APPENDIX A

Previous System Planning Reports

- A.1 City of Merced Collection System Hydraulic Model Conversion and South Trunk Sewer Service Alternatives Analysis (Stantec, June 2020)
- A.2 Executive Summary of City of Merced Wastewater Collection System Draft (Stantec, December 2017)

Collection System Hydraulic Model Conversion & South Trunk Sewer Service Alternatives Analysis

DRAFT Report

June 3, 2020

Prepared for:

City of Merced

Prepared by:

Stantec Consulting Services, Inc.

Revision	Description	Author		Quality Check		Independent Review	

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Abbreviations

ADWF	Average Dry Weather Flow (observed during the dry season)
BMP	Best Management Practice
BRPS	Bellevue Ranch Pump Station
CHI	Computational Hydraulics International
CIP	Capital Improvement Project
DWF	Dry Weather Flow
DU	Dwelling Unit
EDU	Equivalent Dwelling Unit
GIS	Geographic Information System
gpd, gal/d	Gallons per Day
gpcd	Gallons per Capita Per Day
GWI	Ground Water Infiltration
H59PS	Highway 59 Pump Station
HGL	Hydraulic Grade Line
HLR	Hydraulic Loading Ratio
ICM	International Computer Management

IDM	Inch-diameter-mile
IDW	Inverse Distance Weighting
I/I	Inflow and Infiltration
LF	Linear Feet
LOS	Level of Service
MG	Million Gallons
MGD	Million Gallons per Day
NMSAD	North Merced Sewer Assessment District
NOAA	National Oceanic and Atmospheric Association
OS	Open Space
PCSWMM	Personal Computer Storm Water Management Model
PS	Pump Station
PWWF	Peak Wet Weather Flow
RDI	Rainfall Dependent Infiltration
RDII	Rainfall Dependent Inflow and Infiltration
RGN	Rain Gauge North
RGS	Rain Gauge South

ROW	Right of Way
SMSAD	South Merced Sewer Assessment District
SSO	Sanitary Sewer Overflow
SUPD	Specific Urban Development Plan
TSAM	Tentative Subdivision Activity Map
UC Merced	University of California Merced
V&A	V&A Consulting Engineers, Inc.
WCSMP	Wastewater Collection System Master Plan (Stantec, 2017)
WWTF	Wastewater Treatment Facility

1.0 INTRODUCTION

A fully dynamic hydraulic model of the City of Merced's (City's) wastewater collection system was developed using InfoWorks ICM software (version 6.5.5.13016) for use in preparing the Wastewater Collection System Master Plan (Stantec, 2017). This model was updated and converted from ICM to a more cost effective and user-friendly software platform that the City can use inhouse to assess various conditions within the system. The ICM model was converted to the latest version of PCSWMM software developed by Computational Hydraulics International (CHI). The model was updated using flow monitoring data collected within the sewer system and the most recent information on existing sewer accounts, sewer service commitments and land use planning information provided by the City.

To update and recalibrate the existing system model, wastewater flow was monitored at ten strategic locations within the collection system for a four-week period from November to December 2019. The flow monitoring data was used to redistribute flow and calibrate the existing system model after the physical system data was reconstructed in PCSWMM. City planning, sewer account and parcel data is used to represent the existing service area and project flows from future developments. A detailed review of the latest planning information was performed and incorporated into the model.

After completing the hydraulic model update, the new model was used to perform an alternatives assessment which considered servicing options for the future southeast portion of the City, originally proposed to be served by the future South Trunk in the City's Wastewater Collection System Master Plan (WCSMP). The proposed alternatives include sizing and alignment variations of what had been previously proposed and considered the potential of utilizing residual capacity within the existing system.

The purpose of this report is to describe the data, assumptions, and information used to update and convert the model to a new software platform and present the results of the South Trunk alternatives assessment. The updated model results were used to assess residual capacity within the existing system and identify significant hydraulic capacity limitations.

This report is divided into the following sections:

- Introduction
- Background Information and Updated Data
- Model Conversion and Update
- Model Results and Capacity Evaluation
- South Merced Trunk Sewer Service Alternatives

2.0 BACKGROUND INFORMATION AND UPDATED DATA

The following section presents a summary of the existing collection system, planning information, and the updated data that was collected, reviewed, and incorporated into the model update as part of this effort. New wastewater flow data was collected and used to redistribute flow and calibrate the model of the existing collection system along with current information related to existing sewer service accounts and service commitments. Inputs for the future system service areas were updated using recent development and land use information provided by the City to simulate future system wastewater flows.

2.1 EXISTING COLLECTION SYSTEM DESCRIPTION

The City of Merced owns and operates a sewer collection system consisting of over 400 miles of gravity sewers. The system is commonly described as having two geographical regions, North Merced and South Merced, delineated by Bear Creek which runs approximately east to west through the middle of the City. The City's customer base includes residential, commercial, industrial, and public users including the University of California – Merced (UC Merced). The wastewater is conveyed by the collection system to the City's wastewater treatment facility (WWTF) located southwest of the current extents of the City.

The focus of this evaluation is on the existing and residual capacity of large primary trunk sewers within the existing collection system which are included within the skeletonized model. Trunk sewers are the large main branches of the collection system conveying flow from smaller collector sewers to the WWTF. The existing collection system and primary trunk sewers within the northern and southern regions of the system are shown on **Figure 1**.

North Merced Trunk Sewers:

- Bellevue Trunk – 18-inch to 24-inch in Bellevue Road from UC Merced to G Street
- G Street Trunk – 27-inch to 30-inch in G Street between Bellevue Road and Black Rascal Ravine/Campus Drive
- Yosemite Avenue Trunk – 18-inch in Yosemite Avenue between Parsons and G Street
- Black Rascal Trunk (Part 1, North) – 30-inch to 43-inch following Black Rascal Ravine near Campus Drive from G Street to West Olive Avenue Trunk.
- East Olive Avenue Trunk – 12-inch to 18-inch in Olive Avenue between McKee Road and G Street.
- West Olive Avenue Trunk – 18-inch to 21-inch in Olive Avenue between McKee Road and G Street.
- Black Rascal Trunk (Part 2, South) – 42-inch in Devonwood / Stoneybrook Drive between Olive Avenue and Bear Creek
- H59PS Trunk – 18-inch to 27-inch in Hwy 59 from the H59PS to Bear Creek.
- North Merced West Ave Trunk – 36-inch to 42-inch in West Avenue between Bear Creek and West Childs Avenue
- 48-inch Interceptor – 48-inch interceptor pipeline from West Childs Ave to the WWTF.

South Merced Trunk Sewers:

- East Gerard Trunk – 18-inch to 36-inch trunk sewer in Kibby Road from Hwy 140 to East Gerard Avenue continuing west in Gerard Avenue to Tyler Road.
- West Gerard Trunk – 36-inch remaining portion of the Gerard Trunk from Tyler Road to West Avenue
- South Merced West Ave Trunk – 18-inch to 27-inch sewer in West Avenue from Hwy 59 to Gerard Avenue running parallel to the North Merced West Avenue Trunk.
- 42-inch WWTF Trunk Sewer – 42-inch trunk sewer conveying flow from the intersection of Gerard and West Ave to the WWTF.

The only major pumping facilities that exist within the trunk sewer system are the Highway 59 Pump Station (H59PS) and the Bellevue Ranch Pump Station (BRPS). There are several smaller pump stations within the system that serve small portions of the service area such as individual subdivisions. These smaller pump stations are not considered part of the trunk sewer system and are excluded from the hydraulic model.

