REPORT FROM THE FIELD
September 2021

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With
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Contrary to previous postings, I'm going to start this article with a personal story to help set the stage for what follows. Contrary to the volunteer researchers living in the Antelope Valley and surrounding mountains who have commented on how hot Lancaster has been this summer, Long Beach has been literally a breeze, an ocean breeze, so far. During the previous summers I have lived in Long Beach, the ocean breeze periodically stop blowing starting in June or July when the June gloom ends. Without the ocean breeze, Long Beach's temperature rapidly rises into the low to high nineties degrees Fahrenheit and my apartment becomes unbearably hot (my apartment building is almost a hundred years old and the owner claims its electrical system won't handle even window air conditioners in the individual apartment units. This is likely true because the apartment building's electrical system is still protected with mechanical fuses that periodically blow). At least so far this summer, the ocean breezes have consistently blown, especially at night, so my apartment has been remarkably tolerable with the exception of one or two days where the inside apartment temperature climbed into the mid-eighties.

So, what is the cause for my Long Beach unusually cool summer and the AV's exceptionally hot temperatures. My speculation is that the two are connected. The AV's consistently hot temperatures cause the air to rise resulting in a local lower pressure area which, in turn, results in cooler, denser air flowing in to replace the rising air. That cooler air is ocean air and it flows right through Long Beach, and my apartment's open windows, on its way to the Antelope Valley. I have read that the entire Greater Los Angeles area has had a mild summer and this makes sense as the ocean air cools everywhere. If the Antelope Valley's warmer summer is due to global warming and therefore can be expected in the future, then maybe I, and other Long Beachites, will get to enjoy cooler summers. As is true in most cases, some win and some lose from changing conditions.

This beg the questions, "Was the AV's summer truly exceptionally warm?" and if so, "Is this part of a long-term trend?" In my last article, I briefly discussed, and showed, the Poppy Reserve's widely variable seasonal rainfall pattern. I'll revisit the Reserve rainfall later in this article to show that there is a long term decreasing trend in its seasonal rainfall but first what are the temperature trends?

I believe it is appropriate to break any discussion of temperatures into two parts; summer temperatures and winter/spring temperatures. Although the summer temperatures could impact the Reserve's plant species that bloom in the summer and autumn, they unlikely directly impact the spring wildflower displays which are more likely impacted by the winter/spring temperatures. There is the potential for the summer temperatures to have an indirect impact on the spring wildflower displays by increasing moisture evaporation from the soil resulting in dryer, near surface soil conditions in the autumn. Because individual rain storm's maximum soil moisture levels seem to be a major influence on the amount of seed germination, dryer soil might result in smaller amounts of seed germination, at least at the beginning of the winter rainy season. Because I have been writing about this summer's temperatures, this article will focus on any trends in the summer temperatures, but first we must define what I mean by summer. When the articles have discussed seasonal rainfall patterns, the season has been defined as September 1 to May 31 of the following year. These dates were selected due to their importance on the spring poppy and accompanying wildflower species displays. By keeping these same dates for the winter/spring temperature period, leaves June, July and August for the summer months.

Although the internet accessible California Department of Water Resources (CDWR) Poppy Reserve's weather station was established in 1997, it wasn't until 2006 that the weather station's data display format was changed to add the daily maximum, minimum and average temperatures to the prior available hourly air temperature. Therefore, there are sixteen years of daily temperature data available to compare which is marginal to determine long term trends. A National Weather Service representative once told me that they consider data for a minimum of thirty years is required to determine valid long term climate trends. In any case, a plot of the available daily temperature data is shown in Figure 1. The curve marked Series 1 is the data for the summer of 2006, and each series is for the sequentially next summer until Series 16 is for this 2021 summer, marked in the heavier, lavender colored curve.

