Technical Memorandum

SOUTH PLACER WASTEWATER AUTHORITY (SPWA) WASTEWATER AND RECYCLED WATER SYSTEMS EVALUATION PROJECT

Subject: **Wet Weather Flow Projection for the Ultimate SPWA Service Area (Including Urban Growth Areas) -- Draft (TM No. 2c)**

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1 Introduction

This technical memorandum (TM) summarizes the wet weather wastewater flow projections for buildout conditions within the Ultimate SPWA service area. This includes flows generated within the proposed 2005 Service Area boundary and flows generated within the Urban Growth Areas (UGAs) located outside the proposed 2005 Service Area boundary. Wet weather flow projections are used with the hydraulic model to perform the hydraulic assessment of the collection system and for the analysis of the SPWA wastewater treatment plants. Wet weather flows are based on flow monitoring data which are presented in the Flow Monitoring TM (No. 2d).

2 Wastewater Flow Components

Typically, wastewater consists of three components: base sanitary flow (BSF), groundwater infiltration (GWI), and rainfall dependent infiltration and inflow (RDI/I). These components are shown on Figure 1. BSF and GWI during dry weather constitute DWF. DWF components were previously discussed in the Dry Weather Flow Projection TM (No. 2a). GWI can vary seasonally as rainfall causes localized groundwater levels to rise during the winter. This phenomenon occurs within the SPWA service area and results in increased GWI in some areas during the wet season. RDI/I occurs during rainfall conditions and causes the wastewater flow to increase. Together, BSF, GWI, wet season GWI, and RDI/I constitute wet weather flow.

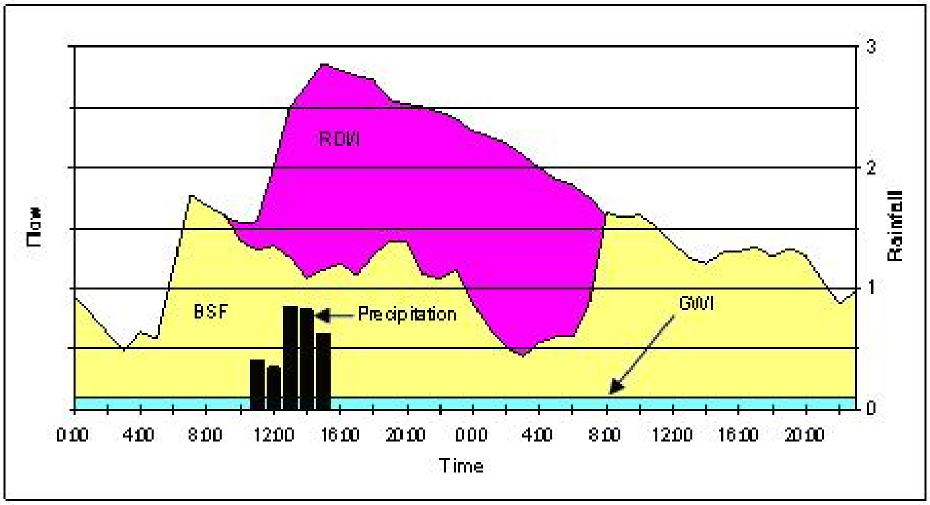

Figure 1 – Wastewater Components

3 Wet Weather Flow and Precipitation Data

Wet weather flow data was collected at 43 locations during the winter of 2005. The monitor network consisted of 37 temporary flow monitors and 6 permanent flow monitors. 27 of the flow monitor sites (including the WWTP monitors) were within the City of Roseville and were utilized for the Roseville Hydraulic Modeling Project. The rest of the monitors were located in Placer County and SPMUD. Some of the temporary monitors located outside of Roseville were located to verify the data from several permanent meter sites. For the wet weather analysis, flow data from the network was evaluated from late January through March 2005. The flow monitor locations utilized for the SPWA wet weather flow projections are listed in Table 1 and are shown on Figure 2.

Precipitation information during the wet weather flow monitoring period was collected at 17 permanent rain gauge sites in the City of Roseville and Placer County and one temporary rain gauge sites in SPMUD. The rain gauge network provided comprehensive coverage over the entire SPWA service area.

Further discussion and analysis of the wet weather flow and rainfall monitoring data is presented in the Flow Monitoring TM (No. 2d).