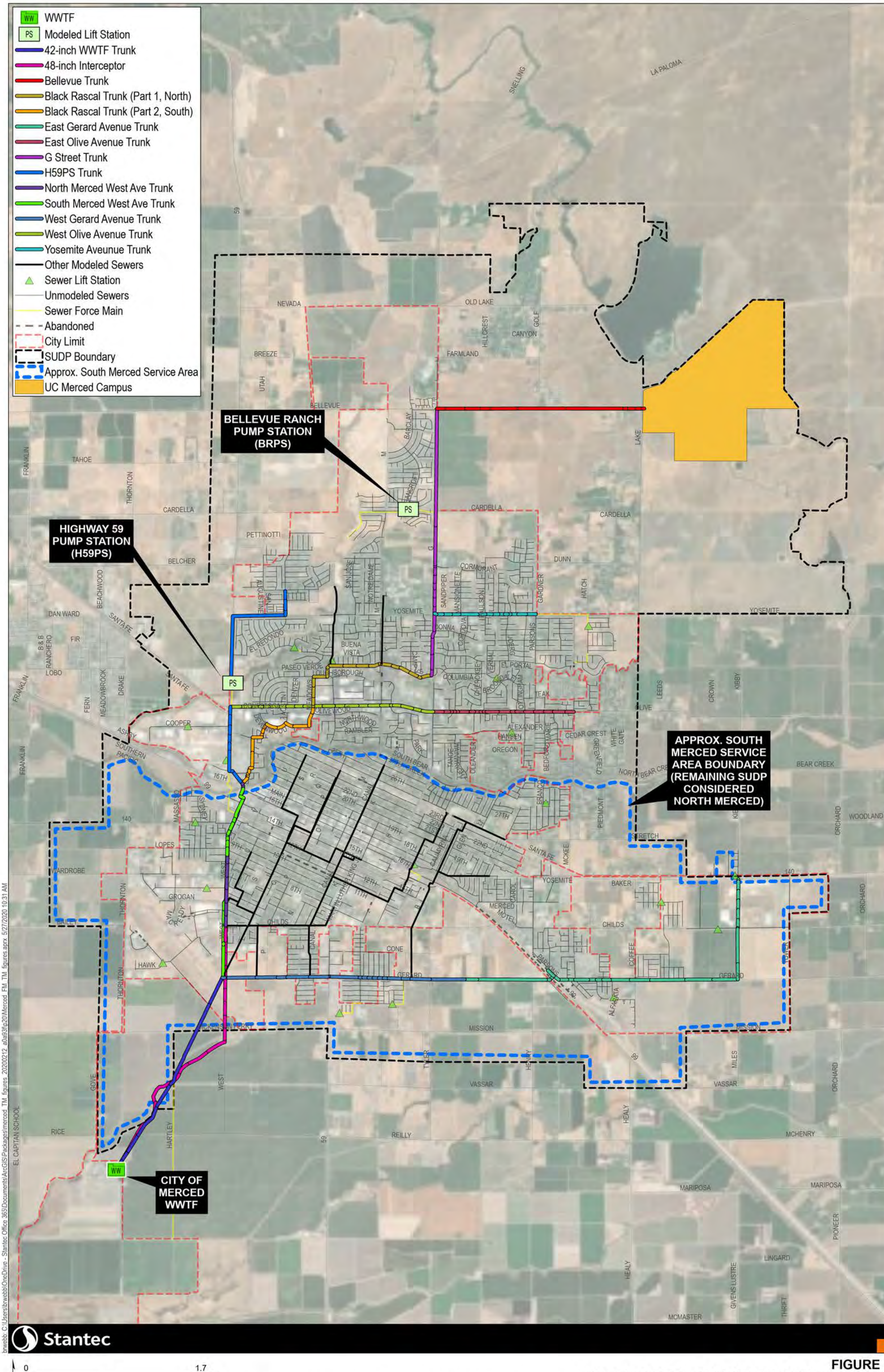

FIGURE 1

EXISTING COLLECTION SYSTEM TRUNK SEWERS

COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

2.2 HISTORICAL COLLECTION SYSTEM PLANNING

The City's 2030 General Plan identifies growth that may occur within the City's planning area, defined by the Specific Urban Development Plan (SUDP) boundary, by the year 2030. Much of that new growth will require new wastewater collection system infrastructure, which is presented in the City's Wastewater Collection System Master Plan (WCSMP). The primary focus of the WCSMP is the planning of new trunk sewers required to serve future developments. The capacity of the existing collection system sewers is quantified as "residual capacity", which provides information on the sizing and alignments of new trunk sewers and determining interim system improvements.

The residual capacity of the existing system is of interest to the development community, some of whom have reserved capacity in the existing trunk sewer system. Parcels that have paid into the North Merced Sewer Assessment District (NMSAD, established in 1981) or that are identified on the City's evolving Tentative Subdivision Activity Map (TSAM) are considered to be "entitled" to sewer service and have received commitments from the City to capacity within the existing system. The NMSAD was established to finance construction of trunk sewers to serve areas within the boundary of the District, the majority of which is located north of Bear Creek.

2.2.1 WCSMP Model Scenarios

The three hydraulic model scenarios simulated as part of the development of the WCSMP represent various levels of development within the City's planning area.

Existing System Scenario: The existing trunk sewer system was modeled to evaluate the extent of hydraulic deficiencies during peak design flow conditions. This scenario simulates hydraulic conditions within the existing collection system during peak wet weather flow events at the existing level of community development.

Interim System Scenario: The interim model scenario is similar to the existing system scenario except that all parcels with planned sewer service commitments are modeled as if they have connected to the existing system. This simulation is intended to guide the City and the development community as to the potential limits of the existing system to convey flow from committed areas prior to the construction of large diameter trunk sewers or other infrastructure. The interim condition also assumes full buildout of the UC Merced Campus and does not include the addition of any new trunk sewers. This scenario was developed in order to identify deficiencies in the existing trunk sewer system if all the parcels with existing and planned sewer service commitments were to develop concurrently.

Buildout System Scenario: The buildout scenario considers full buildout of the 2030 General Plan, including the UC Merced Campus and Campus Community. General Plan land use designations and wastewater flow generation factors are used to approximate wastewater flows that may originate from parcels within the SUDP. This scenario simulates hydraulic conditions within the future collection system under peak wet weather flow conditions at full buildout of the City's General Plan area and includes the addition of new large trunk sewers.

2.2.2 Sewer Assessment District Planning

A Technical Memo (TM) entitled *Merced WWTF Capacity Needed to Serve Existing Commitments* (Stantec 2019) was prepared to determine the City's future wastewater treatment facility (WWTF) capacity needs. The 2019 TM describes the following three broad categories of parcels within the City's SUDP, that generally align with model scenarios described above, and will be used in this report for consistency:

1. **Existing Sewer Service Connections** – The City provided account information for each of its existing sewer service connections, including the address, assessor's parcel number, and the number of equivalent dwelling units (EDUs) associated with each service account.[1]

2. **Planned Sewer Service Commitments** – Planned commitments consist of parcels that have anticipated future sewer services, but are not currently connected to the sewer system, including parcels that participated in the NMSAD, which was established in the 1980's to fund trunk sewers north of Bear Creek. This category also includes the service commitment associated with UC Merced, areas identified in the City's tentative subdivision map database, properties which have received entitlements to develop and are only partially built or have not yet begun to do so, vacant parcels within City limits, and other parcels identified by City staff.

   The planned sewer service commitment parcels were identified in the data provided by the City, either initially defined in the GIS database (2019) or subsequently incorporated after discussions with City staff (2020).

3. **Future Merced Service Area –** The City must also plan how they service parcels within the SUDP that are not currently considered to be "committed". These areas have neither existing sewer service nor an identified entitlement to connect to the existing sewer system[2]. The full development of future parcels represents buildout of the City's sewer service area.

