330081223401	28 33 30	81 22 34	274		ORLANDO UTILITY		O		410	169	12											
283045081225201	28 30 45	81 22 52	61		PHILLIPS IND IN		O		--	--	10											
283715081192601	28 37 15	81 19 26	388		PHILLIPS W C		S		835	101	20											
284102081332301	28 41 02	81 33 23	384		PLY CITRUS CORP		O		1070	218	20											
283242081270701	28 32 42	81 27 07	202		PRESTIGE CORP		O		380	156	4											
282747081321301	28 27 47	81 32 13	11		R D KEEN		O		187	--	8											
282759081320101	28 27 59	81 32 01	17		R D KEEN		O		390	--	6											
282803081321801	28 28 03	81 32 18	19		R D KEENE		O		140	--	6											
283320081373701	28 33 20	81 37 37	260		R L SMITH		O		300	--	4											
282931081232001	28 29 31	81 23 20	32		RANDALL MADE CO		O		400	275	8											
283447081214001	28 34 47	81 21 40	331		ROBT J CANNON		O		120	104	3											
283638081193301	28 36 38	81 19 33	387		SEMINOLE COUNTY		S		--	--	18											
283717081194201	28 37 17	81 19 42	389		SEMINOLE COUNTY		S		--	--	6											
283717081194202	28 37 17	81 19 42	390		SEMINOLE COUNTY		S		290	85	12											
283235081223801	28 32 35	81 22 38	183		SOUTHERN BELL		O		325	153	6											
283024081224201	28 30 24	81 22 42	50		SOUTHERN FRUIT		O		499	--	10											
283548081234401	28 35 48	81 23 44	357		ST MARKS CHURCH		O		150	100	4											
283235081224201	28 32 35	81 22 42	184		U S POST OFFICE		O		283	153	6											
283434081225401	28 34 34	81 22 54	318		UNKNOWN PRIVATE		O		--	--	10											
283404081212001	28 34 04	81 21 20	295		W C PHILLIPS		O		485	292	12											
282514081290301	28 25 14	81 29 03	2		W F BENNETT		O		484	173	10											
282605081220101	28 26 05	81 22 01	5		W H COLLING		O		198	--	6											
282721081214901	28 27 21	81 21 49	10		WALTER A GRAHAM		O		282	100	6											
283045081254201	28 30 45	81 25 42	63		WASH PARK CEM		O		470	106	12											
283543081064701	28 35 43	81 06 47	349		WHEELER & MORGN		O		500	100	8											
283550081070201	28 35 50	81 07 02	358		WHEELER & MORGN		O		500	100	8											
283548081211201	28 35 48	81 21 12	355		WINT PK TELEPHO		O		300	177	6											
283530081214301	28 35 30	81 21 43	345		WINTER PARK		O		372	170	12											

File: DWDB4.XLS

Drainage Well Database Sorted by Owner, Latitude, and Longitude

USGS Site ID (Lat - Long)	Latitude	Longitude	SJRWMD Seq. No.	Owner ID - No.	Owner Name	Status (act./inact.)	County (O/S)	Well Altitude - msl	Well Depth - ft.	Bottom of Casing - ft.	Diameter of casing - in.	Major Basin	Drainage Type	Basin area - ac.	Lake/Pond area - ac.	Overflow elev. - msl	10 yr. with well	25 yr. with well	100 yr. with well	10 yr. w/o well	25 yr. w/o well	100 yr. w/o well
283545081214701	28 35 45	81 21 47	350		WINTER PARK		O		507	131	20											
283547081192701	28 35 47	81 19 27	353		WINTER PARK		O		314	52	6											
283547081210101	28 35 47	81 21 01	354		WINTER PARK		O		400	81	10											
283550081214401	28 35 50	81 21 44	359		WINTER PARK		O		350	--	8											
283616081215101	28 36 16	81 21 51	365		WINTER PARK		O		320	--	6											
283637081200901	28 36 37	81 20 09	368		WINTER PARK		O		330	--	8											
283637081215201	28 36 37	81 21 52	369		WINTER PARK		O		400	115	12											

File: DWDB4.XLS

Appendix B
Federal Underground Injection Control Program

APPENDIX B

Federal Underground Injection Control Program

The 1974 Safe Drinking Water Act (SDWA) provided in Part C thereof protection of underground sources of drinking water (USDW) and directed the Administrator of EPA to publish regulations for federal and state underground injection control (UIC) programs. These regulations are now found in 40 CFR Parts 144, 145, 146 and 147.

Part 144 sets forth the permitting and other program requirements that must be met by State and EPA UIC programs. Part 145 specifically identifies elements of a state application for primacy to administer an UIC program. Part 146 sets forth the technical criteria and standards that must be met in permits and authorizations by rule as required by Part 144. Part 147 establishes the applicable State UIC programs. In addition, Part 124 of 40 CFR specifies public participation requirements that must be met by UIC programs, whether administered by the state or by EPA.

The UIC permit program regulates underground injection by five classes of wells (§ 144.6). These injection wells must be authorized either by permit or by rule. The critical language with respect to drainage wells found in § 144.12, which prohibits injection of fluids containing any contaminant if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR Part 142, or may adversely affect the health of persons."

Part 146 permits the EPA Administrator to exempt certain aquifers otherwise qualifying as USDW from regulation under federal and state programs.