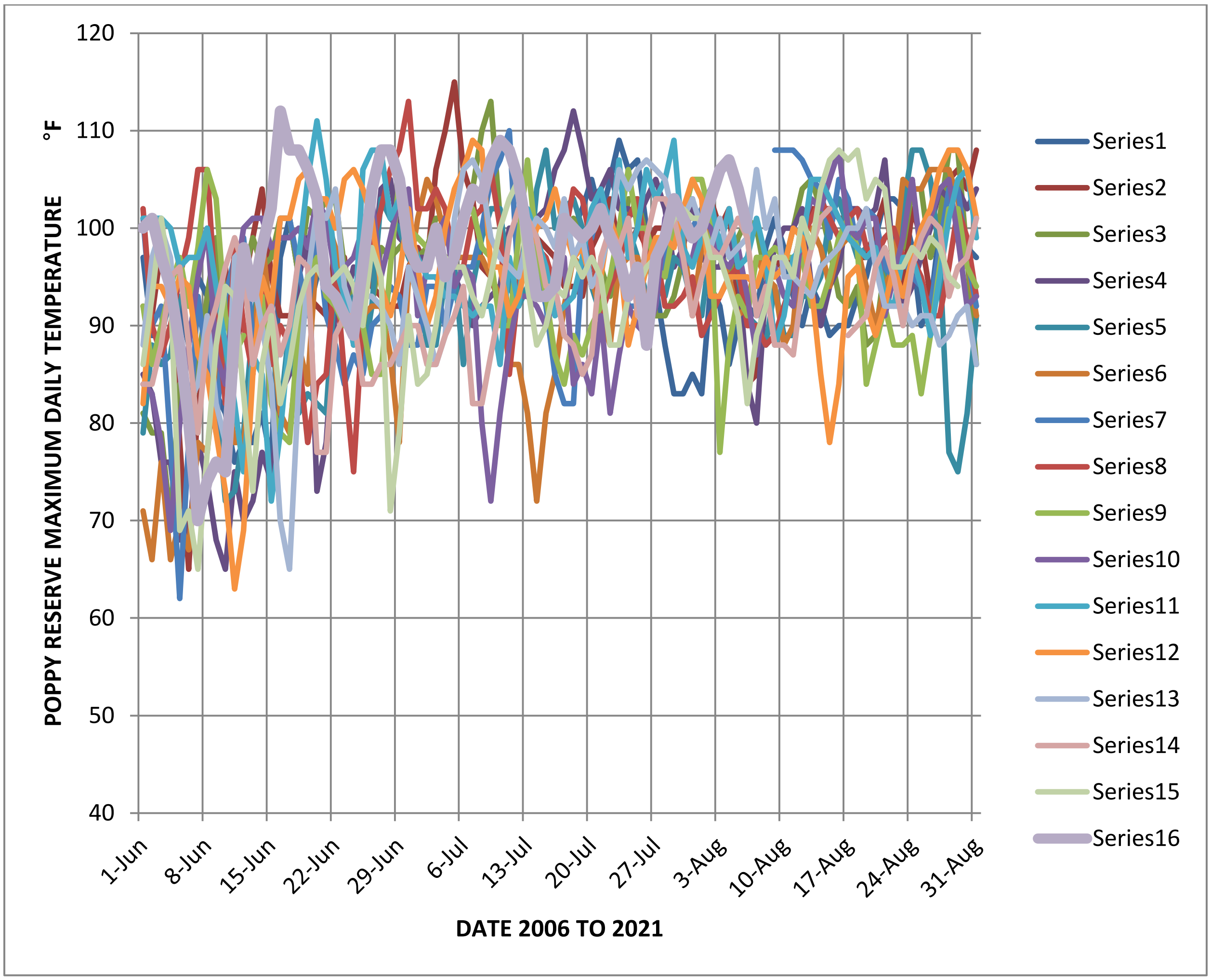

FIGURE 1: POPPY RESERVE DAILY MAXIMUM TEMPERATURE FOR THE LAST SIXTEEN YEARS

Due to the natural variability in the daily temperatures it is difficult to detect any temperature trends but no obvious shift in the daily maximum temperature is apparent in this figure.

In a second attempt to detect any trend in the summer's daily maximum temperatures, each of the yearly curves shown in Figure 1 was broken into sequential seven day periods and each period averaged to eliminate the daily temperature variability. Finally, selected periods covering the summer months were plotted against the years of available daily temperature data, see Figure 2. The data in Figure 2 are the daily maximum temperatures averaged over a seven day period centered on the dates listed for each individual plot. Lastly, a common statistical procedure used to find the best fit for a set of data points was performed on the averaged temperature data to show any trend in the daily maximum temperatures over the last sixteen years starting in 2006. This linear curve fit is the gold line in each plot.