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[1] An EDU is a unit of measure that normalizes all land use types to the equivalent wastewater demand of one single-family residential unit. For example, if a commercial service account has five EDUs, it produces wastewater equivalent to that of five single family residential service accounts.

[2] The City of Merced Wastewater Collection System Master Plan (2017, Stantec) identifies collection system facilities needed to serve the future service area. In addition to preliminary engineering studies, the City is considering establishing an assessment district(s) to fund those future trunk

2.3 PARCEL DATA REVIEW AND UPDATE

The GIS information provided by the City was used as the basis for updating the hydraulic model. In addition to the physical attributes of the collection system network, service area parcels and commitments were updated using the latest planning information. In collaboration with City Public Works staff, Stantec reviewed parcel data and identified parcels with existing sewer service connections, as well as parcels that have received commitments from the City to provide service but are currently unconnected. The approved or projected number of EDUs for each committed parcel was updated in the model database and used to project wastewater flow under future conditions. The revised sewer-shed and EDU data was used to update the hydraulic model scenarios that were originally developed as part of the development of the WCSMP. The City planning area and the existing, planned/committed, and future service areas are identified on **Figure 2**.

The parcel data review compiled information from documents outlining parcel land use changes and specific plan information associated with approved or ongoing development areas. The planned sewer service commitments were reviewed and updated to reflect the most recent projection of land use and EDU counts. Updated parcel data for existing sewer service accounts was also provided and parcels with new sewer service accounts were added to the existing system model. The review of parcel data identified many parcels that have been designated as open space (OS) or are expected to have no wastewater flow contribution, such as parks, rights of way (ROW), and specific public facilities. These areas were removed from the existing sewer service area with the model.

The following summarizes the objectives of the parcel data review and update:

- Update existing sewer service account parcel file for use in the existing system model. The updated file reflects parcels (based on data provided by City staff in early 2020) with connected accounts during the time of the flow monitoring study (November/December 2019).
- Update the parcel file and planning information used to approximate flow from sewer commitments within the interim model.
  - Parcels with existing (Nov/Dec 2019) sewer accounts previously identified in the model as unconnected with service commitments pending were removed from the interim model and incorporated into the existing service area model.
  - With significant input from City staff, the EDU counts of committed parcels were updated in early 2020 to reflect their most recent planning information. This included the review and assembly of data including City specified EDU counts, development plans, and/or land use projections. A summary of information extracted from specific development plans is presented in **Table 1**.

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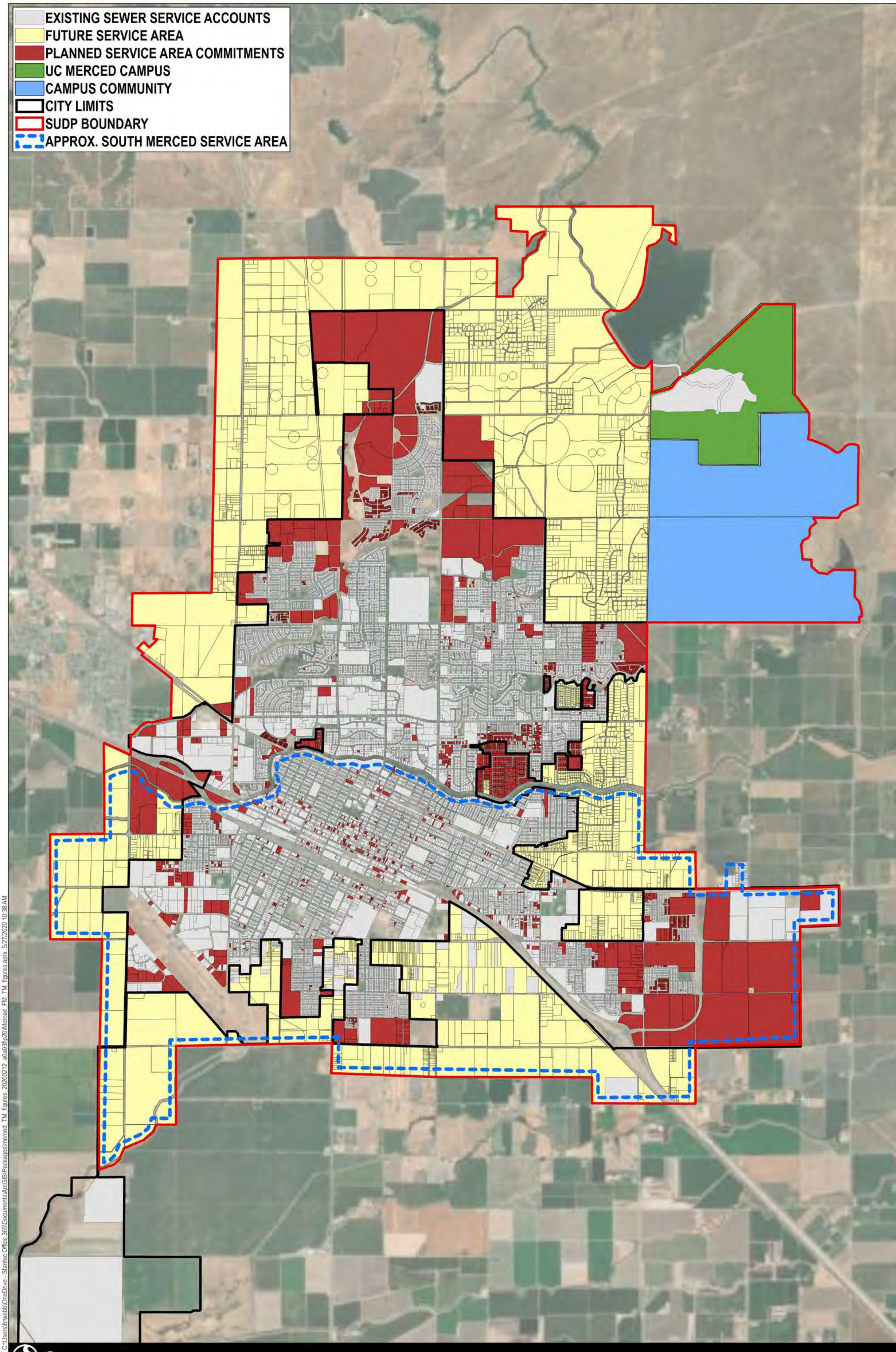
sewers, along with other possible financing options.

- Single residential lots within committed subdivisions or committed parcels that are unlikely to be further divided, were given a service entitlement of 1 EDU, as opposed to projecting service requirements using land use and wastewater generation rates.
- The land uses of parcels projected to be open space and/or having no wastewater flow contribution were updated and removed from the model service area.

- **Table 1 Summary of Specific Development Plan Information**

Development	Gross Area (Acres)	Lots	Other Land Uses	Other Land Uses (Acres)	Other Land Use Density (EDU/ Acre)	Total EDUs
Renaissance No. II	26	152	-	-	-	152
Stone Ridge South	40	160	Apartments	10.0	10 (per Gross Acre)	400
Apartments (near Moraga)	14	-	-	-	-	312
Moraga of Merced Unit No. 2	40	233	-	-	-	233
The Palisades	34	140	-	-	-	140
Bright Development	40	160	Village Residential	3.1	12	198
Bellevue Ranch West V17 & V18	44	249	Elementary School	13.0	14.6	440
Bellevue Ranch West V12	20	100	-	-	-	100
Cypress Terrance	45	260	-	-	-	260



Stantec

0 1.7 Miles

FIGURE 2
EXISTING, PLANNED, AND FUTURE WASTEWATER SERVICE AREAS
COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

Wastewater flow assumed to be generated from parcels with service commitments is projected by assigning an EDU count to each committed parcel. The number of EDUs is converted to a flow projection using the City's standard flow per EDU unit factor of 257 gpd/EDU. The number of EDUs assigned to each parcel can be projected using land use and the City's standard EDU or gpd per acre unit factors for each land use designation, as described in the WCSMP and shown in **Table 2**. Where refined planning information is available, a more specific EDU count can be estimated considering the number of dwellings and more refined plans for nonresidential areas. Wastewater flow projections for parcels with sewer service commitments (committed parcels) are estimated using one of the following criteria:

General Plan Land Use – Land use outlined in the City's General Plan is used along with the associated land use-based gpd/acre wastewater flow unit factors also referred to as wastewater generation rates.

