LONG TERM DISCHARGE STUDY

EXECUTIVE SUMMARY

Johnson Engineering, Inc.

Fort Myers, Florida

239-334-0046

Authored by Michael Lohr, Kimberly Arnold, and Tim Denison in January 2013

The Long Term Discharge Study was initiated in 2006 following a water quality research project in south Lee County then being completed. That project intended to study the effects of littoral plantings in a small lake in the Bonita Bay community. The intent was to capture inflow and outflow samples from the lake during period of discharge. After a year, it was obvious that the lake system did not discharge stormwater runoff through the outfall structure often and maybe not at all in drier years.

In order to investigate the frequency of this type of discharge behavior, Johnson Engineering was selected to develop monitoring plans and perform field work under a Best Management Practices research contract issued to The Bonita Bay Group by the Florida Department of Environmental Protection (FDEP). As such, FDEP was the primary funding source for this research work done under the auspices of the Nonpoint Source Management Section.

Six locations were selected in southwest Florida for the Long Term Discharge Study project, specifically in Lee and Collier Counties. Residential communities of moderate size were selected on lands developed by Bonita Bay Group. All project locations were in some phase of development and none were completely built out, but some were near build out. Basins within the communities that had defined outfalls and surface water basin boundaries were selected and pressure transducer style recording data loggers were installed to monitor water levels at the discharge structures. Once elevations and outfall structure geometries were determined, flow volumes could be determined by standard hydraulic calculations, including approximating the effects of submergence, where applicable.

Data collection began during 2007 and continued through December of 2012. Rainfall was monitored at each site with standard tipping bucket recording rain gages cross-checked by golf course or county maintained rain gage sites. Annual rainfall and total surface water basin area were used to estimate the total amount of stormwater inflow, which was then compared to the calculated flow discharged through the control structures, either through orifice bleed down openings or over the primary crest. Groundwater influence, evaporation and exfiltration through adjacent soils are all known to exist, but were not evaluated in the discharge calculations. The discharge calculations were strictly related to the water discharging through the permitted control structures only.

Rainfall conditions throughout the project duration ranged from moderately low to average and the region experienced multiple tropical storms and hurricane events during the study period, as well as prolonged drought conditions. The historical normal value for annual rainfall for the Fort Myers Page Field Station (1971-2000) is 54.2 inches based on records tabulated by NOAA. The rainfall received at the six project sites during the 2007-2012 study period ranged from below these normal values to above normal values.

A wide range of discharge behaviors was noted for the six projects, from minimal or no discharge, in some years (Mediterra and Twin Eagles), to moderate periods of discharge (Verandah, Brooks and Shadow Wood Preserve), to fairly long periods of discharge throughout the year (Sandoval). Stormwater discharge from the six project sites for the study period of 2007-2012 ranged from multiple occurrences of no discharge at all for entire calendar years to as high as over 40 inches per year at Sandoval. This wide range of discharge behaviors existed throughout the study period under variable rainfall conditions. For example, the project site with the highest amount of annual rainfall was Twin Eagles with 67 inches received in 2008. Twin Eagles also had the smallest amount of discharge for that year, only 1.91 inches, and the smallest amount of discharge among all the sites for the entire study period.

Rainfall is often considered as a primary driver for predicting how much discharge will occur from any location. However, other factors, such as rainfall distribution, groundwater influences, and irrigation activities, all have considerable influence as well. As noted in the water level-rainfall charts for each project site, the distribution of rainfall throughout the year can vary considerably and this has a large impact on how much discharge will occur since it establishes

antecedent conditions for a given discharge event. If a larger proportion of the annual total rainfall is received during the normally drier months of November through May, a lower potential for discharge through the outfall structure exists. Rainfall volumes typically received during those times usually occur through lower intensity events with lower ambient water table levels and, therefore, have more time to exfiltrate from the lake and evaporate from the water management systems. Infiltration into the surrounding land surface where there is available storage capacity in the soils can result in diminished runoff from the study basin. However, the discharge rates and amounts for any of the six study basins do appear to be correlated to the amount of rainfall received during the periods when saturated conditions exist and water surface elevations are near the outfall control elevations. These two conditions rarely exist together at Twin Eagles, for example, but occur relatively frequently at Sandoval.