PART 144—UNDERGROUND INJECTION CONTROL PROGRAM

144.3 Definitions.

Area of review means the area surrounding an injection well described according to the criteria set forth in § 146.06.

Contaminant means any physical, chemical, biological, or radiological substance or matter in water.

Director means the Regional Administrator, State director or Tribal director as the context requires.

Exempted aquifer means an aquifer or its portion that meets the criteria in the definition of underground source of drinking water but has been exempted according to the procedures in § 144.7.

Underground source of drinking water (USDW) means an aquifer or its portion:

(a) (1) Which supplies any public water system; or

(2) Which contains a sufficient quantity of ground water to supply a public water system; and

(i) Currently supplies drinking water for human consumption; or

(ii) contains fewer than 10,000 mg/L total dissolved solids; and

(b) Which is not an exempted aquifer.

144.6 Classification of wells. Injection wells are classified as follows:

(e) Class V. Injection wells not included in Classes I, II, III, or IV.

144.7 Identification of underground sources of drinking water and exempted aquifers.

(a) The Director may identify and shall protect, except where exempted under paragraph (b) of this section, all aquifers or parts of aquifers which meet the definition of USDW in § 144.3. Even if an aquifer has not been specially identified by the Director, it is an underground source of drinking water if it meets the definition in § 144.3.

(b) (3) Subsequent to program approval or promulgation, the Director may, after notice and opportunity for a public hearing, identify additional exempted aquifers. For approved State programs exemption of aquifers identified (i) under § 146.04(b) shall be treated as a program revision under § 145.32; (ii) under § 146.04(c)shall become final if the State Director submits the exemption in writing to the Administrator and the Administrator has not disapproved the designation within 45 days. Any disapproval by the Administrator shall state the reasons and shall constitute final Agency action for purposes of judicial review.

144.8 Noncompliance and program reporting by the Director.

The Director shall prepare quarterly and annual reports as specified.

Subpart B — General Program Requirements

144.11 Prohibition of unauthorized injection. Any underground injection, except as authorized by permit or rule issued under the UIC program, is prohibited. The construction of any well required to have a permit is prohibited under the permit has been issued.

144.12 Prohibition of movement of fluid into underground sources of drinking water.

(a) No owner or operator shall construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 49 CFR Part 142 or may otherwise adversely affect the health of persons. The applicant for a permit shall have the burden of showing that the requirements of this paragraph are met.

144.16 Waiver of requirement by Director. Waivers may be obtained

(a) When injection does not occur into, through or above an underground source of drinking water, . . .

(b) When injection occurs through or above an underground source of drinking water, but the radius of endangering influence when computed under § 146.06(a) is smaller or equal to the radius of the well, . . .

Subpart C — Authorization of Underground Injection by Rule

144.25 Requiring a permit.

(a) The Director may require any Class I, II, II, or V injection well authorized by a rule to apply for and obtain an individual or area UIC permit.

144.26 Inventory requirements. Owners or operators of all injection UIC wells authorized by rule shall submit inventory information as set forth in this section to the Director.

Subpart D—Authority by Permit

144.31 Application for a permit; authorization by permit.

(a) Permit application. Except for owners or operators authorized by rule, all underground injection wells are prohibited unless authorized by permit as specified in this section

144.36 Duration of permits.

(a) Permits for Class I and Class V wells shall be effective for a fixed term not to exceed 10 years.

Subpart E — Permit Conditions

144.51 Conditions applicable to all permits.

The following conditions are incorporated, either expressly or by reference, into all UIC permits: Duty to comply, reapply, mitigate, properly operate and maintain, permit actions, providing information to the Director, permitting inspection and entry, monitor and keep records, signatory requirements, reporting requirements, requirements prior to commencing injection, plugging and abandonment report, mechanical integrity demonstration, etc.

144.52 Establishing permit conditions.

(a) In addition to conditions in § 144.51, the Director shall establish conditions, as required on a case-by case basis under § 144.36 (duration of permits), § 144.53(a) (schedules of compliance), § 144.54 (monitoring), etc. Permits shall also contain when applicable, (1) construction requirements, (2) corrective actions, (3) operation requirements, (4) requirements for wells managing hazardous waste, (5) monitoring and report requirements, (6) plug and abandon, (7) financial responsibility, (8) mechanical integrity, (9) additional conditions, as required on a case-by-case basis.

PART 145 — STATE UIC PROGRAM REQUIREMENTS

Subpart D — Program Approval, Revision and Withdrawal

145.32 Procedures for revision of State programs.

(b) Revision of a State program shall be accomplished as follows:

(1) The State shall submit a modified program description, Attorney General's statement, Memorandum of Agreement, or such other documents as EPA determines to be necessary under the circumstances.

(2) Whenever EPA determines that the proposed program revision is substantial, EPA shall issue public notice and provide an opportunity to comment for a period of at least 30 days. Public notice shall be mailed to interested persons and published in the Federal Register and in enough of the largest newspapers in the State to provide statewide coverage. The public notice shall provide opportunity to request a public hearing, which will be held if significant pubic interest is expressed.

(3) The Administrator of EPA shall approve or disapprove program revisions based on the requirements of this part and the Safe Drinking Water Act.

(4) A program revision shall become effective upon the approval of the Administrator. Notice of approval of any substantial revision shall be published in the Federal Register. Notice of approval, a nonsubstantial program revision may be given by a letter from the Administrator to the State Governor or his designee.

