Piney Point Influent Flow Peaking Factor Analysis

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Client: MetCom

Project Name: Piney Point Wastewater Pump Station Flow Monitoring and Inflow & Infiltration Characterization Study

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Background

Piney Point Wastewater Pump Station (WWPS) is one of four pump stations in St. Mary's Metropolitan Commission (MetCom) Sanitary District (SD) #5. Piney Point WWPS receives flow from 580 other low-pressure sewer grinder pumps and three (3) other pump stations in the district. SD #5 is mostly a low-density residential area, with industrial and town center mix-use. From Piney Point WWPS, the wastewater is pumped to Marlay-Taylor Water Reclamation Facility (MTWRF).

To characterize inflow and infiltration to Piney Point WWPS, Jacobs is currently metering sewer flows at three (3) inflow points near the Piney Point Influent Pump Station (IPS). The six (6) month monitoring period started in September of 2023 and ends in March of 2024. Jacobs is also tasked with completing the design for the Piney Point WWPS upgrades and to confirm that the current future design capacity is less than the planned wet weather design flows to the WWPS.

MetCom has tasked Jacobs to develop wet weather peaking for Piney Point using the first three (3) months of flow monitoring data and three (3) calendar years of historical SCADA data spanning from January 2020 through December 2023. The SCADA data provides instantaneous data on pump cycling and wet well level changes at the influent pump station of Piney Point WWPS. The flow meters provide 5-minute flow rate readings.

The contents of this Technical Memorandum (TM) summarize the analysis, results, and key findings of wet weather peaking factors developed for Piney Point from the flow meter and SCADA data.

Data Analysis

Per Maryland Department of Environment (MDE) *Design Guidelines for Wastewater Facilities*[1], peaking factors are to be calculated independently for each full consecutive calendar year examined. Then, the highest peaking factor on either an hourly, daily, or monthly basis is selected using the following equation:

$$Peaking\ Factor\ (PF) = \frac{Peak\ flow\ for\ the\ calendar\ year\ (hourly, daily, or\ monthly)}{Average\ daily\ flow\ for\ the\ calendar\ year}$$

Historical SCADA data was used to develop peaking factors for calendar years 2020 to 2023. Hourly, daily, and monthly flowrates were calculated by finding a rolling average of the estimated inflow volume at each timestep of the SCADA data. Inflow volume was calculated based on pump runtimes, estimate pump capacities for one and two pump operation, and active storage volumes. Then, the maximum value, or peak flow, from each rolling average at each temporal resolution was taken and divided by the average daily flow for the respective calendar year. The average daily flow was calculated from the estimated total inflow for the calendar year.

In addition to the SCADA data, flow monitoring data was recorded from September 20, 2023, to December 31, 2023. The flow meter records a flow rate in millions of gallons per day (MGD) every five minutes. This data is preliminary and not intended to be a report of final results, which will be provided in the I/I Characterization Report. Peaking factors were calculated from the meter data based on hourly, daily, and monthly rolling averages similarly to what was done for the SCADA data. Because monitoring began part way through September, a monthly flow rate was not calculated only for the month of September and excluded from the summary statistics presented in Table 1 and Table 2. Similarly, peak hourly and daily flowrates were found only for complete hours and days and incomplete hours and days were excluded from summary statistics.

Results

Peaking factors found for the calendar years 2020 to 2023 and respectively flow rates are presented below:

Table 1. Calendar Years 2020 to 2023 Peaking Factors

Data			Peaking Factors		
Year	Duration	Source	Hourly	Daily	Monthly
2020	Calendar Year	SCADA	12.6	6.2	1.3
2021	Calendar Year	SCADA	14.2	4.7	1.3
2022	Calendar Year	SCADA	8.3	4.8	1.3
2023	Calendar Year	SCADA	12.7	6.0	1.4
2023	9/20/2023-12/31/2023	SCADA	10.2	5.5	1.3
Meter	9/20/2023-12/31/2023	Meter	9.2	4.1	1.1

Table 2. Calendar Years 2020 to 2023 Flow Rate Summary

Flow Rates, gpm (mgd)						
Year	2020	2021	2022	2023	2023*	Meter*
Average	89 (0.1)	83 (0.1)	89 (0.1)	81 (0.1)	88 (0.1)	86 (0.1)
Hourly						
Peak	1,124 (1.6)	1,168 (1.7)	742 (1.1)	1,031 (1.5)	869 (1.3)	787 (1.1)
Min	14 (<0.1)	3 (<0.1)	6 (<0.1)	13 (<0.1)	16 (<0.1)	13 (<0.1)
Daily						
Peak	553 (0.8)	389 (0.6)	425 (0.6)	483 (0.7)	483 (0.7)	353 (0.5)
Min	52 (0.1)	31 (<0.1)	50 (0.1)	48 (0.1)	48 (0.1)	51 (0.1)
Monthly						
Peak	116 (0.2)	105 (0.2)	112 (0.2)	115 (0.2)	115 (0.2)	92 (0.1)
Min	66 (0.1)	69 (0.1)	64 (0.1)	68 (0.1)	70 (0.1)	73 (0.1)

*Flow rate calculated from 9/20/2023 to 12/31/2023

Wet Weather Events

For calendar year 2020, the peak hourly flow rate of 1,124 gpm (1.6 mgd) and peak daily flow rate of 553 gpm (0.8 mgd) both occurred on August 4th, 2020. On this day, the peak hourly rainfall was 0.57 inches with a peak daily rainfall of 4.2 inches. The peak hourly rainfall for the calendar year occurred on July 6th, 2020, at an hourly accumulation of 1.13 inches. The peak daily rainfall for the calendar year occurred on November 12th, 2020, at a daily accumulation of 4.52 inches.