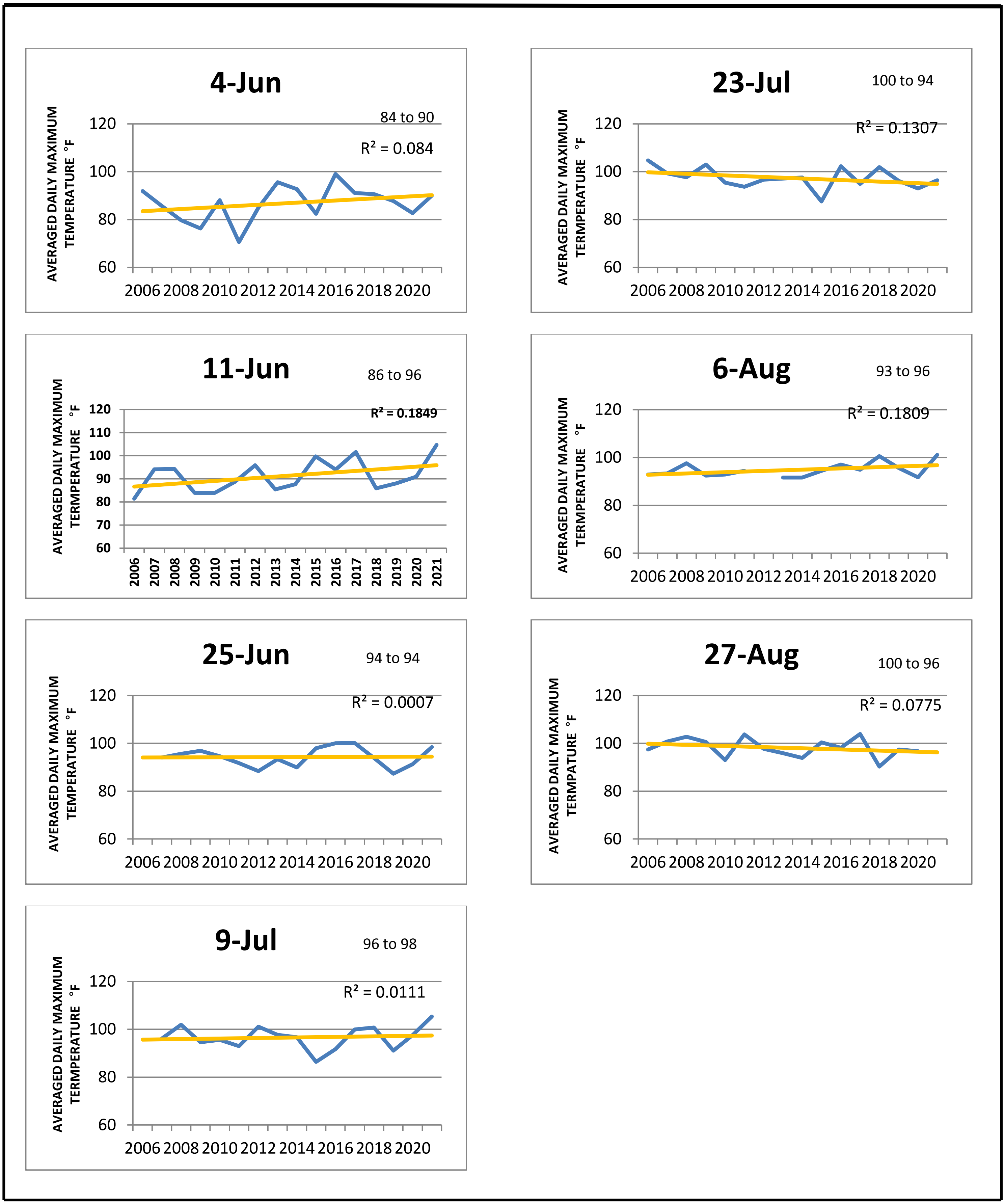

FIGURE 2: POPPY RESERVE SUMMER TEMPERATURE TRENDS

This more sensitive analysis again shows no consist trend in the daily maximum temperatures over the last sixteen years. During the peak of the summer, late June to early August, the trend lines were a combination of both slight increases and an actual decrease so it appears that the summer maximum temperatures have not noticeably increased over the time period where data are currently available. This issue will have to be revisited in 2036 to get a more definitive determination if the Poppy Reserve's summer temperatures are increasing due to global warming.

The two plots for the first half of June both showed more consistent and steeper increases so it is possible that the warm summer temperatures are occurring earlier in the year. On the other hand, the late August plot showed a slight decrease in daily temperatures. To determine if these possible conclusions are actually valid, similar analyses were conducted for periods in late May and early September. These plots are shown in Figure 3.

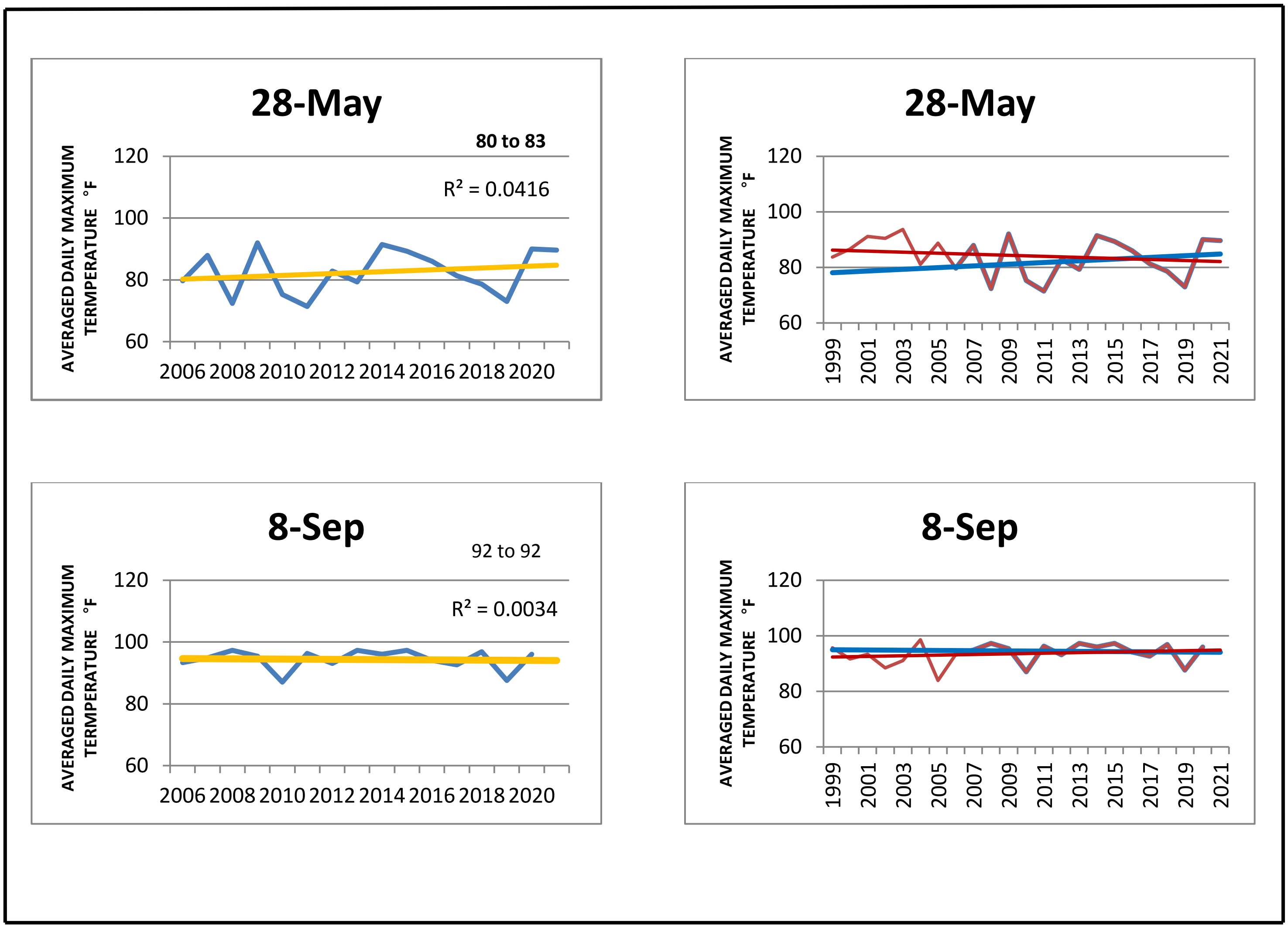

FIGURE 3: POPPY RESERVE LATE SPRING AND EARLY AUTUMN TEMPERATURE TRENDS

When the Figure 3 plot for May 28 is compared with the plots for early June in Figure 2, the May 28 trend line is still slightly increasing but not nearly as steep. The trend line for September 8 in Figure 3 is essentially flat with no change over the sixteen years so it similarly does not confirm an early autumn decrease in the daily maximum temperature shown in the 27 Aug plot of Figure 2. The conclusion is that there does not appear to be any actual shift in the Poppy Reserve's summer daily temperatures over the last sixteen years. The apparent shifts in the Poppy Reserve's summer temperatures indicated by the trend lines in both Figure 2 and Figure 3 are most likely caused by randomness introduced by the curve fitting algorithm itself due to the limited sixteen year dataset. The May and September temperature data can give indirect conformation for this conclusion.

