Inflow and Infiltration Affecting the Water Reclamation Facility #2 in Ocala, Florida

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Abstract *— The Water Reclamation Facility #2 (WRF #2) of the city of Ocala, Florida, is receiving high influent flows on heavy rain events. The hypothesis is that stormwater inflow and infiltration is coming into the sewer system and some possible combined systems may still be in service. Since September 2017, WRF #2 has received high influent flows over the design capacity five times. Hurricane Irma brought more than 10 inches of rainfall over 24 hours, the worst storm over the last three years. The analysis includes registered rainfall, registered flows on heavy rain events and design capacity of the lift stations and the plant. The average sewer flows can be correlated with the received flows during a heavy rain event to confirm the possibility of an inflow and infiltration situation. This correlation showed that sewer flow received after heavy rain events are greater than average, which confirmed the inflow and infiltration hypothesis. Ocala has started a smoke test project throughout the city, and they have found numerous cases of it, including combined systems. This project has been developed understanding the existing conditions and analyzing the best available data in order to identify possible opportunities to minimize the incoming of the inflow and infiltration into the sewer system to help the infrastructure.*

Key Terms *— combined system, infiltration, inflow, water reclamation facility*

INTRODUCTION

The city of Ocala is located in central Florida and is part of Marion County. It's a 45-m^2 city with an estimated population of 60,000, but the utility service area reaches outside the city limits up to 64 m^2. Currently, the city has water, wastewater and reuse water systems throughout the city.

According to city records, some of the city's older infrastructure that was built in the 1930s and 1940s is still active and in service. Knowing that, the city may have several problems related to that old infrastructure, such as collapsing, bursting, combined systems, inflow, infiltration, and others that could be affecting the system, including the treatment plants.

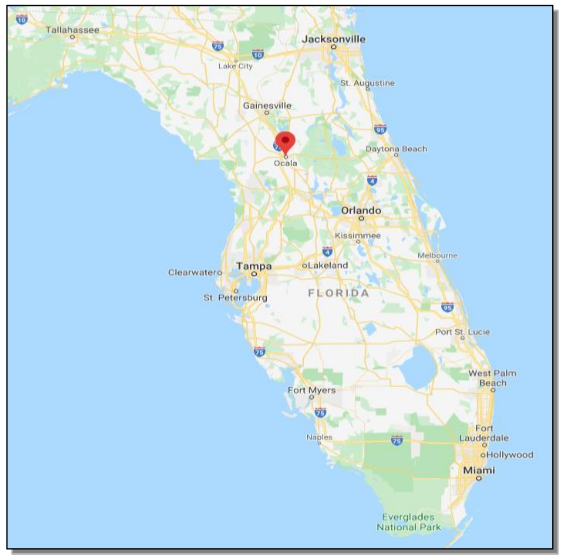

Figure 1
Location of Ocala [1]

BACKGROUND

The city of Ocala currently has two water reclamation facilities to service the entire city. WRF #2 was built in 1970 in the east side of the city. It was designed to receive the majority of the city's flow. The design capacity of the plant (after a 1993 expansion) is 6.5 MGD; average daily flow is 4.2 MGD. This water reclamation facility serves approximately 25,000 ERUs in the city. Figure 2 shows the service area, including the lift station locations. Notice that it mostly serves the east side of the city, which is the oldest area.