City Specified Land Use – The City provided updated land use or EDU information that is used along with the associated land use-based gpd/acre wastewater flow unit factors.

Single Lot/1 EDU – Single residential lots were identified and counted as one EDU.

Specific Development Plan – The City provided development plans where available for committed areas, single lots were counted as one EDU and land use information was used in conjunction with wastewater unit factors to estimate wastewater flow.

Open Space/ No Flow Areas – These parcels are not expected to contribute wastewater to collection system and were removed from the model.

The updated EDU information for existing, committed, and buildout service areas is summarized in **Table 3** and depicted in **Figure 3**.

Table 2 City of Merced Land Uses and Wastewater Generation Rates

Land Use ID	Land Use Name	gpd/Acre	EDU/acre
CG	General Commercial	1,500	5.8
BP	Business Park	1,500	5.8
BP-R	Business Park Reserve	1,500	5.8
CO	Commercial Office	1,500	5.8
CT	Thoroughfare Commercial	1,500	5.8
RC	Regional Community Commercial	1,500	5.8
COM-R	Commercial Reserve	1,500	5.8
CN	Neighborhood Commercial	1,500	5.8
IND	Manufacturing/Industrial	2,000	7.8
IND-R	Industrial Reserve	2,000	7.8
FSCH	Future School	3,765	14.6
SCH	School	3,765	14.6
P/G	Public General Use	1,500	5.8
AG	Agricultural	0	0.0
OS-PK	Open Space - Park Recreation	0	0.0
FPK	Future Park	0	0.0
RR	Rural Residential	513	2.0
LD	Low Density Residential	1,155	4.5
LMD	Low to Medium Density Residential	2,182	8.5
HMD	High to Medium Residential	4,621	18.0
HD	High Density Residential	7,188	28.0
RMH	Mobile Home Park Residential	2,054	8.0
VR	Village Residential	3,080	12.0
RES-R	Residential Reserve	1,155	4.5
CP	Community Plan	1,155	4.5
MU	Mixed Use	3,057	11.9

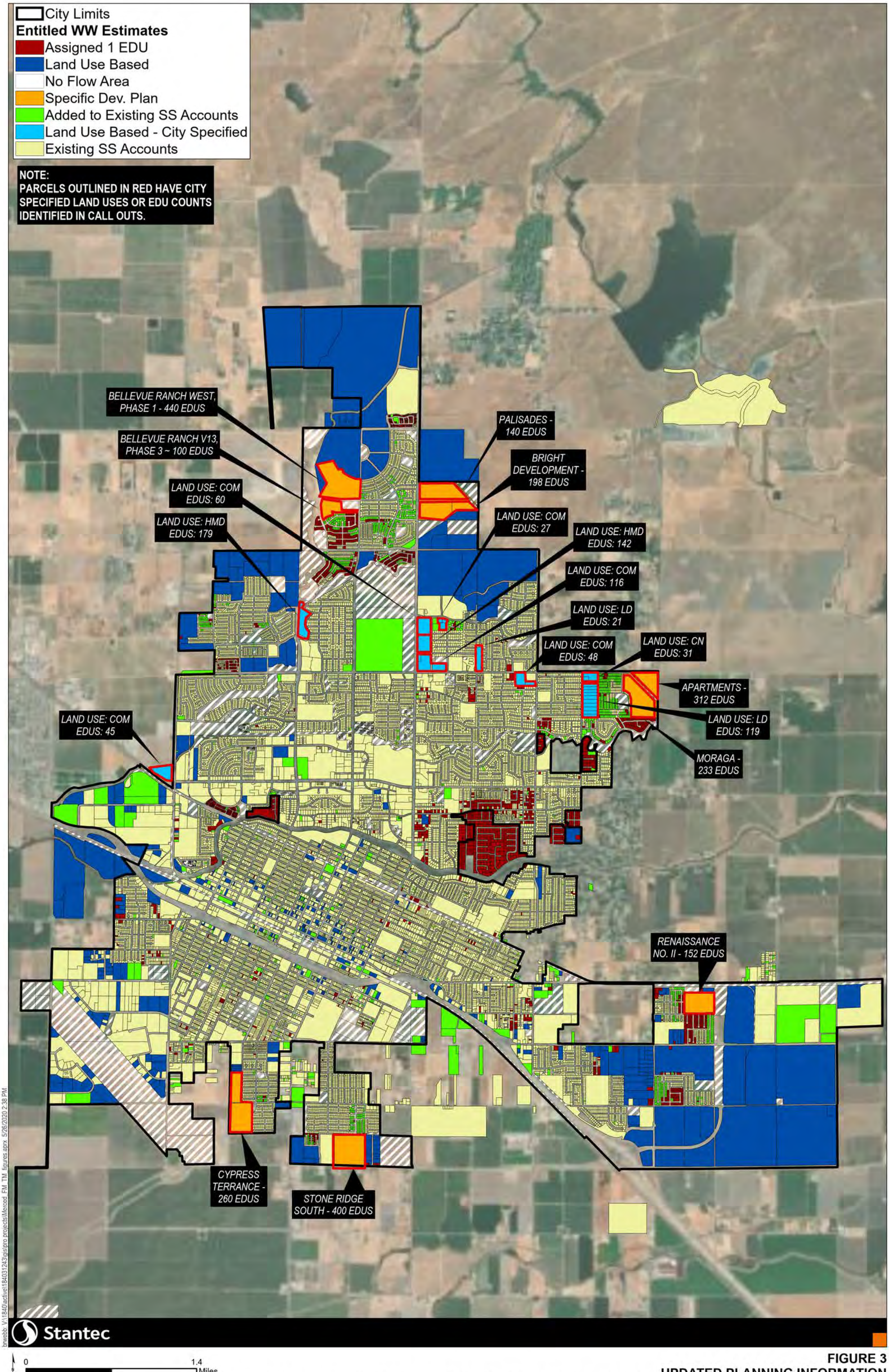


FIGURE 3
UPDATED PLANNING INFORMATION
CITY OF MERCED WASTEWATER COLLECTION SYSTEM – FLOW MONITORING AND SYSTEM CAPACITY UPDATE

Table 3 Summary of Parcel Data Review

Service Area	Total Area (Acres)	Total EDUs
Total Existing Service Area	**6,700**	**~31,000**
Committed Service Area		
• General Plan Land Use Parcels	2,760	19,940
• City Specified Land Use Parcels	80	790
• Single Lot Parcels/ 1 EDU	410	2,130
• Specific Development Plan Parcels	300	2,240
• UC Merced (committed ADWF exceeding existing, 0.77 MGD) (1)	-	-
Total Commitments	*3,550*	*25,100*
Buildout Service Area		
• Remaining Parcels within SUDP (General Plan) Boundary (2)	10,540	57,000
• Campus Community (planning ADWF estimate, 1.96 MGD) (1)	-	-
Total Interim Service Area	**10,250**	**56,100**
Total Buildout Service Area	**20,790**	**113,100**

1. Table 5-3 in the WCSMP, consistent with the UC Merced and University Community Project Environmental Impact Report (March 2009), and the UC Merced 2020 Project Addendum No. 6 to the 2009 UC Merced Long Range Development Plan EIS/EIR (April 2013).
2. The area and EDU estimate of parcels bisected by the City's SUDP boundary are limited to the portion that exists within the City's planning area.

