

RAINWATER INFILTRATION INTO THE MOBILE AREA WATER AND SEWER SYSTEM'S (MAWSS) SEPARATE SEWER SYSTEM

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With the new millennium, the United States faces an aging infrastructure whose upgrade and rehabilitation has been mostly marginalized by fiscal difficulties. In this paper we will look at the effects of intrusive rainwater entering the Separate Sanitary Sewer (SSS) in Mobile, Alabama's Dog River Watershed. Specifically, an area of the Eslava sewershed of the Mobile Area Water and Sewer System (MAWSS) was studied. Through the use of remote historic tracking data that measures the sewer flowrates before, during and after a rainfall event, the amount of rainwater entering into the system can be evaluated. While this water entering the system may seem innocuous, it does have the possible effect of overwhelming the system, causing possible sewage overflows and further degradation of the system itself.

Keywords: Sanitary Sewer Overflow (SSO), Mobile, AL, Rainfall intrusion

Introduction

Mobile, like most of the United States, finds itself in the unenviable position of having an aging infrastructure system. There have been recent incidents across the nation where major bridges have fallen down and old gas line explosions have leveled neighborhoods. While roads, for the most part, are driven on every day and serve as readily visible signs of the state of a community, below, unseen by most, is the city's water and sewer systems.

While many take for granted the clean water that comes into our households and businesses, people tend to think even less so of the waste water that is generated and needs to be properly treated away from these locations. Turn off the water and the effects are immediately felt. But many ignore the waste water that is generated and just assume that it disappears without any effort into nothingness.

Many of these systems are aging. With some sewer systems being built during periods where there was rapid growth as seen in post-World War II, their upgrade and upkeep has become expensive, as these systems are approaching or surpassing their expected lifespans of 40 to 50 years (with some sources saying up to 100 years). Additionally, we have seen population growths and sprawls that were not planned for when systems were initially placed into service (Terry, 2008). As noted earlier, these systems are expensive to install and maintain. It was estimated by the Environmental Protection Agency (EPA) back in 1996, that the cost of the United States sewer infrastructure was over \$1 trillion (EPA, 2014). An example of the cost of upgrading an existing system can be seen in Fort Smith, Arkansas sewer system project, which over the next 12 years, is expected to cost \$225 million (EPA, 2015).

In Rebecca Keesler's article "Stormwater Strategies", she cites that the EPA predicts that by 2020, 45% of the nation's wastewater pipes will be in "poor", "very poor" or "life elapsed" conditions. She also quotes the agency's 2008 prediction that it will cost \$298 billion to repair the country's sanitary and wastewater systems (Keesler, 2011).

MAWSS, came into being in 1952 and is responsible for not only providing potable water for the greater Mobile area, but removing and treating the liquid waste water generated by the citizens of the Mobile area. When first started, they inherited a number of systems that had been in place since the 1800s. The waste water system encompasses over 205 square miles of Mobile County and has over 1200 miles of sewer lines (MAWSS, 2015).

Mobile's waste water movement depends mostly on a gravity type system that is of the Separate Sewer System (SSS) type where only waste water travels through it for further treatment. This is in contrast to the other major type of system called a Combined Sewer System (CSS), where the system takes not only the waste water described above, but rainwater that falls within the area (Seyoum, 2015). Mobile's heavy annual rainfall precludes this type of system due to the cost of treating storm waters the same as waste waters as in the CSS.

As a chain is only as strong as its weakest link, a system's sewershed is only as strong as its weakest pipe. And rainwater, just like humans and electricity, will follow the path of least resistance and sometimes it ends up where it is not supposed to... such as in a SSS.

While this does not sound particularly ominous, and a well maintained SSS can handle some inundation from entering rainwater, when a portion of a system is overwhelmed, there is the potential for hazards in the form of Sanitary System Overflows (SSO). When these occur, there is the possibility for unsanitary conditions to develop quickly that create problems for both the citizens and environment of Mobile.