For calendar year 2021, the peak hourly flow rate of 1,168 gpm (1.7 mgd) occurred on July 8th, 2021, while the peak daily flow rate of 389 gpm (0.6 mgd) occurred the following on July 9th, 2021. Across these two days, the peak hourly rainfall was 1.74 inches, which is the peak hourly rainfall for the calendar year, with a peak daily rainfall of 3.07 inches. Rainfall during July 8th and 9th is associated to Tropical Storm Elsa, which was in the vicinity during this time. The peak rainfall event recorded for the calendar year occurred on June 10th, 2021, where a total of 3.67 inches of rainfall was recorded.

For calendar year 2022, the peak hourly flow rate of 742 gpm (1.1 mgd) occurred on December 15th, 2022, while the peak daily flow rate of 425 gpm (0.6 mgd) occurred on December 23rd, 2022. The peak hourly rainfall attributed to these two days is a peak hourly rainfall of 0.45 inches and 0.32 inches, respectively. The peak daily rainfall attributed also attributed to these two days is 2.17 and 1.23 inches, respectively. For the calendar year, the peak hourly rainfall of 0.93 inches occurred on March 17th, 2020, and the peak daily rainfall of 2.45 inches occurred on May 14th, 2020.

For calendar year 2023, the peak hourly flow rate of 1,031 gpm (1.5 mgd) occurred on April 30th, 2023, and the peak daily flow rate of 483 gpm (0.7 mgd) occurred on December 11th, 2023. The peak daily rainfall also occurred on December 11th, with a total accumulation of 2.98 inches. On April 30th, a peak hourly rainfall of 0.58 inches and a peak daily rainfall of 1.25 inches were recorded. For the calendar year, the peak hourly rainfall occurred on July 14th, with a total hourly accumulation of 0.65 inches.

Figure 1 shows the NOAA Atlas 14 precipitation frequency curves. From this, the frequency of peak rainfall events can be determined. Table 3 summaries the frequency of each peak rainfall event from 2020 to 2023 calendar years.

Figure 1. NOAA Atlas 14 Partial Duration Series (PDS)-Based Precipitation Frequency Curves

