APPENDIX H

COMBINED OPERATIONAL PLAN

HYDRAULICS & HYDROLOGY

ANNEX 7
DESIGN STORMS AND SELECTION OF WET, AVERAGE, AND DRY YEARS

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H-7 DESIGN STORMS AND SELECTION OF WET/AVERAGE/DRY YEARS

H-7.1 SFWMD MEMO ON RAINFALL DISTRIBUTIONS FOR DESIGN STORM EVENTS

TECHNICAL MEMORANDUM
DATE: September 25, 2019
FROM: Ruben Arteaga and Sashi Nair (SFWMD H&H Bureau)
TO: Ceyda Polatel, USACOE
RE: Rainfall distributions for Design Storm Events

Flood assessment in the 8.5 Square Mile Area (8.5 SMA) is required as part of the Combined Operation Plan (COP) project. The Miami-Dade Regional Simulation Model (MDRSM) is the main tool used in the COP project for the development and evaluation of alternative scenarios which include flood mitigation in the 8.5 SMA. Flood assessment with the MDRSM consisted of computing current conditions flood stages in the 8.5 SMA for three pre-selected years with above-normal, normal and below-normal rainfall. The baseline scenario flooding stages were then compared to the stages resulting from the proposed plan with flood mitigation measures which included structural and operational modifications to the baseline system.

In addition to the above flood mitigation analysis, Design Storm event simulation runs are also required as part of the COP project in which standard design storm events of return periods of 10, 25 and 100 years are applied to the baseline and proposed alternative versions of the MDRSM model.

This technical memorandum describes the methodology used to develop the rainfall distributions with return periods of 10, 25 and 100 years.

SFWMD Rainfall Temporal Distribution and Volume

The rainfall distribution used in the Design Storm analysis is the 72-hour rainfall distribution found in the District's Surface Water Environmental Resource Permit Manual (South Florida Water Management District. Environmental Resource Permit Applicant's Handbook Volume II, Section 5.7.2 Rainfall.) May 22, 2016. The volume of rainfall for the 3-day events of return periods of 10, 25 and 100 years were obtained from Appendix C of the same reference (Isohyetal Maps from SFWMD Technical Memorandum, Frequency Analysis of One and Three Day Rainfall Maxima for central and southern Florida) which resulted in volumes of 11 inches, 13 inches and 17 inches respectively for the 10-, 25- and 100-yr events. Figures 1 to 3 show the hyetographs corresponding to the 10-, 25- and 100-yr storm events selected for the COP flood damage assessment.

