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TO:	Tom Jones, V.P. Government Affairs Barron Collier Companies	DATE:	revised March 11, 2009
FROM:	David L. Hoffman, P.G.	RE:	Eastern Collier County Water Resource Availability

Introduction

This paper provides an overview of water supplies available to meet future residential development and agriculture demands in eastern Collier County. This assessment was made using assumptions provided by the Barron Collier Companies and information contained in the Phase I Technical Report, including: a projected population of 234,572 persons at build-out, a conversion of approximately 45,000 acres of existing agricultural land to residential development to accommodate the projected population, and approximately 40,000 acres of agricultural lands remaining under cultivation. The intent of this assessment is to enable the user to visualize the "big picture" of present-day and future water supply demands and availability in eastern Collier County.

This assessment discusses the surplus of traditional water supplies (*i.e.*, shallow fresh groundwater from the Surficial Aquifer System) made available by conversion of 45,000 acres of agriculture to residential development, documented neutral water resource impact of residential development, as well as the use of alternative water supplies (*i.e.*, brackish groundwater, reclaimed water, and storage) to serve future residential developments. This assessment assumes that future water supply approaches will be subject to present-day South Florida Water Management District (SFWMD, 2007) rules and regulations.

Existing Agricultural Water Supply Use

Consumptive water use in agricultural irrigation is that water consumed by the crop through evapotranspiration (ET) and through harvesting (removal of fruit and vegetable). The Modified Blaney-Criddle irrigation model (SFWMD, 2003) was used in this assessment to approximate consumptive use through irrigated crop ET. The volume of water removed through harvesting is considered minimal (<1% of consumptive use) and not quantified in this assessment. The Modified Blaney-Criddle irrigation model is used by the SFWMD to establish irrigation allocations in water use permits based on irrigated acreage, crop type, evapotranspiration, effective rainfall, irrigation system efficiency, under 1-in-10 drought conditions (a drought with a return frequency of once in 10 years). Based on the Phase I Technical Report there are approximately 90,000 acres of agricultural land of which approximately 65,000 acres is irrigated (citrus, vegetable, and specialty crops) and 25,000 acres is not irrigated (fallow land and pasture/rangeland). The 65,000 acres of irrigated acreage consists of approximately 38,233 acres of citrus, 25,035 acres of vegetables, and 1,201 acres of specialty crops. If full conversion to the potential Stewardship Receiving Area (SRA) footprint of 45,000 acres were to occur we would estimate approximately 40,000 acres of irrigated agriculture (20,000 acres of citrus and 20,000 acres of vegetable) to remain. Therefore, approximately 24,469 acres of agriculture will no longer be irrigated including 18,233 acres of citrus, 5,035 acres of vegetable, and 1,201 acres of specialty crop.

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Based on the irrigation model and parameters given, irrigated ET for 18,233 acres of citrus, 5,035 acres of vegetable, and 1,201 acres of specialty crop cultivation is approximately 68, 11, and 5 mgd, respectively (84 mgd total). Two growing seasons, each four months in length, were used to estimate irrigated ET for vegetable crops. Turf was used for the specialty crop. Based on the Blaney-Criddle irrigation model, the average effective rainfall (that portion of total rainfall that is used by the plant to meet ET demand) is approximately 25, 12, and 26 inches for citrus, vegetable, and specialty crops, respectively, at the Immokalee rain station. This average effective rainfall equals approximately 34, 5, and 2 mgd for citrus, vegetable, and specialty crop, respectively (41 mgd total). Therefore, the total irrigated ET demand met by supplement irrigation is approximately 43 mgd (84 mgd – 41 mgd).

Irrigation water to serve existing agricultural uses in eastern Collier County is withdrawn from traditional supplies, mainly shallow aquifers located within the Surficial Aquifer System (*i.e.*, water-table and lower Tamiami). These shallow aquifers yield larges volumes of good quality groundwater, provided the production wells have been constructed properly. There have been no documented occurrences of significant impacts to other existing legal users, wetlands, or the resource from historical (>50 years) withdrawals from these aquifers.