Table 1 – Temporary and Permanent Wet Weather Flow Monitors – Winter 2005

Number	Meter Type	Location	Pipe Diameter (in)
1	Temporary	Roseville	18
2	Temporary	Roseville	15
3	Temporary	Roseville	15
4	Temporary	Roseville	15
5	Temporary	Roseville	21
6	Temporary	Roseville	18
7	Temporary	Roseville	24
8	Temporary	Roseville	30
9	Temporary	Roseville	18
10	Temporary	Roseville	18
11	Temporary	Roseville	15
12	Temporary	Roseville	21
13	Temporary	Roseville	42
14	Temporary	Roseville	66
15	Temporary	Roseville	33
17	Temporary	Roseville	21
18	Temporary	Roseville	24
19	Temporary	Roseville	36
20	Temporary	Roseville	24
21	Temporary	Roseville	33
22	Temporary	Roseville	72
23	Temporary	Roseville	36
24	Temporary	Roseville	42
25	Temporary	Roseville	21
151	Temporary	SPMUD	20
152	Temporary	SPMUD	18
153	Temporary	SPMUD	18
154	Temporary	SPMUD	24
155	Temporary	SPMUD	21
156	Temporary	SPMUD	15
157	Temporary	SPMUD	18
158	Temporary	SPMUD	18
161	Temporary	Placer County	15
162	Temporary	Placer County	15
North Roseville	Permanent	SPMUD	36
Springview	Permanent	SPMUD	42
Strap Ravine	Permanent	Placer County	15
Old Auburn	Permanent	Placer County	18

