MIAMI-DADE COUNTY CLIMATE INDICATORS
RAINFALL SUMMARY

Much of Miami-Dade County is susceptible to localized flooding, particularly during the rainy season of June through October. The County's flat terrain may cause extensive "ponding" due to the lack of elevation gradients to facilitate the quick movement of water.

Since most of the storm water management system in Miami-Dade County work by infiltration, rising sea levels and high groundwater levels would progressively lead to a reduction of the capacity of the storm water management systems, and their ability to provide adequate flood protection levels of service, particularly in coastal areas.

Most systems in the area are designed to handle the volume produced during a 5-year/24 hour or a 10-year/24-hour storm. Therefore, larger storms typically overload the storm water system producing shallow flooding or ponding. Some areas are particularly subject to flooding, such as the Arch Creek and Oleta River basins, due to low ground elevations.

The following pictures show the effects of the flood event of June 7, 2013, in the Arch Creek Area. The maximum intensity of the rainfall event exceeded 7 in/h and 14 inches in 24 h, classifying the event as a 100-year/ 24h rainfall, thus exceeding the capacity of the storm water infrastructure.

Residents experienced flood above the lowest floor, reaching the electrical outlets and causing an emergency evacuation of the affected area. During this event, FEMA reported a total of 14 losses with a total of $350,000 dollars in payments to residents, for this event only. In 2014, FEMA had reported a total of 197 flood insurance claims in the Arch Creek basin since 1999, with a total of $4,136,471 in payments.

FIGURE 1
FLOODING IN ARCH CREEK AREA

NE 2nd CT, between NE 135th ST and NE 141st ST

NE 144th ST, between NE 12th AVE and NE 13th AVE

FIGURE 2
FLOODING IN ARCH CREEK AREA – ACTIONS TAKEN

Firefighter looks into a home to see if there are any residents in need of assistance.

The day after the storm, the streets are still not passable, even though portable pumps were deployed to expedite the recovery of the area.

The 2014 report "Climate Change Indicators in the United States, from EPA", states that a higher percentage of the rainfall in United States has come in the form of heavy precipitation.

In order to evaluate the frequency of the heavy precipitation in our area, tabulations were prepared for rainfall events greater than 25-Year/24h, 25-Year/72h, 50-Year/24h, 50-year/72h, 100-Year/24h, and 100-Year/72h, showing the number of occurrences of the each extreme event, based on historical data between 1939 and 2014.

The Table 1 shows the results of the tabulation of the events, based on the South Florida Water Management District (SFWMD) gauges and Table 2, based on the National Oceanic and Atmospheric Administration (NOAA) Stations.

TABLE 1

SUMMARY OF EXTREME RAINFALL EVENTS- SFWMD RAINFALL STATIONS

STATIONS	Information	Rainfall Events					
		25YEAR/24H	50YEAR/24H	100YEAR/24H	25YEAR/72H	50YEAR/72H	100YEAR/72H
S123_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S167_R	No. of Events	1	0	0	0	0	0
	Rainfall, inches	10.68	0	0	0	0	0
S177_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S20F_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S20G_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S21_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S21A_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S26_R	No. of Events	0	1	0	1	0	0
	Rainfall, inches	0	13.05	0		15.32	0
S27_R	No. of Events	0	1	0	0	1	0
	Rainfall, inches	0	12.64	0	0	15.06	0
S28Z_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
S29_R	No. of Events	0	1	1	0	0	1
	Rainfall, inches	0	13.98	14.89	0	0	18.09
S29Z_R	No. of Events	1	0	0	0	0	0
	Rainfall, inches	9.79	0	0	0	0	0
S334_R	No. of Events	1	1	0	0	0	0
	Rainfall, inches	11.39	12.91	0	0	0	0
S335_R	No. of Events	1	0	0	0	0	0
	Rainfall, inches	10.49	0	0	0	0	0
S338_R	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
TOTAL	**No. of Events**	**4**	**4**	**1**	**1**	**1**	**1**

Storm classification is based on NOAA's frequency analysis of partial duration series, NOAA Atlas 14, Volume 9.