The SFWMD established maximum developable limits (MDLs) for semi-confined aquifers in Section 3.2.4 of the Basis of Review for Water Use Permit Applications (SFWMD, 2007) to provide reasonable assurances that the proposed withdrawals will not cause harmful drawdown. The MDL are aquifer specific and represent an elevation above which corresponding aquifer water levels must be maintained. The SFWMD set the MDLs at 20 feet above the top of the uppermost geologic strata that comprises the aquifer at any point during a 1-in-10 drought condition. The point of compliance for the MDLs is 50 feet from a pumping well. For example, if the uppermost geologic strata (*i.e.*, permeable limestone) marking the top of the aquifer is located at 75 feet below land surface (bls), the MDL would be set at 55 feet bls. There are no reported exceedances of the MDLs in eastern Collier County, thus indicating an adequate water supply is present that historically has supported agriculture.

A good explanation of why water levels in the water-table and lower Tamiami aquifers have exhibited a statistically significant lack of change or slight increase in southwest Florida is provided by Maliva and Hopfensperger (2007). The authors indicate that the 11-fold population increase (1960 to 2004) in southwest Florida and concomitant increase in water use had an overall neutral impact on water levels in the water table aquifer because ET of residential communities is comparable to that of native vegetation and less than that of most agricultural land uses. The authors present evidence supporting their findings using United States Geological Survey (USGS) recorded water levels located throughout southwest Florida. The evidence also shows that water levels in local aquifers recover to near background levels each summer wet season because rainfall exceeds ET during the wet season.

The Surficial Aquifer System consists of the water table and lower Tamiami aquifers (primary sources of irrigation water in eastern Collier County). An existing agricultural water use demand of 43 mgd for 24,469 acres of crop ET is equivalent to yield 1.1 mgd/square mile from Surficial Aquifer System. This yield/area is documented to be sustainable by lack of impacts on water levels.

Present day SFWMD (2006) regulation requires the storage of storm water runoff on-site and thus prevention of over drainage of the developed land. Storage is accomplished through interconnected lake systems (*e.g.*, wet detention). The result is storm water flow across impervious surfaces to the lake systems, minimization of ET consumption, and increase in water table water levels. Johnson Engineering, Inc. is actively engaged in the study of long-term discharge of storm water management systems in existing residential developments throughout southwest Florida. Preliminary results indicate that discharge from some storm water lake systems can be considerably lower than anticipated and that significant recharge to the water table aquifer occurs.

Future Residential Water Supply Demands

Residential water supply demands will include potable and irrigation water. According to the Collier County 10-Year Water Supply Facilities Work Plan (CDM, 2007), the Ave Maria Utility Company, LLLP (AMUC) level of standard service includes a per capita water demand standard of 110 gallons per capita per day (gpcd). Ave Maria has a centralized irrigation water (reuse) system that eliminates the need to irrigate with drinking (potable) water. It is assumed that future residential developments will also have a similar standard. The average annual daily demand for finished water based on a projected population of 234,572 persons each using 110 gallons per day amount to approximately 26 mgd.

The irrigated acreage of a typical residential community in southwest Florida is approximately 30% of the total acreage. Using the Modified Blaney-Criddle irrigation model and assuming 13,500 irrigated acres of turf grass, the irrigated ET is 59 mgd. Based on the Blaney-Criddle irrigation model, the average effective rainfall is approximately 26 inches at the Immokalee rain station. This average effective rainfall equals approximately 27 mgd. Additionally, approximately 90% of the potable water supply (23 mgd) will be treated and reused for irrigation of the turf grass. Therefore, the total irrigated turf grass ET demand met by supplement irrigation is approximately 9 mgd (59 mgd – 27 mgd from effective rainfall – 23 mgd from reuse water).

Another potential consumptive water use of residential communities is evaporation from constructed lakes. Approximately 15% of typical residential communities are constructed as lakes and evaporation is approximately 53 inches per year (FSU, 1984), which from 6,750 acres of lakes is approximately 27 mgd. The average rainfall is 50.46 inches at the Immokalee rain station, which is equal to approximately 25 mgd when applied to the lake area. Thus, the net evaporative loss from the constructed lakes is approximately 2 mgd (27 mgd – 25 mgd).