2.4 SUMMARY OF FLOW MONITORING DATA

V&A Consulting Engineers (V&A) monitored flows within the wastewater collection system between November 22nd, 2019 and December 25th, 2019. Open channel flow monitoring was performed at ten locations to provide sanitary flow data which would allow detailed definition of sewer-sheds within the model during the conversion and re-calibration. The specific flow monitoring locations provide a higher resolution of flow distribution within the hydraulic model than existed in the previous ICM model. Calibration allows the actual distribution of average dry weather flow (ADWF) to be assessed as well as allowing a system specific distribution of peak wet weather flow (PWWF). The Flow Monitoring Site Reports provided by V&A, including data, graphs and information are included in **Appendix A**.

2.4.1 Collection System Flow Data

A summary of the flow monitoring locations, sewer-shed characteristics, and flow data provided by V&A is presented in **Table 4**. The measured ADWF and PWWF are presented for each monitoring site, along with the calculated wet weather peaking factor. The peaking factor is defined as the ratio of PWWF to ADWF for each monitoring location. The City's trunk sewers are designed using a peaking factor of 2.3 per City Design Standards. Peaking factors that exceed this design criteria were observed at Site 1 and Site 9 during the flow monitoring study. Discussions with City staff indicate that on-going construction in these areas may have contributed to the high wet weather response in these sewer-sheds.

Table 4 V&A Flow Monitoring Data

V&A FM ID	FM MH ID	Pipe Size (in)	Trunk Sewer	Location/ Description	Sewer-shed Area (Acres)	ADWF (MGD)	PWWF (MGD)	PF	Period Average (MGD)
1	1M149	18	Yosemite	East Yosemite Ave	444	0.38	1.12	**2.95**	0.41
2	5M040	30	G Street	Camp Drive West of G St	590 (1)	1.03	2.34	2.27	1.03
3	6M376	21 or 24	Hwy 59	Hwy 59 near Olive South of RR	386	0.90	1.89	2.10	0.92
4	6M125	43	Black Rascal (North)	Meadows Ave, North of Olive	521	1.48	3.15	2.12	1.50
5	6M161	21	Olive	Olive Ave, East of Meadows	873	0.67	1.46	2.18	0.69
6	16M071	39	Black Rascal (South)	North of Hwy 99 Crossing	391	3.43	6.59	1.92	3.51
7	16M050	42	42-inch Trunk	Near Airport LS discharge	482	3.36	7.29	2.17	3.57
8	16M192	36	Gerard Trunk West	Gerard Trunk at West Avenue	2,122	2.76	6.00	2.17	2.88
9	[39729]	36	Gerard Trunk East	Gerard Trunk East of Tyler Rd	754	0.52	1.37	**2.63**	0.58
10	16M097	48	48-inch Interceptor Sewer	Interceptor Sewer at Gerard Ave	22	3.52	6.71	1.90	3.58

1. Only 200 acres of UC Merced campus is included in the sewer-shed area presented for Site 2.

V&A noted that Site 8 and Site 10 are in proximity to each other and both had a large amount of sediment build-up. High amounts of sediment at the monitoring location can impact the quality of the associated flow monitoring data. They also noted that generally, there was a noticeable decrease in observed flows during the Thanksgiving and Christmas holidays. This presumably may be due to the University of California – Merced (UC Merced) student population and holiday travel. V&A cautions that ADWF rates and wet weather flow responses may not have been at "full strength". Further noting that the data may not be representative of average conditions due to the timing of the study, which took place during the holiday season. The existing collection system and flow monitoring locations are presented in **Figure 4**.

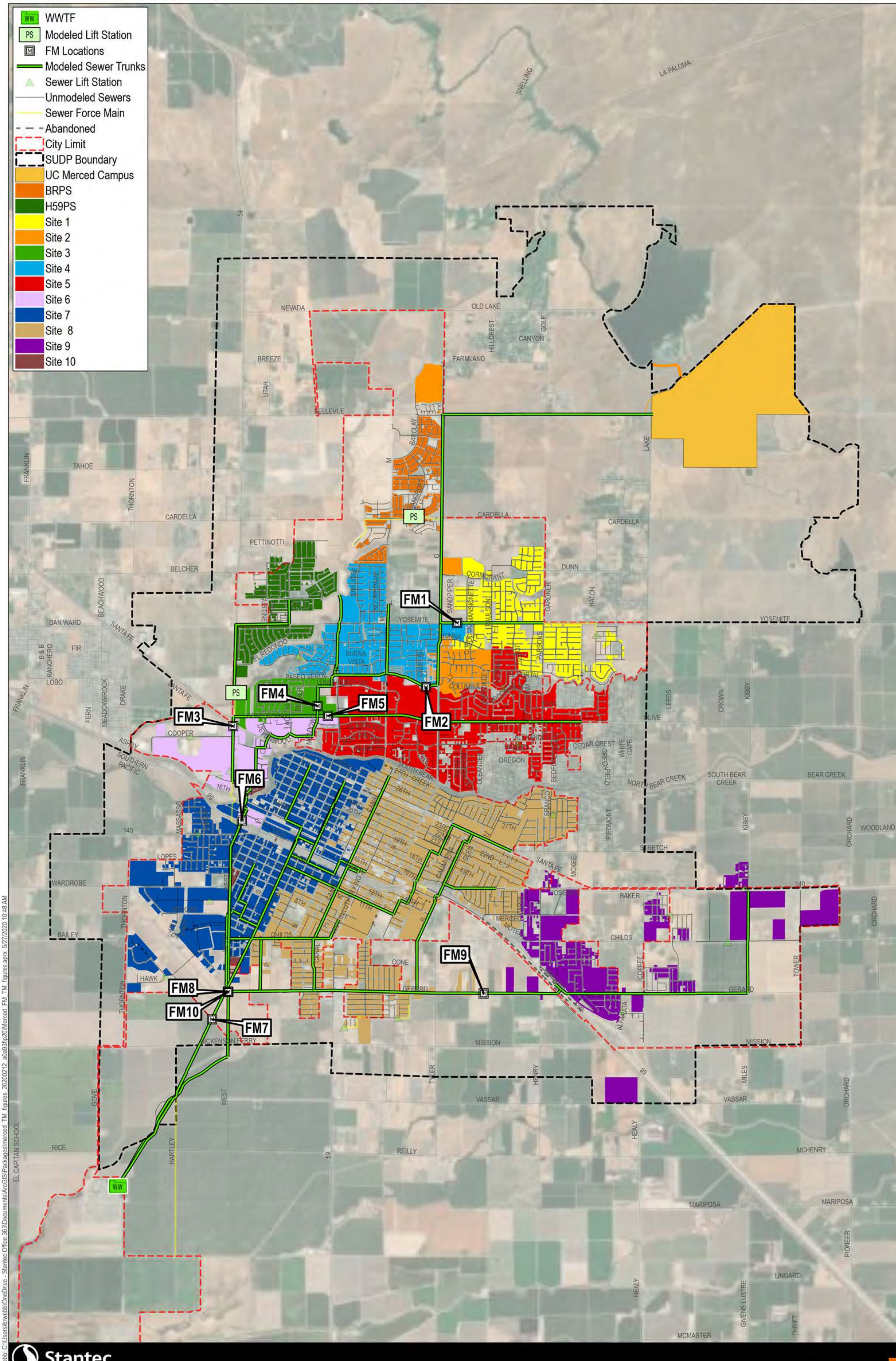


FIGURE 4

FLOW MONITORING LOCATIONS - V&A FLOW MONITORING STUDY (DEC-NOV 2019)

COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

2.4.2 Rainfall Data

The Merced Wastewater collection system is designed to provide flow capacity to meet the level of service (LOS) to accommodate a peak flow resulting from the 10-year, 24-hour design storm event. A 10-year, 24-hour design storm in the City of Merced has a total rainfall depth of 2.31 inches (NOAA Atlas 14, Volume 6, Version 2, point precipitation frequency estimates for the City of Merced). V&A installed two rain gauges to track rainfall throughout the monitoring period. Rain Gauge North (RGN) was positioned in the northern portion of the City near flow monitoring Site 2, and Rain Gauge South (RGS) was positioned in the southern part of the City at the Meadows sewer lift station, south of Sites 8 and 9.