This will become a greater problem not only due to the increasing amount of municipal sewer systems reaching their maximum life span discussed earlier, but due to climate change, we may see increased amounts of rainfall. Between 1958 and 2007, the overall number of days with heavy rainfall has increased with increases being seen as high as 58% in the Northeastern parts of the U.S. (Keesler, 2011).

Sanitary Sewer Overflows themselves cause expensive problems. Besides the esthetic value of untreated sewage, there is also a physical factor. Health hazards exist not only from direct contact with contaminated waste, but water sources can become contaminated, recreational areas become unavailable due to possible health hazards and food sources such as fish and shellfish become contaminated. In Shibata, et al.'s 2014 study of overflows in the Tokyo, Japan area, we see that their effects are not always localized and can cause problems miles away.

Research Question

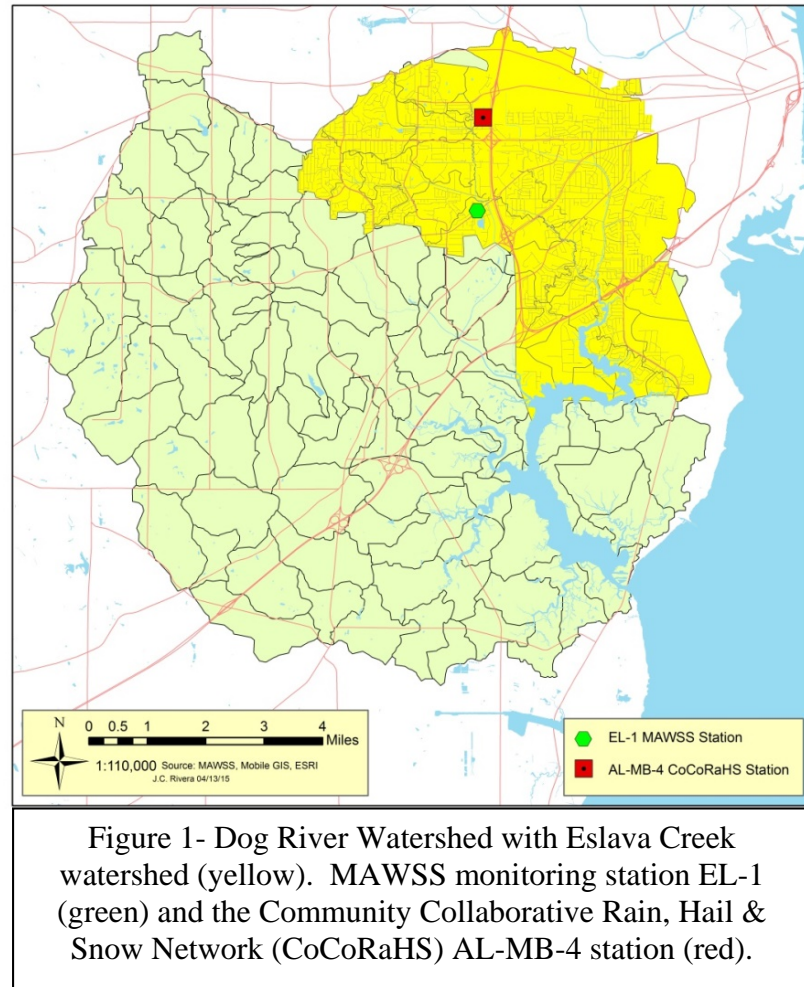
Are there parts of the MAWSS sanitary sewer system that are being inundated by rainwater causing an un-designed taxing of this system which has the potential of causing potentially hazardous sanitary sewer overflow (SSO)?

Methods

Through the use of historic sewer flow rates and levels from MAWSS, independent rainfall data, and GIS systems, 24 hour "snap shots" were developed to provide a view of the effects of rain on the sanitary sewer system rates in the Eslava sewershed of Mobile, Alabama (Fig1).