The net consumptive use of water for future residential is approximately 37 mgd (26 mgd potable + 9 mgd for supplement irrigation + 2 mgd for evaporation), which is roughly equivalent to 0.5 mgd/square mile from Surficial Aquifer System. This is yield/area is less than that of existing agriculture, thus further demonstrating sustainable traditional sources of water.

The following is a summary of average residual irrigation requirements (that supplemental water needed for irrigation in addition to rainfall) needed to meet the 24,469 acres of agricultural crop ET demands. The summary also provides net consumptive use for future residential development, which includes potable water use and evaporation from the surface water

management lake system. Finally, the reduction in consumptive water use resulting from the conversion of agriculture to residential land use is shown. The results demonstrate that consumptive water use (ET) will decline when agriculture is converted to residential land use.

Converted Irrigated Agriculture (24,469 acres)
Average Residual Irrigation Requirement

Annual Average Daily Demand (mgd)	43
Annual Demand (million gallons)	15,695

Net Consumptive Use for Residential Development (45,000 acres)
Potable, Lake Evaporation, and Average Residual Irrigation Requirement

Annual Average Daily Demand (mgd)	37
Annual Demand (million gallons)	13,505

Reduction in Consumptive Water Use

Annual Average Daily (mgd)	6
Annual (million gallons)	2,190

Alternative Water Supplies

Another abundant source of water is referred to by the SFWMD as alternative water supplies. The alternative water supplies that can meet the future residential demands in eastern Collier County include brackish groundwater, reclaimed water, and storage. The Floridan aquifer underlies all of Florida and is characterized as moderately to highly productive in southwest Florida. This deep, brackish aquifer occurs beneath the shallow freshwater aquifers typically utilized in eastern Collier County. The Floridan aquifer is primarily recharged in central Florida (*e.g.*, Polk County). The Floridan aquifer is prolific and stores a tremendous volume of moderate to poor quality water that is available for withdrawal but requires advanced treatment, at increased cost, such as reverse osmosis. The SFWMD points out that other than some water quality deterioration associated with pumping of the Floridan aquifer, no other environmental impacts have been identified in association with use of this resource (SFWMD 2005-2006 Lower West Coast Water Supply Plan). Water quality deterioration associated with Floridan aquifer withdrawals is localized near the wellfield and is not a regional issue. The SFWMD raises concern about water quality deterioration so that the utility can design its treatment works in anticipation of the change.

The SFWMD (2002) initiated a hydrogeologic study of the Floridan aquifer near Immokalee to support future water supply planning. The study consisted of exploratory well construction, aquifer testing, and long-term monitoring of water quality and aquifer water levels. According to the SFWMD, a long-duration (71.6 hours) aquifer performance test was conducted to determine the hydraulic performance of a test zone (1,050 to 1,160 feet bls) of the upper Floridan aquifer at the test site. A high transmissivity value of 268,000 gallons/day/foot was calculated by the SFWMD for the test zone. After nearly 3 days (71.6 hours) of continuous pumping at 1,100 gallons per minute (gpm: 1.6 mgd), only 3 feet of aquifer water level drawdown was observed in

the Floridan aquifer at a distance of 240 feet from the pumping well. Based on the SFWMD information, withdrawals of 1 mgd/square mile from the Floridan aquifer is feasible, which totals approximately 70 mgd on the 45,000 acres converted from agriculture to residential. Withdrawals of 1 mgd can also occur from the 40,000 acres remaining under agricultural production to provide an additional 63 mgd water supply for future residential use. The total available water supply for future residential use from the Floridan aquifer is in excess of 133 mgd. The SFWMD promotes the use of the Floridan aquifer and provides funding from its alternative water supply funds to encourage its use. There are few competing users of the Floridan aquifer in eastern Collier County since traditional supplies are abundant and meet existing demands.