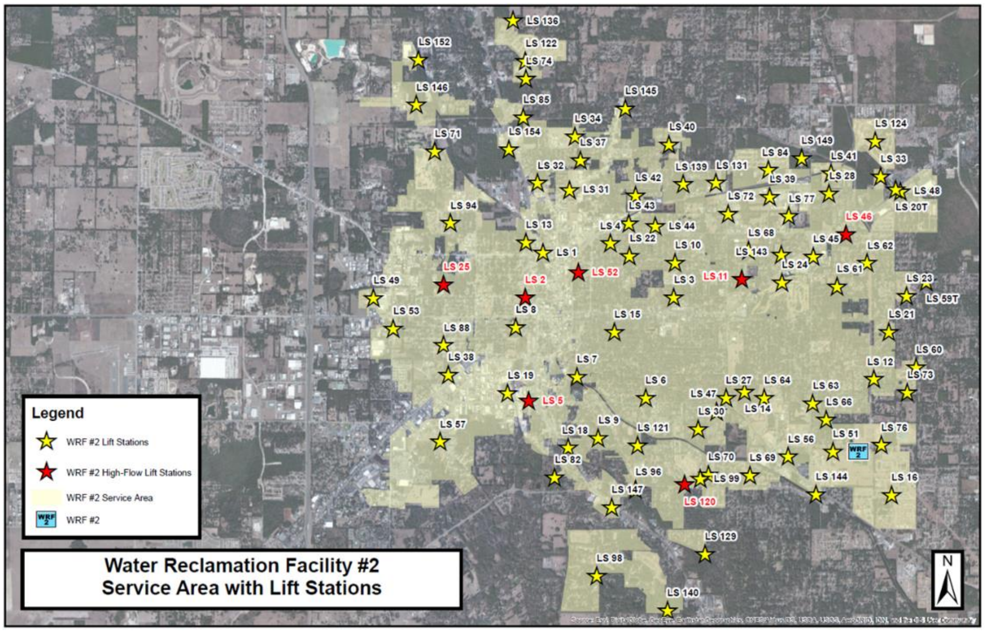

Figure 2
WRF #2 Service Area [2]

PROBLEM

WRF #2 is having inflow and infiltration problems during every heavy rain event in the city. In the past three years, the treatment plant received five heavy rain events that drastically increased the sewage flows incoming to the plant. During those rain events, the influent flow overpassed the plant's design capacity. Since Hurricane Irma, on September 10, 2017, these events affected sewage treatment, occasioning a sewage spill one time. If the flow keeps increasing during the rain events, not only will they affect treatment, but it may also affect the infrastructure (lift stations, manholes, piping, etc.) and, eventually, citizens and the environment.

HYPOTHESIS

During heavy rain events, WRF #2 has experienced an influent flow increase. Those influent flow increases were difficult to handle by the operation team, affecting treatment. Also, some lift stations triggered the high flow alarms at a moment during the rain event. These are some reasons to believe that the rain is affecting the sewer system.

SCOPE OF WORK

1. Identify dates when WRF #2 received high influent flows over capacity.
2. Identify heavy rain events in the area during the past three years that affected WRF #2.
3. Correlate the heavy rain events with WRF #2's high influent flows.
4. Identify sewer flow diagram of WRF #2.
5. Identify design capacity of lift stations.
6. Identify flows on lift stations during same dates and compare with the design daily flow.
7. Correlate lift station flows pumped to WRF #2 with the influent flows.
8. Correlate the heavy rain events with the high flow lift stations flows.
9. Identify specific location of the lift stations.
10. Identify sewer basin of the lift stations.
11. Identify high/low groundwater table seasons.
12. Identify average groundwater table heights on high flow lift stations.
13. Estimate the inflow and infiltration for every high flow lift station.
14. Correlate the I&I estimate with average daily flow.

15. Correlate lift station sewer basin locations with the groundwater table.
16. Identify any combined systems in the area using smoke test reports provided by the city.

METHODOLOGY

The methodology for the analysis is to relate storm rain events with influent flows at the wastewater plant. The starting date of the analysis is August 1, 2017. This date was chosen because, after Hurricane Irma, on September 10, 2017, the high influent flow receiving is more often.

First Analysis

The first data compilation for the analysis is:

- Daily rainfall data
- High influent flow dates

This first analysis is to prove the correlation between the heavy rain events and the high influent flow at WRF #2. This will be the first indication that the plant receives some rain flow.

Second Analysis

The second data compilation is the sewer high flows on lift stations for the same heavy rain events.

- Average daily flow at lift stations
- Design capacity of lift stations
- Registered daily flow at lift stations

The second analysis, following the sewer flow diagram, is to verify the flow from the lift stations that pump directly to the WRF #2 and compare it to the influent flow. If the pumped flows are more than the plant's design capacity, it's an indication that the plant was affected by the high flows of the lift stations.