Because May and September are both part of the months making up the poppy season dataset, the daily maximum temperatures for these months are available extending back to 1999. For the seven years prior to 2006, when the Poppy Reserve's weather station printout was modified to include daily temperature data, the daily maximum and minimum temperatures were grabbed from the hourly temperatures recorded since the weather station was first established. Because the volunteer researchers' primary focus has been on gaining a better understanding of the factors influencing the quality of the spring wildflower displays, the time intensive effort to grab daily temperatures from the recorded hourly temperatures has not been done for the Reserve's summer months but has been accomplished for the poppy season months. This allows a similar analysis to be conducted for the full 23 year dataset and the two calculated trend lines compared. The results of this comparison are shown in the last two plots of Figure 3. For both plots, the red curves, and calculated trend lines, are for the full 23 years of available temperature data and the blue curves are for only the last sixteen years. Starting in 2006 the daily maximum temperatures are, of course, identical so the two curves are superimposed. Both months show some differences in the two calculated trend lines. The two May trend lines are even reversed; the trend line for the last sixteen years shows increasing temperatures with time while the full 23 year trend line shows decreasing temperatures. The two September trend lines are closer but still show a noticeable difference. Clearly, we are going to have to wait another seven to ten years (14 to 20 years for the summer months), before we finally learn how global warming is affecting the Reserve's temperatures.

With the possibility of warming spring months potentially impacting the quality of the spring poppy displays, another approach to investigating changes in the Reserve's temperatures was also explored; is there any trend in the dates that the Reserve first records 80°F, 90°F and 100°F. Although this investigation was only partially successful, it appears that it did solve a mystery I wrote about in an earlier article. Figure 4 shows how those first days have varied since 1998. Over the intervening years, the Reserve reached a maximum daily temperature of 80°F as early as mid-February and as late as late April. The Reserve reached 90°F as early as mid-March and as late as early June. Because February, March and April are the peak months of the poppy season, these early, or late, hot spells can have, and have had, a profound impact on the quality and duration of the annual spring wildflower season. Combining these temperature patterns with the preceding winter/spring total seasonal rainfall seemingly has great potential to better explain what has to happen to get a super bloom year or poor poppy display seasons which can be a topic for a future researcher's "Report from The Field" article. Although further analysis is needed to gain a fuller understanding of how the subtle dance of temperature patterns and seasonal rainfall combine to impact the splash of radiant poppy orange across the hillsides of the Reserve each season, two examples will be discussed later in this article. Before that discussion, let's finish the summer temperature discussion as well as the promised discussion on the Poppy Reserve rainfall trends.

With the earliest 100°F day not occurring until mid-May, long after the spring's peak poppy color, it appears that the warmest part of the summer should have little impact on the spring wildflower displays.

Unfortunately, even after many attempts and approaches, we were unsuccessful in inserting Figure 4's chart into this article. We were left with the only option of making Figure 4 a separate posting on this website. Although inconvenient, we are asking our readers to bear with us in this case and view Figure 4 in the accompanying posting.

FIGURE 4: POPPY RESERVE'S SUMMER FIRST DATES

Similar to the averaged temperature data shown in Figures 2 and 3, long term trend lines were also calculated for this data as well. The linear trend lines are the appropriately colored straight lines shown in Figure 4. Unexpectedly, two of the three general trend lines show the hot portion of the summer temperatures are slowly occurring later in the summer. Because of the inconsistency of the trend lines, this conclusion has to be considered tentative even though the trend lines are based on twenty four years of data; closer to the needed thirty years. This data will also have to be watched in the ensuing years to see if this apparent trend continues.

Although the previous discussion concluded that there hasn't been any discernible increase in the summer average temperatures over the last sixteen years, there is still an open question, "Has there been an increase in the number extremely hot days?" Figure 5 answers that question.