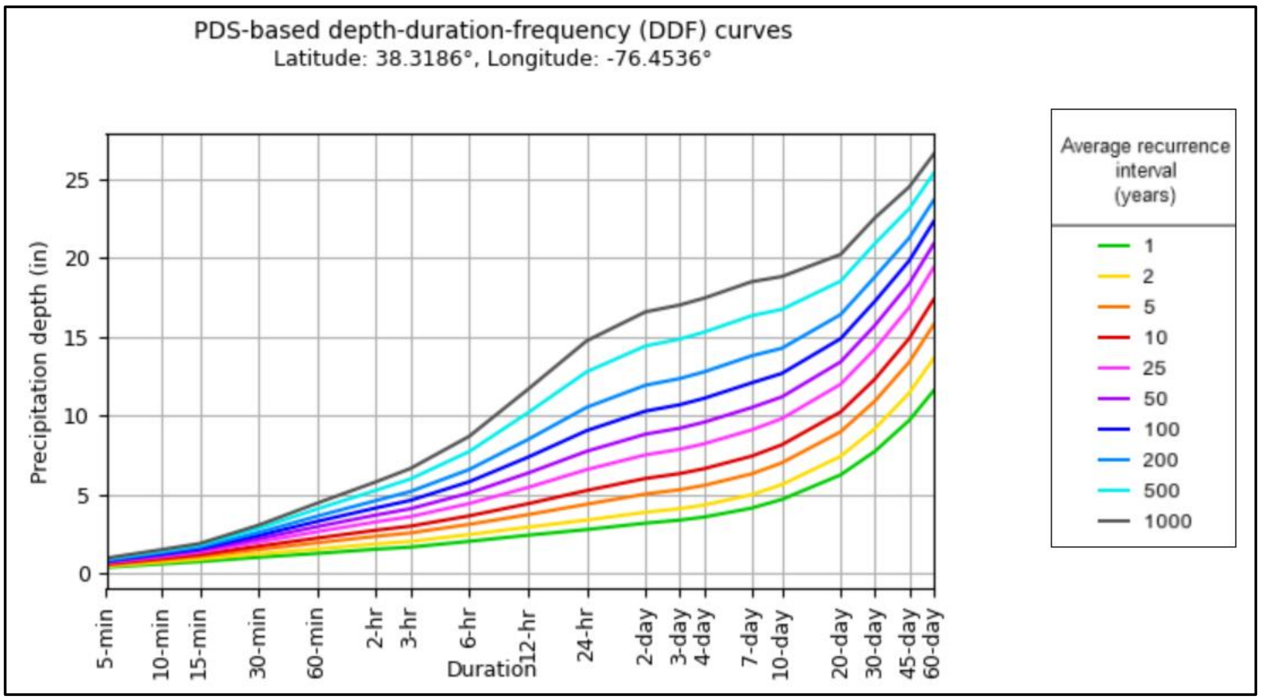


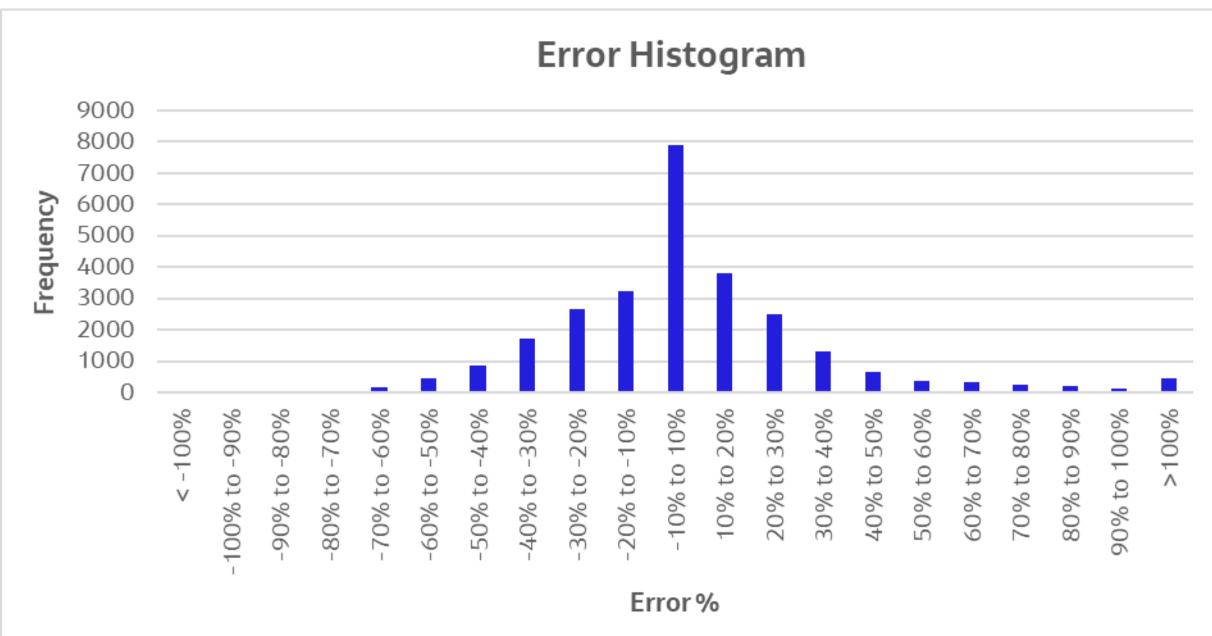
Table 3. NOAA Atlas 14 Peak Precipitation Frequency

	2020	2021	2022	2023
Duration	(Inches / Frequency)			
1-hr	1.13 / **1-yr**	1.74 / **5-yr**	0.93 / **1-yr**	0.65 / **1-yr**
2-hr	1.43 / **1-yr**	3.18 / **25-yr**	1.24 / **2-yr**	1.02 / **1-yr**
3-hr	1.76 / **1-yr**	3.52 / **25-yr**	1.96 / **2-yr**	1.45 / **1-yr**
6-hr	2.59 / **2-yr**	3.6 / **10-yr**	2.38 / **2-yr**	2.13 / **1-yr**
12-hr	3.75 / **5-yr**	3.6 / **5-yr**	2.4 / **1-yr**	2.34 / **1-yr**
24-hr	4.52 / **5-yr**	3.67 / **2-yr**	2.45 / **1-yr**	2.98 / **1-yr**

SCADA Validation

With having flow monitoring data, the SCADA dataset used to develop peaking factors can be validated against the meter data to assess accuracy. The overlapping period used for validation spans from September 20th, 2023, to December 31st, 2023. To measure accuracy, a histogram of the percent difference, or error, of the estimate flowrate from SCADA data to measured flowrate of the meter data was developed, which is shown in Figure 2.

Figure 2. SCADA Data Error Histogram



The histogram shows that more than 50% of the data points have an error between -30% to 30% with the overall dataset overall skewing to negative errors.

From **Figure 2**, about 74% of the data points have an error between -30% to 30% from the meter data with the overall dataset skewing to positive errors, which suggests the SCADA data generally overestimates flowrates. For the validation period, the meter measured a peak hourly flow of 787 gpm (1.13 mgd) on 12/10/2023 at 11:05PM while the SCADA data estimated a total peak hourly flow of 688 gpm (0.96 mgd) for the entire day of 12/10/2023. Over the entire monitoring period, the SCADA data estimated a peak hourly flow of 903 gpm (1.3 mgd) on 12/11/2023 at 11:55AM. **Table 4** provides additional summary statistics of the flow rates and volumes found from the meter data and SCADA data for the monitoring period. **Figure 3** and **Figure 4** shows the overall trend of the meter and SCADA flow data for the validation period and the peak rainfall event, respectively.