TABLE 2

SUMMARY OF EXTREME RAINFALL EVENTS- NOAA RAINFALL STATIONS

STATIONS	Information	Events					
		25-Y/24H	50-Y/24H	100-Y/24H	25-Y/72H	50-Y/72H	100-Y/72H
08-5658 Miami Beach	No. of Events	0	0	0	0	0	0
	Rainfall, inches	0	0	0	0	0	0
08-7020 Perrine 4W	No. of Events	1	0	1	2	0	0
	Rainfall, inches	10.55	0	15.10	13.67 13.76	0	0
08-3909 Hialeah	No. of Events	1	0	1	0	1	1
	Rainfall, inches	11.30	0	16.39	0	0	17.07, 17.89
08-7760 Royal Palm	No. of Events	0	0	0	1	0	1
	Rainfall, inches	0	0	0	12.36	0	0
08-5663 Miami Intl. Airport	No. of Events	3	1	0	0	1	0
	Rainfall, inches	12.56, 11.51, 12.48	0	14.85	0	16.24	0
TOTAL	**No. of Events**	**5**	**1**	**2**	**3**	**2**	**2**

Storm classification is based on NOAA's frequency analysis of partial duration series, NOAA Atlas 14, Volume 9.

Even with the available period of record of over 50 years, the number of extreme events (over 25-year) per station results in less than 25 data points per station, therefore the number of extreme events is not sufficient to perform a conclusive statistical analysis of the trends.

An alternative way to verify if strong rainfall events are more frequent is to calculate what percentage of the total precipitation in a given year has come in the form of events greater than a threshold, such as events greater than 2 inches, in 24h.

Percentage of Total Rainfall Generated by Events Greater than 2 inches

The threshold of 2 inches was selected because it corresponds to an approximate frequency of one in 30, for the daily values on all stations, and provides sufficient number of occurrences to perform a simple statistical analysis.

The period of record for the stations was divided in 2 samples of similar size: one older and one newer. A test for homogeneity of data was applied to check if all data of the 2 samples belong to the same population.

A test was performed using the Students Distribution with the generally accepted level of significance of 5%, for flood analysis. If the sample passes the test, it means that the overall frequency of significant rainfall days has not changed through the years.

TABLE 3

PERCENTAGE OF TOTAL RAINFALL GENERATED BY EVENTS WITH MORE THAN 2 INCHES, IN 24H

SUMMARY TABLE

STATION	Sample X	Sample Y	Mean X	Mean Y	S_x	S_y	F_t	F_c	T_t	T_c	Pass, if $T_c<T_t$
MIAMI BEACH, 085658	1940-1976	1977-2014	23%	27%	11%	10%	1.8	1.1	1.7	1.8	NO
PERRINE - 4W 649059	1942-1972	1989-2014	26%	25%	13%	12%	1.8	1.2	1.7	-0.4	YES
ROYAL PALM 649061	1949-1981	1982-2014	25%	24%	12%	8%	1.8	2.2	1.7	-0.1	NO
HIALEAH 649055	1940-1976	1977-2014	23%	27%	11%	9%	1.8	1.5	1.7	1.9	NO
MIA INTL 085663	1939-1976	1977-2014	25%	28%	11%	13%	1.8	0.7	1.7	1.2	YES

Note: YES, means that number of rainfall events fall within the expected range, with 95% of certainty, and the frequency of significant rainfall events with more than 2 inches has not changed.

The results seems to indicate that percentage of rainfall events with more than 2 inches has changed for 3 stations: MIAMI BEACH, ROYAL PALM and HIALEAH, meaning that there is evidence of changes in the percentage of rainfall events over 2 inches; for the other 2 stations, the percentage of rainfall generated by events over 2 inches fall within the acceptance region, with 95% level of probability, meaning that there is no evidence of changes in the percentage of rainfall events over 2 inches.

Note that there data gaps in 2 stations: PERRINE and ROYAL PALM, therefore the sample split and size reflect these data gaps. The results obtained for those stations need to be qualified due to the existence of the large data gaps and consultations with NOAA are necessary to determine if there are possible effects of the changes in technology affecting the results of these calculations.

The precipitation frequency analysis methods used in NOAA Atlas 14 volume are based on the basic assumption that annual maximum series (AMS) data are stationary over the period of observation, and meaning that there **were no trends in the annual maximum series**. A number of statistical tests were presented by NOAA in this report and the results from the regional trend analysis also indicated that there are no trends in AMS, at the 5% significance level, for the 1-hour and 1-day durations.

Standardized Precipitation Index (SPI)

Since there are no clear trends established by the analysis of the previous indicators, we chose to use the Standardized Precipitation Index (SPI), which may provide additional insights on the evolution of the rainfall trends through the years.

This indicator tracks the occurrence of unusually high total yearly precipitation or unusually dry years. It does so by looking at the Standardized Precipitation Index (SPI), which compares actual yearly precipitation totals with the range of precipitation totals that one would typically expect at a specific location, based on historical data.

The SPI is a drought index first developed by T. B. McKee, N.J. Doesken, and J. Kleist and in 1993 (McKee et al. 1993). The SPI is used for estimating wet or dry condition based on precipitation variable. The Table 4 below shows the classification of the Wet and Dry Years established by application of this Index.