PART 146 — UNDERGROUND INJECTION CONTROL PROGRAM: CRITERIA AND STANDARDS

146.4 Criteria for exempted aquifers. An aquifer or a portion thereof which meets the criteria for an underground source of drinking water in § 146.3 may be determined under 40 CFR 144.8 to be an exempted aquifer if it meets the following criteria:

(a) It does not currently serve as a source of drinking water; and

(b) It cannot now and will not in the future serve as a source of drinking water because:

(1) It is mineral, hydrocarbon or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

(2) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

(3) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

(4) It is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

(c) The total dissolved solids content of the ground vaster is more than 3,000 and less than 10,000 mg/L and it is not reasonably expected to supply a public water system.

146.5 Classification of injection wells.

(e) Class V. Injection wells not included in Class I, II, III, or IV. Class V wells include:

(6) Recharge wells used to replenish the water in an aquifer;

(7) Salt water intrusion barrier wells used to inject water into a fresh water aquifer to prevent intrusion of salt water into the fresh water;

(15) Injection wells used in experimental technologies.

146.6 Area of review.

The area of review for each injection well or each field, project or area of the State shall be determined in accordance with either paragraph (a) Zone of endangering influence or (b) Fixed radius, as set forth in this section

146.8 Mechanical integrity.

(a) An injection well has mechanical integrity if it meets the test established in this action.

Subpart F — Criteria and Standards
Applicable to Class V Injection Wells

146.52 Inventory and assessment.

(a) The owner or operator of any Class V well shall within one year of the effective date of an underground injection control program notify the Director of the existence of any well meeting the definitions of Class V under his control and submit the inventory information required in 40 CFR 144.26(a).

PART 147 — STATE UNDERGROUND INJECTION CONTROL PROGRAMS

Subpart K--Florida

147.500 State-administered program--Class I, III, IV, and V wells.

The State of Florida UIC program was approved by EPA pursuant to § 1422 of the SDWA. Notice of this approval was published in the Federal Register on February 7, 1983 (48 FR 5556).

147.502 Aquifer exemptions are reserved to EPA.

Appendix C
State of Florida Underground Injection Control Program

APPENDIX C

State of Florida Underground Injection Control Program

The U.S. EPA delegated administration of Florida's UIC program for Class I, III , IV and V injection wells to the State in March, 1983. Florida's program closely follows the federal program. The rules governing underground injection in Florida are contained primarily in Chapter 62-528 F.A.C, last amended in 1995. Other rules closely related to regulation of the UIC program are contained in Chapters 62-520 and 62-522. The citations below refer to those chapters of the Florida Administrative Code.

CHAPTER 62-528
UNDERGROUND INJECTION CONTROL

62-528.100 and .120 Underground Injection Control: Purpose and Scope

(1) The purpose of Chapter 62-528, F.A.C., Underground Injection Control (UIC), is to protect the quality of the State's underground sources of drinking water and to prevent degradation of the quality of other aquifers adjacent to the injection zone that may be used for other purposes. This purpose is achieved through rules that govern the construction and operation of injection wells in such a way that the injected fluid remains in the injection zone, and that unapproved interchange of water between aquifers is prohibited.

(1) Chapter 62-528, F.A.C., covers all injection wells defined in Rule 62-528.300(1), F.A.C., as Class I, III, IV or V wells.

62-528.200 Definitions.

(15) "Contaminant" means any substance which is harmful to plant, animal or human life.

(22) "Exempted aquifer" means an aquifer or its portion that meets the criteria in the definition of "underground source of drinking water" but which has been exempted according to the procedures of Rule 62-528.300(3), F.A.C.

(26) "Facility or activity" means any installation as defined by section 403.031(4), F.S., that is subject to regulation under the Underground Injection Control Program. These terms shall include federal facilities and activities.

(41) "Major Class V well" means any Class V, Group 3 well used to inject fluids into or above the lowermost formation containing, within one-quarter mile of the well bore, an underground source of drinking water, any Class V, Group 1 well used to inject fluids through an open loop system or containing additives, or any Class V, Group 2, 4, 5, 7, or 8 well as defined in Rule 62-528.300(1)(e), F.A.C., except swimming pool drainage wells.

(44) "New injection well" means a well for which a final construction permit has been issued by the Department and which began injection after April 1, 1982.

(55) "Subsidence" means the lowering of the natural land surface in response to: earth movements; lowering of fluid pressure; removal of underlying supporting material by mining or solution of solids, either artificially or from natural causes; compaction due to wetting (hydrocompaction); oxidation of organic matter in soils; or added load on the land surface.

(60) "Underground source of drinking water" means an "aquifer" or its portion:

(a) Which supplies drinking water for human consumption, is classified by Rule 62-520.410(1), F.A.C., as Class F-I, G-I or G-II ground water, or contains a total dissolved solids concentration of less than 10,000 mg/L; and

(b) which is not an exempted aquifer.

(63) "Well injection" means the subsurface emplacement of fluids through a well by gravity flow or under pressure.

62-528.300 Underground Injection Control: General Provisions.