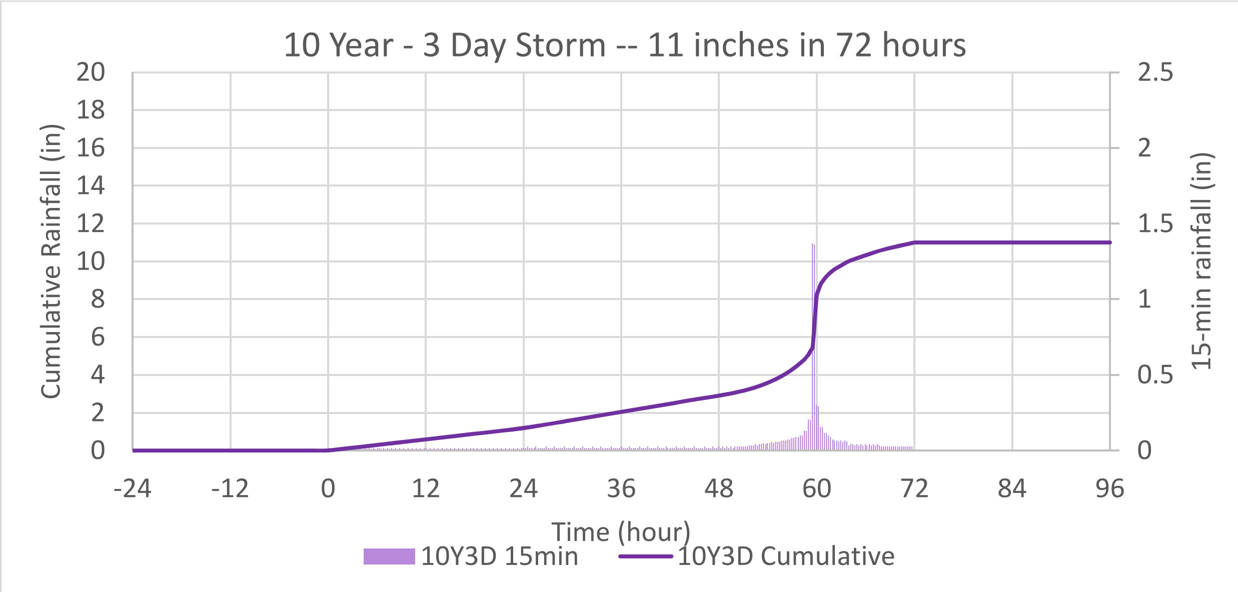

Figure 1. SFWMD Rainfall Distribution for 10-yr 72-hr Storm Event

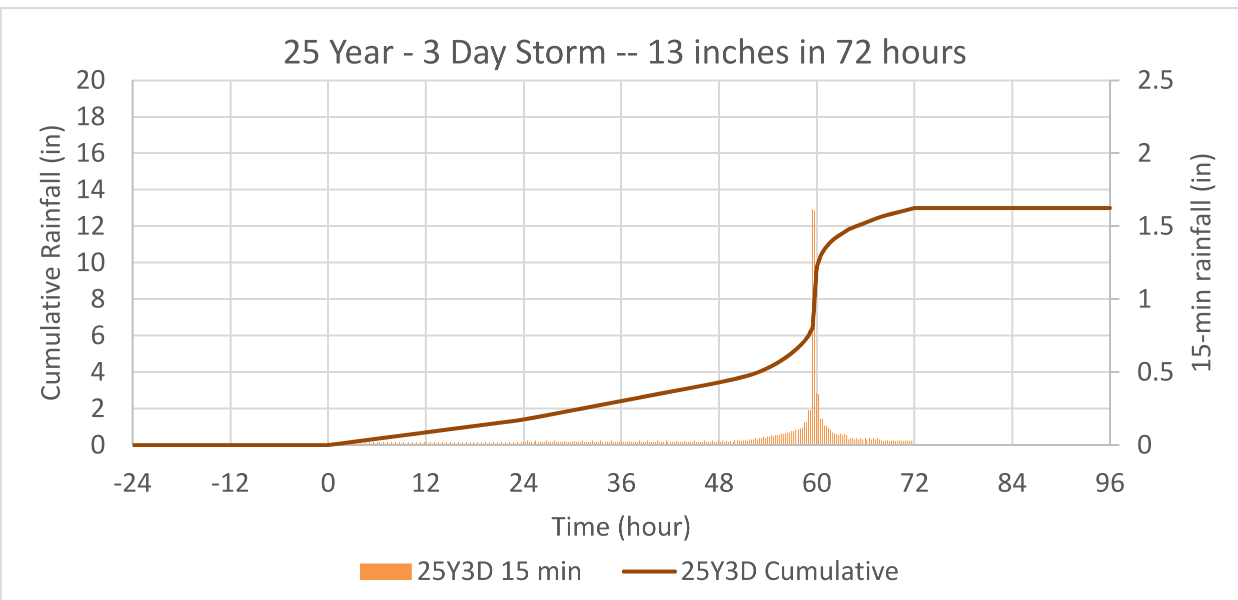

Figure 2. SFWMD Rainfall Distribution for 25-yr 72-hr Storm Event

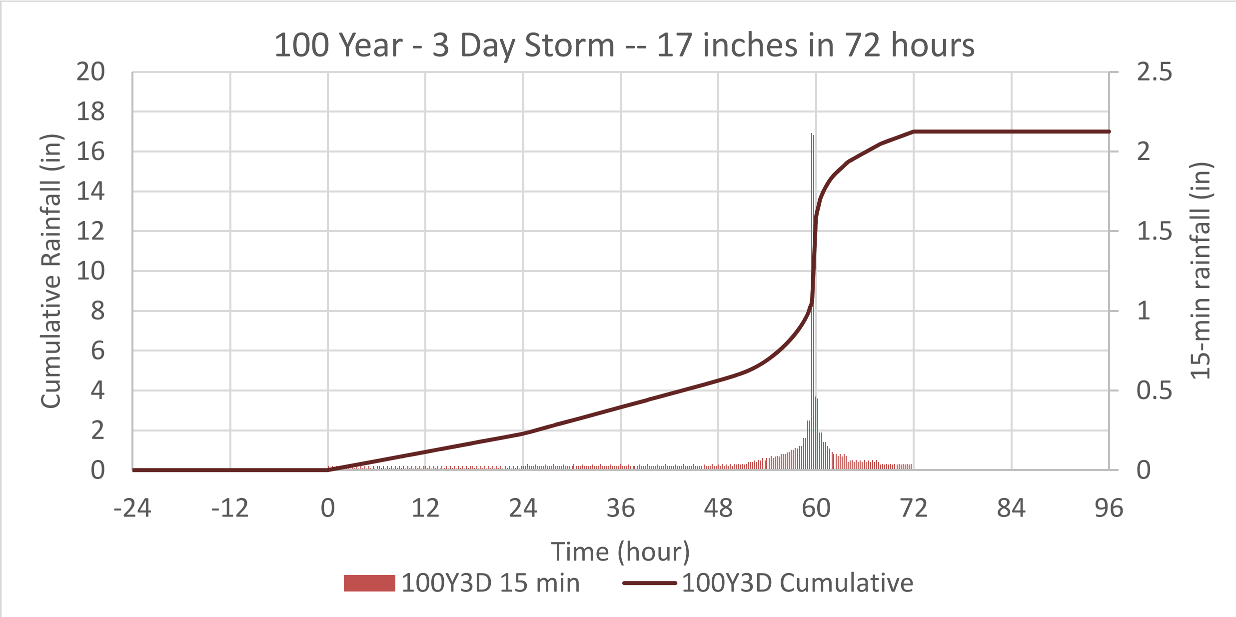

Figure 3. SFWMD Rainfall Distribution for 100-yr 72-hr Storm Event

Wet Year Rainfall

The COP project required the application of Design Storm events of 10, 25 and 100 years return periods to evaluate flooding conditions in the 8.5 SMA. This was accomplished by using the 2006 Water Year 15-min NEXRAD rainfall data to simulate above average rainfall conditions. The 2006 Water Year as defined in the COP projects starts in May 1st of 2005 and ends in April 30, 2006 with an additional five months, which were needed to warm up the model to reach stable initial conditions, resulting in a simulation run starting in January 1st, 2005 and ending in April 30, 2006. This Water Year had a total rainfall volume of 60 inches and a significant storm event in Hurricane Katrina that hit south Miami-Dade with 11.8 inches of rain over a three-day period (August 25 - 27). Figure 4 shows the radar image of cumulative rainfall in South Miami-Dade County for the period of August 25-27, 2005. This figure illustrates the spatial distribution of rainfall produced by Hurricane Katrina with the highest rainfall recorded in the C-102 and C-1 West basins just east of the 8.5 SMA.