The Community Collaborative Rain, Hail & Snow Network's (CoCoRaHS) station AL-MB-4, located in the Eslava watershed, was used to initially identify days between 01 February and 01 December 2014 where there was greater than one inch of precipitation. CoCoRaHS issues a reading everyday ending at 0700 in the morning. This amount of one inch was chosen due to the probability that lesser amounts of precipitation

would be able to be absorbed into the ground before reaching the sewer system. There were a total of 18 events at this station.



MAWSS historic records from the RG-EL-1 monitoring station in Eslava, also for the period of 01 February 2014 to 01 December 2014, were reviewed concentrating on the above dates. These records provide local rain rates, flow levels, rates and velocities in 15 minute increments, 24 hours a day. These gauges monitor local rainfall in the local area and are co-located.

The two monitoring stations were approximately 1.5 miles distance from each other (Fig 1) with the CoCoRaHS station almost due north. Of the 18 days identified by the CoCoRaHS, they were 8 days where they were less than 0.5 inch difference in their rainfall readings with six MAWSS station reading falling below the one inch threshold. These dates were still studied due to the nature of rainfall in the Eslava watershed as a whole versus point rainfall measurements. With this data, I was able to not only see the effects on levels at the MAWSS remote station, but was able to track lag times and the influence of multiple day rain events at the point.

Results

Simply, we can clearly see in Figure 2 and Table 1, that there is rain water entering the closed sewer system in the Eslava watershed area. Of the 18 days studied there was only one SSO reported (28-29 May 2014) by MAWSS News Release page. In figure 2, we see the days studied and their corresponding rates. These include the stations recorded rainfall, as well as high and low flowrates.

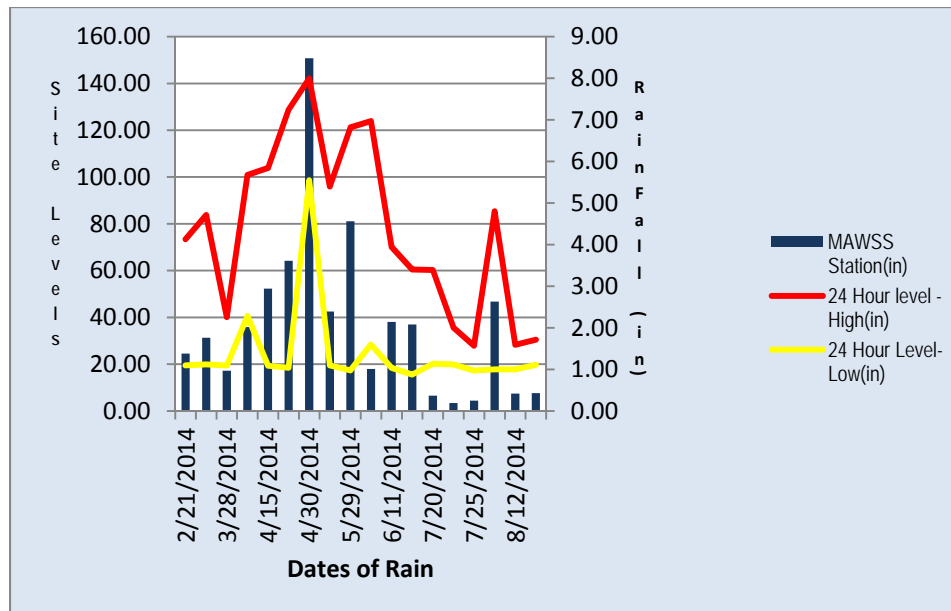


Fig 2. MAWSS Station RG-EL-1 reports, of days studied, local rainfall in inches, as well as 24 High and Low site levels.

While, again, rain water was seen to enter the system, we see in Table 1, that levels normally returned to normal heights (providing that there was no additional rain) after less than 12 after the rain event. This indicated, that while the system did take on additional intrusive water, except for the SSO of 29 May 2014, the system was able to quickly recover without incident and return to homeostasis.