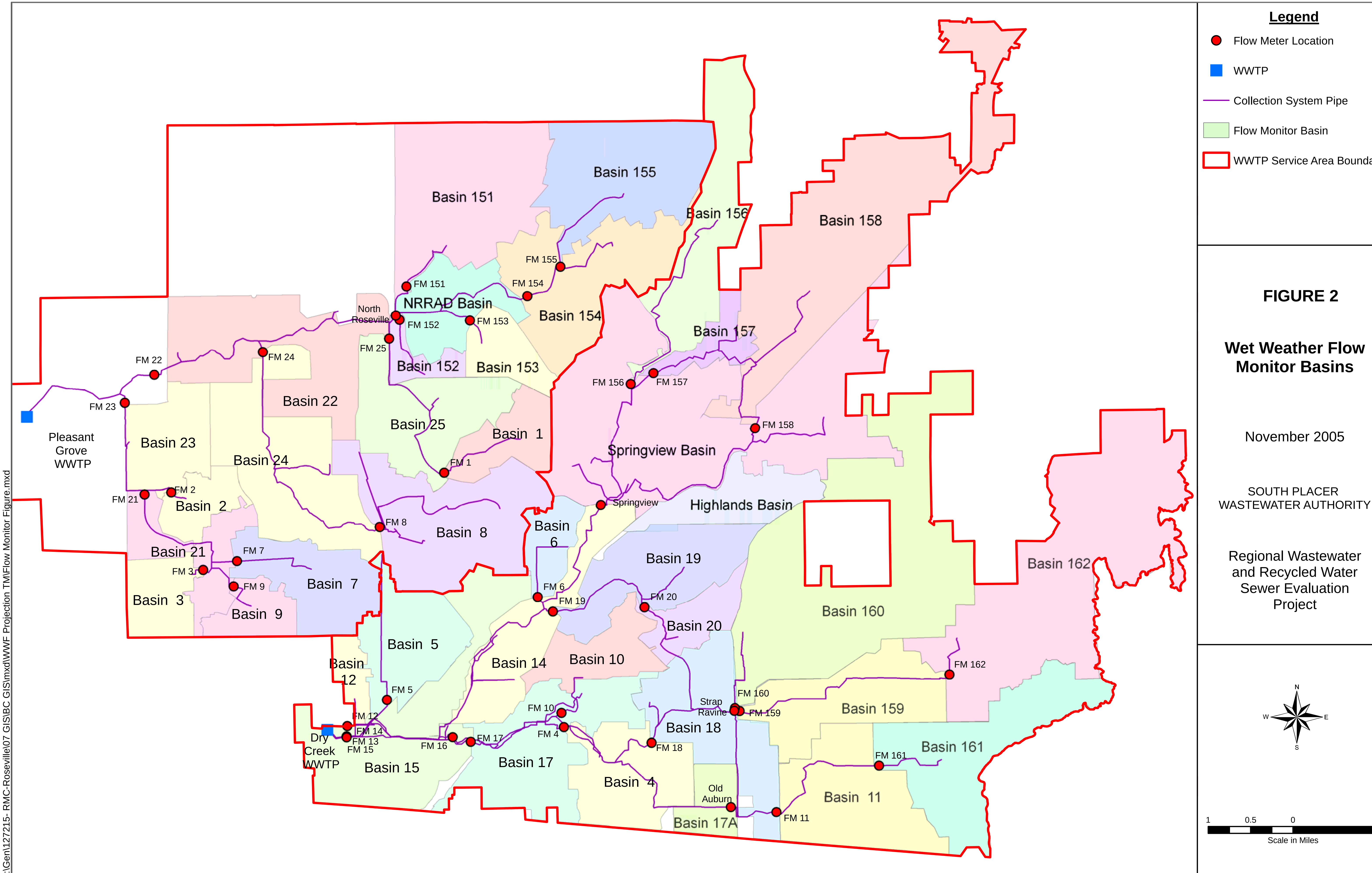

FIGURE 2

Wet Weather Flow Monitor Basins

November 2005

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4 RDI/I Modeling with H_20MAP Sewer Pro

The hydraulic analysis of the SPWA collection system is being performed using H_2OMAP Sewer Pro, a commercially available modeling program. The program has several modules that can be used to simulate RDI/I. The modules are calibrated using flow monitor and precipitation data described above. Once the model is calibrated, a design storm is applied to develop design RDI/I flow projections. Design RDI/I and wet weather GWI are combined with design base flows to compute predicted design peak wet weather flows and identify collection system deficiencies.

RDI/I is modeled within H_2OMAP Sewer Pro using the modules to simulate storm water runoff. H_2OMAP Sewer Pro has a unit hydrograph module with four different unit hydrograph methods for projecting runoff. The tri-triangle method was utilized to simulate RDI/I because it is widely used for projecting RDI/I, it is very flexible and it can be readily used to simulate RDI/I. The module simulates how much of and how quickly RDI/I enters the collection system from the contributing basins and subbasins.

The parameters needed to simulate RDI/I with the tri-triangle module are illustrated in Figure 3. Up to three synthetic hydrographs and three corresponding sets of parameters are defined for each basin, representing the fast, medium, and slow response components of the total RDI/I hydrograph. Each synthetic hydrograph has an associated time to peak (T) and recession constant (K) that defines the shape of its respective hydrograph and a rainfall volume factor (R) percentage that determines the volume of RDI/I. These parameters are adjusted during wet weather calibration to vary how much and how quickly rainfall enters the collection system and how long it takes the flow to recede, until a reasonable match is obtained between the actual monitored wet weather hydrograph and the RDI/I projection. In some cases, only one or two synthetic hydrographs are needed to calibrate the RDI/I.