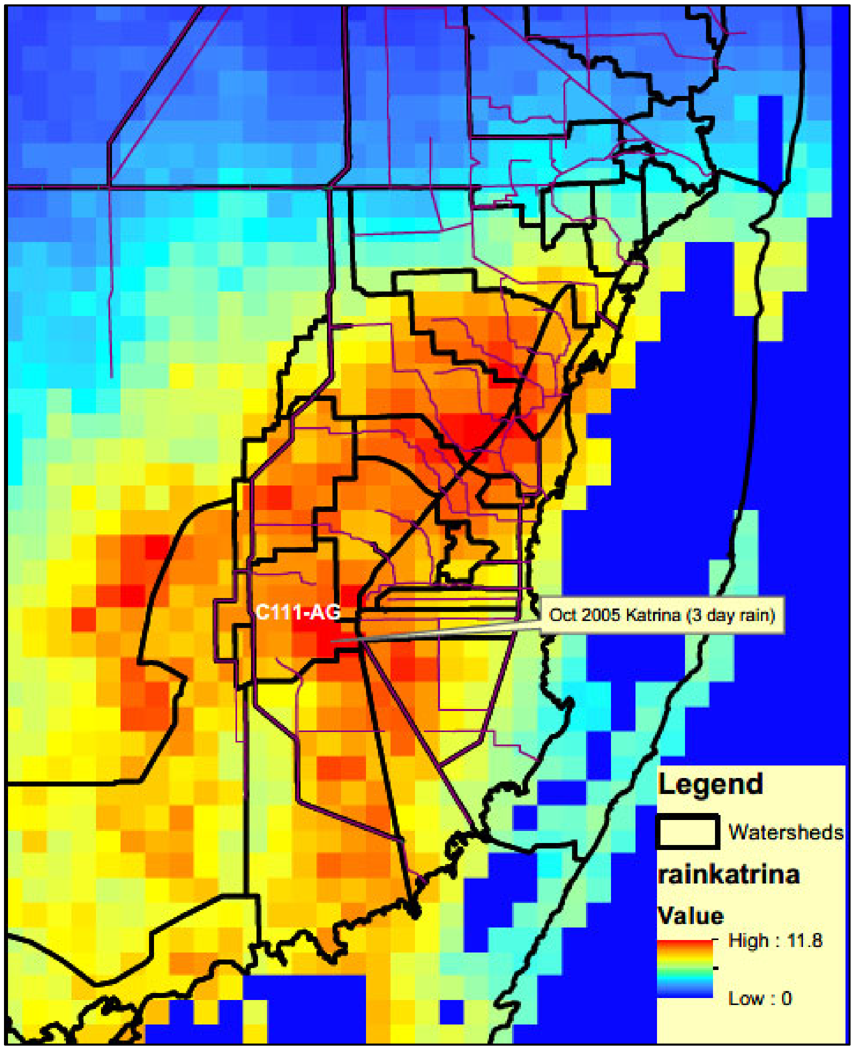

Figure 4. Spatial cumulative rainfall distribution in South Miami-Dade County during Hurricane Katrina (August 24-26, 2005)

For the simulation of the Design Storm events with the MDRSM model, the same Wet Year (Water Year 2005) was used with the synthetic 72-hr rainfall distribution replacing the observed data for the period of October 24-26. The procedure to create each of the rainfall dataset for each of the Design Storm events is described next.

1) The three-day Hurricane Katrina rain event produced rainfall volumes as high as 11.8 inches in the C111-Ag basin as shown in Figure 4. First, we assigned weights to each cell of the NEXRAD grid which has a resolution of 2 km by 2 km. A weight of 1 was assigned to the cells with the highest recorded rainfall value of 11.8 inches. The rest of the cells were given weight values between 0 and 1 equal to the ratio of the rainfall in that cell to the maximum rainfall value of 11.8 inches. This method allowed us to spatially reproduce the spatial distribution of the actual 3-day storm event over the NEXRAD grid. Once we had the spatial distribution of weights over the grid, we proceeded to apply the Design Storm rainfall volumes for the 10-, 25- and 100-yr events.

2) With the spatial distribution of weights over the NEXRAD grid, we proceeded to incorporate the Design Storm event rainfall over the three-day period between August 24 – 26. The Design Storm data are in 15-minute time steps which corresponds to the time step of the NEXRAD rainfall data. These rainfall values were multiplied by the weight in each grid cell every 15-minute of the 72-hr event between August 23 and August 27, 2005. During the 5-day period all background or recorded NEXRAD rainfall data were converted to zero and replaced with the newly computed values. This resulted in a 72-hr rainfall event preceded and followed by 24-hr periods with no rainfall as shown in Figure 5.

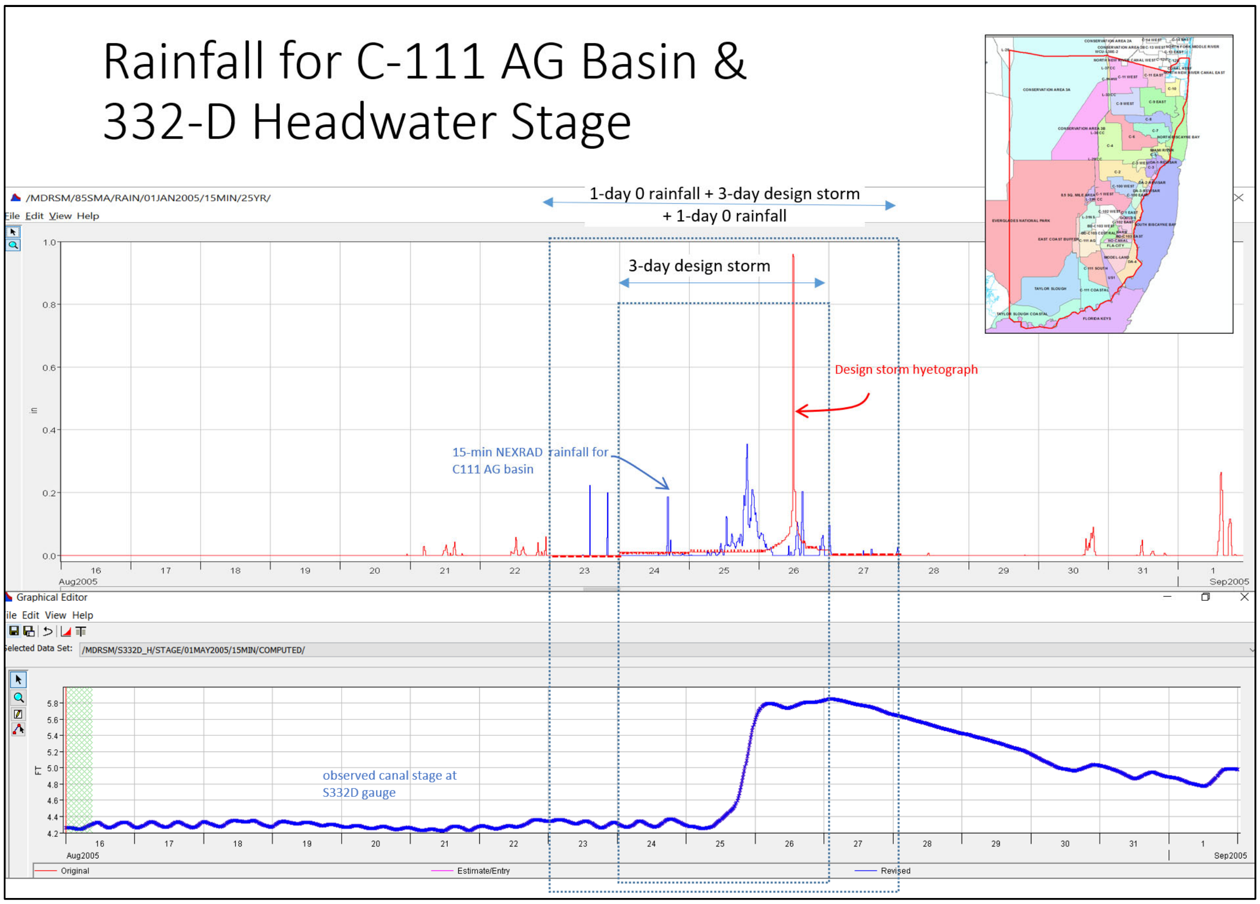

Figure 5. NEXRAD and synthetic 25-yr storm event rainfall hyetographs

3) This process was repeated for the 10-, 25- and the 100-yr event rainfall events. This process resulted in the data sets for the three Design Storm event simulation runs which encompass the period from January 1, 2005 to April 30, 2006. Figure 5 shows the observed 15-minute NEXRAD hyetograph (blue line) and the synthetic 25-yr event rainfall (red line). Outside the August 24 – 26 period, both rainfall datasets are identical. Figure 6 shows the Wet Year rainfall hyetograph with the 100-yr rainfall event occurring on August 24 -26, 2005 while Figure 7 shows the rainfall for the three storm events of 10, 25 and 100 years return period.