Table 4. Flow Monitoring vs SCADA Data Estimates

Value	Meter	SCADA
	9/20/2023-12/31/2023	
Peak Hour Flow[1] (12/10/2023) (gpm/mgd)	787 / 1.3	688 / 0.99
Average Flow (gpm/mgd)	86 / 0.12	87 / 0.12
Min Hour Flow (gpm/mgd)	13 / 0.01	2 / <0.01
Peak Daily Flow[2] (gpm)	353	482
Total Inflow Volume (Gallons)	12,694,661	13,015,946
October 2023 Total Volume (Gallons)	3,757,429	3,113,664
November 2023 Total Volume (Gallons)	3,171,017	3,328,694
December 2023 Total Volume (Gallons)	4,105,417	5,120,578

[1]Peak hour flow represents peak hourly flow observed by meter, which occurs on 12/10/2023, and the corresponding peak hourly flow from the SCADA data for the entire day

[2]The peak daily flow for both meter and SCADA data occurs on the same day on 12/11/2023

Figure 3. Meter and SCADA Flowrate Comparison Graph

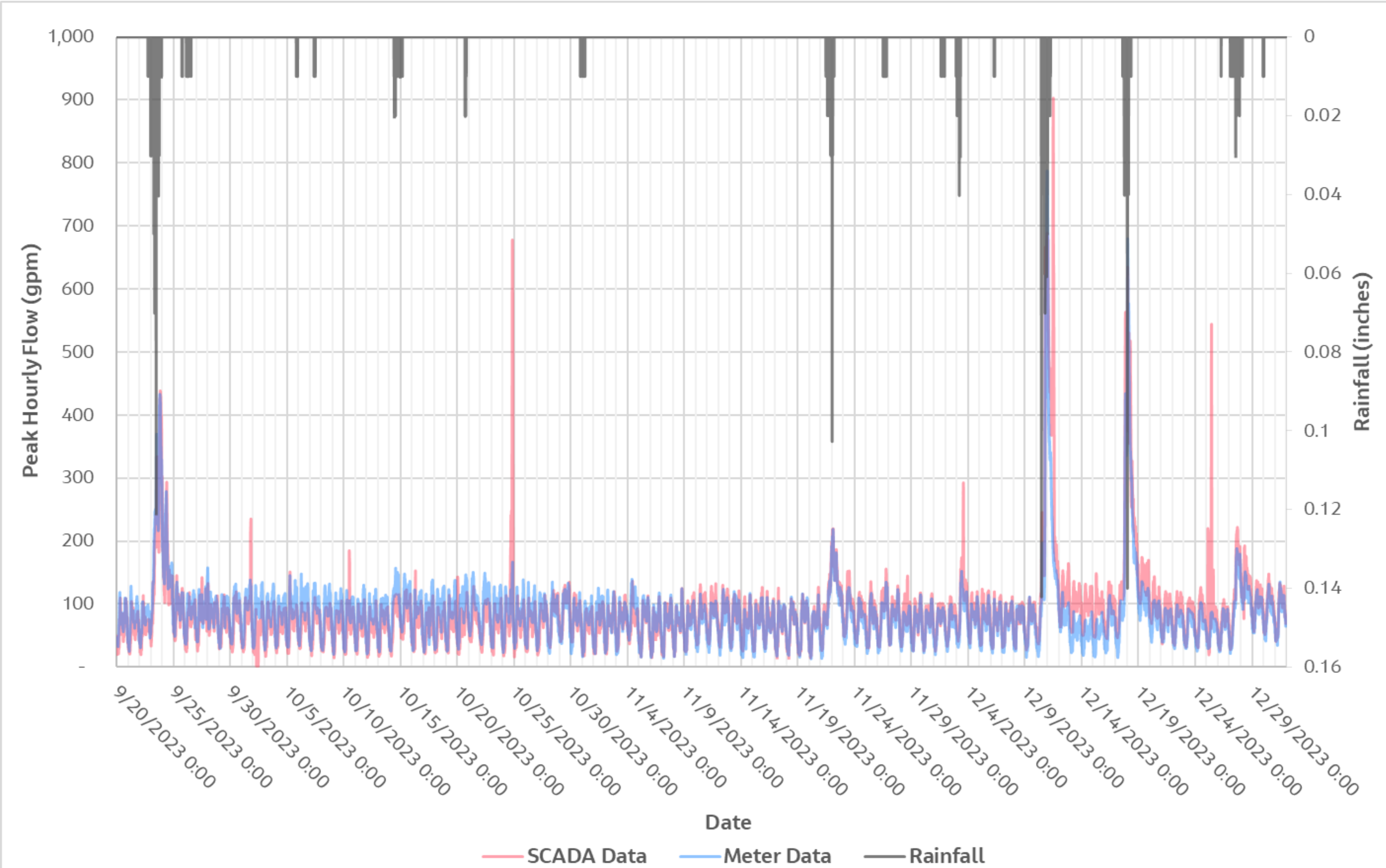
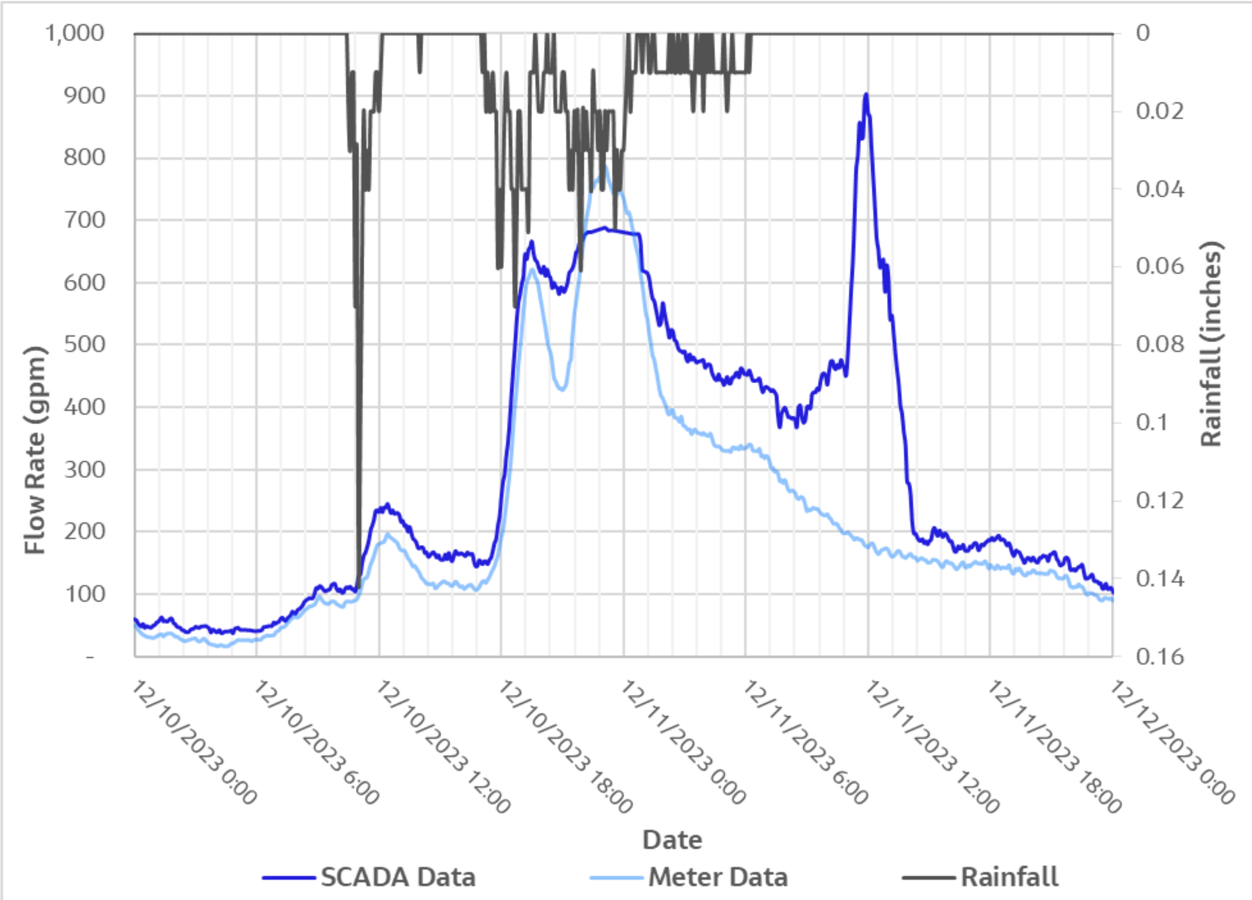


