Temperature Data Collection
City of San Luis Water Distribution Network

Prepared for:

City of San Luis Public Works Department
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Director of Public Works

Prepared by:

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July 2015

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ARIZONA, U.S.A.
EXPIRES 9/30/16

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1. Introduction

The City of San Luis Public Works Department has retained the service of Nicklaus Engineering, Inc. (NEI) to collect temperature data on portions of the San Luis water distribution network that experience high water temperatures during the summer. According to public works staff, affected residents have stated that temperatures at their tap can reach temperatures well over a hundred degrees Fahrenheit for long periods of time. The purpose of the data collection was to gain a better understanding of the scope of the problem and to see if patterns emerge from the data that may hint at viable solutions. The scope of the initial phase of this data collection was a small trouble area of the distribution network known to be an area that experiences elevated temperatures.

2. Data Collection

Data was collected over a three day period starting July 6, 2015 and ending July 8, 2015. Temperature was measured at various locations in the network at two times per day, once in the morning at approximately 8AM and once in the evening at approximately 4PM.

The locations where the data was collected can be found on the Temperature Sampling Map (Attachment A). The trouble area selected for the study included two streets both ending in a cul-de-sac in the Frontera Estates Subdivision: Washington Lane and San Luis Lane. Samples were collected systematically in order to map how the temperature changes as the water makes its way through the distribution network. The data was first collected at Well Site #3, the closest water source to the trouble area, and was collected at various hydrants along the loop feeding the trouble area. Additionally, samples were taken at Well Site #2 which is the next closest water source. Then, samples were collected on the dead end mains at the end of each cul-de-sac. Finally, samples were taken at various residences within each cul-de-sac; one from an outside hose bib, and one inside at a bathroom faucet. Every attempt was made to collect samples at the same locations for the three day period. However, if a resident was not available another residence was sampled.

At each location, water was collected in a beaker and measured with a laboratory quality digital thermometer. The initial temperature was collected immediately upon opening the valve and filling the beaker, and another sample was taken after letting the water flow for two minutes.

3. Analysis

The collected data can be found summarized on the Temperature Sampling Map (Attachment A). Here, the average temperatures for the test period are shown at each of the sample locations. Additionally, the average ambient air temperature, average soil temperature at a depth of four inches, and the average soil temperature at a depth of twenty inches is shown for comparison. These temperatures were taken from the Yuma South station of the Arizona Meteorological Network maintained by the University of Arizona. Additionally, a water main temperature range is shown. This range is estimated from the samples along the main closest to a given location. As can be seen from the map, the water leaving Well Site #3 is estimated to be between 78˚F and 84˚F. Then as it heads toward Well Site #1 and the loop feeding Washington Lane and San Luis Lane it increases to be between 84˚F and 90˚ F. Finally, as the water enters the dead end mains on the two cul-de-sacs it jumps again to be between 90˚F and 96˚F, with the very end of the mains increasing to be between 96˚F and 102˚F.

In the Location Temperature Data (Attachment B), the temperature data at each location for each sample time is graphed along with the nearest hydrant temperature, ambient air temperature, four inch soil temperature, and twenty inch soil temperature. Additionally, the average of these temperatures over the sample period is also graphed. In reviewing this data and the associated map, the following observations can be made:

Well Site #3

The water at Well Site #3 is relatively isolated from the large daily temperature swings in both ambient air and soil temperatures. This is as expected as the water entering the treatment system is at an approximate ground water temperature between 72˚F and 75˚F, and the large volume of stored water in the storage tank helps to keep that temperature from rising too rapidly. The entire treatment and storage process only increases the temperature three to six degrees.

Well Site #1

The water at Well Site #1, while isolated from the large daily temperature swings, is much warmer than the water leaving Well Site #3. This well site has a much smaller storage tank that can heat up much more rapidly. Additionally, there is a possibility that the well site wasn't in operation during afternoon sampling. The average temperature leaving this well site is 87˚F which close to the temperature of the entire loop feeding the trouble area.

B St. & 5th Ave.

Sampling at this location dramatically shows the heating that can take place in a dead end line connected to a hydrant, valve, or other such appurtenance. The average initial temperature at this location is 104˚F, however after a two minute flush the temperature drops down to the line temperature of 83˚F. This twenty degree swing in temperature can be understood by looking at drawing 5-120 of the Public Works Standards for Yuma County, Volume 1. This drawing shows the typical fire hydrant layout that can be expected throughout the City of San Luis. As the drawing depicts, a steel fire hydrant is connected to a ductile iron pipe down to a ductile iron elbow before connection to another type of pipe material (PVC, ACP, RCP etc.). Steel has a thermal conductivity of approximately 50 Watts per meter per degree Kelvin (W/m K). The thermal conductivity of a dry soil is approximately 0.15 W/m K and the thermal conductivity of water is approximately 0.58 W/m K. This shows that as the hydrant is heated by direct exposure to the sun it will easily transfer that heat through the ductile iron pipe down into the water main, and into the water. Though the water main is at a depth of 42 inches and the likely soil temperature is only 75˚F to 78˚F, the pipe is conducting surface heat down to that depth where it conducts much more easily into the water than into the soil, effectively heating the water to very high temperatures. Not all of the hydrants tested show such a large swing in temperature. This may be due to the amount of water flowing past the hydrant etc. However, this example shows the primary means by which heat is entering the water main system.

San Luis Lane

Sampling at this location again shows heating of the dead end hydrant line as the difference between the initial and two minute flush temperatures was as high as twenty degrees. Additionally, it shows that the estimated main temperature is higher on these dead end mains than is found out on the looped portion of the system.

1135 San Luis Lane

This location is the most extreme example of service line heating found. Initially low temperatures within the house rise dramatically to 116˚F in one case after a two minute flush. Running the tap for two minutes is not enough time to clear out the very hot water within the service line. Looking at drawing 5-150 and 5-151 of the Public Works Standards for Yuma County, Volume 1, it seems reasonable that this line could be heated to such an extent. The service is connected to the main with a copper pipe. Copper has a thermal conductivity of approximately 400 W/m K. This is very high as copper is and extremely efficient conductor of heat. If this line is made of another type of material with a much lower thermal conductivity, it is still possible for the water itself to conduct water down to the main and or service piping. The water service line then goes from a depth of 42 inches at the main to 24 inches over to the meter box where the soil temperature is approximately 83˚F (as opposed to 75˚F at the water main depth). The meter box is only 12 inches from the surface with the top of the meter only a few inches from the surface. Though not in direct sunlight, the temperature of the meter housing can be expected to be very close to ambient. Then, depending on the construction, the service line travels to the house at a shallow depth. Additionally, if the water lines in the house travel through the attic rather than through the floor, the line remains at this elevated temperature resulting in a potential run of pipe of 80 feet or more. With this very long run of service line at very high temperatures, it could take well over two minutes to reach the temperature at the main which is already over 90˚F.