Also, local geology and water table elevations have a significant effect on discharge behavior, as do interactions of groundwater with the surface water systems. These factors combine to make accurate prediction of stormwater discharge behavior difficult and dependent on site specific conditions. In addition to site-specific hydrogeologic conditions, the slope of the study basin may also play a role in characterizing stormwater discharge behavior. Sites with greater slopes, such as Verandah, can act as groundwater discharge areas, which will contribute to the total water budget of the stormwater management ponds and may lead to increased discharge through the control structure.

Water quality sampling was added to the study project starting in 2007 and continuing through 2012 with samples being taken both during periods of discharge and directly from lakes during periods of no discharge. Sampling parameters included nutrient components of nitrogen and phosphorus, as well as chlorides, chlorophyll a, total suspended solids, hardness, copper, iron and lead, all analyzed by a certified state laboratory according to Florida Department of Environmental Protection standard protocols and practices. A total of 82 surface water sample sets were taken from 2007-2012 during discharge conditions, 82 sets taken during static or no discharge conditions, and 38 sets taken from adjacent groundwater wells.

Various sources of irrigation (surface water, groundwater, reclaimed water) were used by the communities monitored. Each of these sources has different levels of nutrient concentrations typically associated with that source type. Reclaimed water, which was the primary irrigation

source for Sandoval, has nutrient levels that are up to ten times as high as nutrient levels normally found in surface water. Levels of nutrients in groundwater are typically higher than nutrient levels in surface water, but lower than levels present in most reclaimed water. However, groundwater is a common irrigation source for southwest Florida, including Verandah, Shadow Wood Preserve, and The Brooks communities. Irrigation activities on a project site have the potential to affect long term discharge behaviors as well as water quality if the discharged water.

In 2010, a groundwater component was added to the study to assess the influence of groundwater interactions. Monitor well networks in selected study basins were established at Verandah and Shadow Wood Preserve, two sites selected to represent low and high discharge behaviors, respectively. Water levels in monitor wells and stormwater ponds were monitored for a period of two years and compared with rainfall and discharge volumes to establish water budgets for each site. Aquifer performance testing was also conducted to determine the hydraulic properties of the Surficial and Sandstone aquifers at the project sites. Additional details for the water levels, water quality and groundwater portions can be found in the body of this report in their respective sections.

This research project and its findings have important implications with respect to the State of Florida's water regulatory programs, especially its stormwater/environmental resource permitting rules, but also with respect to the implementation of Total Maximum Daily Loads and meeting load reductions established as part of the wasteload allocation (WLA) for regulated points or the load allocation (LA) for nonpoint sources. The treatment effectiveness of wet detention systems is related primarily to the treatment volume and the residence time of the system. However, ancillary factors affecting treatment efficiency include the amount of infiltration that may occur, the seasonal water table fluctuations, and the relationship between the wet detention system's control elevation and the seasonal high water table. The results of this research dispute some assumptions about the functioning and effectiveness of wet detention systems. Generally, it has been assumed by some that wet detention systems discharge after most or all storm events, especially during the wet season when recovery of the treatment and flood control volume may not occur between storm events. As seen from the results of this project, this is not always true, especially when the soils and underlying geology at a site allow for substantial infiltration. These results suggest that more careful consideration must be given

to site specific conditions in assessing the discharge behaviors of wet detention systems, especially in evaluating soils, geology, groundwater influences, and seasonal high water table conditions. This is especially true for systems that potential discharge to impaired waters where the level of treatment is "net improvement" whereby the post-development loading can't exceed the predevelopment loading from the project site. Instead of making wet detention systems larger, some areas may have hydrogeologic conditions that allow wet detention systems to get much higher levels of treatment because they do not discharge as often as previously assumed.

The Long Term Discharge Study has shown that significant variations in discharge behavior exist among six well maintained, typical communities in the southwest Florida region. These variations within a region can be dramatic, as evidenced in this study by a large community like Twin Eagles in Collier County with no discharge for an entire year while during the same year Sandoval in Lee County, for example, had significant discharges and similar annual rainfall. It is not known with certainty how these variations might apply to other parts of Florida and additional work is needed to better understand the stormwater discharge behaviors over a wider area. A similar project is being considered to the north of this study area funded by Sarasota County.