Figure 4. Flow Distribution From 12/10 to 12/11 Rain Event



Overall, because most of the SCADA data correlates well with the meter data for the validation period, it is reasonable to use the previous years of SCADA data as representative inflow data to Piney Point WWPS to develop a basis of design for upgrades.

Equalization Tank Analysis

With historical inflow data to the influent pump station, the total volume required for equalization during peak flow events can be estimated. Figure 5 shows the total volume required for equalization based on SCADA data from calendar years 2020 to 2023. Required volume for equalization was calculated by the cumulative difference between estimated inflow and estimated outflow, which was set to the estimated maximum capacity of the force main pumps at 450 gpm.

Figure 5. Equalization Volume 2020-2023

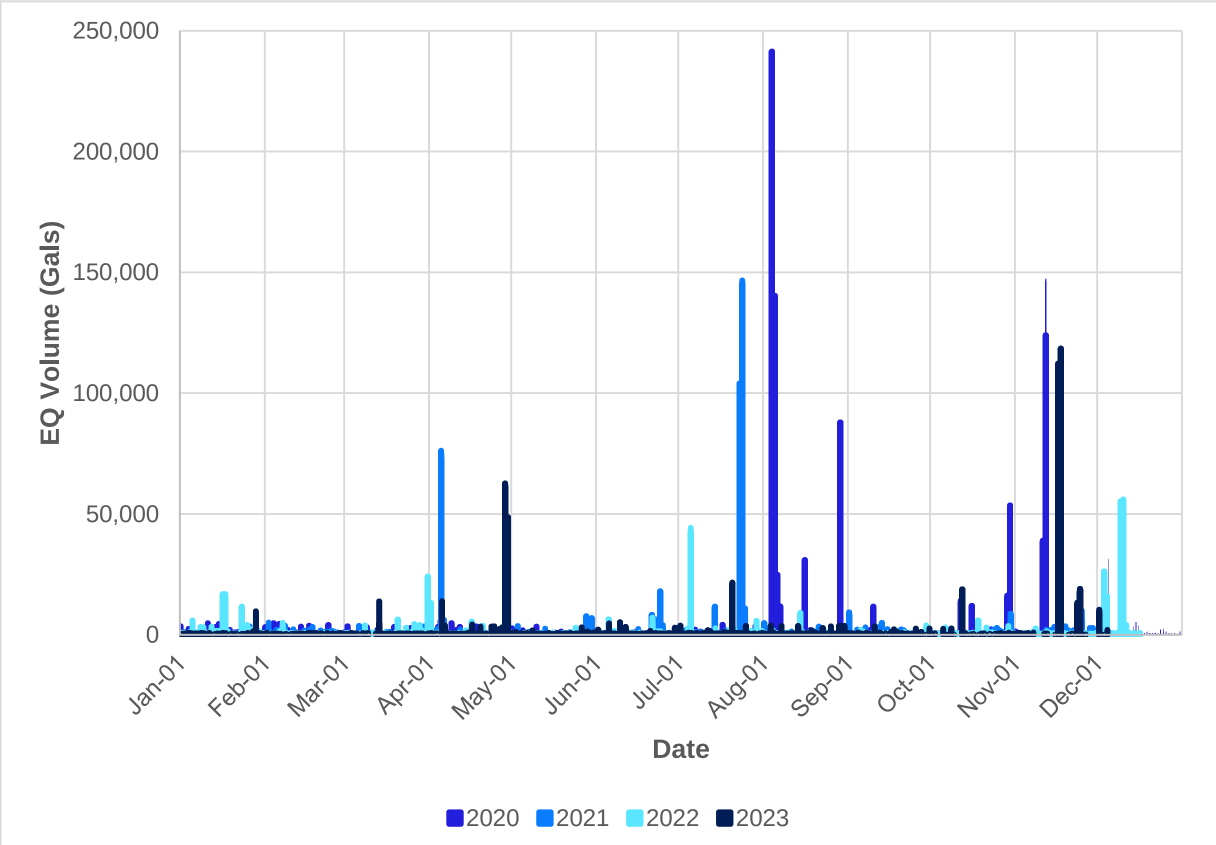


Figure 5 shows that the maximum volume required for equalization occurred on August 4th, 2020, across all calendar years. Table 5 summarizes the maximum required equalization volume that was required for each year and with the addition of a safety factor of 1.2. A safety factor of 1.15 to 1.20 is recommended for EQ sizing, however, it can be adjusted based on project specific conditions and engineering judgment.

Table 5. Maximum Equalization Volume 2020-2023

Year	Date and Time	Maximum EQ Volume (with Safety Factor of 1.2), gals	
		Alternative 1 w/ FM Capacity @ 450 gpm	Alternative 2 w/ FM Capacity @ 375 gpm
2020	8/4/2020 12:44 PM	241,401 (289,681)	298,689 (358,427)
2021	7/9/2021 5:15 AM	146,776 (176,132)	177,693 (213,231)
2022	12/23/2022 1:41 AM	56,165 (67,398)	90,562 (108,674)
2023	12/11/2023 1:24 PM	118,493 (142,191)	204,455 (245,346)

Piney Point Upgrades

Firm capacity is defined as the maximum capacity of the pump station with the largest pump out of service. The basis of design for the firm capacity of the Piney Point IPS has been evaluated on the following conditions:

1. **Gravity Pipe:** Full flow capacity of the 16-inch gravity sewer inflow pipe to IPS wetwell.

   A single 16-inch gravity sewer conveys wastewater from the Piney Point collection system to the IPS. The full-flow capacity was calculated by using Manning's Equation for a circular pipe. Under gravity flow conditions without surcharging, the 16-inch pipe has a full-flow capacity of ~1,900 gpm (2.74 mgd) at its existing slope of 0.15% and assuming a like-new roughness at 0.011 for a class 52 ductile iron pipe.

2. **Minimum Peaking Factor:** Apply peaking factor of 4.25 to the projected average daily wastewater flows.

   As shown on **Table 6**, the projected average daily flow for 2045 is 0.19 mgd which equates to a peak flow of 0.81 mgd (565 gpm). The projected average daily flow at full build-out is 0.39 mgd which equates to a peak flow of 1.66 mgd (1,151 gpm).

3. **SCADA Peak Factor:** Apply highest observed peaking factor from past three (3) calendar years of SCADA data to the projected average daily wastewater flows.

   The highest peaking factor presented in **Table 1** from the SCADA data is 14.2. The projected average daily flow for 2045 is 0.19 mgd, as shown in **Table 6**, which equates to a peak flow of 2.7 mgd (1,874 gpm). The projected average daily flow at full build-out is 0.39 mgd, as shown in **Table 6**, which equates to a peak flow of 5.5 mgd (3,846 gpm).