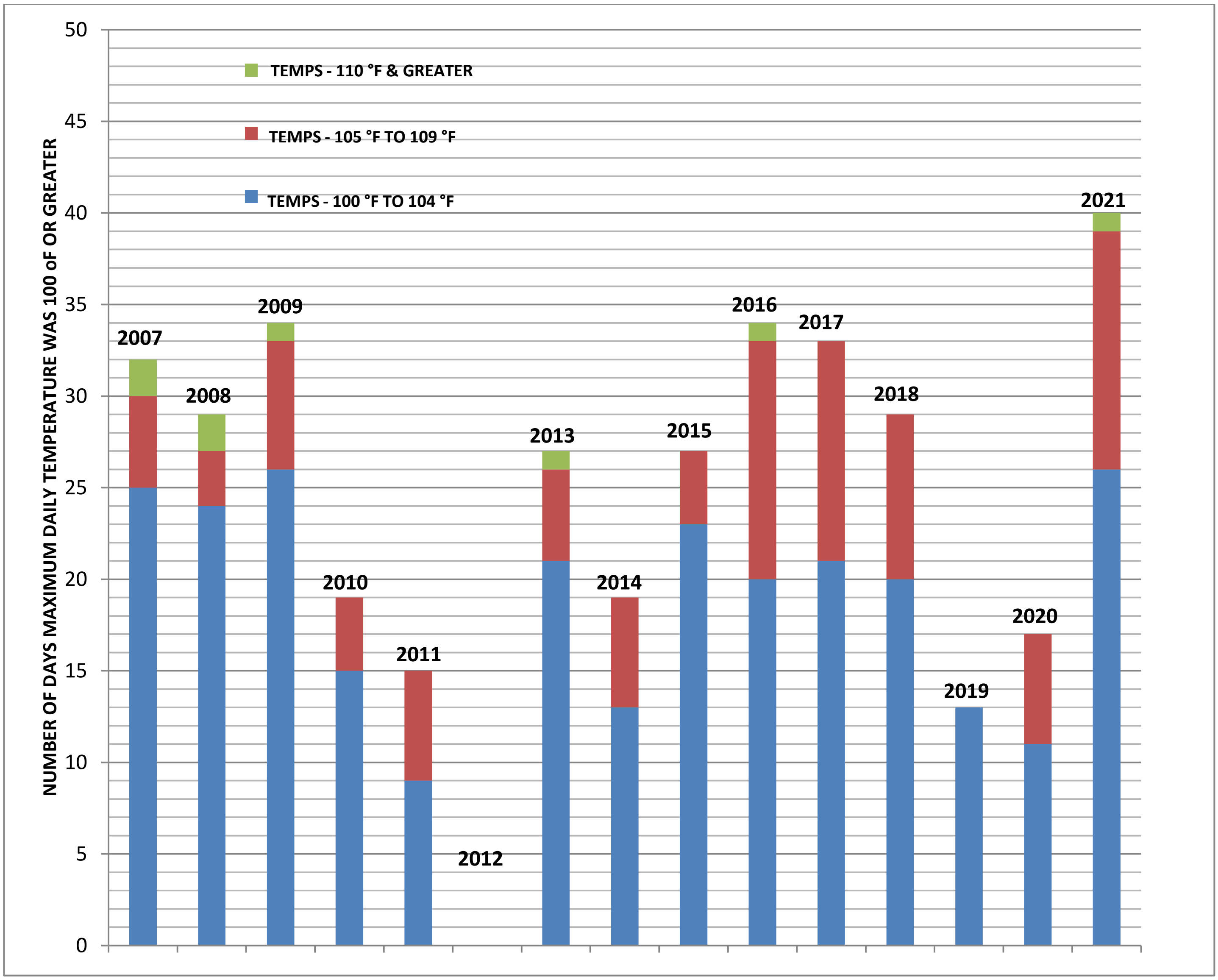

FIGURE 5: NUMBER OF DAYS THE POPPY RESERVE TEMPERATURE EXCEEDED 100°F

As of the late August, the summer of 2021 has already set a record for the total number of days where the daily maximum temperature was 100°F or higher. That said, there still doesn't appear to be any increasing trend in hot days. Every chart has to have a maximum value and this summer just happens to be the maximum number of days. The only possible trend observed in the figure is that four of the last six summers had more days with maximum temperatures between 105 and 109°F compared to earlier summers in the comparison but, even in this period, the summer of 2019 had no days exceeding 104°F. Some analyses of the effect of global warming predict that the weather will become more variable and, maybe, this data is reflecting that increased variability. Extremely hot days with maximum temperatures of 110°F and higher are still very rare; only six of the fifteen years in the comparison reached this level of temperature. The summer of 2007 holds the record for the hottest day at the Poppy Reserve with a recorded temperature of 115°F. The summer of 2012 was eliminated from this comparison because there was a six-day period in early August where the daily maximum temperatures were clearly erroneous, with recorded temperatures between 137 to over 300°F.

Although probably of lesser interest to most, this discussion on the Poppy Reserve's summer temperatures will end with its summer daily minimum temperatures, Figure 6, with the current summer temperatures again highlighted.