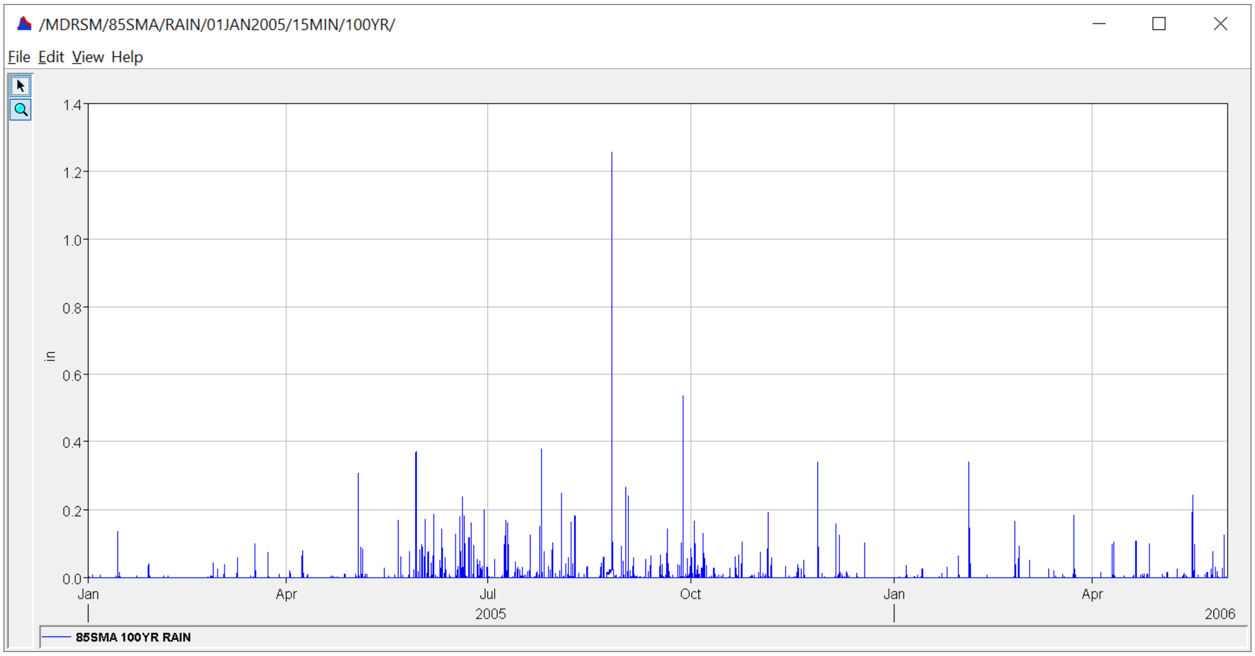

Figure 6. Wet Year hyetograph with 100-yr event occurring on August 24-26, 2005

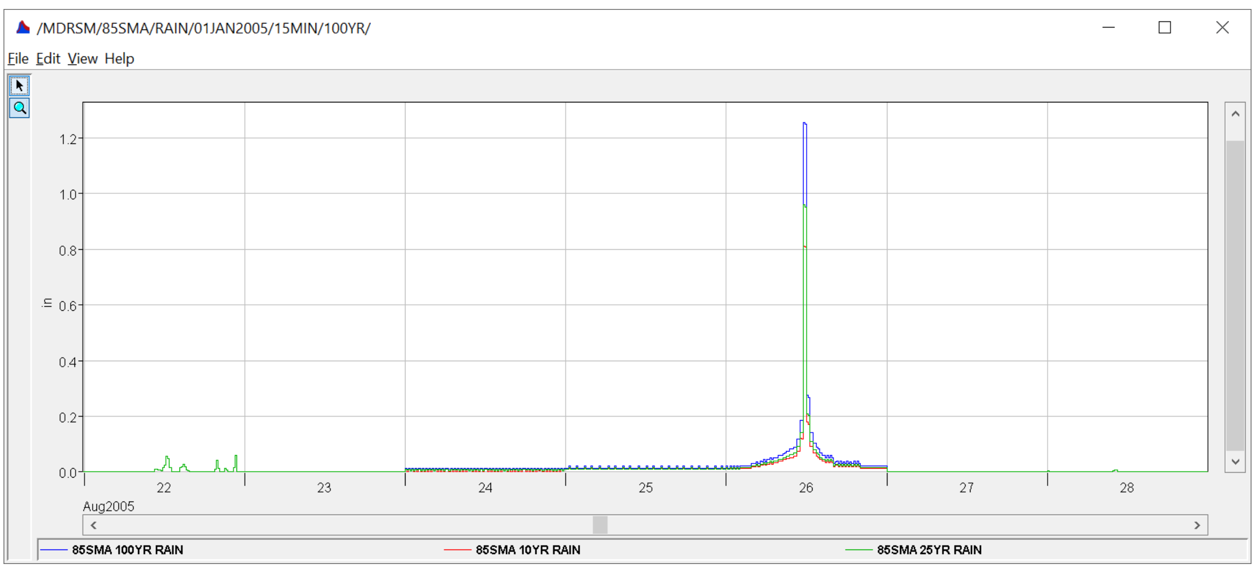

Figure 7. Rainfall hyetographs for 10-, 25- and 100-yr storm events

H-7.2 SFWMD TECHNICAL MEMO ON MDRSM WET AVERAGE AND DRY WATER YEAR SELECTION

The selection of wet dry and average water years for the MDRSM model was a collaborative effort between the South Florida Water Management District, the Jacksonville branch of the USACE and the Everglades National Park. After several rounds of discussions, a consensus was reached that the water year should be defined to start on May 1 and run through April 30 of the year assigned to designate it. Thus, water year 2006 starts on May 1, 2005 and ends on April 30, 2006. After reaching a consensus on the water year period of record, several rounds of proposals and discussions on how to evaluate wetness and dryness in the analysis ultimately led to the following the following criteria.