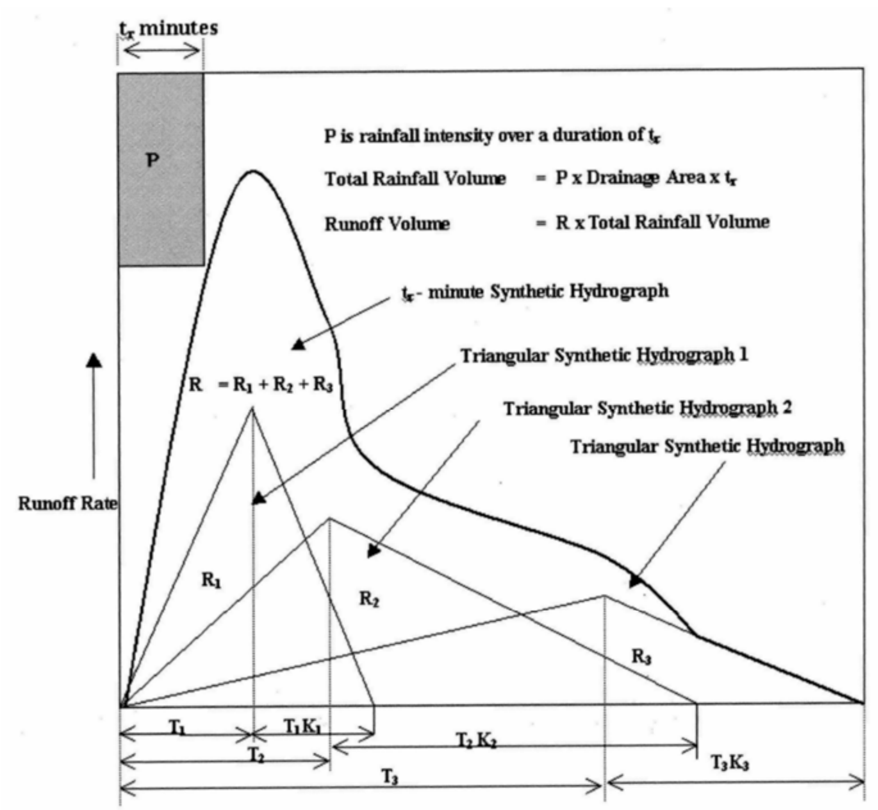


Figure 3 – Tri-Triangle Synthetic Hydrograph Method

5 RDI/I Calibration

RDI/I calibration was performed by adjusting the parameters in H_2OMAP Sewer Pro until the modeled flow at the wet weather flow monitor sites reasonably simulates flow monitor data for an actual storm event. Once the model is calibrated, the design storm rainfall profile can be applied to predict design RDI/I responses. A key assumption is that the design storm response will be similar to that of the calibrated storm event. Therefore it is important that the conditions of the calibration event (e.g., antecedent soil and groundwater conditions, magnitude and intensity of rainfall) be as close as possible to the desired design storm condition. The storm on March 1-2, 2005 was chosen as the calibration event because it was the largest storm during the flow monitoring period and there was a reasonable flow response at most of the flow monitoring locations.

The goal for calibration is to match the peak measured flow with the peak modeled flow and the general shape of the flow response (e.g., time to peak and duration and slope of hydrograph recession). However, as with any model, some flow monitor sites calibrate better than others. This was observed previously during the dry weather model calibration. For this model, calibration at critical locations on the trunk sewers entering Roseville from Placer County and SPMUD and trunk sewers within Roseville was successful. Flow data anomalies at some flow meter sites prevented better calibration at those locations.

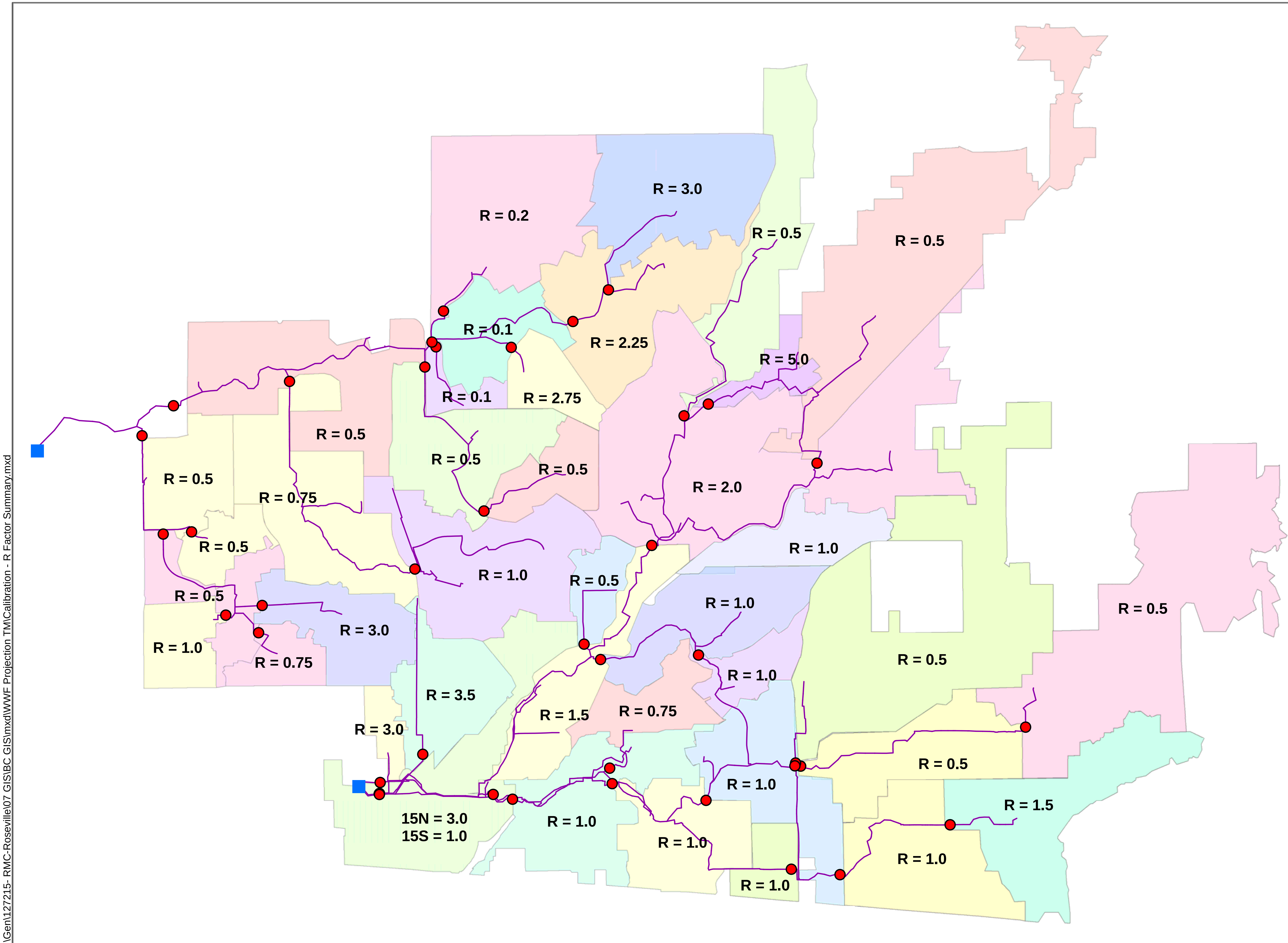
The calibration constants for the March 1-2 storm for each flow monitor basin are listed in Table 2. The plots of the model flow and flow monitor data are provided at the end of this TM in Attachment A. Figure 4 shows the wet weather flow monitor basins that were used to calibrate the model and their relative R factors.