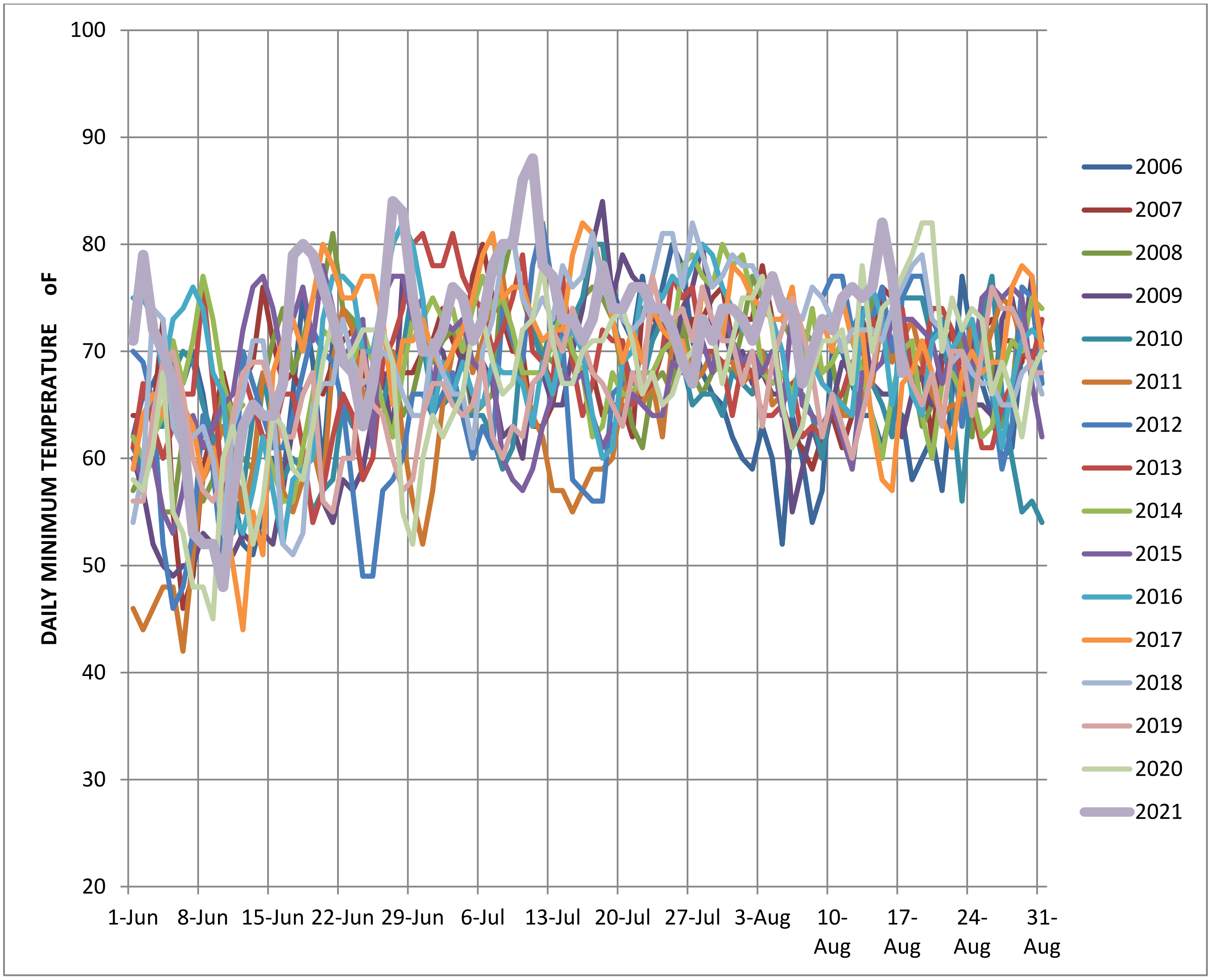

FIGURE 6: POPPY RESERVE DAILY MINIMUM TEMPERATURES

Again, there doesn't seem to be any discernible trend of the daily minimum temperatures over time. Although it could be argued that this summer's minimum temperatures seem slightly warmer than normal, the data for the previous two summers are very consistent with the whole temperature dataset. Even if the average of this summer's daily minimum temperatures is slightly above the long-term average, it appears that this summer's warmer temperatures are the result of natural year-to-year variability in the climate rather than any global warming driven long term trend.

If no clearly discernible trends were discovered in the analyses of the available temperature data discussed above, that is not true for the available rainfall data. The rainfall data has been discussed in several previous posted articles so it will be summarized here and updated with this past poppy season's rainfall data.

Figure 7 shows the Poppy Reserve's seasonal rainfall for the last twenty three years. The calculated best fit linear trend line is also shown in the figure as the gold-colored line.

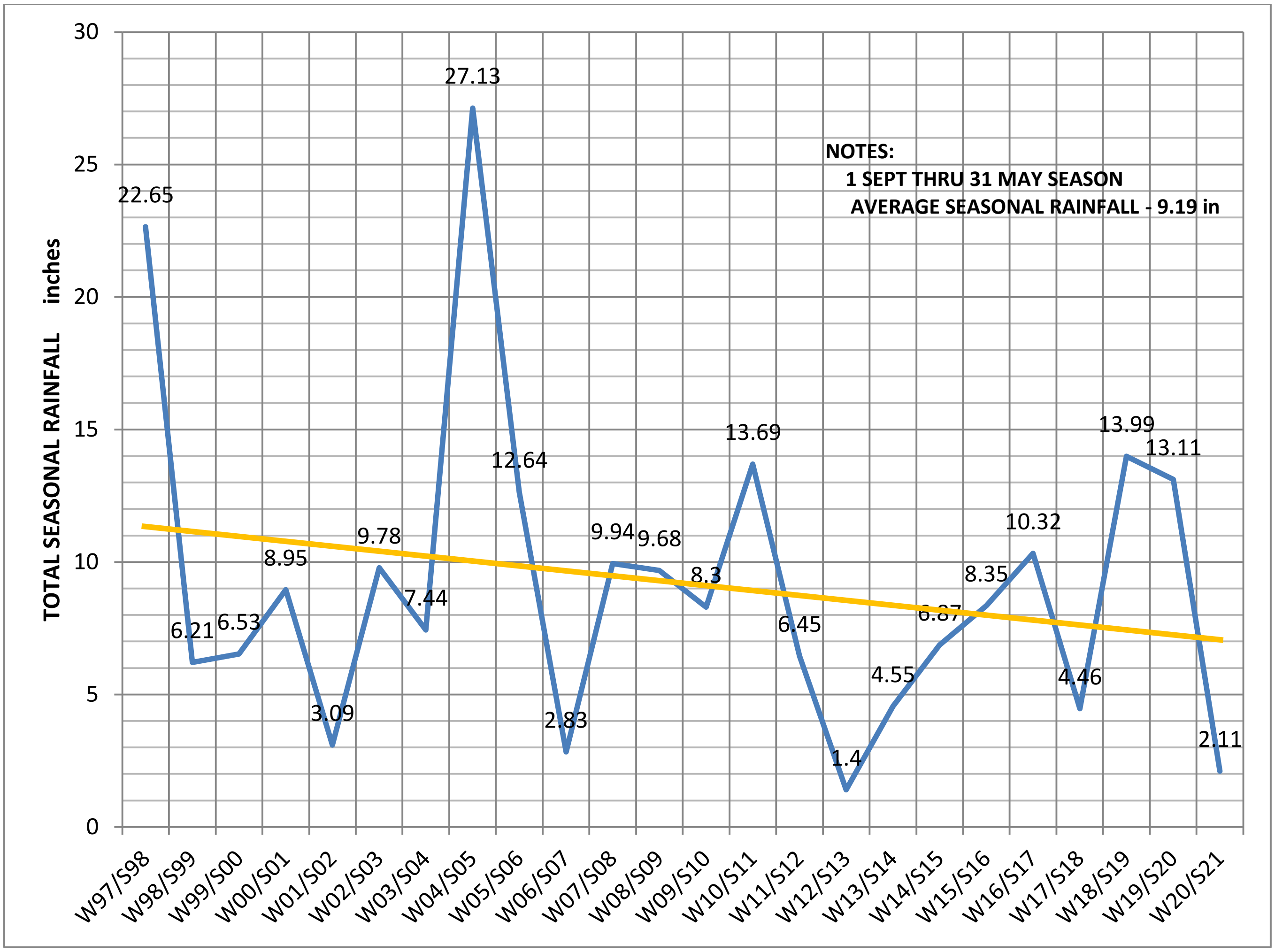

FIGURE 7: POPPY RESERVE SEASONAL RAINFALL

The total seasonal rainfall can be considered being made up of two components; an average value being the long term trend value for each year and a random component superimposed, plus and minus, on the average value. Figure 7 shows a quite significant decrease in the average rainfall value since the winter of 1997/98; dropping from over eleven inches to only seven inches for last winter. This level of decrease is likely to be enough to result in fewer storms of sufficient strength to trigger large quantities of poppy seed germination thereby seasons with outstanding poppy displays could become less frequent as well as decreasing the amount of moisture stored in the soil resulting in shorter poppy seasons.