4. **Metering Peak Factor:** Apply highest observed peaking factor from three (3) months of flow metering data to the projected average daily wastewater flows.

   The highest peaking factor presented in **Table 1** for metering period is 9.2. The projected average daily flow for 2045 is 0.19 mgd, as shown in **Table 6**, which equates to a peak flow of 1.7 mgd (1,214 gpm). The projected average daily flow at full build-out is 0.39 mgd, as shown in **Table 6**, which equates to a peak flow of 3.6 mgd (2,492 gpm).

5. **Blended Peak Factor:** Apply a blended peaking factor to the projected average daily wastewater flows.

   To calculate future peak flows we might suggest applying the maximum peak factor observed from the SCADA data to calendar year 2024 daily flows and applying the 4.25 minimum peak factor to future flows.

   As shown in **Table 6**, the average daily flow for 2024 is 0.13 mgd and the projected average daily flow of 0.39 mgd would occur in the year 2081 based on an estimated flow increase of 2% per year. By applying a peak factor of 14.2 to calendar year 2024 flows of 0.13 mgd plus applying a peak factor of 4.25 to the future flows of 0.26 mgd, the total peak flow equals 2.93 mgd (2,032 gpm) in the year 2081. This equates to a blended peak factor of 7.5 based on projected average daily flows.

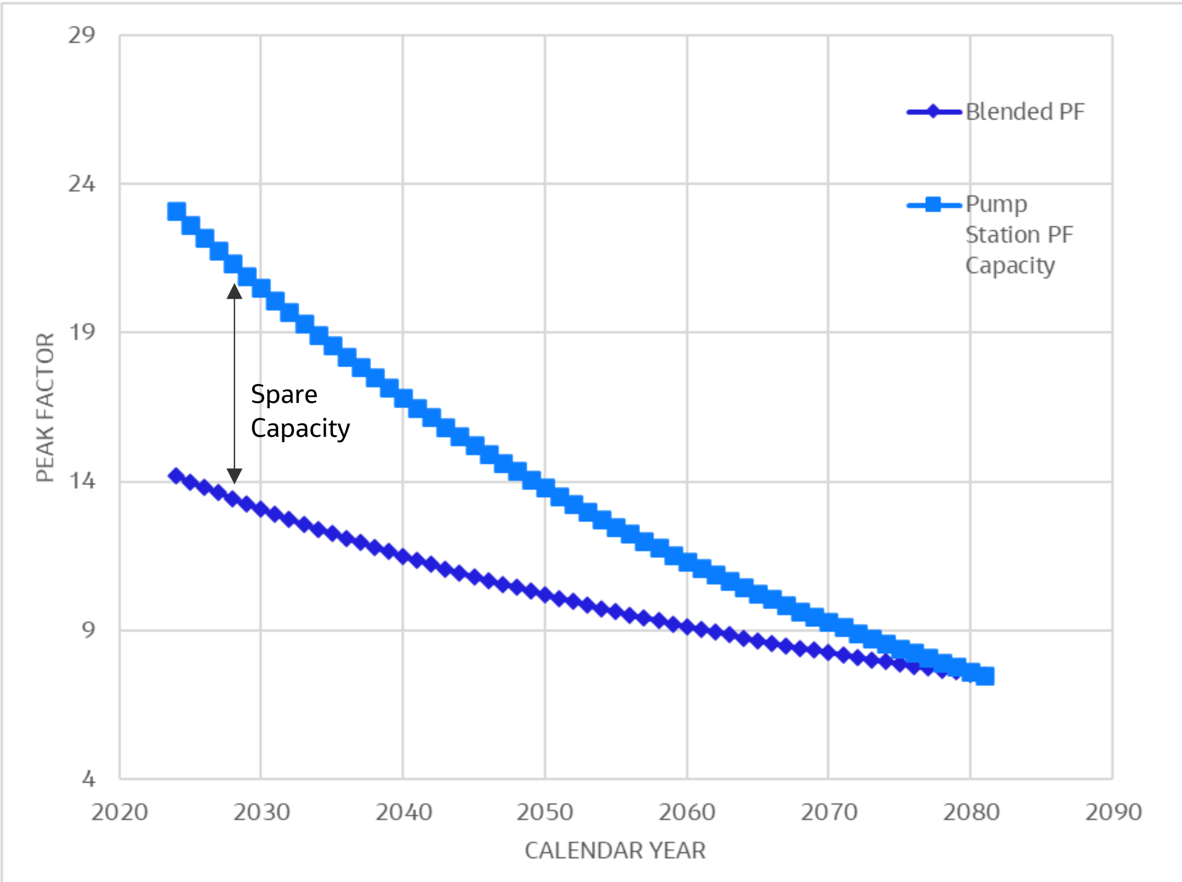
Table 6. Projected Flows and Peak Factors