Relatively low R factors ($\leq$ 1.5%) generally indicate a “tight” system with low rates of RDI/I. Some of the higher R factors ($\geq$ 3%) were found in the older areas of Roseville where pipes and laterals may have a higher level of deterioration, thus allowing more I/I into the system.

Table 2 – RDI/I Calibration Parameters for March 1-2, 2005 Storm Event

		Hydrograph 1[b]			Hydrograph 2[b]			Hydrograph 3[b]		
Flow Monitor Basin	Total R[a] (%)	R_1 (% of R)	T_1	K_1	R_2 (% of R)	T_2	K_2	R_3 (% of R)	T_3	K_3
1	0.5	60	1	2	40	8	3	0	24	2
2	0.5	60	2	0.5	40	6	3	0	24	2
3	1.0	75	1	1	25	8	3	0	24	2
4	1.0	60	1.5	1	40	8	3	0	24	2
5	3.5	65	2	2	35	6	3	0	24	2
6	0.5	60	1	2	40	8	3	0	24	2
7	3.0	70	1.5	1	30	6	3	0	24	2
8	1.0	50	2	0.75	50	8	3	0	24	2
9	0.75	75	1	1	25	8	3	0	24	2
10	0.75	70	2	1	30	8	3	0	24	2
11 [d]	1.0	30	1	2	60	8	3	10	24	0.5
12	3.0	65	2	2	35	6	3	0	24	2
14	1.5	80	2	2	20	8	3	0	24	2
15N	3.0	65	2	2	35	6	3	0	24	2
15S	1.0	65	2	1	35	6	3	0	24	2
17/17A [c]	1.0	70	2	1	30	6	3	0	24	2
18	1.0	80	2	2	20	8	3	0	24	2
19	1.0	80	2	2	20	8	3	0	24	2
20	1.0	80	2	2	20	8	3	0	24	2
21	0.5	60	2	0.5	40	6	3	0	24	2
22	0.5	75	2	2	25	8	3	0	24	2
23	0.5	65	2	0.5	35	6	3	0	24	2
24	0.75	75	5.5	2	25	8	3	0	24	2
25	0.5	50	1	2	50	8	3	0	24	2
151	0.2	0	1	0.5	100	6	0.5	0	24	2
152	0.1	5	1	2	70	8	1	25	24	2
153	2.75	0	0.5	0.5	50	8	0.5	50	24	0.5
154	2.25	10	1	2	10	8	1	80	24	1
155	3.0	10	0.5	2	90	8	3	0	24	2
156	0.5	40	2	2	40	8	3	20	24	2
157	5.0	0	1	0.5	80	6	0	20	24	2
158	0.5	40	2	2	40	8	3	20	24	2
161	1.5	7	1	2	50	7	1	43	24	0.5
162	0.5	20	2	2	40	8	3	40	24	2
North Roseville	0.1	0	0.5	1	80	6	0.5	20	24	2
Springview	2.0	5	2	2	30	8	3	65	24	2
Strap Ravine [e]	0.5	40	1	1	45	8	1	15	24	2

[a] Total percent of rainfall volume that enters the collection system as RDI/I
[b] Refer to Figure 3 for R, T, and K coefficient definitions. R_1, R_2, and R_3 are a percentage of Total R (total 100%)
[c] Flow from Monitor Basin 17A flows through the area representing Basin 4 but is tributary to flow monitor 17.
d Data from Flow Monitor Basin 11 represents the majority of the area tributary to the Old Auburn flow monitor.
e Data from the Strap Ravine Flow Monitor Basin represents the area tributary to the flow monitors 159 and 160.