Third Analysis

The third analysis is to prove the correlation between the heavy rain events and lift station flows, comparing the average daily flow, design capacity and the flow registered during the rain events. This correlation will show which lift station has a flow increase during the rain event. This will be another indication that the plant receives some rain flow.

Fourth Analysis

The fourth analysis is to estimate the inflow and infiltration [3] coming into the sewer basins of the high flow lift stations. Specific location, groundwater level and high/low groundwater level seasons are needed for the estimation.

- Infiltration can be estimated from the difference between the high groundwater level season average flow and the low groundwater level season average flow. These average flows must be measured in a dry weather period. During the low groundwater level season, the infiltration is assumed zero and that's the average flow of the lift station.
- Inflow can be estimated from the difference between the high groundwater level season average flow and registered sewage flow during the rain event.

Fifth Analysis

The fifth analysis is to verify whether the provided smoke test reports have any identified combined system. The smoke test is a white smoke injection into the sewer system; the smoke travels the entire underground system and comes out from any structures. This test can identify any irregularity in the system as damaged structures, illegal connections or combined systems.

Solution

This project analyzed the existing conditions and the problems in order to provide possible solutions to address the situation.

DISCUSSION AND RESULTS

The city of Ocala has a weather station on WRF #2 that collects daily rain data. The historical data can be downloaded from the NOAA website [4]. The influent flow data was downloaded from a database (VTSCADA) [5] and provided by the city.

Five high influent flow events have been registered during the past three years.

- September 10, 2017: Hurricane Irma
- December 14 - 21, 2018: 2nd storm

- July 25, 2019: 3rd storm
- August 15, 2019: 4th storm

The second and third rain event were considered as one storm because they were very close to each other.

Analyzing the graph, we gather that during Hurricane Irma WRF #2 received 9.76 MGD of sewage and registered 10.8 inches of rainfall. During the second storm, the total accumulated rainfall was 8.96 inches and two more high influent flow events were registered: 11.49 MGD and 9.96 MDG respectively. The third and fourth storms registered 8.06 MGD and 8.08 MGD respectively.

On this first analysis, figure 3 proves that the correlation between heavy rain events and the high influent flows coming into WRF #2 is correct.

On the second analysis, following the sewer flow diagram, nine lift stations pumping to the plant with registered flow were identified. The flow totals of these station, assuming that they were pumping at the same time, confirmed that WRF #2 was receiving flow over capacity during these heavy rain events.

For the third analysis, the correlation between the heavy rain events and lift station flows were analyzed. Seven lift stations were identified as they triggered the high flow alarm in one occasion. Figure 4 shows an example of this correlation. Notice how the sewer flow overpassed the design capacity on the same day as the heavy rain event.

After analyzing all the stations, the tendency of sewer flow increase during every rain event is confirmed. Now it’s proven that the high influent received by WRF #2 during this rain events is related with the rainfall.

Inflow and Infiltration

Inflow and infiltration can be estimated. The estimation depends on the following information:

- Specific location of the lift stations
- Sewer basin of the lift stations
- High/low groundwater table seasons
- Groundwater table heights