The random variability component of the Reserve's seasonal rainfall is shown in Figure 8 for the same time period. The variability was calculated by subtracting each season's calculated trend line values, obtained from Figure 7, from the actual seasonal rainfall. For example, the trend line value for the 1997/98 winter/spring of 11.3 was subtracted from the actual seasonal rainfall of 22.65 giving a variability component value of +11.35. This process was repeated for each year and the resulting variability values were plotted to give Figure 8. A linear best fit trend line was also calculated for this data with the intention of determining if there has been any changes in the variability component of the seasonal rainfall; the figure's gold line. Unexpectedly, at first, the resulting trend line simply lies along the X axis of the plot with a constant value of near zero. Eventually, it was realized that this is expected if the trend line in Figure 7 is correctly calculated. That leaves only the eyeball test to detect any changes in the rainfall variability component. It is left to each reader to draw their own conclusion but, for me personally, it seems the variability has increased some over the last ten years or so.

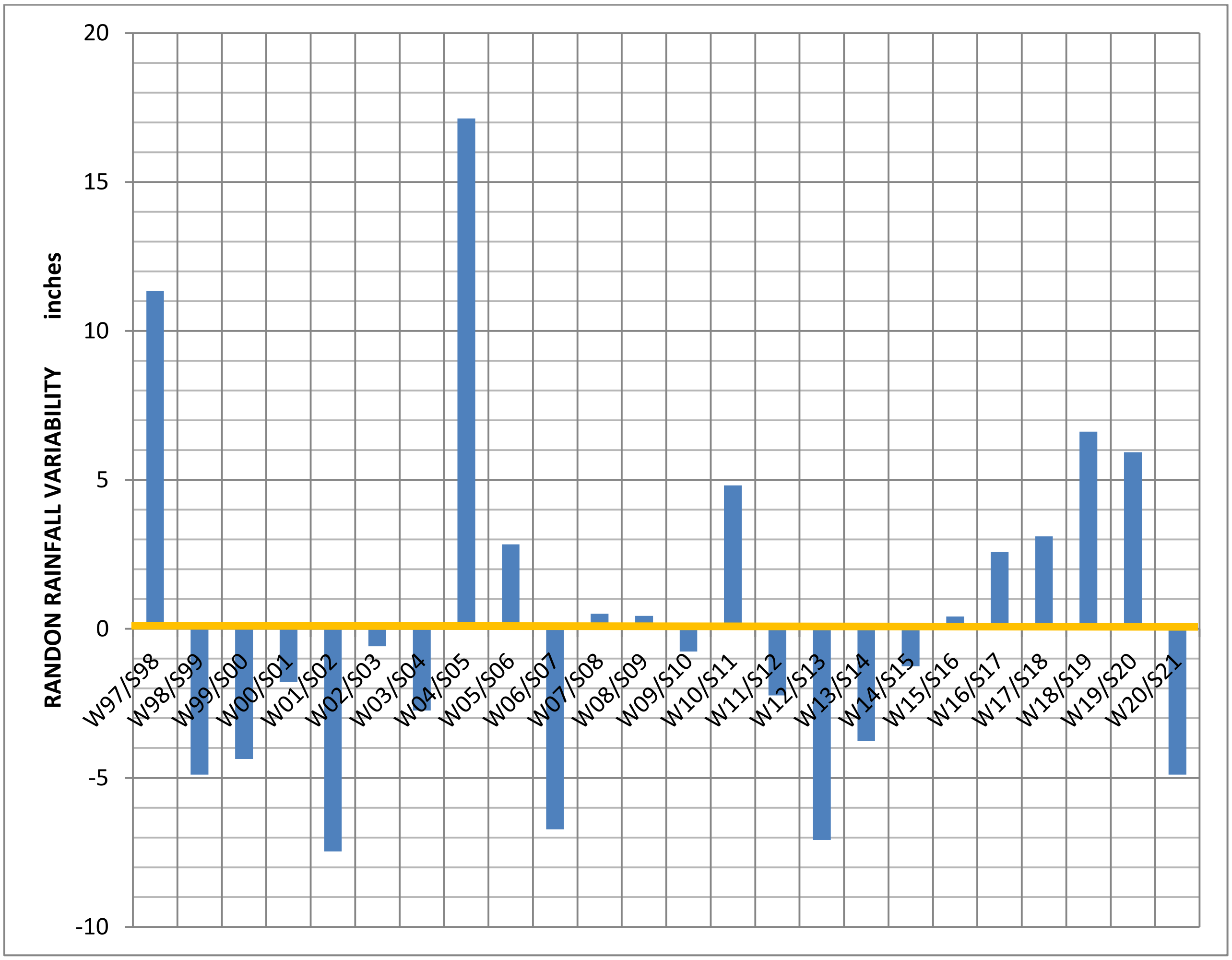

FIGURE 8: RANDOM VARIABILITY OF POPPY RESERVE SEASONAL RAINFALL

Figure 8 shows the profound impact of the narrow, approximately two hundred mile wide, atmospheric rivers which, although relatively frequently hit the west coast of North America, only infrequently take direct aim at the Poppy Reserve. Although these events are simply part of the natural variability of the Reserve's weather, they do make it harder to draw valid conclusions when analyzing the Reserve rainfall data. Because of their large variability, they have a large impact on any calculated trend line.

