HYDROLOGICAL CHARACTERIZATION AND GROUNDWATER FLOW MODEL OF A GEOGRAPHICALLY ISOLATED WETLAND

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Abstract

Geographically isolated wetlands (GIW's), defined by the US Fish and Wildlife Service as "wetlands with no apparent surface water connection to perennial rivers and streams, estuaries, or the ocean," can pose unique water management challenges due to their heavy reliance upon groundwater for viability. The study focuses on the Pondhawk Natural Area in Boca Raton, Florida, a 78 acre preserve which includes two constructed geographically isolated wetland cells within 200 meters of a municipal well field. Observations of the hydrological characteristics of a GIW over time, particularly one with changes in land use over the observed period, can help determine the impact of specific stressors, such as groundwater pumping, on the long term hydrological properties of a GIW. A groundwater flow model of the study area is in development using MODFLOW to compare flow patterns during each of the three time periods, and quantify the extent of municipal pumping's influence upon the nearby wetland cells. Alternative pumping regimes, with temporal and flow rate variations will be simulated to develop recommended pumping regimes that minimize impact on the wetland. Interpretations from this study can be used to better inform water resource managers when designing pumping regimes aimed at minimizing impacts on an environmentally sensitive area. Data from the study may also improve the efficacy of future restoration projects involving GIWs influenced by human activities. Our presentation includes preliminary results and interpretations including water level and pumping data, as well as initial model design.

Methodology

The study breaks down into three distinct time periods correlating with shifts in land use in and around the preserve:

- **Monitoring prior to wetland construction (2003-2007)**
- **Post wetland-construction monitoring (2010-2014)**
- **Post municipal pumping well installation (2014-present)**

The primary data set for the study is water level data from pressure transducers in monitoring wells around the preserve (Figure 4) recording hourly water levels, as well as a barometric pressure recorder in Well 11. Well 11 resides approximately 150m from the edge of a municipal well field installed in 2014. Rainfall data was acquired from SFWMD NEXRAD.

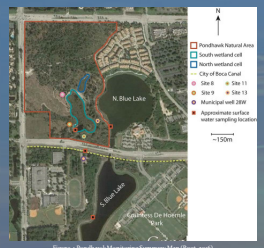


Figure 4 Pondhawk Monitoring Summary Map (Root, 2016)

Pumping Well Influence

In 2014, the city of Boca Raton installed three 2ft diameter municipal wells to the south of Pondhawk, averaging 62.5 meters deep. Well 28 (nearest the preserve) extends to 65m and runs at a targeted 70% flow capacity (average 1224.5 gallons per minute). Figure 5 (below) illustrates the increasing frequency and intensity of pumping in the area, with a rapid increase in pumping in 2018 nearly quadrupling the total water withdrawals since the summer of 2015.

Hourly statistics on flow rate, water level, and pumping status were provided by the city of Boca Raton (2018) for all three wells, with emphasis placed upon 28 due to its proximity to the study area.

Time Start	Time End	Event Frequency	Total Volume (MG)	Total hours Pumping	Avg Flow Rate (GPM)
02/11/15	06/19/15	15	100.47	1360.00	1259.66
06/19/15	06/07/16	32	299.32	3902.00	1229.10
06/07/16	06/07/17	65	296.12	3920.00	1215.59
06/07/17	06/07/18	185	809.40	4275.00	1208.67

Figure 5: Summary of Pumping from Municipal Well 28 Feb 2015 - June, 2018.

Discussion

Water levels near Pondhawk are primarily affected by precipitation and pumping. As shown in Figure 6, declines in water levels occurred throughout the Fall and Winter of 2017/2018, a time period normally associated with decreased precipitation in South Florida. The low recharge rate combined with the intensive pumping may have contributed to the generally depressed water levels observed during the study period.

The data shown in Figure 6 is a sample from semi-continuous monitoring of water levels since the preserve was established in 2002. Figure 9 (below) highlights a similar period during 2015 (Root, 2016) , providing further evidence of a relationship between pumping activity (specifically form Well 28) and a decline in water table levels.

One of the overall goals of the study is to aggregate all data from monitoring throughout the preserve's history by both FAU and DERM, and build a comprehensive timeline of the hydrology at Pondhawk over 16 years as a preserve.