Class V injection wells in Florida are grouped together on the basis of usage and expected quality of injected water. Drainage, recharge, and related well groups are defined in Rule 62-528(1)9e), and include:

Group 2 - Aquifer Recharge Wells.

a. Recharge wells used to replenish, augment, or store water in an aquifer;
b. Salt water intrusion barrier wells used to inject water into a fresh water aquifer to prevent the intrusion of salt water into the fresh water;
c. Subsidence control wells (not used for the purpose of oil or natural gas production) used to inject fluids into a zone which does not produce oil or gas to reduce or eliminate subsidence associated with the overdraft of fresh water;
d. Connector wells used to connect two aquifers to allow interchange of water between those aquifers;

Group 6 - Stormwater Wells. Wells used to drain surface fluid, primarily storm run-off or for lake level control, into a subsurface formation.

Group 7 - Aquifer Storage and Recovery System Wells. Wells associated with an aquifer storage and recovery facility where surface water or ground water is injected and stored for later recovery for potable or non-potable use. Wells used to store and recover effluent or reclaimed water from a domestic wastewater treatment plant shall be permitted as Group 3 wells.

62-528.300(2) Identification of Underground Sources of Drinking Water.

An aquifer is defined as an "Underground Source of Drinking Water" (USDW) if:

(a) It supplies drinking water for human consumption, is classified by Rule 62-520.410(1), F.A.C., as Class F-I, G-I or G-II ground water, or contains a total dissolved solids concentration of less than 10,000 mg/L; and

(b) is not an exempted aquifer..[Rule 62-528.200(60)]

62-528(300) Identification of Criteria for Exempted Aquifers

An aquifer or a portion thereof which meets the criteria for USDW may be exempted from protection as a USDW if it meet criteria defined in this Rule. Aquifer exemptions are classed as "Major" or Minor", depending of their water quality

(b) . . . Exemption of aquifers identified under (c)2. below are considered major aquifer exemptions and shall be treated as a program revision subject to the provisions of 40 C.F.R. pt. 145.32 (1994) and requiring public notice in the Federal Register. Exemption of aquifers identified under (c)3. below are considered minor aquifer exemptions and shall become final if the Department submits the exemption in writing to the Environmental Protection Agency Administrator, or an authorized delegatee, and the administrator, or an authorized delegatee, has not disapproved the designation within 45 days. Any disapproval by the Administrator shall state the reasons and shall constitute final Environmental Protection Agency action for purposes of judicial review.

(c) To be an exempted aquifer, an aquifer or a portion thereof which meets the criteria for a USDW. . . shall meet the following criteria:

1. It does not currently serve as a source of drinking water; and
2. It cannot now and will not in the future serve as a source of drinking water because:
   a. It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant for a Class III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible;
   b. It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;
   c. It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or
   d. It is located over a Class III well mining area subject to subsidence or catastrophic collapse, or
3. The total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/L and it is not reasonably expected to be or become a supply of drinking water; and
4. Has satisfied the following requirements in accordance with paragraph (b) above:
   a. A major aquifer exemption has been approved by the Environmental Protection Agency; or

b. A minor aquifer exemption has not been disapproved by the Environmental Protection Agency.

62-528.305 Underground Injection Control: Permit Processing.

The time frames in Rule 62-4.055, F.A.C., shall apply to underground injection control permits. However, the failure of the Department to approve or deny a permit for an underground injection well within the 90-day time period shall not result in the automatic approval or denial of the permit and shall not prevent the inclusion of specific permit conditions which are necessary to ensure compliance with applicable statutes or rules. If the Department fails to approve or deny such a permit within the 90-day period, the applicant may petition for a writ of mandamus to compel the Department to act consistently with applicable regulatory requirements.

PART V
CRITERIA AND STANDARDS FOR CLASS V WELLS

62-528.600 General Criteria for Class V Wells.

Classification of wells in Classes I through V is contained in Rule62-528.300(1).Criteria and standards to regulate Class V injection are set forth in Rules 62-528.600 through .645, F.A.C.

Generally, wells covered by these rules inject non-hazardous fluids into or above formations that contain underground sources of drinking water. Class V wells in Florida are grouped together in order to facilitate the determination of permitting, operating, and monitoring requirements. See 62-528.300(1)(e) for a description of Class V well groups and subgroups.

62-528.605 Well Construction Standards for Class V Wells.

(1) .... a well shall be designed and constructed for its intended use, in accordance with good engineering practices, and the design and construction shall be approved by the Department through a permit.

(2) The Department shall apply some or all of the criteria for Class I wells (Rules 62-528.400 through .460, F.A.C., to the permitting of Class V wells if the Department determines that without the application of Class I permitting criteria, the Class V well may cause or allow fluids to migrate into an underground source of drinking water which may cause a violation of a primary or secondary drinking water standard contained in Chapter 62-550, F.A.C., or minimum criteria contained in Rule 62-520.400, F.A.C., or may cause fluids of significantly differing water quality to migrate between underground sources of drinking water. Class I injection well permitting standards shall not be required if the injection fluids meet the primary and secondary drinking water quality standards contained in Chapter 62-550, F.A.C., and the minimum criteria contained in Rule 62-520.400, F.A.C.

(3) Class V wells shall be constructed so that their intended use does not violate the water quality standards of Chapter 62-520, F.A.C., at the point of discharge, except where specifically exempted in Rule 62-522.300(2), F.A.C., provided that the drinking water standards of 40 C.F.R. pt. 142 (1994) are met at the point of discharge. Migration or mixing of fluids from aquifers of substantively different water quality (through the construction or

use of a Class V well) shall be prevented by preserving the integrity of confining beds between these aquifers through cementing or other method acceptable to the Department.

(4) All Class V wells shall be constructed by a Florida licensed water well contractor.