4. Conclusions

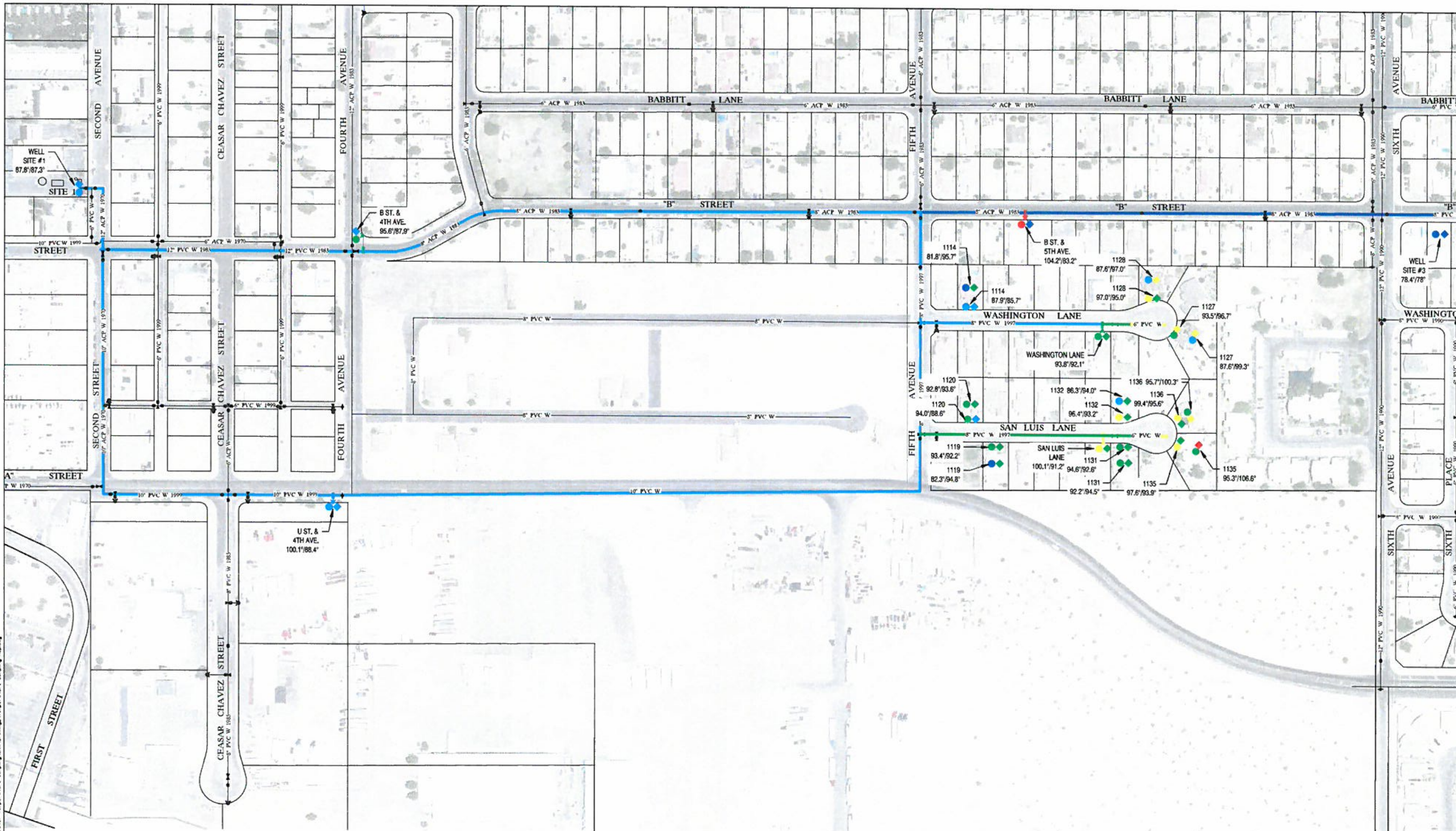
The temperature sampling shows that high temperature in the service lines feeding the houses is a significant problem. Temperatures at the tap of 116˚F were recorded after flushing the line for two minutes. This water temperature is close to the recommended setting for a typical household water heater. These high temperatures are due to low flow water mains that are being heated through surface appurtenances, and water service lines that are shallow and connected to water meters located near the ground surface. In some residences, a two minute flush period is not sufficient to reduce the temperature to main line temperatures. If household water piping is ran through the attic, the length of service piping can greatly increase the amount of time it takes to get main line water temperatures.

If service line piping is constructed according to Yuma County public works standards, as is expected, the configuration is similar to what is used all over the state. Copper service taps at the main are standard practice, and the water meter box is set at a standard depth. Changes to these standards could be made to help keep these temperatures at lower levels. Eliminating dead end mains, keeping service line piping at water main depths, changing piping materials and insulating shallow service lines near the meters, and running household piping through the foundation rather than through the attic are all measures that may help to isolate the water system from high temperatures. The impact of any or all of these measures is difficult to quantify without further testing and analysis.

Moving forward, one avenue of investigation that could be pursued would be to pothole the service piping of one or more of these residences to determine the actual buried depth of the line. Also, an investigation to determine where the internal piping in the residence is run may be helpful. A pilot study can be conducted to modify the service piping of one or more of these residences to lower the pipe down to the water main depth, change the pipe materials as the line comes up to the meter, lowering and potentially insulating the meters and meter boxes, etc. In this way, the actual impact of these changes can be determined and appropriate useful changes to construction standards can be made.

Attachment A

Temperature Sampling Map



NOTES:

AVERAGE AMBIENT AIR TEMPERATURE = 95°
AVERAGE 4" SOIL TEMPERATURE = 91°
AVERAGE 20" SOIL TEMPERATURE = 83°

LEGEND

TEMPERATURE RANGE	ESTIMATED WATER MAIN TEMPERATURE	AVERAGE INITIAL TEMPERATURE	AVERAGE 2 MINUTE FLUSH TEMPERATURE
78° - 84°	dark blue line	●	◆
84° - 90°	light blue line	●	◆
90° - 96°	green line	●	◆
96° - 102°	yellow line	●	◆
102° - 108°	red line	●	◆

LOCATION NAME
1119
78°/84°
AVERAGE INITIAL TEMPERATURE
AVERAGE 2 MIN. FLUSH TEMPERATURE

San Luis Water System Temperature

Temperature Sampling Map

SCALE:	AS SHOWN
DATE:	July, 2015
DES. BY:	
DRAWN BY:	D.K.J.
SURVEYED BY:	
JOB. No.:	015-0114
FILE No.:	
SHEET	OF

Nicklaus Engineering Inc.
1851 West 24th Street P.O. Box 6029
YUMA, ARIZONA 85364 (928)344-8374
Email: nei@nelaw.com