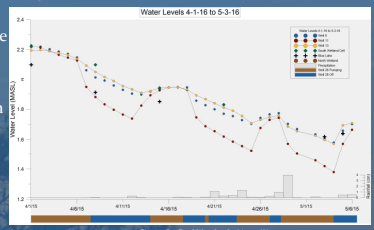


Figure 9: Pondhawk Water Levels 4/1/15 to 5/8/15

Study Area

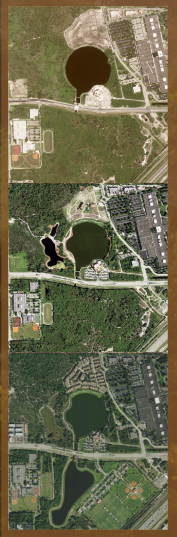


Fig 1: (Top to Bottom) : Fig 1 - 2006 USDA APFO Aerial
Fig 2: 2010 USDA APFO Aerial Fig 3: 2017 USDA NAIP

The Pondhawk Natural Area is a 78-acre preserve in Boca Raton, Florida. The area is within the Surficial Aquifer System, an area with little topography and generalized NW to SE flow. The upper aquifer is characterized by medium to fine sand overlying limestone at around 25 meters. Local recharge is mostly from rainfall, infiltrating quickly through the porous sands (Root, 2016). The primary surface water feature is Blue Lake, created in the 1970's when the area was an IBM campus.

The water table in the SAS is typically between 1 and 3 meters below the surface. Mesic and scrubby flatwoods, hydric hammock, and disturbed basin marsh are the predominant natural communities present on the site (DERM, 2008). Endangered cutthroat grass has also been observed in several locations throughout the preserve (Khun and Root 2012).

Acquired in 2002 by the Palm Beach County Environmental Resource Management Department, the preserve and surrounding area have undergone several land use changes. Figure 1 shows the area mostly unchanged since its acquisition. In 2010 (Figure 2) two wetland cells were dredged to restore hydric conditions largely absent since the 1960's. By 2017 (Figure 3) Blue Lake had been extended south to the newly built athletic fields and well complex.

Preliminary Results

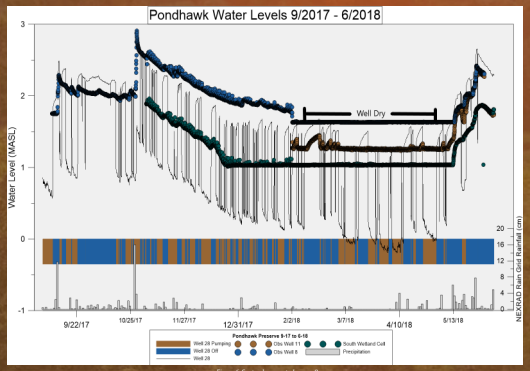
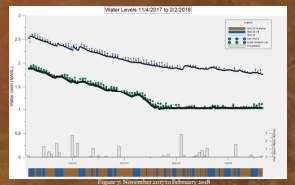


Figure 6: September 2017 to June 2018



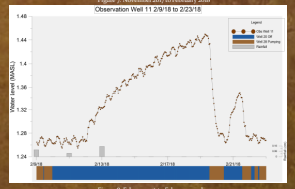


Figure 8: February 9th to February 23rd

An example of our data (Figure 6) begins on September 6th 2017, 4 days before Hurricane Irma made landfall in South Florida. A significant precipitation event on 10/28 marked the peak water levels recorded during this period of the study, followed by a consistent decline throughout the Fall of 2017 (Figure 7). During the November 2017 to February 2018 period, levels consistently declined during a period which saw municipal well 28 pumping for 62.4% of the time.

A close up of a 2 week period in February is seen in Figure 8. This period shows what can be construed as natural water level recovery with little influence from precipitation, followed by a classic "saw-tooth" pattern commonly associated with drawdown related to pumping.

Future Research and Modeling

Future research includes creating a finite difference groundwater flow model using MODFLOW for each of the three time periods discussed. Comparisons will be made between the groundwater flow over time to determine the influence of specific stressors on the local water table. The model of time period 3 will be designed so that alternative temporal pumping regimes can be simulated and analyzed for ways to match the yield desired by the city, while also minimizing the impact upon the nearby wetlands.

Interpretations from this study can be used to better inform water resource managers when designing pumping regimes aimed at minimizing impacts on an environmentally sensitive area. Data from the study may also improve the efficacy of future restoration projects involving GIWs influenced by human activities.

References

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