The 24-hour precipitation totals recorded at V&A's north and south rain gauges are graphed in relation to storms with 2-year, 5-year, and 10-year return frequencies in Figure 5. RGN recorded a total of 4.16 inches and RGS recorded a total of 4.77 inches of rainfall over the course of the flow monitoring period. The largest rainfall event, Event 1 occurred over a 48-hour period beginning at 7:30 PM November 30th and ending December 2nd. RGN recorded 2.44 inches of rainfall and RGS recorded 2.87 inches, exceeding the total rainfall associated with a 2-day storm event having a 10-year return period (2.76 inches).

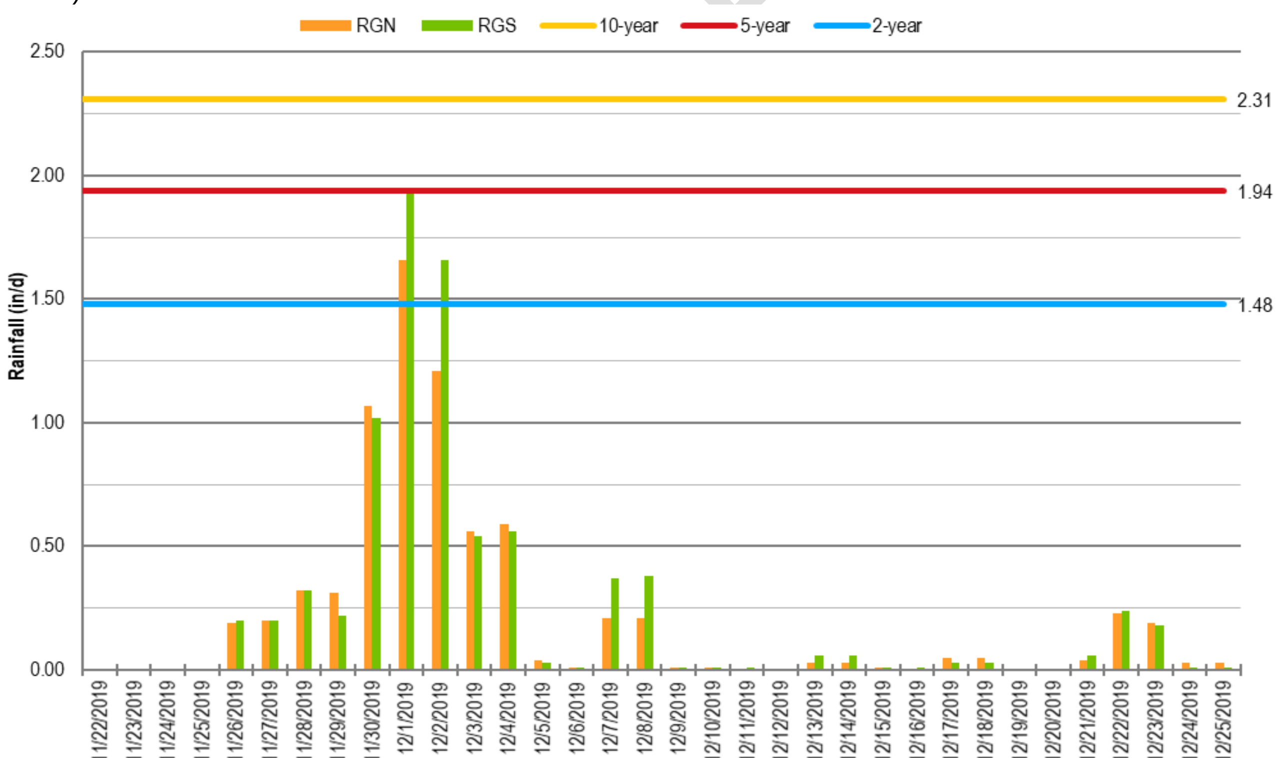


Figure 5 RGN and RGS 24-hour Rainfall Totals and NOAA Precipitation Return Frequencies

During the flow monitoring period RGS also recorded two 24-hour periods in which total rainfall exceeded a 2-year event. The larger of these periods, Event 2 occurred between 8:15 AM December 1st and

December 2nd, totaling 1.93 inches, just under the threshold of a 5-year rainfall event (1.94 inches). RGN recorded slightly less rainfall than RGS during Event 2, but still recorded enough rainfall to be classified as a 2-year, 24-hour rainfall event. A summary of data collected at RGN and RGS is presented in **Table 5**.

Table 5 Rainfall Data

Rainfall Data				RGN	RGS
Item	**Duration**	**Start Time**	**End Time**	**Total Rainfall (in)**	**Total Rainfall (in)**
Event 1	48 hours	11/30/2019 19:45	12/2/2019 19:30	2.44	2.87
Event 2	24 hours	12/1/2019 8:30	12/2/2019 8:15	1.50	1.93
FM Period	34 days	11/22/2019 0:00	12/25/2019 23:45	4.16	4.77

3.0 MODEL CONVERSION AND UPDATE

The purpose of this section is to provide a description of the collection system model update and conversion from ICM to PCSWMM software. It presents the assumptions and data used to update the model, in addition to the notable changes and differences between the original ICM model and updated PCSWMM model. The hydraulic model conversion and update process included the following:

1. Export data associated with the physical asset database from the ICM model, compare the data with the latest sewer system GIS database provided by the City, and reconstruct the collection system network within PCSWMM.
2. Collect and review sewer service account, planning, and sewer service commitment data. Update the land use and planning data used to project wastewater generated from developing areas in model simulations with planning information provided by the City. Update the existing system service area and commitments within model scenarios.
3. Wastewater flow distribution and calibration within the existing system model using flow monitoring data collected by V&A.
4. Rebuild the interim and buildout model scenarios presented in the WCSMP using the updated existing system model and incorporate the revised planning and parcel data.
5. Run updated models and use the results to perform the existing sewer system capacity analysis.

The following subsections provide a description of the updates to the physical collection system network, simulated scenarios, wastewater distribution, model calibration, and the design storm used to simulate peak wet weather flows.

3.1 PHYSICAL NETWORK

The wastewater collection system physical asset database was exported from the original ICM model and imported into PCSWMM. The physical system components in the PCSWMM model were compared with latest version of the GIS database provided by City Public Works staff. Discrepancies in asset information were resolved and brought into PCSWMM as appropriate to form the basis for the updated model physical characteristics. Differences between the existing and updated model were noted and discussed with City staff. This new data generally is more complete than the data used to develop the master plan ICM model, allowing more resolution in the assignment of assets and flows to sewer-sheds within the system.

3.2 UPDATED MODEL SCENARIOS

The hydraulic model scenarios simulated as part of the development of the WCSMP were updated with the latest planning information as part of this effort. Each of the scenarios and the updates associated with this effort are further described below:

Existing System Scenario: The existing system scenario represents the City's existing level of development and simulates flow conditions in the collection system considering wastewater collected from existing sewer service accounts. GIS parcel data associated with existing sewer service accounts was used to update sewer-sheds within the existing collection system model. Flow data provided by V&A was distributed between parcels within the revised sewer-sheds.