There is at least one more nugget in the tabulated rainfall data but, because of the need to get this article to the webmaster, doing the needed analysis is going to have to wait for a future article; stay tuned.

This article will conclude with two examples of how combining the rainfall data with the Reserve's temperature data displayed in Figure 4 has the potential for explaining the observed variations in the yearly poppy displays. The first example is the spring display of 2004. That was this author's second season as a Reserve volunteer. I started volunteering the previous spring because a happenstance hike at the Reserve in early February led me to conclude that that year was going to have super displays of poppies so why not get the best right away. Although there is no quantitative data to support my conclusion, in February of 2004, I felt that there were as many young poppy plants growing as the previous year and expected another outstanding poppy display season. That didn't happen; 2004 had rather poor poppy displays. So what happened? Figure 7 shows that the total seasonal rainfall during the winter/spring leading into the 2004 wildflower season was almost 2½ inches less than the previous year so the young wildflower plants had a significantly smaller reservoir of soil moisture to draw on. Storm timing was very comparable for the two seasons. Both seasons had rainstorms depositing 0.5 to 0.6 inches of rainfall in early November that likely resulted in a very limited amount of poppy seed germination. The first rainstorm that most likely resulted in a large amount of poppy seed germination didn't occur until mid-December of both years of 2002 and 2003. This relatively late first germination date made the smaller, less mature poppy plants susceptible to what subsequently happened with the Reserve's daily temperatures in 2004 as shown in Figure 4. In 2003, the Reserve's daily maximum temperature didn't reach even 80°F until the end of March while 2004 reached that temperature barely a week into March. Probably more telling, 2004's daily maximum temperature reached 90°F only a week and a half later in mid-March. These premature hot temperatures caused the soil's moisture to evaporate resulting in a vast majority of the young poppy plants to quickly die. Those few poppy plants that did survive the soil drying were permanently stunted and only produced one or two blossoms at any time. By the end of March, the 2004 poppy season was completely over. In contrast, the Reserve's daily maximum temperature didn't reach 90°F until mid-May; one of the latest dates in the last 23 years. A couple of inches of seasonal rainfall and an early hot spell were the difference between an outstanding color season and a poor one.

It should be noted that the 2002/2003 rainfall was approximately average for that time period and that was clearly adequate for producing outstanding, long lasting poppy displays but the 2003/2004 total rainfall of slightly over seven inches is only approximately the current average rainfall. This example points out how the current reduced rainfall pattern is putting the Reserve's wildflower displays at risk to at least earlier than normal hot spells.

This article's last example is a comparison between the 2019 and 2020 spring poppy seasons. It is not about differences in the quality of the poppy displays because both seasons had outstanding poppy displays. This discussion is about the notable differences in the duration of those outstanding poppy displays. In 2019, it was easy to observe healthy poppy plants with multiple large, still orange open blossoms even in mid-July of that summer, see Figure 9. In contrast, the poppy displays were essentially surprisingly over by the end of the first week in May. A satellite image taken of the Poppy Reserve, and surrounding area, on April 30, 2020 showed outstanding poppy color and yet only one week later there was no poppy blossoms to be seen.

FIGURE 9: POPPY RESERVE, PHOTOGRAPH TAKEN JULY 18, 2019

This comparison was previously discussed extensively in the Jun' 20 article; still posted on the PR/MDIA website, if you have an interest in reading it for context. That discussion ended with the difference in display durations still an unexplained mystery.

Differences in seasonal rainfall played no role in this mystery. Both seasons had almost identical total rainfall amounts as showed in Figure 7 and those rainfalls were almost twice the trend line average. It would seem that the soil had more than adequate reservoirs of moisture in both years for extended poppy display durations.

In the earlier article, air temperature was also investigated. The way air temperatures for 2019 and 2020 were compared in that article did not show any obvious differences to explain the poppy display duration differences. Figure 4 is simply a different way displaying the same temperature data set but Figure 4 highlights some obvious differences between the two years. The spring of 2020 appears to have been quite mild because that spring had the latest date the Reserve's daily maximum temperature reached 80°F of any of the twenty-three years temperature for which data are available. The daily maximum temperature first reached 80°F two weeks earlier in 2019. What happened next in 2020 appears to be most telling. That spring, the Reserve's daily maximum temperature first reached 90°F only four days later in late April and, a week and a half later than that, the poppy displays were over even with what appeared to be an adequate soil moisture reservoir. The poppy displays were long gone long before the Reserve first reached 100°F in early June of that summer. It appears that warm temperatures can trump even abundant seasonal rainfall totals, demonstrating the importance of tracking temperatures when predicting the impact of global warming on the Reserve's future poppy displays.

In contrast, the Reserve's daily maximum temperature did not reach 90°F until early June in 2019; the latest date for this milestone in the last twenty-three years. The available temperature data shows that the summer of 2019 also had the latest date of first reaching 100°F. Several weeks after that mid-July date, the poppy displays were largely over. A relatively mild early summer combined with an abundant reservoir of soil moisture resulted in the unusually extended poppy season in 2019.

The two, just discussed, examples seem to demonstrate the great promise of combining the Poppy Reserve's rainfall data with its temperature data in a format presented in Figure 4 for explaining both the quality and duration of the Reserve's poppy seasonal displays. Applying this same analysis technique to other seasons will help to confirm and refine this promise. Hopefully, this confirmation will be reported in future articles.

As always, I encourage everyone to continue to visit the Reserve throughout the year. During many years, you can see plant species blooming almost year around. Unfortunately, with the Reserve's limited rainfall last winter, there will likely be far fewer to observe this year. These are different plant species that you don't find during the spring season so you can add to your personal plant list. The autumn months have some of the best weather conditions – reasonable temperatures and mild winds. If you visit early enough, even the summer months can be quite nice.

If you have any questions, comments, corrections, want to add a year to the best poppy display year competition, or simply just want to say "hi", you can contact me at mfpowell@verizon.net. I always enjoy hearing from any readers. May all stay safe and healthy.