1) A wet rainfall year should yield wet hydrologic conditions in the study area over the period of record and likewise a dry rainfall year should yield dry conditions. In practice, this criterion favors years in which the rain occurs early in the water year rather than toward the end, so there is time for its impact to be reflected in the hydrologic conditions.
2) The selection of water years should be coherent with the maximum stage in WCA 3A, which is a good indicator of how wet it is in south Dade and the COP project area.
3) When possible, the analysis should favor years where there is good agreement between NEXRAD rainfall and gage data. However, because the model uses NEXRAD data, this is a secondary criterion that is considered only after the previous criteria have been met.

Figure 1 presents the NEXRAD and gauge rainfall over the MDRSM model domain and the difference between them for water years 2001 through 2016. This information was used in conjunction with the 3A-4 stage presented in Figure 2 to select a couple candidate years for additional analysis.

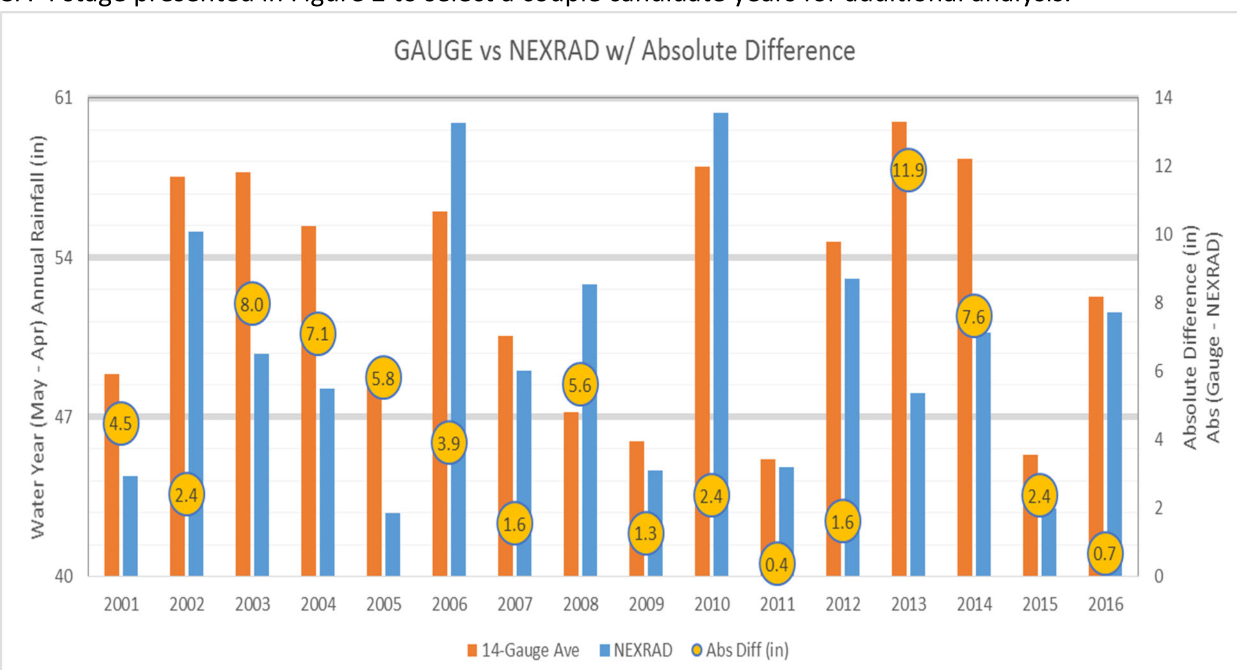

Figure 1: NEXRAD and Gauge Rainfall over MDRSM model Domain

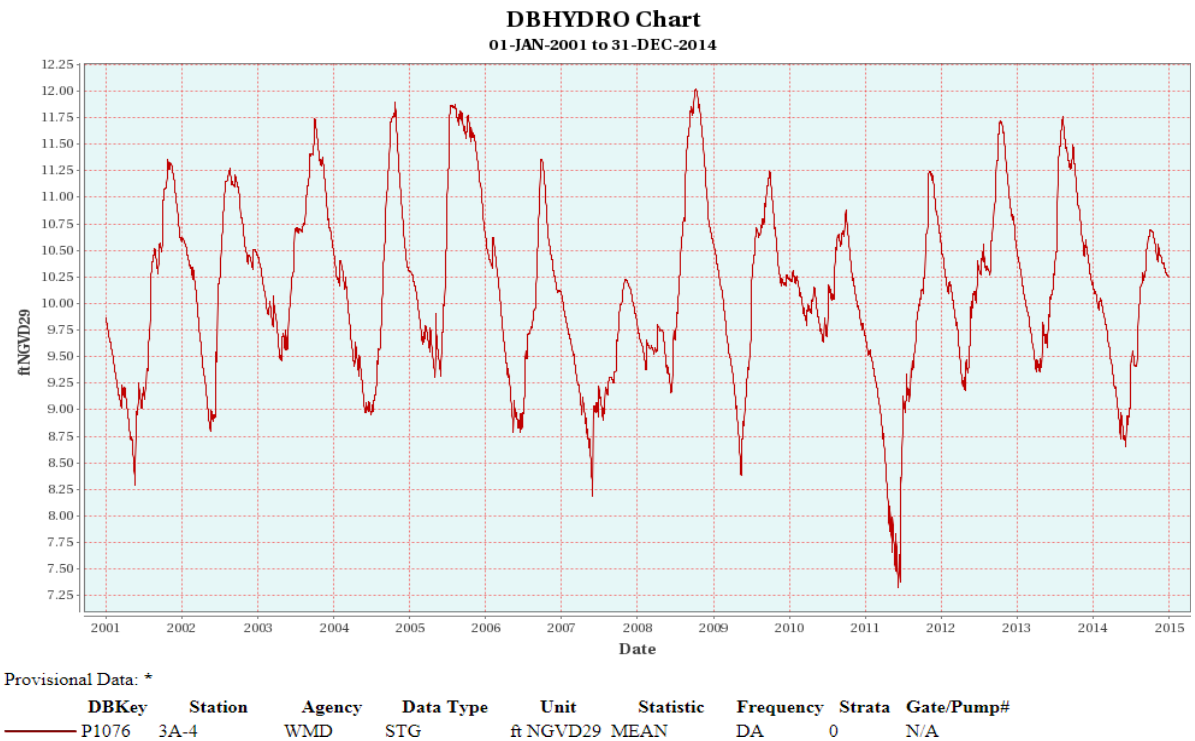

Figure 2: WCA 3A Water Levels

<u>2006 WET YEAR SELECTION</u>