Interim System Scenario: The interim system scenario represents an interim level of development condition within the City and simulates flow conditions within the existing collection system (no new infrastructure) after connection of all planned sewer service commitments. The latest planning data and committed parcel information was reviewed and incorporated into the interim model.

Buildout System Scenario: The buildout system scenario represents the City's future buildout level of development condition and simulates flow conditions within the future collection system after connection of all parcels within the SUDP boundary. The model includes new trunk sewer infrastructure that would be required to serve buildout of the City's General Plan. The latest planning data and parcel information was reviewed and incorporated into the buildout model.

3.3 FLOW DATA AND DISTRIBUTION

Wastewater flow contributions were distributed to manholes within the existing system model using flow monitoring data and parcel data for the existing service area. Flow data from each monitoring site was distributed within each sewer-shed based on the proportion of the overall sewer-shed area contributing to each manhole. Wastewater flow data is collected by the City on a continuous basis at the WWTF influent junction structure, large pump stations (BRPS & H59PS), and connection (service) point of UC Merced.

Flow data corresponding to the time period of the flow monitoring study was provided by the City for the WWTF, UC Merced campus, the H59PS, and the BRPS to further refine the distribution of flow within the model. The following provides additional discussion of the data considered to distribute flow within the model and each data source.

3.3.1 WWTF Influent Flow Meter

Historical influent wastewater flow data from the City's WWTF was provided for use in this assessment. The data was compared to the flows recorded by V&A during the period of the flow monitoring study. The total wastewater flow measured at the WWTF equates to approximately the sum of flow monitored along the two influent trunk lines. The variance of 0.8 MGD can be attributed to flow attenuation, travel time between each site and the WWTF, and connections downstream of monitoring sites in addition to differences in data sources and quality. Flow in each of the major trunk lines that convey flow to the WWTF were recorded at Site 7 and Site 10 in the V&A study. It should be noted that a large amount of sediment was observed at Site 10, which likely impacts the quality of the data measured at that location.

As previously mentioned, the period of the flow monitoring study corresponds to the holiday season (November 22nd – December 25th), and may not be representative of average conditions on an annual basis. Historical influent wastewater flows recorded at the City's WWTF show an atypical annual pattern when compared to what is typically observed at wastewater treatment facilities in the region. Typically, the lowest monthly flows are observed during the dry weather season (June - September). The ADWF, or the average flow recorded during the three driest months of the season, is typically used to represent baseline wastewater flow because it is unimpacted by groundwater or rainfall dependent inflow and infiltration (RDII) which contribute to peak wet weather flows (PWWFs).

In California, PWWFs are typically observed during the wet weather season (November – March) occurring due to high groundwater levels and RDII from storm events. Peak month flows in the City of Merced typically occur between June and October, with January and December typically having the lowest recorded flows. The monthly flow pattern for the City of Merced, and typical monthly flow patterns for other Central Valley WWTFs is depicted in **Figure 6**.

City's inverse monthly pattern may be attributed to the following City specific considerations:

- Depleted groundwater levels in the region due to over pumping of agricultural wells, virtually eliminating the impact of high seasonal groundwater on the collection system. This may also increase the rate at which rainfall is absorbed by the underlying groundwater basin as opposed to infiltrating into the collection system. This combined with persistent drought and limited rainfall in the region limit the impact of wet weather events on the collection system.
- Numerous irrigation canals that traverse the City, a portion of the water flowing through these unlined canals infiltrates into the ground and the wastewater collection system. Canals are operated and flow full during the irrigation season (dry season), causing higher flows in collection system during periods of dry weather.
- The UC Merced wastewater contribution, the student population on the UC campus and surrounding community is dependent on the academic calendar. Students return home for the holidays (wet weather season) and typically return in late January, thereby reducing baseflows during the end of the year (November – December).

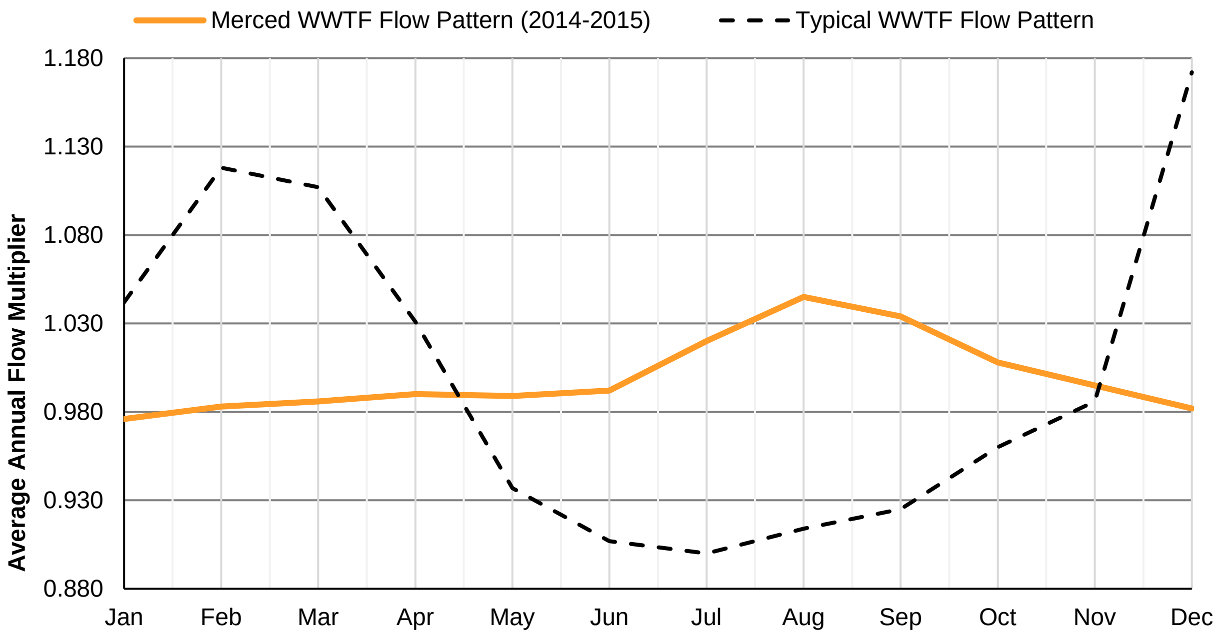


Figure 6 Typical Monthly Wastewater Flow Patterns

3.3.2 UC Merced Service Meter

The monthly wastewater volume data provided for the UC Merced campus shows a significant variance in the amount of wastewater generated from the UC on a monthly basis. Based on data collected between May 2017 and December 2019, the highest monthly flow volume typically occurs in February during the wet-weather season when students are on campus. The lowest monthly volume is typically observed in July, during dry weather conditions when students are typically off campus for summer break.

The average daily flow in February 2019 (0.35 MGD) was 3.9 times higher than what had been recorded for July 2018 (0.09 MGD). Although data was only provided for total monthly wastewater volume, it's also likely that flow varies significantly on a daily and hourly basis, due to the fluctuation in campus population and activities. This variance has a large impact on flow conditions within the City's overall wastewater collection system specifically in North Merced as UC Merced is the most upstream connection and impacts the trunk system between the Bellevue Trunk to 48-inch Interceptor.

Seasonal, daily, and hourly wastewater flow patterns originating from UC Merced should be further monitored and studied. The actual flows should be considered to further refine the model and determine service agreement discharge limitations, if necessary, to maintain a desirable level of service within the downstream collection system as the UC Merced expands.