(5) A well completion report defining details of construction and describing various formations penetrated by the well shall be forwarded to the Department within two days after completion of the drilling operation.

(6) Samples of formations penetrated shall be obtained during the construction of any major Class V well as defined in Rule 62-528.200(41), F.A.C.

(7) All drilled wells shall, at a minimum, meet the casing and cementing requirements for water well construction set forth in Chapter 62-532, F.A.C.

(8) Class V wells shall not be dynamited except with written permission from the Department.

(9) A test well or boring shall be filled with cement within five days after completion of the testing for which it was drilled. Such test wells or borings shall not be used as drainage wells unless a permit has been obtained in accordance with this Chapter. Failure to obtain a permit prior to drilling of the well or boring shall bar future use except for testing purposes not connected with drainage in any manner.

62-528.610 Operation Requirements for Class V Wells.

(1) All Class V wells shall be used or operated in such a manner that they do not present a hazard to an underground source of drinking water.

(2) Domestic wastewater effluent or reclaimed water quality shall meet the criteria established in Rules 62-600.420(1)(d)2. and 62-600.540(2) and (3), or 62-610.660, F.A.C., as appropriate.

(3) Pretreatment shall be required for fluids injected through existing wells if necessary to ensure that the injected fluid does not violate water quality standards.

62-528.615 Monitoring Requirements for Class V Wells, and
62-528.620 Reporting Requirements for Class V Wells

Monitoring and reporting requirements for Class V wells are determined by the type of well, nature of the injected fluid, and water quality of the receiving and overlying aquifers. Monitoring is required for some or all wells in Group 2, 6 and 7. Monitoring requirements and exceptions are set forth in the following sections of 62-528.615 F.A.C.

(1) (a) (2). Group 2 and Group 7 wells except when the injection fluids meet the primary and secondary drinking water standards contained in Chapter 62-550, F.A.C, and the minimum criteria contained in Rule 62-520.400, F.A.C.; and the injection fluids have been processed through a permitted drinking water treatment facility; and

(1)(a)(3). Group 6 wells if injection is into an underground source of drinking water; or

(1)(a)(4). Any Class V well where either an exemption from water quality criteria under Rule 62-520.500 or .510, F.A.C., or an aquifer exemption under Rule 62-528.300(3), F.A.C., was required.

(1) (b) The Department shall not require monitoring for the following:

1. Wells used to inject fluids that meet the primary and secondary drinking water standards contained in Chapter 62-550, F.A.C., and the minimum criteria contained in Rule 62-520.400, F.A.C., and the injection fluids have been processed through a permitted drinking water treatment facility;

3. Other Class V wells that the Department determines will provide reasonable assurance of compliance with this rule, without monitoring.

(2) The Department shall determine the frequency of monitoring based on the location of the well, the nature of the injected fluid and, where applicable, the requirements of Chapters 62-600 and 62-601, F.A.C. The monitoring parameters and frequency shall be addressed in the Class V permit or authorization to use a Class V well under Rule 62-528.635(4), F.A.C.

62-528.625 Plugging and Abandonment for Class V Wells.

(1) The Department shall order a Class V well plugged and abandoned when it no longer performs its intended purpose, or when it is determined that the presence of the well may cause or allow a violation of a primary or secondary drinking water standard contained in Chapter 62-550, F.A.C., or may otherwise adversely affect the health of persons.

(2) A plugging and abandonment plan shall be submitted to the Department with the construction permit application.

(3) Prior to abandoning Class V wells, the well shall be plugged with cement in a manner which will not allow movement of fluids between underground sources of drinking water. The proposed plugging method and type of cement shall be approved by the Department by inclusion as a condition of the permit. Placement of the cement shall be accomplished by any recognized method which is approved by the Department in the permit.

PART VI
CLASS V WELL PERMITTING

62-528.630 General Permitting Requirements for Class V Wells.

In general, any Class V well which begins operation after April 1, 1982, is required to have a permit. The construction, modification or operation of any Class V well required to have a permit under Rules 62-528.600 through .645, F.A.C., is prohibited until the permit has been issued. Some Group 1, Group 4 and Group 8 wells are exempt from permitting under this Rule. General permitting requirements applicable to Group 2, 6 and 7 wells are set forth in the following sections of rules 62-528.630 and 62-528.are set forth in the following sections of Rule 62-528.630. Construction permit requirements are set forth in Rule 62-528.635, and operating permit requirements are set forth inn Rule 62-528.640. Permits are also required for abandoning and plugging Class V wells. (62-528.625 and 62.528.645)

(3) No underground injection control authorization by permit or rule shall be allowed where a Class V well causes or allows movement of fluid containing any contaminant into underground sources of drinking water, and the presence of that contaminant may cause a violation of any primary drinking water regulation under Chapter 403, F.S., and Chapter 62-550, F.A.C., or which may adversely affect the health of persons.

(4) If at any time the Department learns that an existing Class V well may cause a violation of primary drinking water standards under Chapter 403, F.S., or Chapter 62-550, F.A.C., the Department shall:

(a) Require a permit for such Class V well;

(b) Order the injector to take such actions including where required, closure of the injection well when necessary to prevent the violation;

(c) Require monitoring to demonstrate that the water quality criteria in Rule 62-520.420, F.A.C., are not violated; or

(d) Take enforcement action.

(5) Whenever the Department learns that a Class V well may be otherwise adversely affecting the health of persons, the Department shall prescribe action necessary to prevent the adverse effect, including any action authorized under subsection (4).