Based on Figure 1, water years 2006 and 2010 were selected as candidates for the wet year and the accumulated NEXRAD rainfall plots presented in Figures 3 and 4 were reviewed. The accumulated NEXRAD rainfall in each basin with the model domain is presented as an individual curve in each of these plots and reveals that a significant portion of the 2010 rainfall occurs near the end of the period of record, whereas the 2006 rainfall tends to occur earlier making it a better candidate based on the first criterion. In addition, the WCA 3A water levels in Figure 2 tend to be higher in 2006 than 2010 and substantiate this selection. Unfortunately, there is a larger discrepancy between the NEXRAD and gauge in 2006 than 2010, however the superior performance of 2006 of 2010 in the first two criteria doesn't justify changing the selection base on the third criterion.

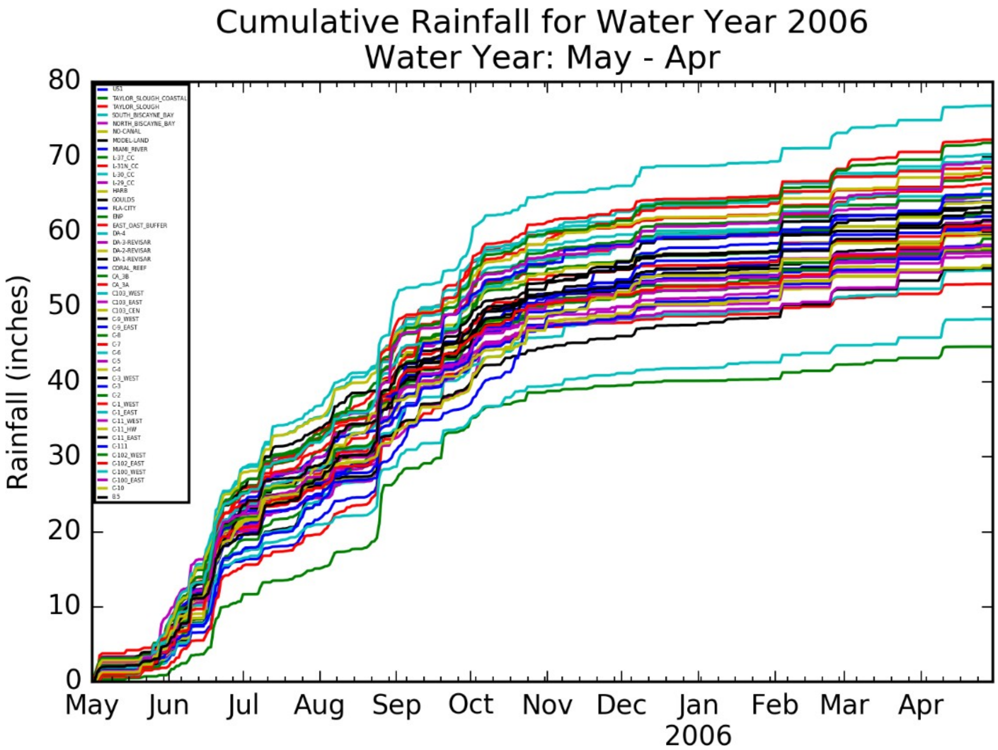

Figure 3: 2006 Accumulated Rainfall

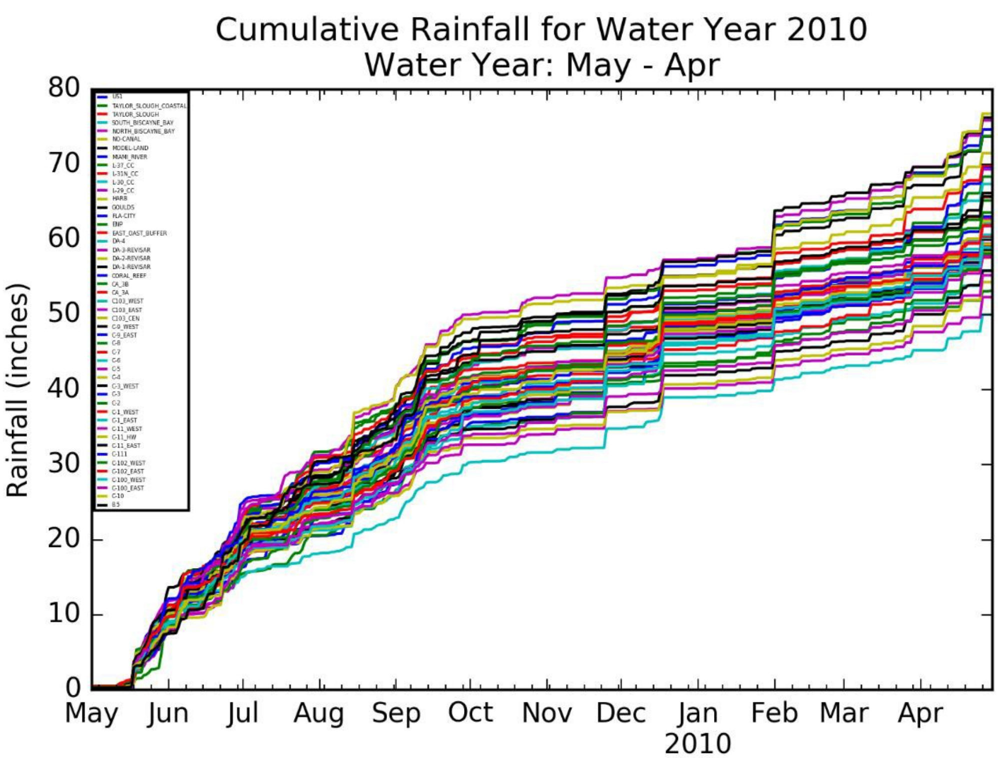

Figure 4: 2010 Accumulated Rainfall

2011 DRY YEAR SELECTION

Based on Figure 1, water years 2011, 2015 and 2009 were selected as candidates for the dry year and the accumulated NEXRAD rainfall plots presented in Figures 5, 6 and 7 were reviewed. While the accumulated rainfall plots for all the years looks reasonable, Figure 2 reveals that WCA 3A water levels drop to extremely low levels over the 2011 water year which suggest very dry conditions in the south Dade area. In addition, the 2011 water year had the smallest discrepancy between the NEXRAD and gauge data. Thus 2011 was selected as the dry year, based on the second and third criteria