Date	Day	MAWSS Station(in)	CoCoRaHS Reading (in)	24 Hour level - High(in)	24 Hour Level-Low(in)	24 Hour Level Avg.	12 Hour Post Event
2/21/2014	Friday	1.38	1.39	73.44	19.45	30.71	30.97
3/17/2014	Monday	1.76	1.64	83.78	19.89	45.18	31.31
3/28/2014	Friday	0.97	1.20	40.13	19.40	24.57	75.19
3/29/2014	Saturday	2.02	2.50	100.88	40.60	70.80	42.83
4/15/2014	Tuesday	2.94	3.46	103.89	19.34	59.59	54.82
4/29/2014	Tuesday	3.61	4.09	128.76	18.45	39.28	107.28
4/30/2014	Wednesday	8.48	8.21	142.13	98.61	119.27	120.67
5/10/2014	Saturday	2.39	4.51	95.93	19.50	41.71	46.82
5/29/2014	Thursday	4.56	3.09	121.26	17.38	52.33	43.17
5/31/2014	Saturday	1.01	1.04	123.91	28.34	78.53	38.71
6/11/2014	Wednesday	2.14	2.40	70.11	18.46	39.61	32.67
7/19/2014	Saturday	2.08	1.99	60.44	15.57	23.53	32.51
7/20/2014	Sunday	0.37	1.10	60.23	20.16	34.94	31.85
7/21/2014	Monday	0.19	1.14	35.61	19.92	25.74	23.78
7/25/2014	Friday	0.25	1.15	27.88	17.27	22.43	50.37
7/26/2014	Saturday	2.63	0.81	85.31	17.75	39.95	28.39
8/12/2014	Tuesday	0.42	1.11	28.30	17.74	22.81	27.50
10/14/2014	Tuesday	0.43	1.09	30.48	19.78	25.69	24.64

Table 1. MAWSS Station RG-EL-1 Reported Levels. This includes 12 Hour “Post Rain Event” site levels.

One of the most significant days of the period studied was the 29 May 2014 SSO. We see in Figure 3, two days (30 April 14 and 29 May 14) where significant amounts of rain fell. The graphs track height levels (inches), flow rates (Million Gallons per Day) and velocity (feet per second). The 30 April 14 graph served as where the highest rainfall

over a 24 hour period for the period studied was seen at 8.48 inches, with 29 May 14 being the date of a sever SSO with just 4.56 inches of rainfall.

On this day we saw over 144,000 gallons of SSO in the Mobile area. Of this, almost 120,000 gallons were spilled in the Eslava Creek area. Additionally, a further 20,500 gallons was spilled in other parts of the Dog River Watershed (MAWWS, 2014).

What was most interesting is that the SSO occurred on a day that reported only a 24 hour total of 4.56 inches (but the day prior did have 3 inches from about 2:30 pm to midnight) and occurred after approximately 1 inch of local rain occurring from midnight to 3:45 am. These are well below the rain received the 29 and 30 April 2014 (3.61 in and 8.48 in), days that did not see a SSO.