Year	Average Daily Flow		Peak Flow		Blended PF	Pump Station PF Capacity
	gpm	mgd	gpm	mgd		
2024	88	0.13	1250	1.80	14.2	23.1
2025	90	0.13	1257	1.81	14.0	22.6
2026	92	0.13	1265	1.82	13.8	22.2
2027	93	0.13	1272	1.83	13.6	21.8
2028	95	0.14	1280	1.84	13.4	21.3
2029	97	0.14	1289	1.86	13.3	20.9
2030	99	0.14	1297	1.87	13.1	20.5
2031	101	0.15	1305	1.88	12.9	20.1
2032	103	0.15	1314	1.89	12.7	19.7
2033	105	0.15	1323	1.90	12.6	19.3
2034	107	0.15	1332	1.92	12.4	18.9
2035	109	0.16	1341	1.93	12.3	18.6
2036	112	0.16	1350	1.94	12.1	18.2
2037	114	0.16	1359	1.96	11.9	17.8
2038	116	0.17	1369	1.97	11.8	17.5
2039	118	0.17	1379	1.99	11.6	17.2
2040	121	0.17	1389	2.00	11.5	16.8
2041	123	0.18	1399	2.01	11.4	16.5
2042	126	0.18	1410	2.03	11.2	16.2
2043	128	0.18	1420	2.05	11.1	15.8
2044	131	0.19	1431	2.06	10.9	15.5
2045	133	0.19	1442	2.08	10.8	15.2
2046	136	0.20	1454	2.09	10.7	14.9
2047	139	0.20	1465	2.11	10.6	14.6
2048	142	0.20	1477	2.13	10.4	14.4
2049	144	0.21	1489	2.14	10.3	14.1
2050	147	0.21	1501	2.16	10.2	13.8
2051	150	0.22	1514	2.18	10.1	13.5
2052	153	0.22	1527	2.20	10.0	13.3
2053	156	0.23	1540	2.22	9.9	13.0
2054	159	0.23	1553	2.24	9.7	12.7
2055	163	0.23	1567	2.26	9.6	12.5

Year	Average Daily Flow gpm	Average Daily Flow mgd	Peak Flow gpm	Peak Flow mgd	Blended PF	Pump Station PF Capacity
2056	166	0.24	1580	2.28	9.5	12.3
2057	169	0.24	1595	2.30	9.4	12.0
2058	173	0.25	1609	2.32	9.3	11.8
2059	176	0.25	1624	2.34	9.2	11.5
2060	180	0.26	1639	2.36	9.1	11.3
2061	183	0.26	1654	2.38	9.0	11.1
2062	187	0.27	1669	2.40	8.9	10.9
2063	190	0.27	1685	2.43	8.8	10.7
2064	194	0.28	1701	2.45	8.8	10.5
2065	198	0.29	1718	2.47	8.7	10.3
2066	202	0.29	1735	2.50	8.6	10.1
2067	206	0.30	1752	2.52	8.5	9.9
2068	210	0.30	1769	2.55	8.4	9.7
2069	215	0.31	1787	2.57	8.3	9.5
2070	219	0.32	1806	2.60	8.3	9.3
2071	223	0.32	1824	2.63	8.2	9.1
2072	228	0.33	1843	2.65	8.1	8.9
2073	232	0.33	1863	2.68	8.0	8.8
2074	237	0.34	1882	2.71	7.9	8.6
2075	242	0.35	1902	2.74	7.9	8.4
2076	246	0.35	1923	2.77	7.8	8.2
2077	251	0.36	1944	2.80	7.7	8.1
2078	256	0.37	1965	2.83	7.7	7.9
2079	262	0.38	1987	2.86	7.6	7.8
2080	267	0.38	2009	2.89	7.5	7.6
2081	272	0.39	2032	2.93	7.5	7.5

In addition, and as shown by Figure 4, because the peak design capacity is calculated based on future conditions, the pump station peak factor capacity is greater than the calculated blended peak factor required for any given year, up to 2080. For the year 2025, the pump station would have a peak factor capacity of 22.6 versus 14.0 blended PF minimum.

Figure 6. Peak Factors Over Time



Conclusion and Recommendation

While applying the highest peak factor to average daily flows estimated at full build-out generates the highest theoretical peak flows, we recommend using a blended approach to determine the firm capacity requirements for the Piney Point IPS. As discussed above, the firm capacity required would equal 2,032 gpm (2.93 mgd).

This approach provides a rational way to utilize the SCADA data for long term planning while providing spare capacity over an extended period. This approach provides a pump station peak factor capacity greater than 14.2 through the year 2048. Should average daily flows increase more than projected, or if future peak flows are not within the blended targets, corrective actions can be taken in advance of full build-out conditions. These activities include I/I reduction through SSES and rehabilitation, additional flow metering, modification to construction guidelines, construction inspection and testing, and connection restrictions if necessary.

The flow monitoring data does capture the peak storm event of the year, but it is not recommended to develop a basis of design around a small window of monitoring if other longer-term data, such as the SCADA data, can be supplemented and indicates peak factors higher than the meter data. We recommend that SCADA and flow metering data continue to be reviewed on a scheduled basis for monitoring of peak and average flows.

References

1. Maryland Department of the Environment, *Design Guidelines for Wastewater Facilities*, Engineering and Capital Projects Program, 2021. Available: https://mde.maryland.gov/programs/water/wwp/Documents/Wastewater%20Design%20Guidelines%20-%202021.pdf

2. National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, "NOAA Atlas 14 Point Precipitation Frequency Estimates," *National Oceanic and Atmospheric Administration*, 2017. Available: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=md