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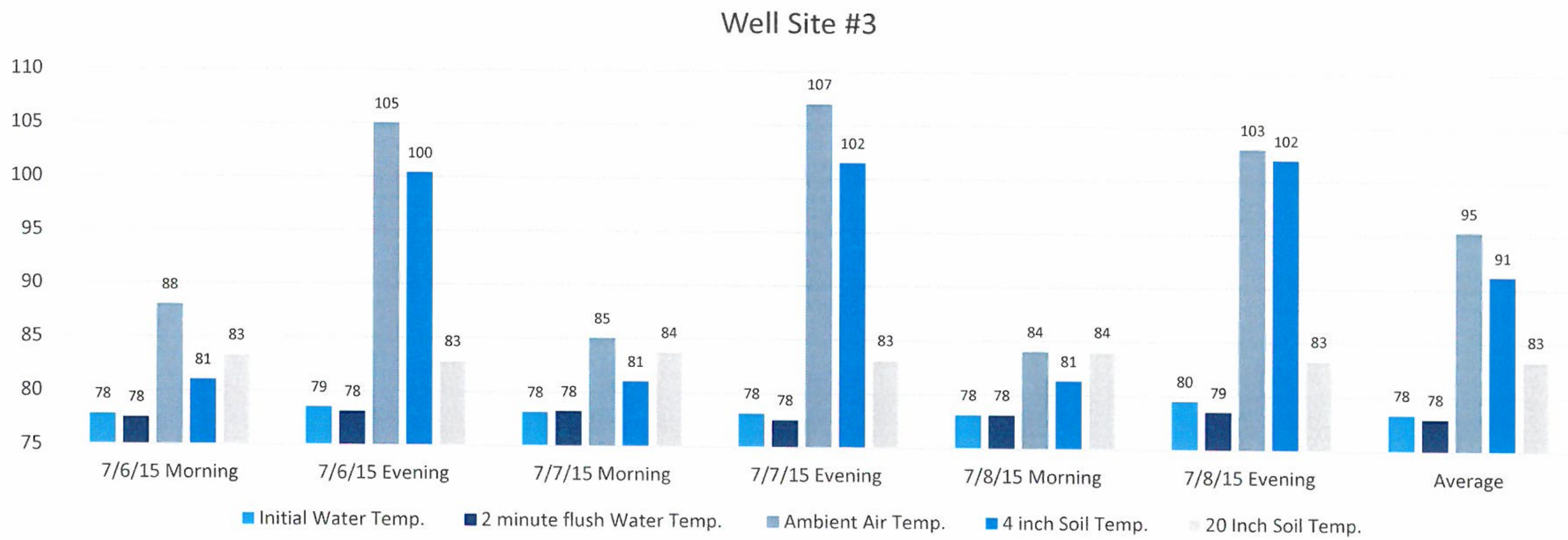
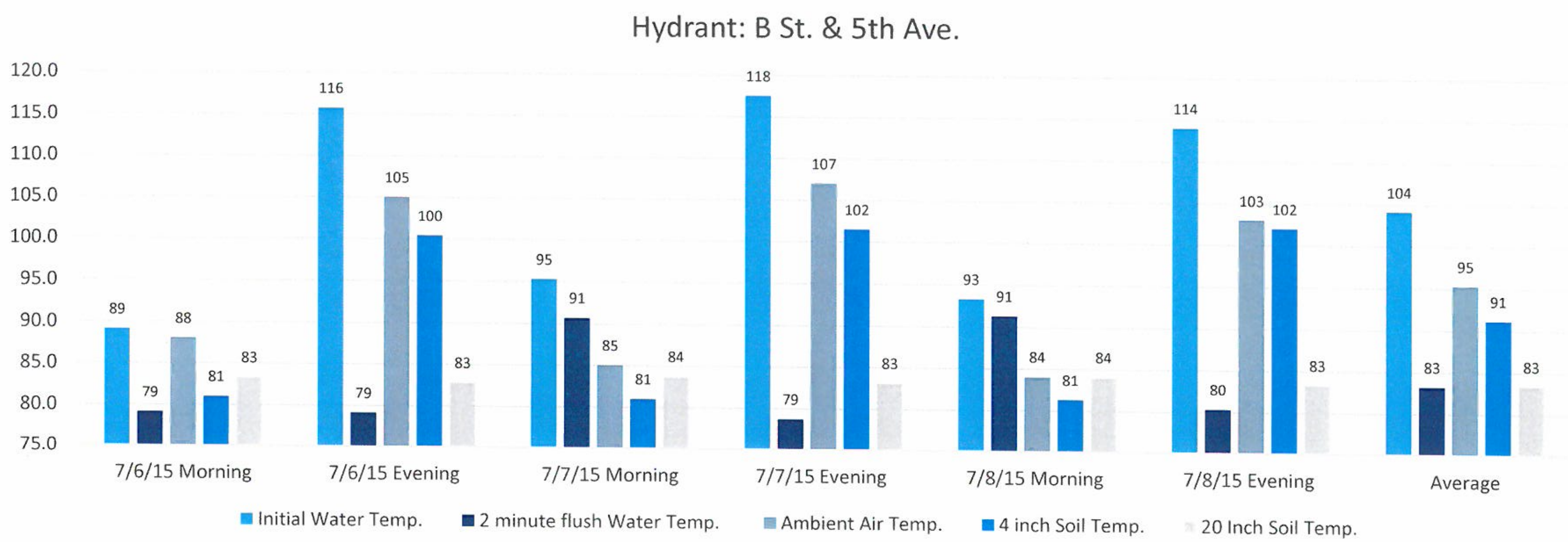
Attachment B

Location Temperature Data

San Luis Water System Temperature

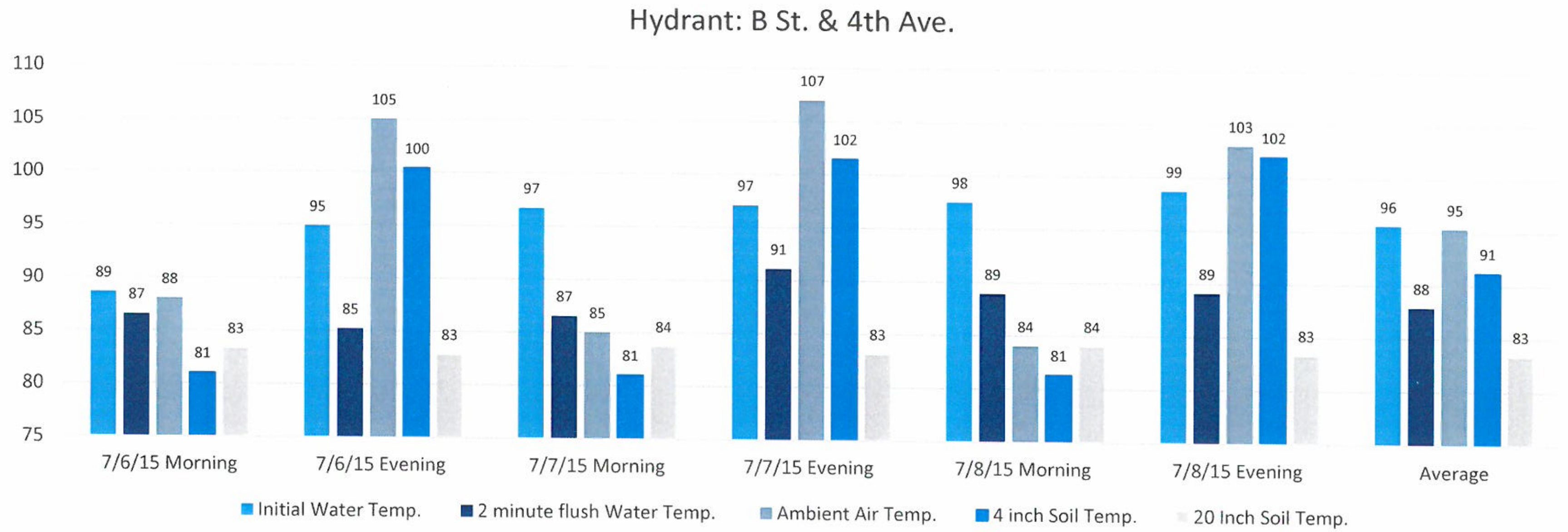
July 6 - July 8 2015 Sampling Data (Degrees Fahrenheit)

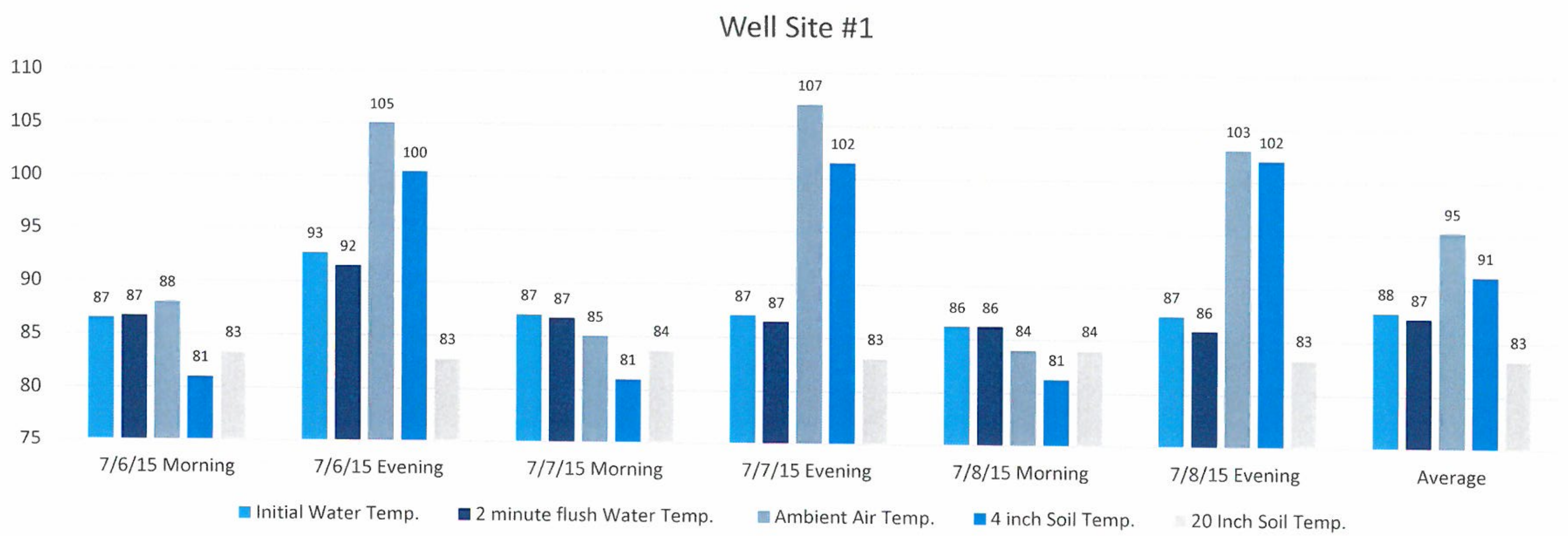




San Luis Water System Temperature

July 6 - July 8 2015 Sampling Data (Degrees Fahrenheit)