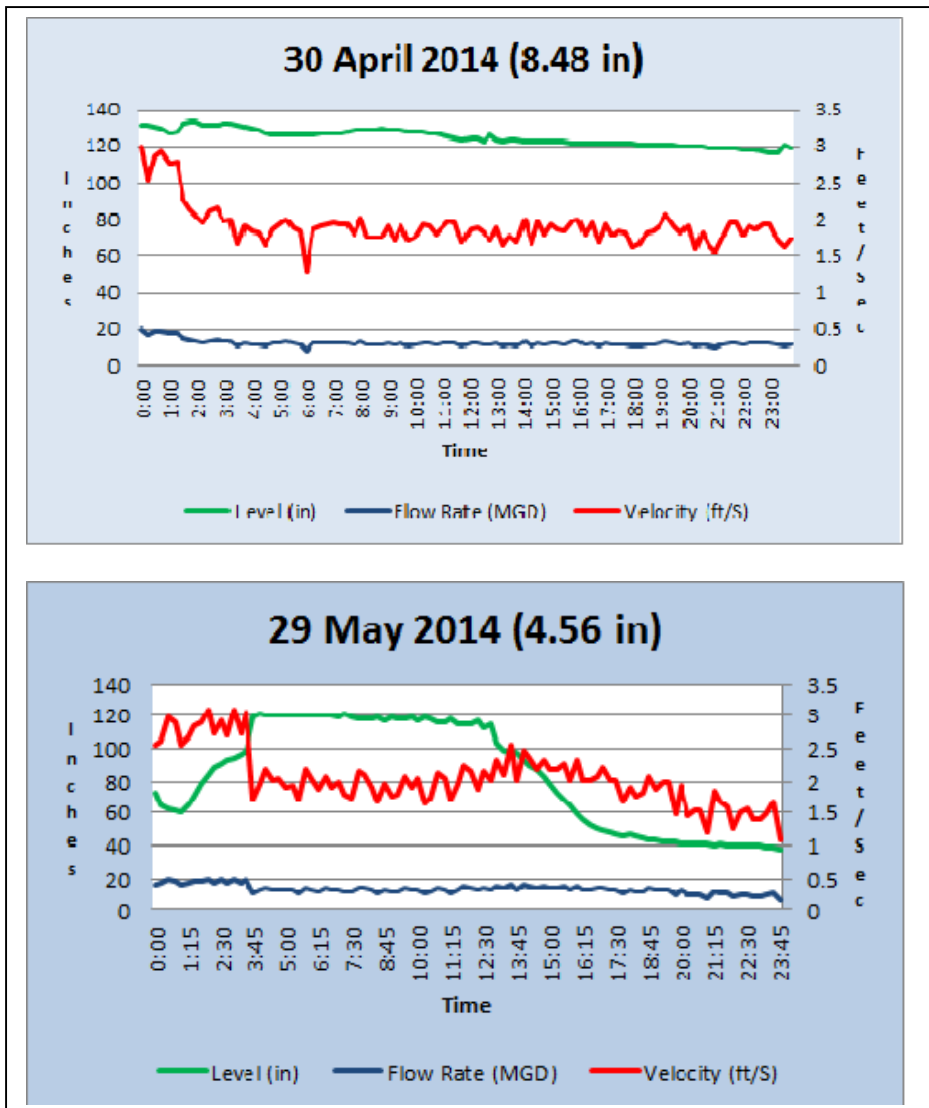


Fig. 3- Graphs showing 30 April 14 (the day with the highest rainfall 24 hour period studied) and 29 May 14 (Date of recorded SSO).

Graphs track MAWSS Station RG-EL-1, flow rate, velocity of water in system and level at site.

Discussion / Conclusions

While we see rainwater entering the sanitary sewer system, the incidents of sanitary sewer overflow have declined. In 2012 and 2013, we saw three incidents each of sewer overflow. In 2014 we saw just one (28-29 May 2014). In discussions with MAWSS representatives and readings, I have seen where GIS systems have been used to identify problem or potential problem areas and either fix or mitigate potential hazardous incidents. While not the only problem caused by intruding water, sewer overflows are the most acutely seen and felt.

Due to the limited scope of this paper, there was no definitive correlation found between the amount of rainfall in a 24 hour period and the rise of levels at the recording site where one can predict, with accuracy, an episode of rain causing a specific rise.

My research left me with more questions past the initial research topic. The topic of sewers and their workings proved vastly more complex than I originally thought. The data provided offered a plethora of other topics to be studied. Some of these include the study of what causes SSOs. Is it chronic obstructions like a buildup of Fats, Oils and Greases (FOGs) or acute obstructions? Can they be minimized by design, education or is it strictly a case of needing rehabilitation or replacement?

Acknowledgements

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