Table 4
Standardized Precipitation Index (SPI) Categories

SPI	Cumulative Probability	Interpretation
-3.0	0.0014	extremely dry
-2.5	0.0062	extremely dry
-2.0	0.0228	extremely dry (SPI < -2.0)
-1.5	0.0668	severely dry (-2.0 < SPI < -1.5)
-1.0	0.1587	moderately dry (-1.5 < SPI < -1.0)
-0.5	0.3085	near normal
0.0	0.5000	near normal
0.5	0.6915	near normal
1.0	0.8413	moderately wet (1.0 < SPI < 1.5)
1.5	0.9332	very wet (1.5 < SPI < 2.0)
2.0	0.9772	extremely wet (2.0 < SPI)
2.5	0.9938	extremely wet
3.0	0.9986	extremely wet

Source: http://gmao.gsfc.nasa.gov/research/subseasonal/atlas/SPI-html/SPI-description.html

The **Tables 5 and 6** show the results of the calculations of the SPI for the NOAA Stations. The same analyses were not performed for the SFWMD Stations due to changes in equipment and shorter period of record.

Table 5
Tracking Number Wet/Dry Years Using SPI for Each Station

STATION	Sample X	Sample Y	Sample X # of Wet Years SPI>0	Sample Y # of Wet Years SPI>0	Sample X # of Dry Years SPI<0	Sample Y # of Dry Years SPI<0	OBSERVED CHANGES
MIAMI BEACH, 085658	1942-1976	1977-2014	34% 12/35	67% 24/36	66% 23/35	33% 12/36	WETTER
PERRINE - 4W 649059	1942-1972	1989-2014	47% 14/30	68% 19/28	53% 16/30	32% 9/28	WETTER
ROYAL PALM 649061	1949-1981	1982-2014	46% 13/28	54% 21/39	54% 15/28	46% 18/39	WETTER
HIALEAH 649055	1940-1976	1977-2014	38% 14/37	66% 25/38	62% 23/37	34% 13/38	WETTER
MIA INTL 085663	1939-1976	1977-2014	53% 20/38	69% 25/36	47% 18/38	31% 11/36	WETTER

The Table 5 seems to indicate that the percentage of wet years has increased and that the percentage of dry years decreased based on the calculations for the SPI, and the classification categories shown on **Table 4**. The **Table 6** seems to indicate that the percentage of both extreme wet and dry years have decreased, based on the calculations for the SPI, and the classification categories shown on Table 9.

Table 6
Tracking Number Extreme Wet/Dry Years Using SPI for Each Station

STATION	Sample X	Sample Y	Sample X # of Extreme Wet Years SPI>2	Sample Y # of Extreme Wet Years SPI>2	Sample X # of Extreme Dry Years SPI<-2	Sample Y # of Extreme Dry Years SPI<-2	OBSERVED CHANGES
MIAMI BEACH, 085658	1942-1976	1977-2014	0% 0/35	0% 0/36	8% 3/35	0% 0/36	LESS EXTREMES
PERRINE - 4W 649059	1942-1972	1989-2014	0% 0/30	0% 0/28	13% 4/30	4% 1/28	LESS EXTREMES
ROYAL PALM 649061	1949-1976	1977-2014	7% 2/28	0% 0/39	7% 2/28	0% 0/39	LESS EXTREMES
HIALEAH 649055	1940-1976	1977-2014	0% 0/37	0% 0/38	3% 1/37	0% 0/38	NO CLEAR TREND
MIA INTL 085663	1939-1976	1977-2014	3% 1/38	0% 0/36	3% 1/38	6% 2/36	NO CLEAR TREND