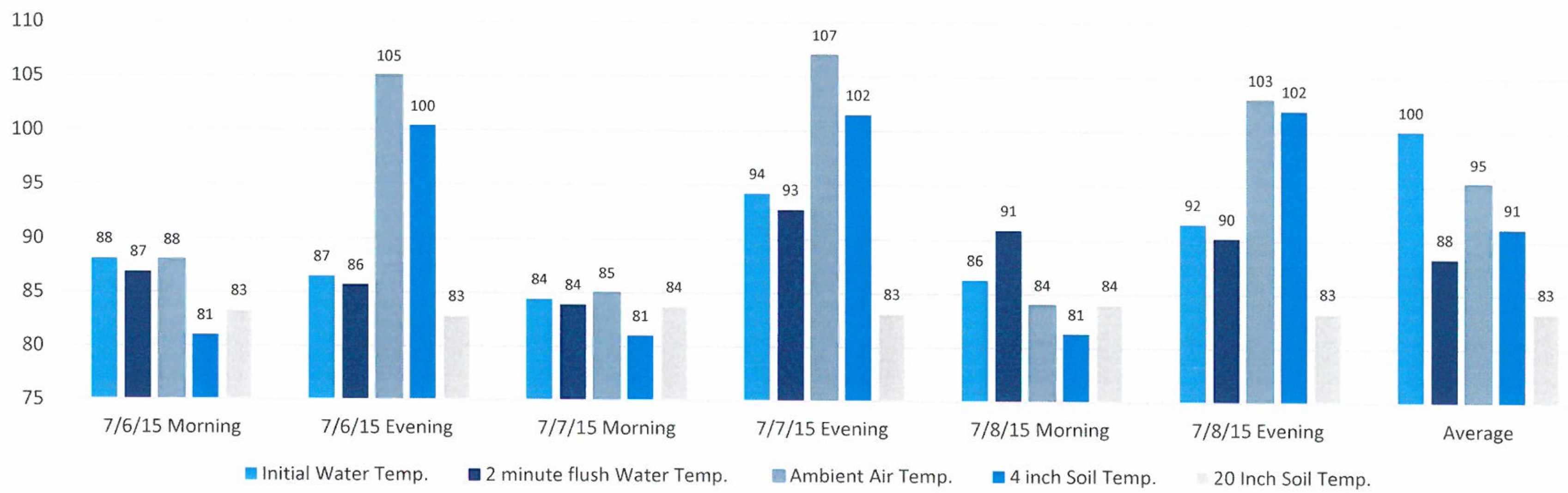




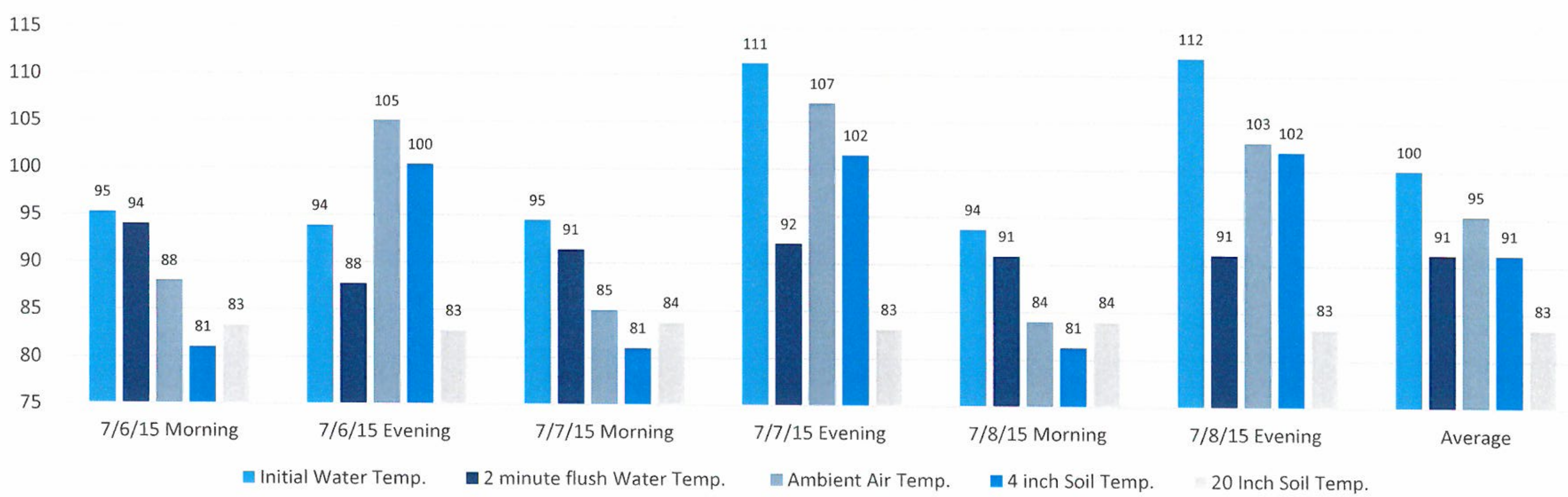
San Luis Water System Temperature

July 6 - July 8 2015 Sampling Data (Degrees Fahrenheit)

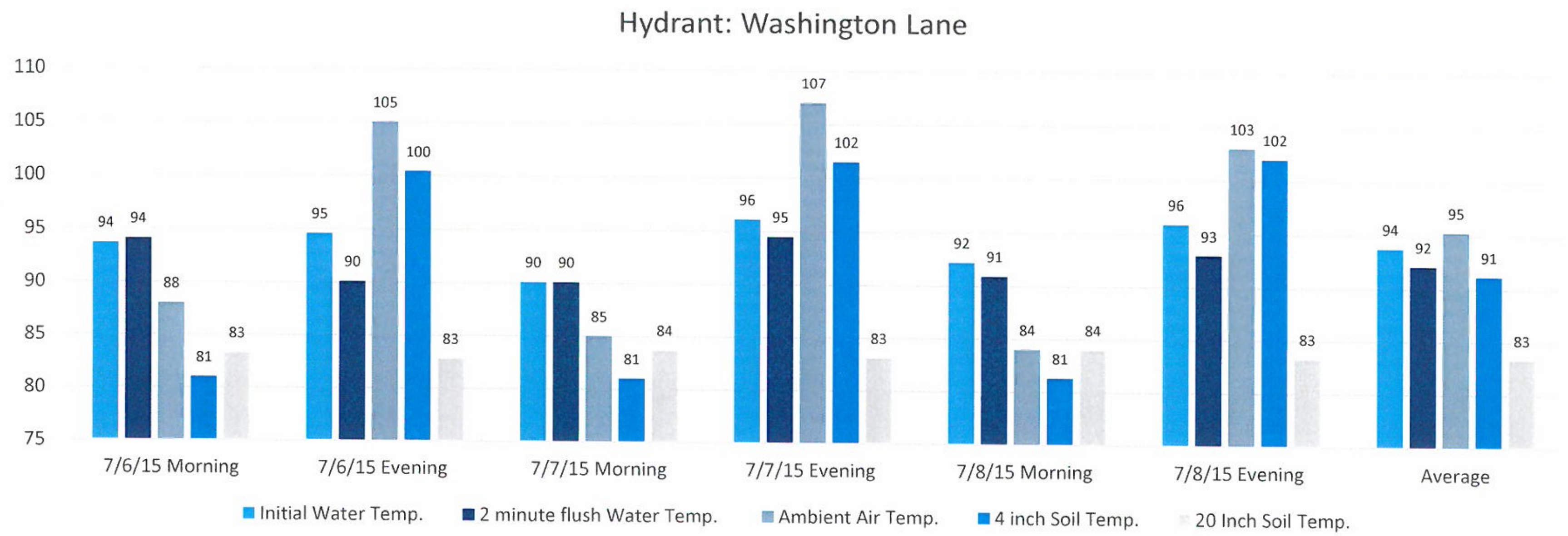
Hydrant: U St. & 5th Ave.