Legend

- Flow Meter Location
- WWTP
- Collection System Pipe
- Flow Monitor Basin
- R — % of rainfall volume that enters system as RDI/I

FIGURE 4

Wet Weather Flow Monitor Basins with Calibration R Factors

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6 Wet Season GWI

Wet season GWI occurs in addition to the dry season GWI that was defined in the Dry Weather Flow Projection TM (No. 2a). Wet season GWI was determined by comparing average daily flows at the permanent flow monitor sites in Roseville, SPMUD and Placer County during the 2004 dry season and 2005 wet season. Wet weather GWI was calculated for each area tributary to the permanent flow monitoring sites and was applied to each parcel in the model according the area of the parcel. Wet weather GWI is summarized in Tables 3 and 4. Based on the results of this analysis, a wet season GWI rate of 200 gpd/acre was applied to currently developed parcels in the Dry Creek watershed. A wet season GWI rate of 100 gpd/acre was applied to currently developed parcels in the Pleasant Grove watershed. Wet season GWI was not applied to parks, open space, or Union Pacific Railroad property.

Table 3 - Estimated Wet Season GWI in the Dry Creek Watershed

Permanent Monitor Location	Tributary Area (acres)	2005 Wet Season ADWF (mgd)	2004 Dry Season ADWF (mgd)	Wet Season GWI (mgd)	Wet Season GWI Rate (gpd/acre)
Roseville[a]	5,076	6.32	5.09	1.23	242
SPMUD (Springview)	3,791	3.65	2.99	0.66	174
Placer County (Strap Ravine)	2,533	1.47	1.03	0.44	174
Placer County (Old Auburn)	1,555	1.46	1.25	0.21	135
Dry Creek WWTP	**12,955**	**12.90**	**10.36**[b]	**2.54**	**196**

[a] Calculated flow rates. Includes the following areas outside of Roseville: Highlands and West Dry Creek
[b] 2004 dry season ADWF estimated based on 2005 dry season ADWF data at Dry Creek and Pleasant Grove WWTP

Table 4 - Estimated Wet Season GWI in the Pleasant Grove Watershed

Permanent Monitor Location	Tributary Area (acres)	2005 Wet Season ADWF (mgd)	2004 Dry Season ADWF (mgd)	Wet Season GWI (mgd)	Wet Season GWI Rate (gpd/acre)
Roseville[a]	4,064	5.27	4.79	0.48	118
SPMUD (North Roseville)	1,841	1.96	1.84	0.12	65
Pleasant Grove WWTP	**5,905**	**7.23**	**6.63**[b]	**0.60**	**102**

[a] Calculated flow rates. Includes the following areas outside of Roseville: Sunset Industrial Park
[b] 2004 dry season ADWF estimated based on 2005 dry season ADWF data at Dry Creek and Pleasant Grove WWTP

7 RDI/I Projections

The hydraulic model was run to simulate the March 1-2, 2005 storm using the calibrated RDI/I parameters and GWI. The peak flows from the model runs at key flow monitoring locations on the trunk sewers are listed in Table 5. The peak hour model results matched the flow data relatively well at the key flow monitoring sites in the system. Some of the other monitoring sites did not calibrate as well, particularly the sites where the dry weather calibration did not match the monitored flows. The model results at the Dry Creek WWTP calibration point was approximately 15 percent low. The model results at the Pleasant Grove WWTP calibration point was approximately 24 percent high. This may be explained by the metering at each WWTP. According to the City of Roseville, there have been some flow monitor problems at the Dry Creek WWTP for some time. The City has developed some average daily flow adjustment factors that are applied to the monitor data. It is not clear if these adjustment factors are as accurate when applied to hourly flow data. Flows at the Pleasant Grove WWTP monitor are limited (flow backs up in the collection system) by the influent pump station capacity of approximately 9 mgd.A typical diurnal pattern shape would normally peak very close to the modeled flow. This case is presented in the calibration hydrographs in Attachment A.