(6) Notwithstanding any other provision of this Chapter, the Department shall take emergency action upon receipt of information that a contaminant which is present or is likely to enter a public water system may present an imminent and substantial endangerment to the health of persons.

(8) Inventory Requirements.

(a) The owner or operator of any Class V well constructed on or before April 1, 1982, shall notify the Department of the existence of any well meeting the definitions of Class V under his control, and submit the inventory information required in subsection (9) below.

(c) If the owner or operator of any Class V well authorized under this section or Rule 62-528.630(2)(b), F.A.C., fails to comply with the inventory requirements of this section or Rule 62-528.630(2)(b), F.A.C., that authorization shall automatically terminate.

(9) As part of the inventory, the Department shall require the following information:

(a) Facility name and location, including a plot plan showing location of well(s);

(b) Name and address of legal contact;

(c) Ownership of facility;

(d) Nature and type of injection wells, including installed dimensions of wells and construction materials;

(e) Operating status of injection wells, including history of injection;

(f) Volume of injected fluid;

(g) Nature of injected fluid;

(h) Description of injection system, including monitoring well(s), if any

(10) A group of similarly designed injection wells within the same wellfield, owned and operated by the same applicant serving the same purpose may be permitted as a system rather than as individual wells, however a separate permit fee as specified in Rule 62-4.050(4)(k), F.A.C., shall be assessed for each well.

(11) At least 30 days prior to sale or legal transfer of a Class V well, the new owner shall notify the Department. Until such time as notice of change in ownership is submitted, the owner reflected on the permit/clearance shall be responsible for the operation of the well and for damages resulting from improper operation of the wells.

62-528.635 Construction/Clearance Permit for Class V Wells.

(1) All owners or operators of Class V wells shall obtain a two-part Construction/Clearance Permit, except as provided in Rule 62-528.630(2), F.A.C. The applicant shall submit to the Department the following information before receiving permission to construct:

(a) Facility name and location;

(b) Name, address, and signature of owner (or authorized representative) of facility;

(c) Name, address, license number, and signature of Florida licensed water well contractor;

(d) Well location and depth, and casing diameter and depth for all water supply wells on the applicant's property, and well location for all water supply wells of public record within a one-half mile radius of the proposed well;

(e) Description and use of proposed injection system, including type and construction of injection wells, physical and chemical analyses, estimated quantity, pertinent bacteriological analyses of injected fluid, and any proposed pretreatment.

(f) Proposed drilling and testing plan for any exploratory borehole or exploratory well proposed for the purpose of determining feasibility of Class V well injection at that site.

(g) If the flow of surface or other waters is directed by ditches or other artificial methods to the well, a delineation of the area drained by these features shall be provided.

(2) If necessary to protect underground sources of drinking water, the applicant shall be required to submit to the Department the following information before receiving permission to construct:

(a) Completed report of inspection by local programs or water management districts which have agreements with the Department.

(b) Bacteriological examination of the injection fluid, on-site monitor wells, and the nearest down-gradient domestic or public water supply well within a one-half mile radius that are drilled to the same formation(s) as the proposed Class V well.

(c) If a drainage well or drainage structure will present a possible pollution hazard to an underground source of drinking water, additional data shall be required.

(3) Upon completion of the well construction, the water well contractor shall certify with the Department that the well has been completed in accordance with the approved construction plan, and submit any other additional information required by the construction permit before the well can be put into service.

(4) .... Class V wells not specifically exempted under Rule 62-528.640(1)(c), F.A.C., shall obtain an operation permit before injecting fluids into the well.

(5) Initial or periodic testing of the well shall be required for all Class V wells if necessary to provide reasonable assurance that underground sources of drinking water are being adequately protected.

62-528.640 Operation Permit for Class V Wells.

This rule requires operation permits for Group 2 (Recharge , Group 6 (Stormwater and lake control) and Group 7 (ASR) wells if injection is into an underground source of drinking water.

(1)(c) Operation permits are not required for ... Group 7 wells when the injection fluid meets the primary and secondary drinking water standards .

62-528.645 Plugging and Abandonment Permit for Class V Wells.

Rule 62.528.625 provides for the plugging and abandonment of Class V wells (All Groups). The plugging method is subject to FDEP approval, as described in this rule.

CHAPTER 62-520
GROUNDWATER CLASSES, STANDARDS AND EXEMPTION

52-520.200. Definitions for Ground Water.

This Chapter defines the classification of groundwater sources by quality and potential use, and sets the water quality criteria and monitoring requirements for facilities discharging to groundwater. The types of facilities covered and the concept of "zone of discharge" are defined as follows:

(11) **"Installation"** means any structure, equipment, facility, or appurtenances thereto, operation or activity which may be a source of pollution

(23) **"Zone of Discharge"** means a volume underlying or surrounding the site and extending to the base of a specifically designated aquifer or aquifers, within which an opportunity for the treatment, mixture or dispersion of wastes into receiving ground water is afforded.

62-520.400. Minimum Criteria for Ground Water.