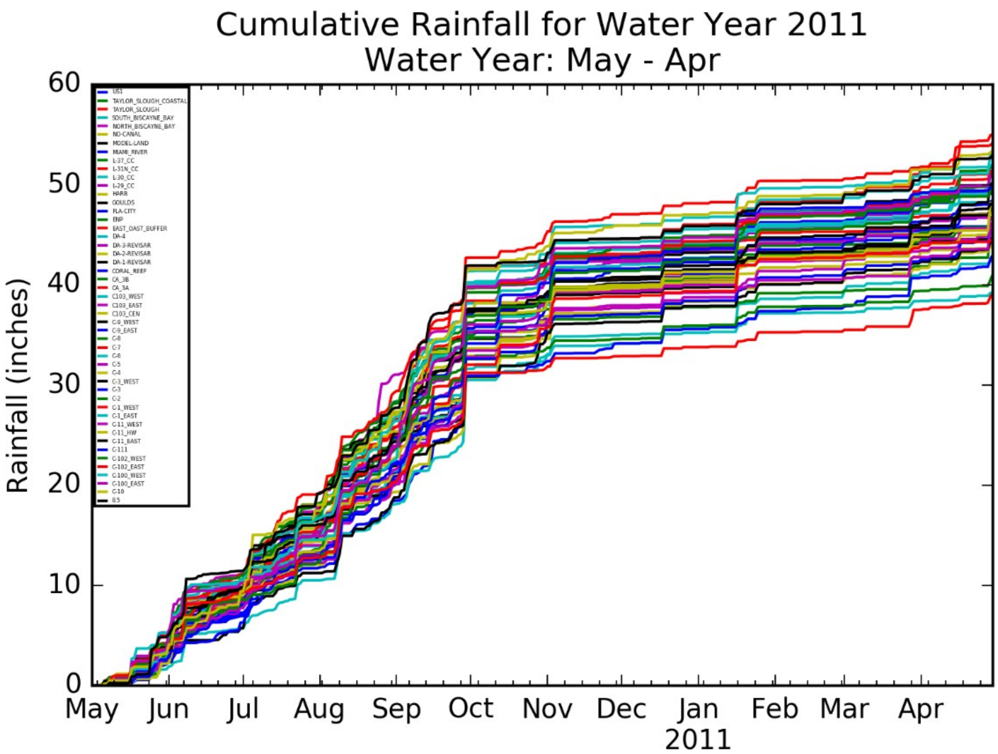

Figure 5: 2011 Accumulated Rainfall

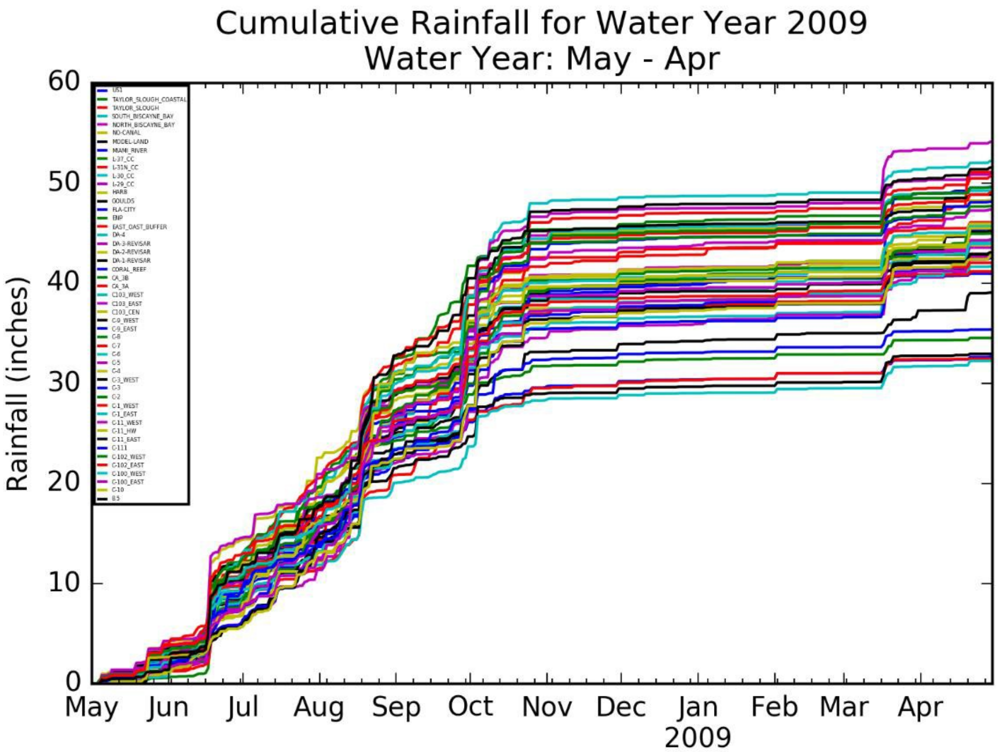

Figure 6: 2009 Accumulated Rainfall

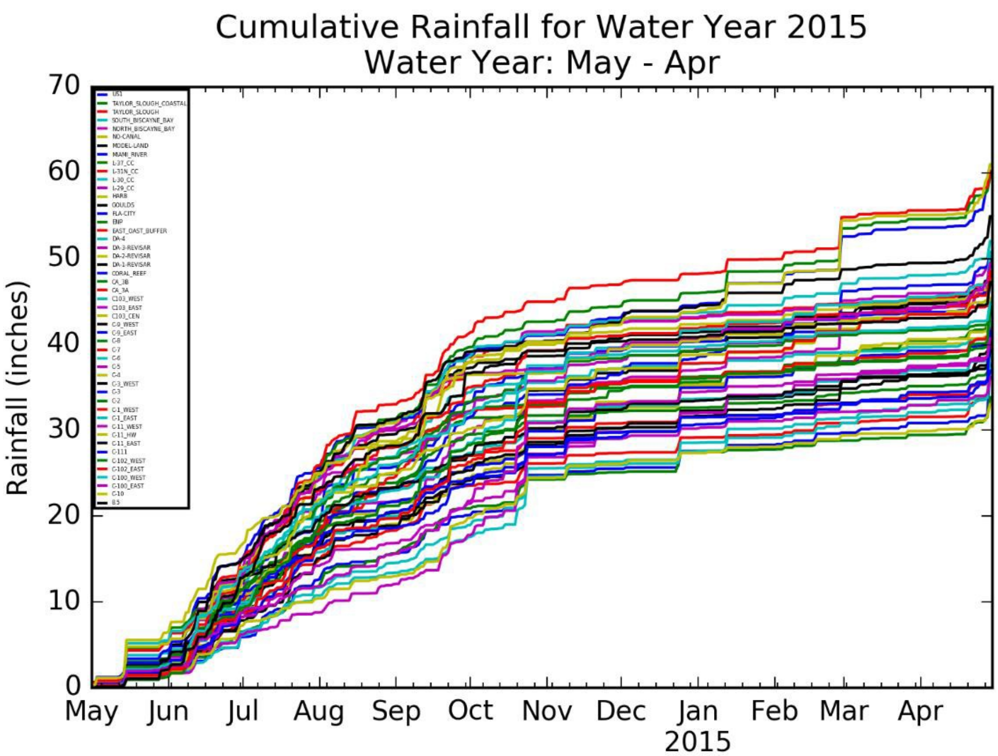

Figure 7: 2015 Accumulated Rainfall

2007 AVERAGE WATER YEAR SELECTION

Based on Figure 1, water years 2007 and 2003 were selected as possible candidates for the average year and the accumulated NEXRAD rainfall plots presented in Figures 8 