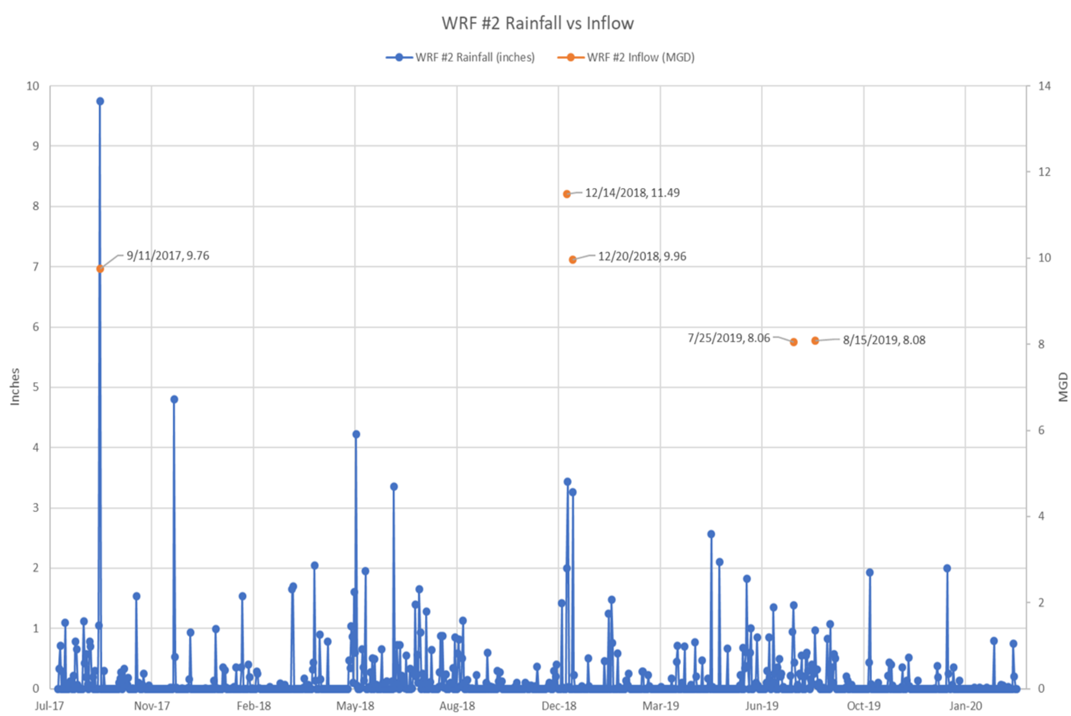

Figure 3
WRF #2 Rainfall vs. Influent Flow

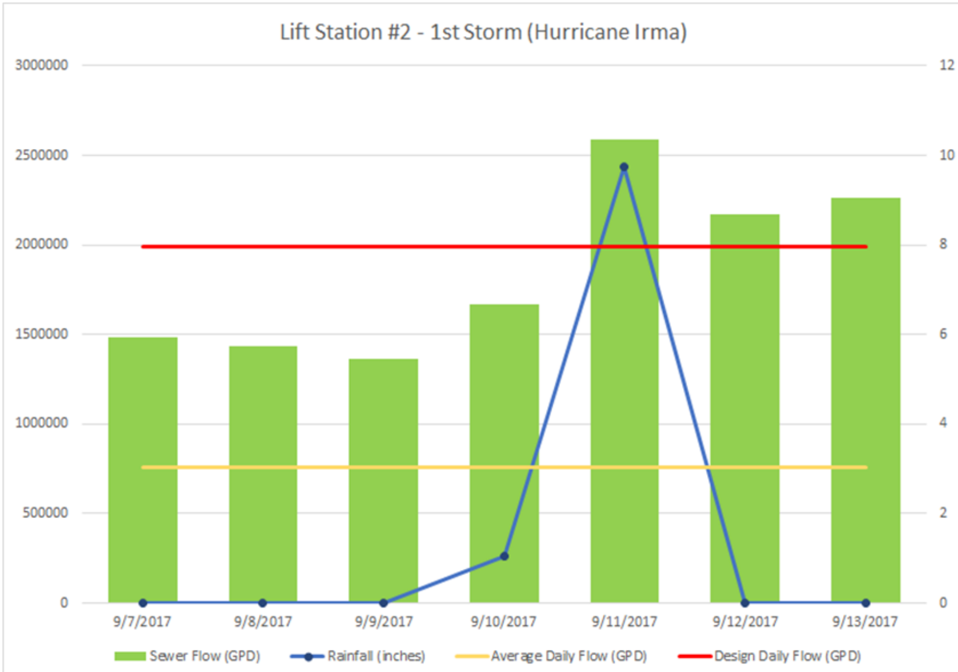

Figure 4
Lift Station #2 – Hurricane Irma Sewer Flow & Rainfall

Figure 5 shows the recorded water table heights during all of 2019. Notice that the high groundwater level season occurs between the months of September and October. The low groundwater level season occurs between June and July. Knowing the high/low groundwater seasons, the real average flow on each lift station can be estimated. Real average flow is the registered flow on low groundwater level season during a dry weather period. A dry weather period is three days or more without rain.