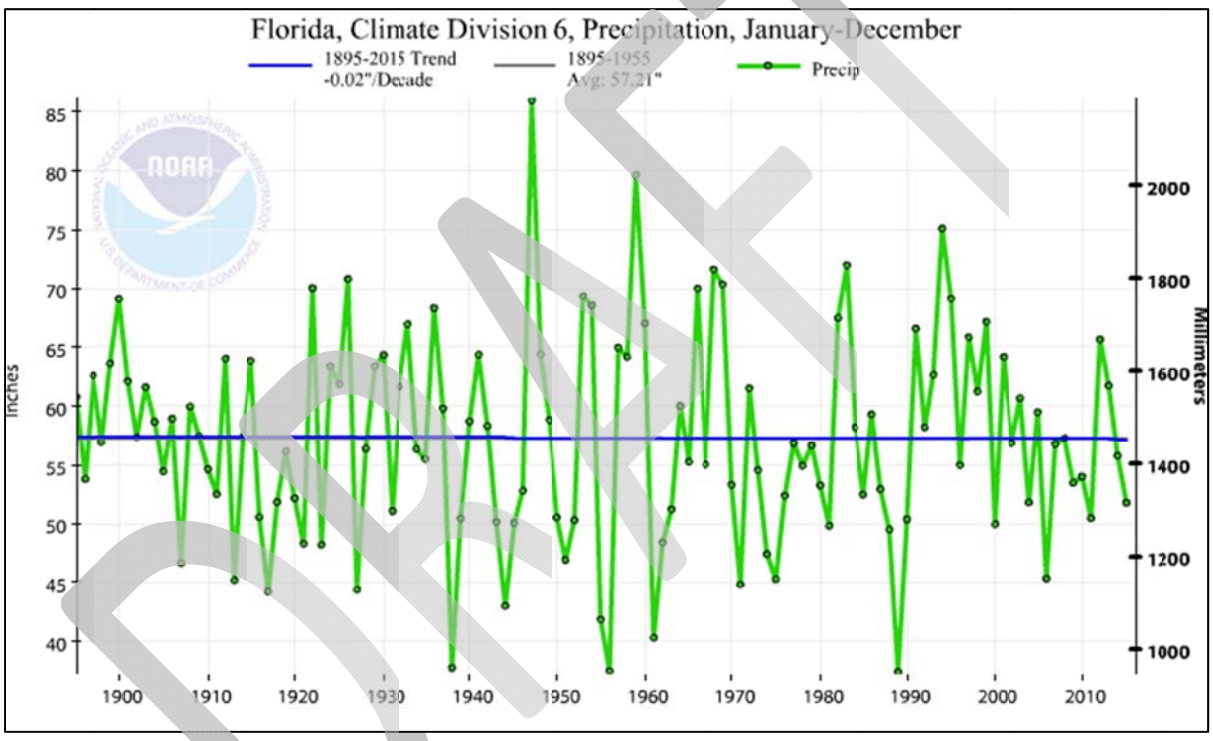
Again, there data gaps in 2 stations: PERRINE and ROYAL PALM, therefore the results obtained for those stations need to be qualified due to the existence of the large data gaps and consultations with NOAA are necessary to determine if there are effects due the changes in technology, affecting the results of these calculations.

The precipitation frequency analysis methods used in NOAA Atlas 14 volume does not present any analysis on the annual rainfall totals or clarification on possible changes of equipment and gauge setup.

NOAA had provided an assessment of climate extremes on regional, statewide and sub-regional scales. The graphics produced for the Lower East Cost do not show any clear trends for the total yearly precipitation, for the period from 1895 through 2015, indicating a variation of -0.02" per decade.

The result of this assessment is provided in the website: http://www.ncdc.noaa.gov/cag/time-series/us .

Figure 3
NOAA Climate at a Glance – Annual Precipitation Time Series



Source: NOAA – National Centers for Environmental Information

Conclusions:

- The percentage of rainy days does appear to have changed in 3 stations, based on the statistic test applied to the samples; however, for 2 stations, the values fall within the acceptable range of 95%, meaning that there is no evidence of increase in the percentage of rainy days in those stations.

- The 2014 report "*Climate Change Indicators in the United States, from EPA*", states that a higher percentage of the rainfall in United States has come in the form of heavy precipitation. The local data appears to be inconclusive, based on the results show on **Table 3**, for events over 2 inches. The results of 3 out of 5 stations do not support this statement, while the results for 2 stations show evidence of changes in the percentage of annual rainfall resulting of extreme events.

- The results for the Standardized Precipitation Index (SPI), shown on **Table 5,** seems to indicate that the percentage of wet years has increased and that the percentage of dry years decreased, based on the classification categories shown on **Table 4**

- The results for the Standardized Precipitation Index (SPI), shown on **Table 6**, seem to indicate that the percentage of extreme wet and dry years have decreased, based on the calculations for the SPI, and the classification categories shown on **Table 4**.

- While the use of the proposed indicators show some differences in rainfall patters, the number of years of observed rainfall is not sufficient to establish changes in climate patterns. However, if consistent data collection is done in the future, the use of the proposed indicators may be useful to confirm or deny future results of climate models studies.

- The trend analysis produced by NOAA for the Lower East Cost do not show any clear trends for the total yearly precipitation, for the period of record (1895-2015), indicating a value of -0.02" per decade, which is close to the detection limit of the rainfall measurements (0.01") and less than the calculated standard error of 0.79" for the annual precipitation values, for the same time series.

References

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