Table 5 – Peak Wet Weather Flow at Key Flow Monitoring Sites for March 1-2, 2005 Storm Event

Monitor Location	Peak Hour Monitor Flow (mgd)	Peak Hour Model Flow (mgd)
Dry Creek Watershed		
Dry Creek WWTP	21.10	17.89
13	6.88	7.11
14	7.98	7.82
15	3.43	3.10
Old Auburn	2.85	2.99
Strap Ravine	2.31	2.41
Springview	6.08	6.00
Pleasant Grove Watershed		
Pleasant Grove WWTP	9.19	11.38
22	6.27	8.21
23	3.57	3.50
24	2.43	3.31
25	1.60	1.13
North Roseville	3.76	3.98
154	1.75	1.72

8 Future RDI/I

In order to project flows from future development, reasonable assumptions for future I/I were made based on trends in the existing system. I/I from future development may not appear immediately, but most likely will occur over time as the system deteriorates. I/I from future development was projected in the model by applying the following I/I parameters to the future development parcels. These rates coincide with I/I rates in some of the newer developed areas within the SPWA service area.

- Urban Growth Areas and West Roseville: R_t = 0.5% distributed evenly between R_1 and R_2 (T_1=2, K_1=2, T_2=8, K_2=3) and 100 gpad wet season GWI.
- Infill Development: Utilize the same RDI/I parameters and GWI rate as surrounding developed areas (GWI: 100 gpad in PG basin, 200 gpad in DC basin).
- RDI/I and wet season GWI are not applied to future parks or open space.
- Due to the extremely low development density in the Placer UGA (10 acres/du), RDI/I and wet season GWI were only applied to 1 acre per developed parcel.

9 Design Storm

RDI/I flows are dependent on several factors including rainfall amount. RDI/I flows are typically projected using a design storm event. For this project, a 10-year, 24-hour design storm was chosen to project peak wet weather flows in the model. This is the design condition adopted by Sacramento County and recently required by the Central Valley Regional Water Quality Control Board in an order to the City of Folsom. The design storm hyetograph was developed utilizing Table 5-A-1 (elevation (h) = 150 feet) from the Placer County Flood Control and Water Conservation District Stormwater Management Manual (September 1, 1990). The peak rainfall hour was set at 6 a.m. so that the peak RDI/I response (which would normally occur about 1-2 hours after the rainfall for a typical basin) roughly coincides with the peak hour of the dry weather profiles to give a conservative flow response in the collection system. The 24-hour rainfall and peak intensity for the 10-year design storm are listed in Table 6. The design storm hyetograph is shown in Figure 5.

Table 6 – Design Storm Volumes

Design Storm Recurrence Frequency	24-hour Rainfall Volume (inches)	Peak 6-hour Rainfall Volume (inches)	Peak 1-hour Rainfall Volume (inches)
10-year	2.97	1.65	0.77

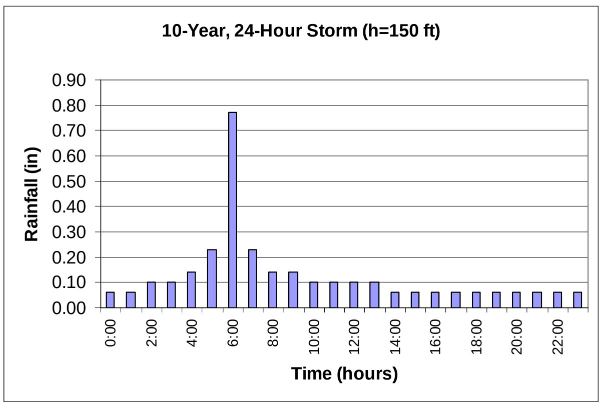

Figure 5 – Design Storm Hyetograph

10 Wet Weather Flow Projection

The hydraulic model was used to project current and buildout wet weather flows under 10-year design storm conditions using the calibration and future RDI/I parameters and GWI values previously presented. The design storm peak wet weather flows at the key monitor locations are listed for current and buildout conditions in Table 7. Design flow hydrographs for buildout conditions at Dry Creek and Pleasant Grove WWTPs are shown in Figure 6 and Figure 7. Based on these projections, the ratios of peak hour wet weather flow to average dry weather flow for the Dry Creek and Pleasant Grove WWTPs at buildout are approximately 3.0 and 2.1, respectively.