Hydrant: San Luis Lane



San Luis Water System Temperature
July 6 - July 8 2015 Sampling Data (Degrees Fahrenheit)



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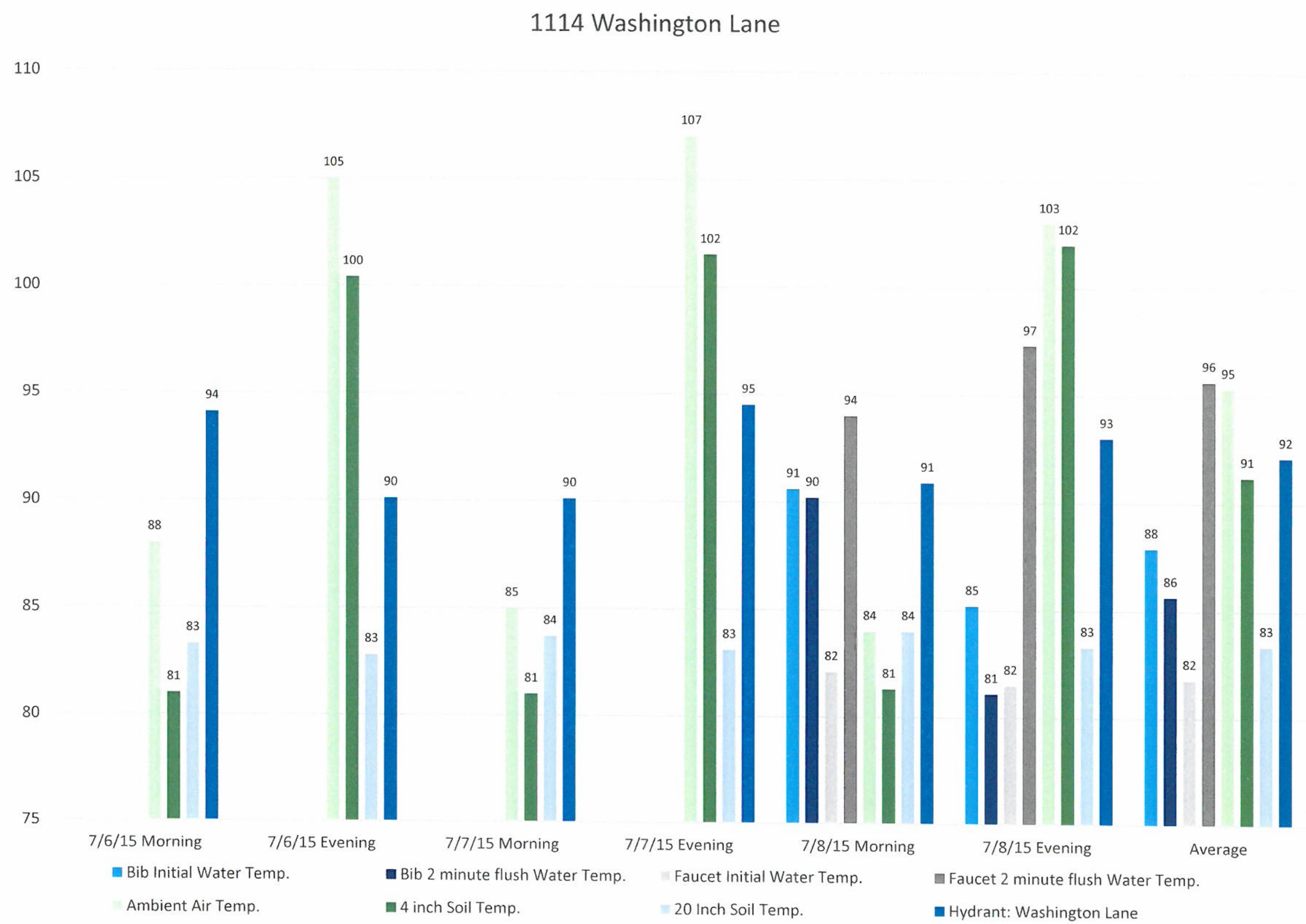

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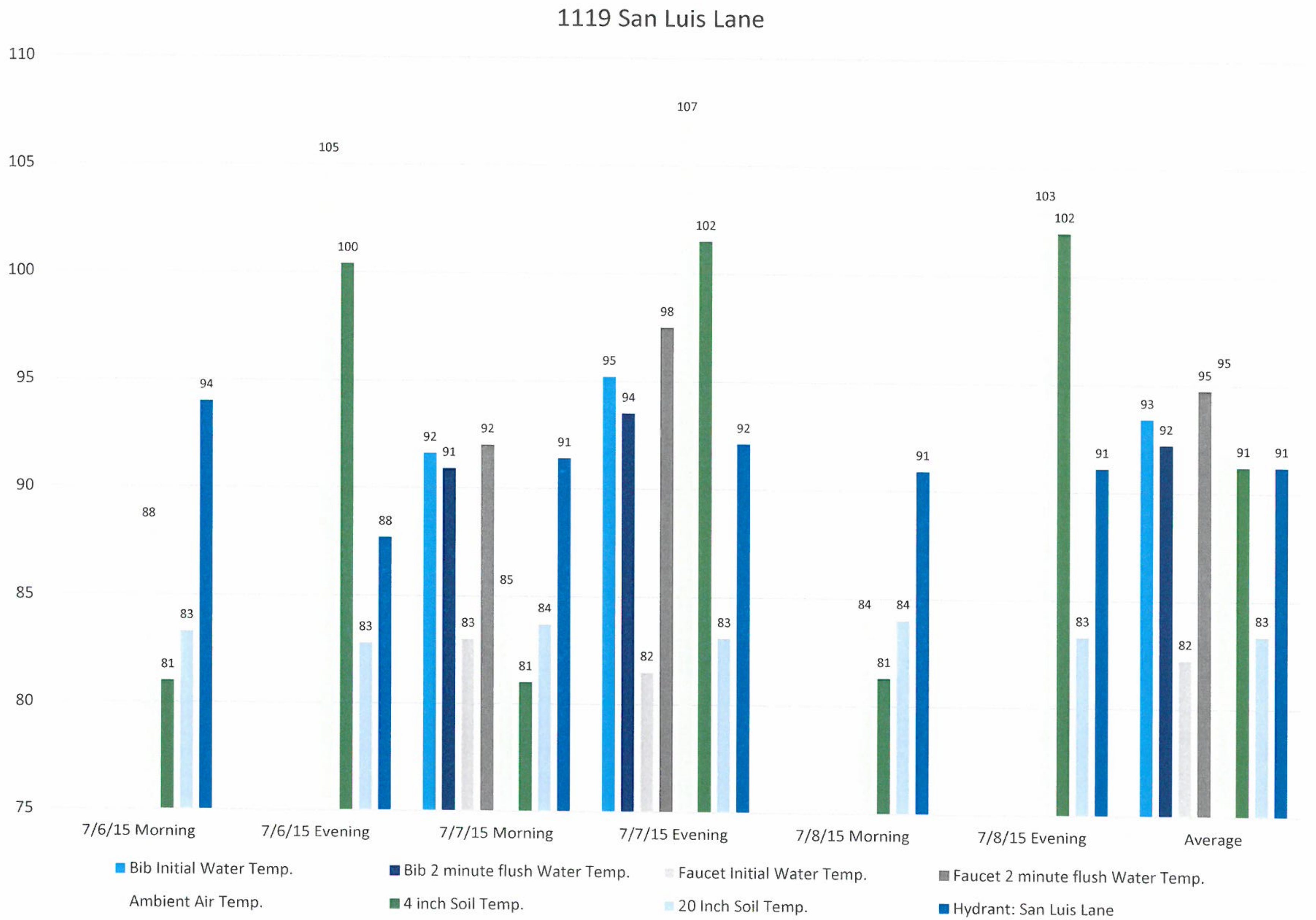