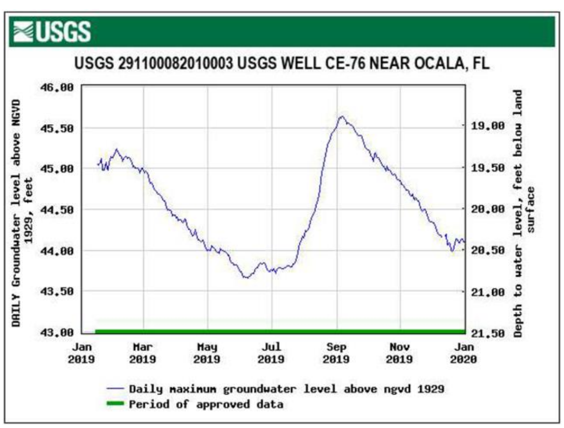

Figure 5
USGS Monitoring Well near Ocala, FL [6]

Infiltration is the difference between the high groundwater level season average flow and the low groundwater level season average flow.

Inflow is the difference between the high groundwater level season average flow and registered sewage flow during the rain event.

After the estimation, three of the seven high flow lift stations reflected infiltration, and six reflected inflow.

Combined Systems

A combined system is stormwater and sewage system using the same infrastructure. In the past, it was very common to use a combined system due to different reasons. Nowadays, most of the municipalities prefer not to have it because it makes handling the flows during rain events a challenge.

To be able to identify these combined systems, the city of Ocala has performed smoke tests around the city. They have provided the reports for this analysis. After analyzing them, combined systems were found at different locations. Figure 6 shows how the smoke is coming out of a storm inlet. This confirms the theory of combined system affecting WRF #2.

Figure 6
Combined System Identified During Smoke Test [7]

RECOMMENDATIONS

Most of the current big developments in the city of Ocala are in the west side of the city. New residential neighborhoods, all kinds of commercial projects, hospitals, etc. are some of the new developments. WRF #3 is the treatment plant designated to serve the west side of the city, with a capacity of 4 MGD. Considering these facts, the city of Ocala is planning to double the capacity of WRF #3 (to 8 MGD) during the following 5 to 10 years. Taking into consideration such plant expansion, the proposed solution to solve the high influent flows coming into WRF #2 during every heavy rain event is to divert some flows to WRF #3. For this solution to be effective, the city of Ocala must combine this solution with other alternatives such as minimizing the inflow-infiltration and eliminating the combined system throughout the city.

CONCLUSION

After the analysis, it can be confirmed that WRF #2 is receiving an extra influent flow during heavy rain events. The results proved that inflow, infiltration and combined systems are contributing to the problem. It's known that the city of Ocala has a very old infrastructure still in operation. Also, the smoke test reports revealed a lot of inflow cases and combined systems. The groundwater table level is also a contributor to the problem. When all these factors are combined, the problem could be worse than expected.

As a short-term solution, the recommendation to the city is to continue the smoke testing throughout the city. Next, they assess how old the infrastructure is, mostly in the Downtown area, and then start a program to fix or replace the damaged infrastructure. Some solutions may be lining the gravity sewer main, lining manholes, pipe bursting, manhole lid replacement and eliminating illegal connections and combined systems.

As a long-term solution, the recommendation to the city is to pursue the WRF #3 expansion project to double the capacity of the plant. Then, divert some flows to WRF #3 instead of WRF #2. Some upgrade projects will be needed to pursue this solution, but will match city growth.

The city of Ocala is growing as a city and utility companies such as water and sewer should be considering future expansion and how to be on the frontline of this expansion.

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