Table 7 – 10-Year Design Storm Peak Wet Weather Flow for Current and Buildout Conditions

Monitor Location	Current Average Daily Flow (mgd)	Buildout Average Daily Flow (mgd)	Current Peak Hour Flow (mgd)	Buildout Peak Hour Flow (mgd)
Dry Creek Watershed				
Dry Creek WWTP	9.34	19.3	27.8	57.7
13			10.4	12.2
14			10.9	25.3
15			6.5	8.6
Old Auburn			3.4	3.4
Strap Ravine			3.0	8.1
Springview			7.1	14.7
Pleasant Grove Watershed				
Pleasant Grove WWTP	7.33	23.4	17.4	48.1
22			11.2	25.3
23			7.3	7.7
24			4.6	7.8
25			1.6	2.3
North Roseville			4.7	9.1
154			2.5	3.9

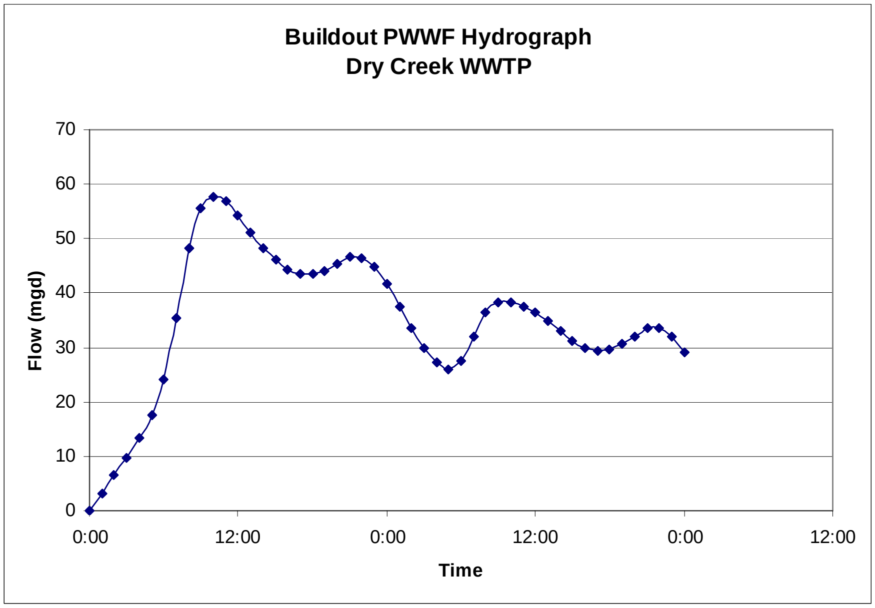

Figure 6 – Dry Creek WWTP – Design Flow Hydrograph

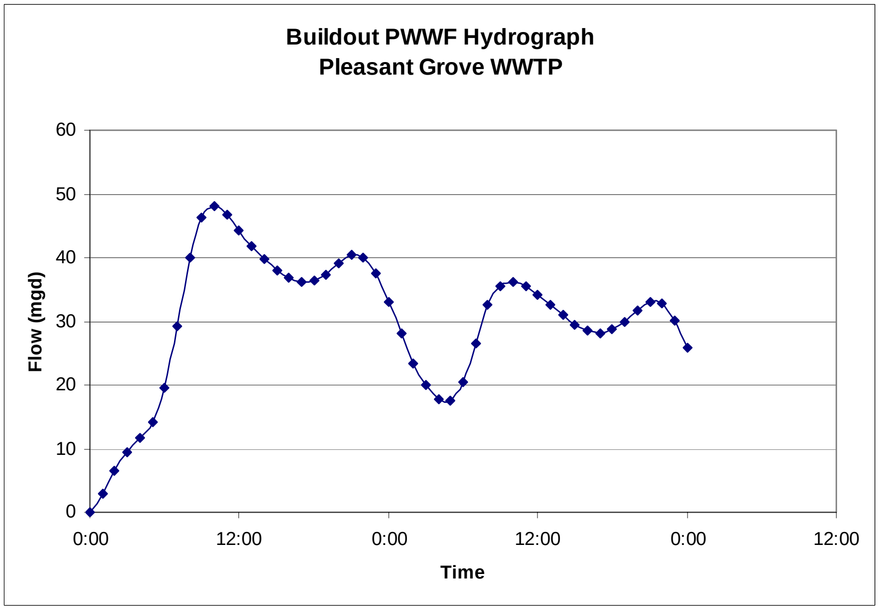

Figure 7 – Pleasant Grove WWTP – Design Flow Hydrograph