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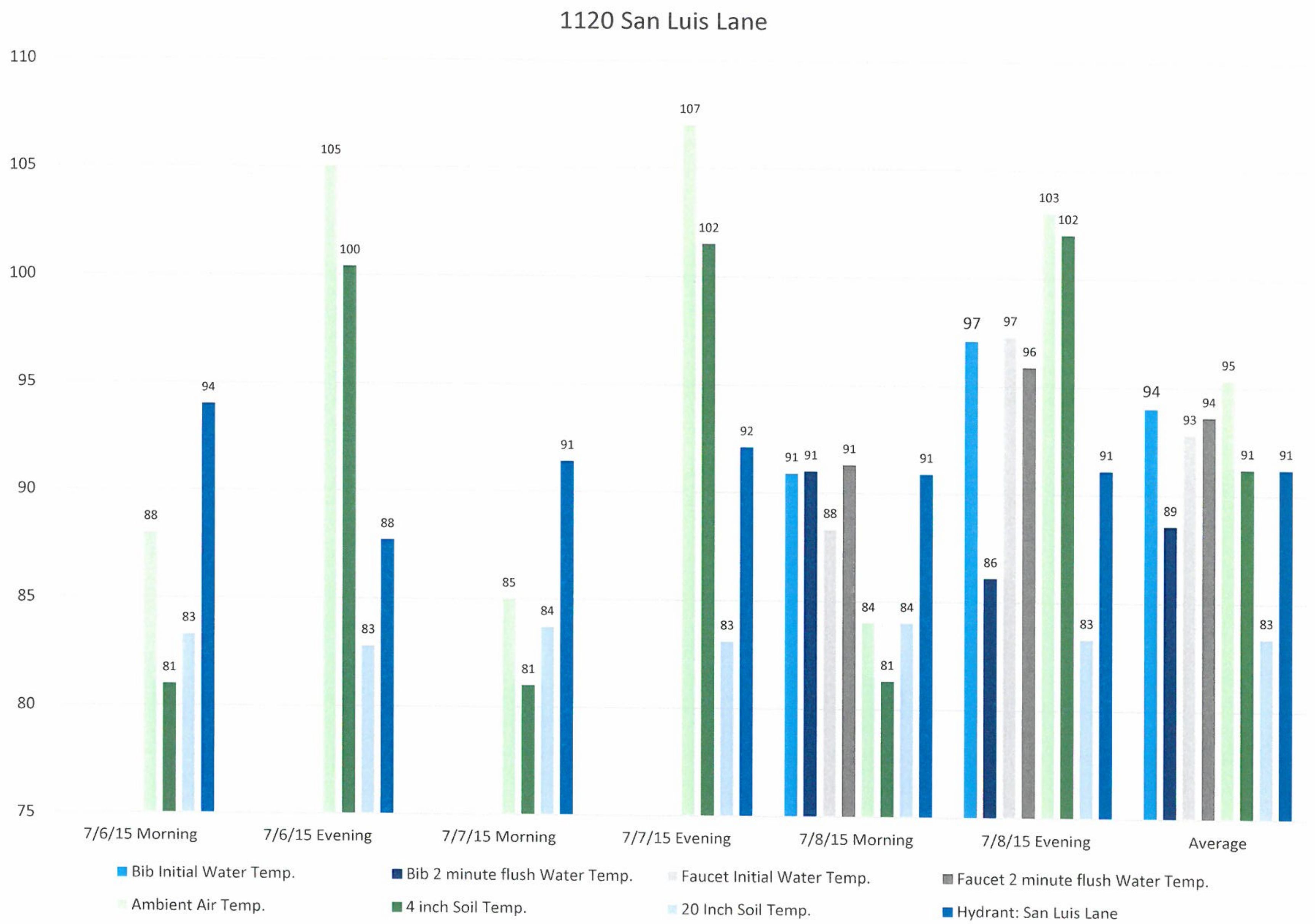

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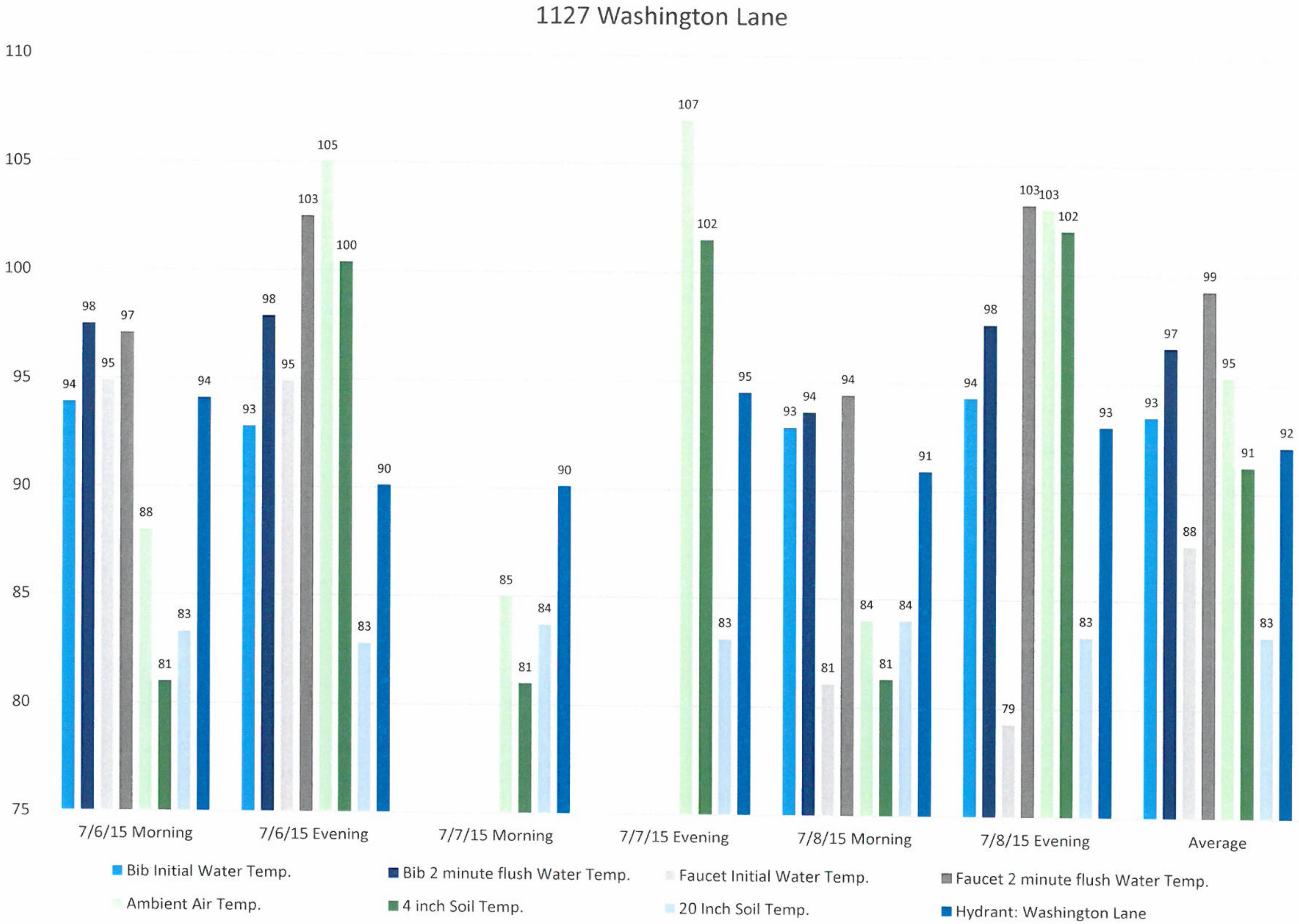