The general "free from" criteria, applicable to all classes of groundwater, except G-IV groundwater as define in (2) below, are defined in this rule. This rule also contains a procedure, (3) below, for quantifying "free from" criteria:

(1) All ground water shall at all places and at all times be free from domestic, industrial, agricultural, or other man-induced non-thermal components of discharges in concentrations which, alone or in combination with other substances, or components of discharges (whether thermal or non-thermal):

(l)(a) Are harmful to plants, animals, or organisms that are native to the soil and responsible for treatment or stabilization of the discharge relied upon by Department permits; or

(l)(b) Are carcinogenic, mutagenic, teratogenic, or toxic to human beings, unless specific criteria are established for such components in Rule 62-520.420, F.A.C.; or

(l)(c) Are acutely toxic within surface waters affected by the ground water; or

(l)(d) Pose a serious danger to the public health, safety, or welfare; or

(l)(e) Create or constitute a nuisance; or

(l)(f) Impair the reasonable and beneficial use of adjacent waters.

(2) The minimum criteria shall not apply to Class G-IV ground water, unless the Department determines there is a danger to the environment, public health, safety or welfare.

(3) The following procedures shall apply in the implementation of (l)(b) above:

(3)(a) The Secretary is authorized to make determinations, in individual permitting or enforcement proceedings, that a particular level for a substance is a prohibited concentration in violation of a minimum criterion pursuant to (l)(b) above. This determination may not be delegated to Department districts.

62-520. 410. Classification of Ground Water, Usage, Reclassification.

(1) All ground water of the State is classified according to designated uses as follows:

Class F-I	Potable water use, ground water in a single source aquifer described in Rule 62-520.460, F.A.C., which has a total dissolved solids content of less than 3,000 mg/1 and was specifically reclassified as Class F-I by the Commission.
Class G-I	Potable water use, ground water in single source aquifers which has a total dissolved solids content of less than 3,000 mg/L.
Class G-II	Potable water use, ground water in aquifers which has a total dissolved solids content of less than 10,000 mg/1, unless otherwise classified by the Commission.

Class G-III	Non-potable water use, ground water in unconfined aquifers which has a total dissolved solids content of 10,000 mg/L or greater, or which has total dissolved solids of 3,000--10,000 mg/L and either has been reclassified by the Commission as having no reasonable potential as a future source of drinking water, or has been designated by the Department as an exempted aquifer pursuant to Rule 62-28.130(3), F.A.C.
Class G-IV	Non-potable water use, ground water in confined aquifers which has a total dissolved solids content of 10,000 mg/l or greater.

62-520.420. Standards for Class G-l and Class G-ll Ground Water.

This section defines the standards applicable to all groundwater in confined aquifers and having less than 10,000 milligrams per liter of dissolved solids. . Criteria for exception from the standards within a "Zone of discharge" are defined in (4) below, and the provision "Grandfathering of existing facilities is :contained in (5).

(1) In addition to the minimum criteria provided in Rule 62-520.400, F.A.C., waters classified as Class G-I and Class G-II ground water shall meet the primary and secondary drinking water quality standards for public water systems established pursuant to the Florida Safe Drinking Water Act, which are listed in Rules 62-550.310 and 62-550.320, F.A.C., except as provided in Rule 62-520.520, F.A.C., and subsections (4) and (5) below, and except that the total coliform bacteria standard shall be 4 per 100 milliliters. In addition, the primary drinking water standard for public drinking water systems for asbestos shall not apply as a ground water standard.

(2) If the concentration for any constituent listed in subsection (1) above in the natural background quality of the ground water is greater than the stated maximum, or in the case of pH is also less than the minimum, the representative natural background quality shall be the prevailing standard for Class G-I and Class G-II ground water.

(3) Where natural background quality of the ground water cannot be determined in the upgradient well, and the concentration for any constituent listed in subsection (1) above in the background quality of the groundwater is greater than the stated maximum, or for pH is also less than the minimum, the representative background quality shall be the prevailing standard for those installations.

(4) These standards shall not apply within a permitted zone of discharge as provided in Chapter 62-522, F.A.C. The minimum criteria specified in Rule 62-520.400, F.A.C., shall apply within the zone of discharge.

(5) Installations legally discharging or permitted to discharge to Class G-I, Class G-II, and Class F-I ground water on or before August 1, 1992, shall not be required to comply with the additional or more stringent drinking water standards approved for adoption by the Commission on July 27, 1992, and effective January 1, 1993, until January 1, 1995. However, all installations discharging to these ground waters are prohibited from causing

a violation of such standards at any private or public water supply well outside the zone of discharge.

62-520.500. Exemptions for Installations Discharging Into Class G-I or G-II Ground Water.

This section defines procedures for obtaining an exemption from water quality standards. Section **62-520.520** provides for exemptions outside a "Zone of discharge" for existing installations.

> "The Secretary shall, upon petition of an affected person or permit applicant and after public notice in the Florida Administrative Weekly, and in a newspaper of general circulation in the area of the exemption placed by the petitioner, and after opportunity for public hearing pursuant to Section 120.57, F.S., issue an order, which shall be included as a permit modification, for the duration of the permit specifically exempting an installation discharging or designed to discharge into Class G-I or G-II ground water from the standards contained in Rule 62-520.420, F.A.C., or the minimum criteria contained in Rule 62-520.400, F.A.C."

The criteria for exemption are also defined in this rule:

(1) granting the exemption is clearly in the public interest;

(2) compliance with such criteria is unnecessary for the protection of present and future potable water supplies;

(3) granting the exemption will not interfere with existing uses or the designated use of the waters or of contiguous water;

(4) the economic, environmental, and social costs of compliance with the criteria outweigh the economic, environmental and social benefits of compliance;

(5) an adequate monitoring program approved by the Department is established to ascertain the location and approximate dimensions of the discharge plume, to detect any leakage of contaminants to other aquifers or surface waters, and to detect any adverse effect on underground geologic formations or waters; and

(6) The exemption will not present a danger to the public health, safety or welfare.