and 9 were reviewed. While the accumulated rainfall plots for each of the candidate years look reasonable, 2007 has better agreement between the NEXRAD and gauge data. In addition, water level in WCA 3A over the 2007 water year are bounded by those of the 2006 wet and 2011 dry years.

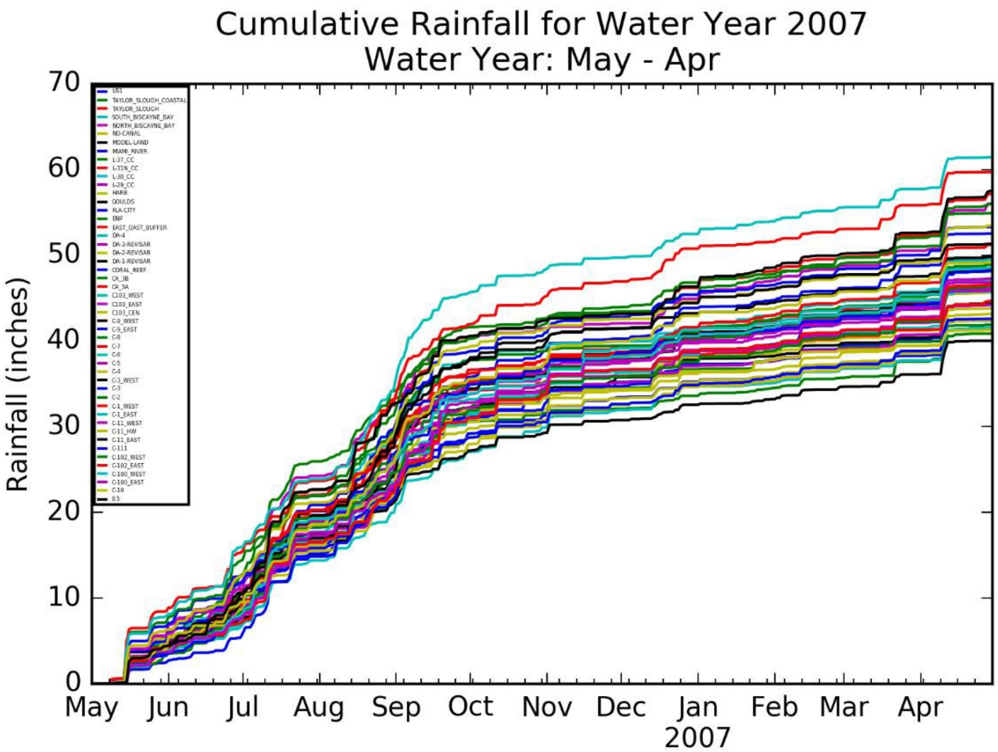

Figure 8: 2007 Accumulated Rainfall

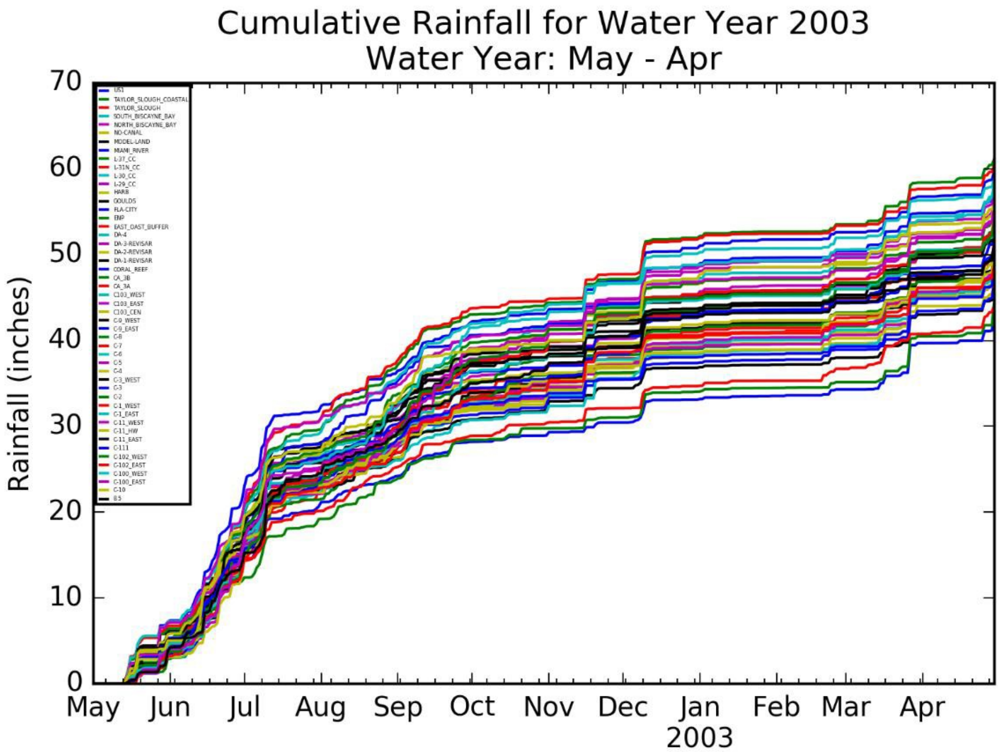

Figure 9: 2003 Accumulated Rainfall