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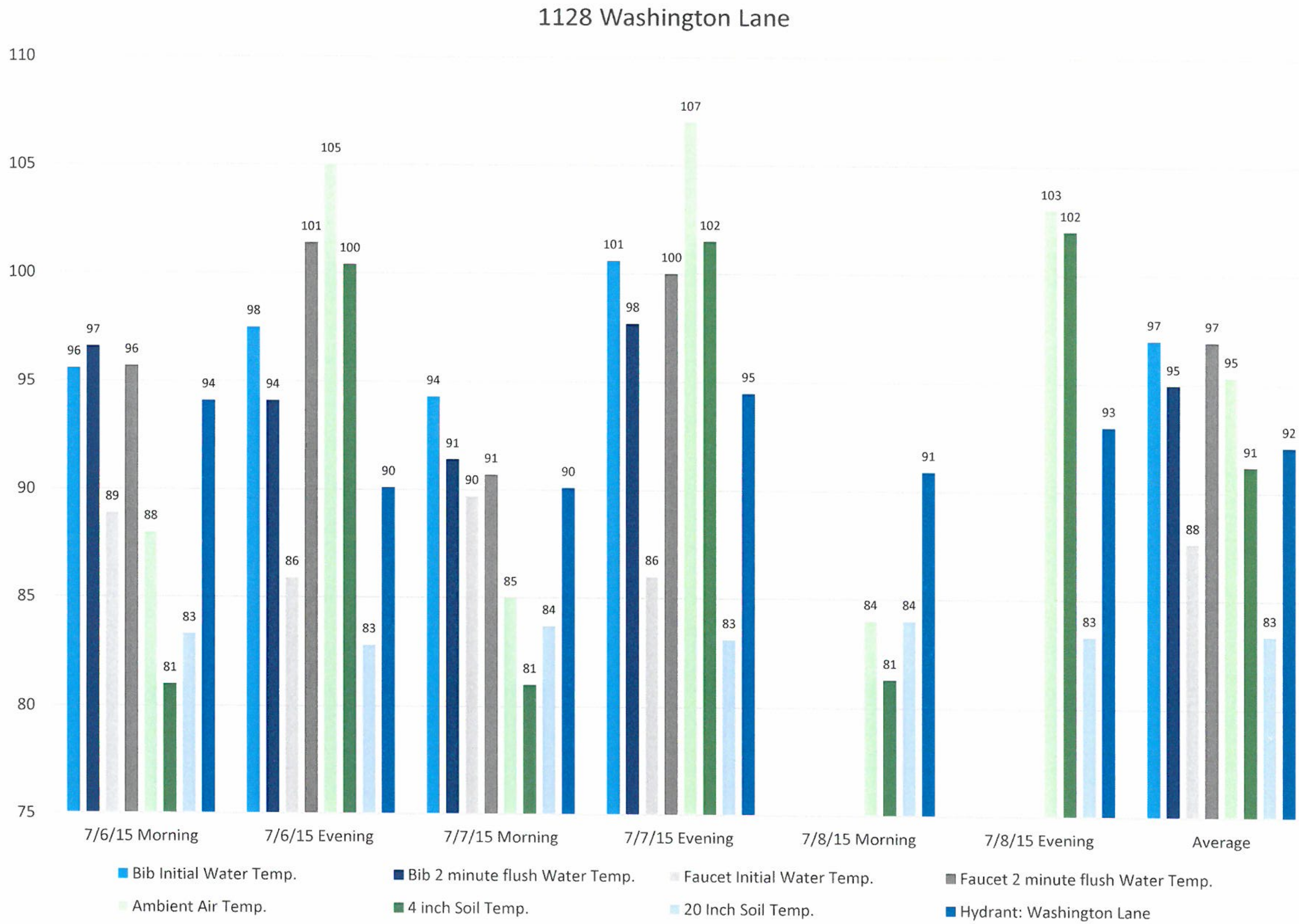

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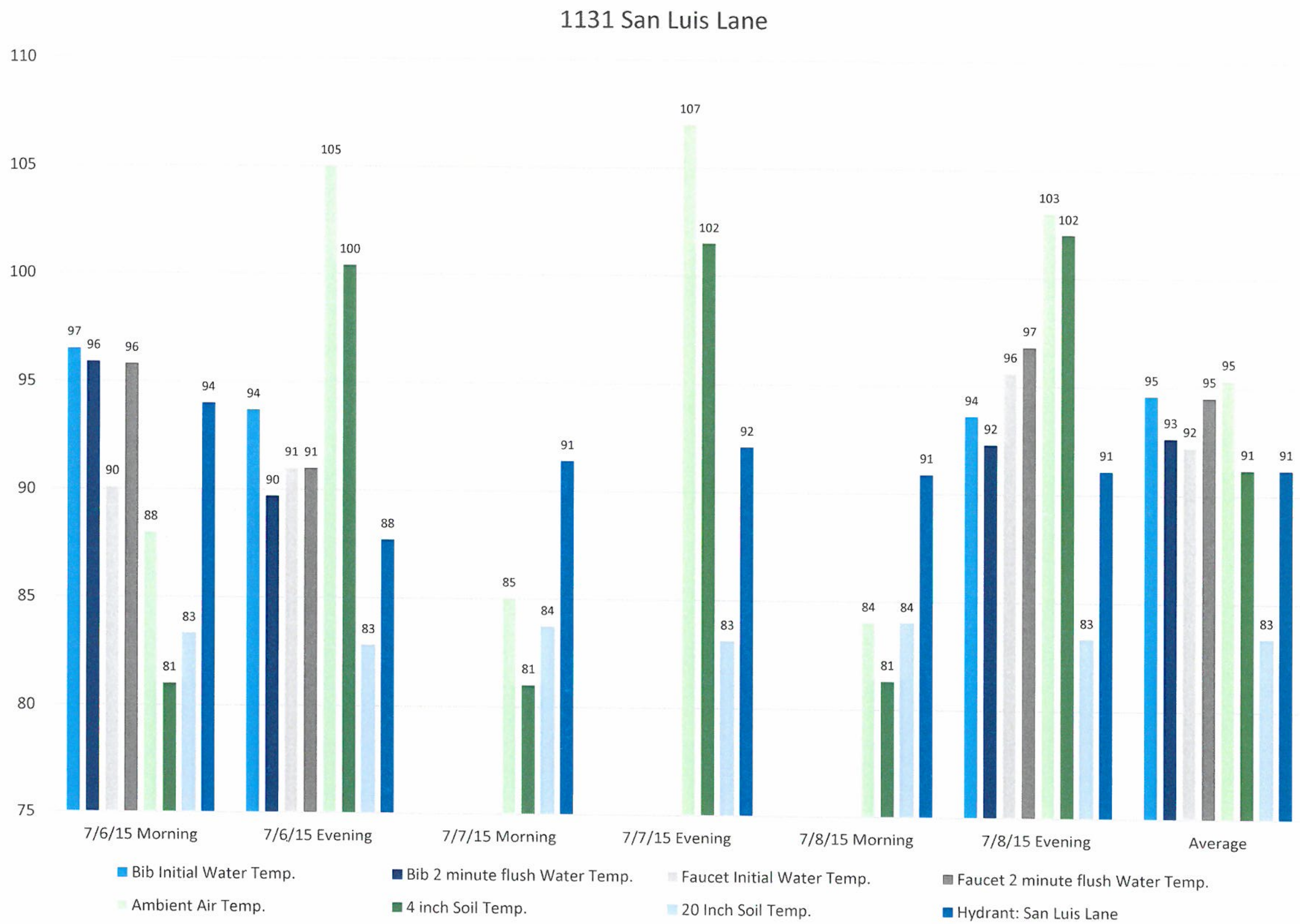