62-520.520. Exemptions from Secondary Drinking Water Standards Outside a Zone of Discharge in Class G-II Ground Water.

(1) An existing installation discharging to Class G-II ground water is exempt from compliance with secondary drinking water standards unless the Department determines that compliance with one or more secondary standards by such installation is necessary to protect ground water used or reasonably likely to be used as a potable water source. Such determination shall be based upon:

(l)(a) A determination that the portion of the aquifer(s) reasonably likely to be affected by the discharge:

(l)(a)1. is used as a potable water source, or (l)(a)2. is identified in a planning document as a future potable water source by a state agency, water management district, regional water supply authority, or local government, and is reasonably likely to be used as such.

(l)(b) A site specific hydrogeologic characterization of the receiving aquifer which defines:

(l)(b)1. direction and rate of ground water flow, and

(l)(b)2. depth and degree of confinement.

(l)(c) A waste stream characterization, site specific hydrogeologic characterization, and review of monitoring data which demonstrates that the discharge is likely to cause a violation of one or more secondary standards outside the zone of discharge in:

(l)(c)1. the portion of the receiving aquifer identified in (a)2. above, or

(l)(c)2. a known public or private potable water supply well.

(2) The perimetee can avoid the application of one or more secondary standards upon an affirmative demonstration that the economic, social, and environmental costs outweigh the economic, social and environmental benefits of compliance; provided, however, that such demonstration shall not operate to relieve the permittee from compliance with (6) below.

(3) Upon permit renewal, the Department shall review available data to determine the need for compliance with secondary standards.

(4) Upon determination by the Department that an existing installation must comply with one or more secondary standards, the Department shall revoke the exemption and require compliance or corrective action considering the factors in Rule 62-522.700(2), F.A.C. Such revocation shall be included in an appropriate Department permit as a specific condition after February 1, 1988.

(5) Secondary drinking water standards constituents may be included as waste characterization, monitoring, and indicator parameters as specified by permit.

(6) All installations discharging to Class G-II ground water are prohibited from causing a violation of the secondary drinking water standards at any private or public water supply well outside the zone of discharge.

(7) Failure of an existing installation to submit monitoring data to the Department as required pursuant to any permit addressing ground water shall be a basis for removal of that installation's secondary standards exemption. The installation may regain such exemption at such time as it can demonstrate compliance with monitoring requirements, unless removal of the exemption is otherwise authorized pursuant to this rule.

(8) Existing cooling ponds approved by the Department for treatment of thermal discharges to surface water as defined in Rule 62-302.520, F.A.C., are exempt from secondary standards so long as the cooling pond waters are monitored pursuant to Department permit to ensure that the ponds does not impair the designated use of contiguous ground waters and surface waters. In addition, the Secretary may order such monitoring of

ground waters as may be reasonably necessary to ensure that the designated use of affected ground waters and surface waters is not impaired.

CHAPTER 62-522
GROUND WATER PERMITTING and MONITORING REQIREMENTS

62-522.200 Definitions for Ground Water Permitting and Monitoring.

(1) For the purposes of Chapters 62-520 and 62-522, F.A.C., "Existing Installation" means any installation which filed a complete application for a water discharge permit on or before January 1, 1983, or which submitted a ground water monitoring plan no later than six months after the date required for that type of installation as listed in Rule 17-4.245, F.A.C., (1983) and a plan was subsequently approved by the Department, or which was in fact an installation reasonably expected to release contaminants into the ground water on or before July 1, 1982, and operated consistently with statutes and rules relating to ground water discharge in effect at the time of the operation.

62-522.300 General Provisions for Ground Water Permitting and Monitoring.

This section prohibits direct or indirect discharge into ground water that causes a violation in the water quality standards and criteria for the receiving ground water outside a specified zone of discharge. It contains a specific prohibition on a permitted "zone of discharge" under the circumstances described in (2)(a) and (2)(b) below. The following section **[62-522.400]** contains special provisions for ZODs for Class I groundwater The latter also are intended to apply only to <u>indirect</u> discharges.

(2)(a) Discharges through wells or sinkholes that allow direct contact with Class G-I and Class G-II ground water, except for projects designed to recharge aquifers with surface water of comparable quality, or projects designed to transfer water across or between aquifers of comparable quality for the purpose of storage or conservation.

(2)(b) Discharges that may cause an imminent hazard to the public or the environment through contamination of underground supplies of drinking water or surface

62-522.400 Dimensions of Zones of Discharge for Class G-I Ground Water.

(1) No zone of discharge shall be allowed into Class G-I ground water, except that domestic effluent or reclaimed water and stormwater discharge sites authorized by Department permit or rule shall have zones of discharge extending no more than 100 feet from the site boundary or to the installation's property boundary, whichever is less, unless a smaller zone of discharge is necessary to protect the designated use of adjacent waters outside the zone of discharge.

(2) Other discharge sites shall be granted zones of discharge of the same size as those in (1) above if the discharges meet the criteria for domestic effluent or reclaimed water in chemical, physical, and microbiological quality and are treated to the degree required in Rule 62-600.530, F.A.C.