Available Floridan Aquifer Withdrawals

Annual Average Day (mgd)	133
Annual (million gallons)	48,545

Use of reclaimed water for residential irrigation is an alternative water supply that further reduces the overall irrigation water use demand from traditional supplies for future residential developments. Approximately 90% of the average annual daily demand for potable water is returned to a wastewater treatment plant and treated for use as irrigation. Therefore, approximately 23 mgd of reclaimed water is available for residential irrigation.

While traditional supplies, brackish groundwater and reclaimed water will be readily available to meet future irrigation ET losses, storage represents one of the greatest solutions for future water supply needs. Southwest Florida gets upwards of 65% of its total rainfall during a four month (June – September) rainy season when most of this water is quickly lost to evapotranspiration and surface water flows to tide. At the same time, agriculture and residential (potable and irrigation) water use are correspondingly at their lowest. The solution is multi-year storage of water during the rainy season until times of demand (*i.e.*, dry season) or prolonged demand (*i.e.*, drought).

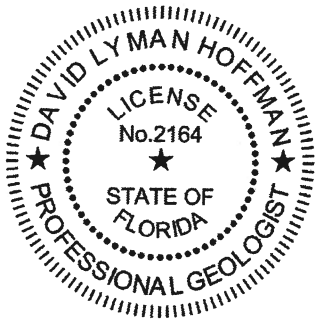
Aquifer storage recovery (ASR) is the storage of water (*i.e.*, drinking water, storm water, and/or reclaimed water) in a deep aquifer during times of excess and withdrawal (recovery) during times of demand. ASR has proven successful in southwest Florida due to the limited land surface area (< 1 acre) required to store hundreds of millions of gallons and thus minimized land costs and environmental impacts as opposed to a large surface water reservoir. Furthermore, water stored in a confined aquifer is not subject to evaporative losses. Existing ASR programs in southwest Florida include Bonita Springs Utilities, Lee County Utilities, Collier County Utilities, and City of Cape Coral. The St. Johns River Water Management District (SJRWMD: 2004) prepared a position paper in support of ASR that discusses recovery efficiency of ASR wells. Recovery efficiency is an indication of the amount of mixing that occurs between the stored water and native groundwater in the aquifer system. Acceptable recovery efficiency ranges between 70 and 100 percent. SJRWMD (2004) indicates that ASR recovery efficiency in Florida generally improves with successive operating cycles due to the freshening of the storage zone and that virtually all ASR wells operating for five years or more have reached acceptable and economically viable levels of recovery efficiency. Permitted daily storage in a single ASR well

in Florida typically ranges between 1 and 3 mgd. The spacing of ASR wells is dependent on aquifer characteristics and stored water volume. Thirty ASR wells each storing 3 mgd during the 120 day rainy season (storage cycle) would result in the storage of approximately 10,800 million (10.8 billion) gallons. An ASR recovery efficiency of 80% will result in approximately 8,600 million (8.6 billion) gallons or 35 mgd if withdrawn over the remaining 245 days of the year (recovery cycle).

Summary

Historical agricultural water use from traditional sources is significant with no documented impacts. Conversion of land from agriculture to residential will result in a decrease in water use due to decreased ET. The traditional sources have served agriculture well and their continued use should be pursued in the future. Studies of USGS measured water levels indicate a neutral water resource impact of residential development not only because residential irrigation ET is less than agriculture, but also that residential ET is similar to that of natural systems. Also, water levels are maintained each year as rainfall exceeds ET during the wet season.

Alternative water supplies are proven and promoted by the SFWMD in southwest Florida. A large sustainable volume (113 mgd) of brackish groundwater is available from the Floridan aquifer from land area (1 mgd/square mile) referenced in this paper. A large reclaimed water volume of approximately 23 mgd would be available for residential irrigation. Finally, capture of abundant water during the wet season and storage via ASR wells represents a sustainable and drought-proof technology. Recovery from thirty ASR wells during a 245 day recovery cycle would provide approximately 35 mgd. In summary, the abundance of traditional and alternative water supplies discussed in this paper clearly demonstrates that future land uses are not limited by water supplies in eastern Collier County.



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