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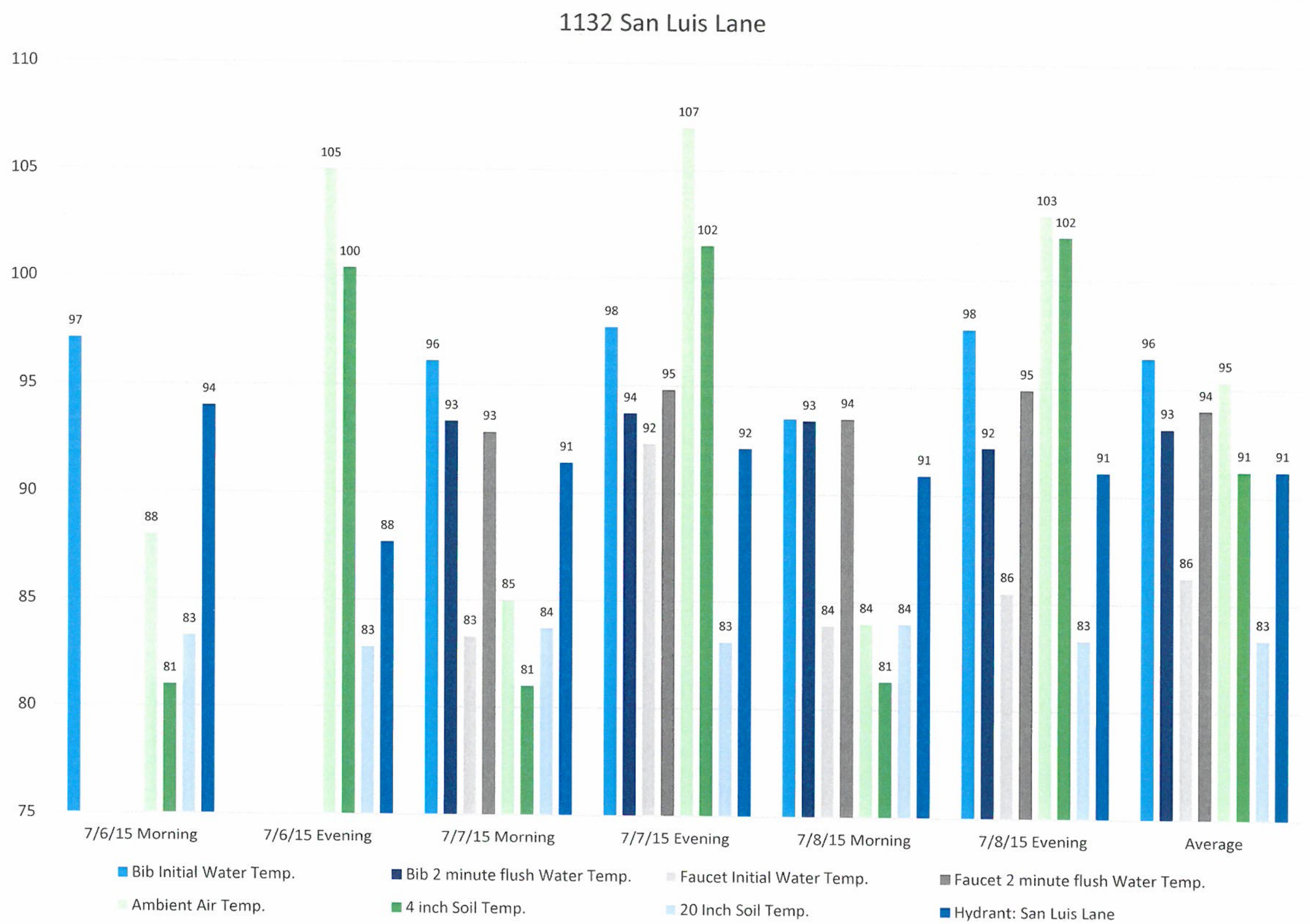

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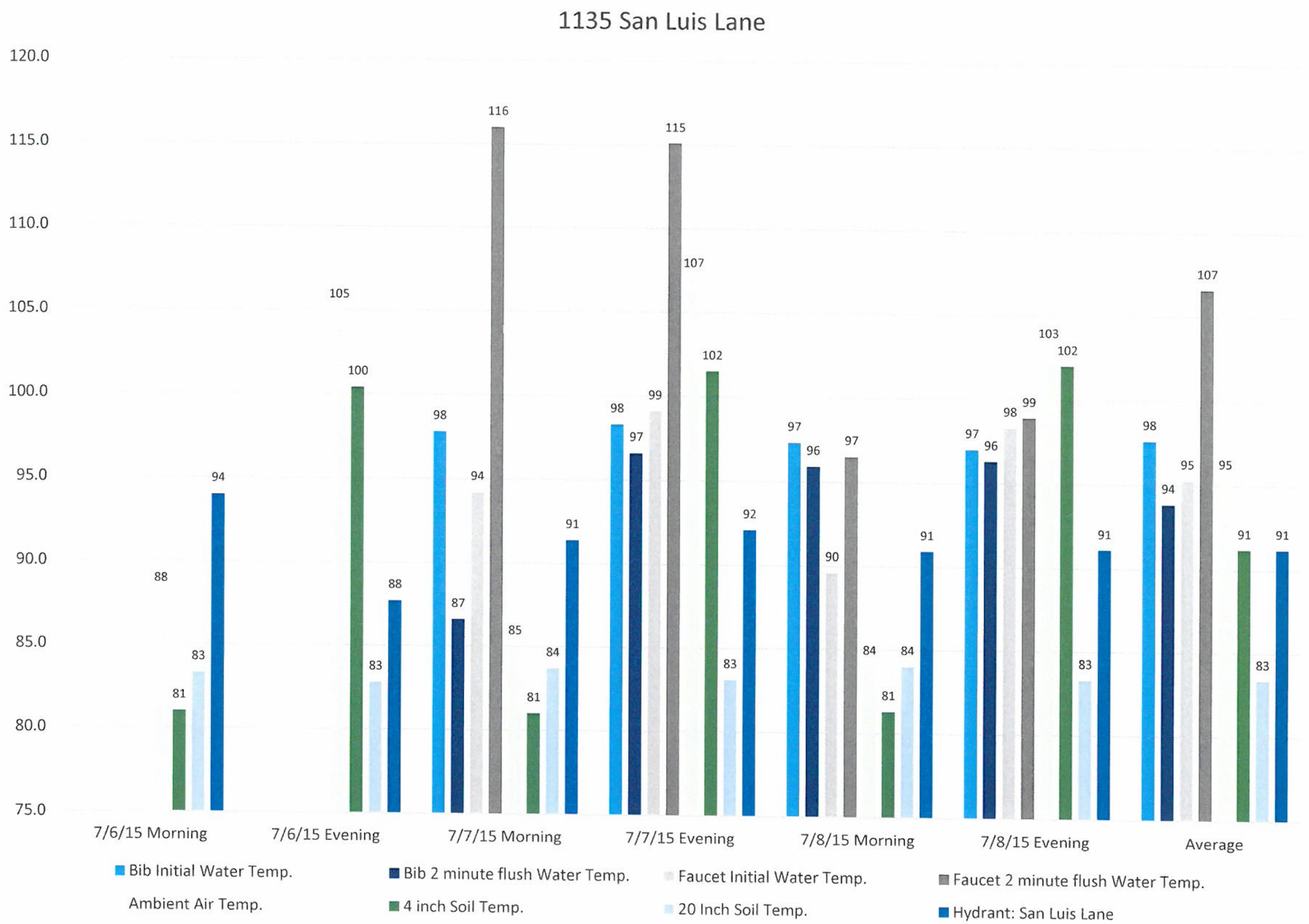

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