3.3.3 Lift Station Operating Data

Data provided for the H59PS and BRPS was provided in the form of daily total flows. Review of the data indicated lower flow rates during the wet weather period and higher flows during the dry weather period of the flow monitoring study. This is inconsistent with what is typically observed within wastewater collection systems. Peak flows within the system typically occur during periods of wet-weather due to RDII. Therefore, flow from these areas was approximated considering the data providing by V&A and the City, as well as, land use and population data of the pump station collection areas.

Table 6 Additional Flow Data

ID	Description	Sewer-shed Area (Acres)	Within V&A Sewer-shed	City Data ADWF (MGD)	City Data PWWF	EDU	Modeled ADWF (MGD)
UCM	UC – Merced	200	2	0.193 [1]	0.345 [2]	NA	0.190
BRPS	Bellevue Ranch Pump Station	148	2	0.141 [3]	0.097 [4]	~ 725	0.186
H59PS	Highway 59 Pump Station	216	3	0.148 [3]	0.130 [4]	~ 1,075	0.276
Airport Area	Airport Area (Industrial)	100	NA	NA	NA	~ 580	0.150
WWTF	WWTF Influent Data	6,065	Equal to 10+7	7.8	13.6		7.0

1. Average daily flow approximated from total flow recording in November and December 2019. (November 2019 = 6.21 MG; December 2019 = 5.53 MG)
2. Peak average daily flow from monthly flow records from May 2017 through December 2019. (February 2019 = 9.67 MG)
3. Average of total daily flow data for 12/10/2019 through 12/22/2019, corresponding to dry weather experienced during the flow monitoring period. These data were considered inaccurate and sewer-shed EDU data was used to approximately ADWF.
4. Average of total daily flow data for 11/26/2019 through 12/9/2019, corresponding to wet weather experienced during the flow monitoring period.

3.3.4 Modeled Flow Distribution Summary

Many of the flow monitors in the V&A flow monitoring study were aligned in series, such that a downstream monitor receives flow from one or more upstream monitors. To distribute flow to manholes within the hydraulic model, flow contributions from sewer-sheds in series were estimated by subtracting flow from upstream sheds. Upstream flows are subtracted from the data associated with monitors in series to estimate the flow contribution of the difference in area. A summary and description of the updated sewer-shed areas under existing and interim conditions is provided in **Table 7**.

There are inherent errors introduced when subtracting flow monitors in series due to variations in data quality, and travel time between monitors. Despite the induction of error, the use of unique parameters for each area between successive monitors provides increased resolution of both dry weather diurnal patterns and wet weather flow responses. Characteristic dry weather flow (DWF) parameters and wet weather flow (WWF) characteristics were determined for the sewer-sheds associated with each flow monitoring station in the V&A study.

The discharge location of the BRPS is adjusted to reflect historical planning to utilize its secondary forcemain after capacity of its current forcemain is reached (1.96 MGD). The discharge location is moved from its current location along the G Street Trunk to the end of the sewer in R Street (the ultimate location of connection planned as the Bellevue Ranch subdivision is built out) in the interim model.

Flow data provided for the collection areas of the BRPS and H59PS were used to further refine the distribution of flow within sewer-sheds 2, 3, and 4. Similarly, the flow data provided for the UC Merced campus was used to further refine flow distribution in sewer-shed 2.

For each monitor in series, the initial DWF parameter estimation assumed a straight subtraction of the upstream DWF values.

Table 7 Sewer-shed Areas

Sewer-shed ID	Sewer-shed Description/ Landmarks	Existing Sewer-shed Area (Acres)	Committed Sewer-shed Area (Acres)	Interim Sewer-shed Area (Acres)
1	Yosemite Ave, Silverado, Moraga	444	84	528
2	G Street, BRPS, UC Merced	186	944	1,131
3	H59PS, Conestoga	155	8	163
4	Fahrens Park, Merced College, Oakbrook	521	39	560
5	Olive Ave, East of R Street, north of Bear Creek	873	241	1,114
6	Merced Marketplace, West Industrial Development	391	255	646
7	Airport Industrial Park, “Old Town” east of Sheehy Elementary	482	108	591
8	“Old Town” south of Bear Creek, Gerard Ave east of Hwy 99	2,122	275	2,398
9	Gerard Trunk East of Tyler Rd, Lyons Properties to CVS	754	1,125	1,879
10	Limited connections to the 48-inch Interceptor/ West Avenue Trunk	22	4	26
UCM	UC Merced Campus, included in V&A Site 2	200	-	151
BRPS	Bellevue Ranch PS, included in V&A Site 2	204	233	427
H59PS	Hwy 59 PS, included in V&A Site 3	231	196	437
Airport Area	Downstream of all FMs, assumed V&A Site 7 parameters	110	41	200
	Total:	**6,697**	**3,554**	**10,251**

The equations used to isolate flow contributed by each sewer-shed are presented in **Table 8**. The flow split that occurs at the intersection of Olive and Meadows Avenue was reviewed to determine the amount of flow from sewer-shed five that is conveyed south in the Black Rascal Trunk (South) and what continues flowing west in the Olive Trunk. It was determined that during the monitored dry weather flow period, the flow from sewer-shed 5 is split approximately in half. Roughly 48 percent of flow continues in the Olive Trunk and 52 percent of flow turns south entering the Black Rascal Trunk (South). The portion of flow that remains in the Olive trunk is represented by the variable “X” in the sewer-shed isolation equations presented in **Table 8**. The proportion of the flow split varies with depth and flow volume and “X” was determined to be closer to 60 percent under wet-weather conditions.

Table 8 Sewer-shed Flows and Isolation Equations

Basin Flow ID	Average Monitored Flow, Q_x [(1)] (MGD)	Sewer-shed Isolation Equation	Current Shed Flow Contribution, Q_{sx} (MGD)	Committed Shed Flow Contribution (MGD)	Total Interim Shed Flow (MGD)
Q_1	0.39	$Q_{S1} = Q_1$	0.39	0.18	0.57
Q_2	1.05	$Q_{S2} = Q_2 - Q_1$ - BRPS - UCM	0.28	1.76	2.05
Q_3	0.90	$Q_{S3} = Q_3$ - H59PS - X(Q_5)	0.30	0.05	0.34
Q_4	1.50	$Q_{S4} = Q_4 - Q_2$	0.46	0.10	0.56
Q_5	0.68	$Q_{S5} = Q_5$	0.68	0.26	0.94
Q_6	3.44	$Q_{S6} = Q_6 - Q_3 - Q_4 - (1 - X)(Q_5)$	0.69	0.37	1.05
Q_7	3.45	$Q_{S7} = Q_7 - Q_8$	0.68	0.19	0.87
Q_8	2.77	$Q_{S8} = Q_8 - Q_9$	2.21	0.46	2.67
Q_9	0.56	$Q_{S9} = Q_9$	0.56	2.06	2.62
Q_{10}	3.48	$Q_{S10} = Q_{10} - Q_6$	0.04	0.01	0.05
UCM	0.19	-	0.35 [(2)]	0.77	1.13
BRPS	0.19	-	0.19	0.58	0.76
H59PS	0.28	-	0.28	0.36	0.63
Airport Area	0.15	-	0.15	0.08	0.23
Total Modeled	-	-	7.23	7.23	14.46

1. Q_X = the average monitored for at the flow monitoring location, while Q_{SX} = the isolated sewer shed flow distributed to manholes within the model. The average monitored flow is the average flow for the selected dry weather period of the flow monitoring study, which was a seven-day period recorded from December 14th to December 21st, 2019.
2. The model was calibrated assuming the measured flow for UC Merced of 0.19, the average existing flow (0.35), simulated in the existing system model, was estimated to be proportional the its current student population vs. that projected at buildout using the buildout flow estimate of 1.13 MGD, outlined in existing planning documents. It was assumed that there are currently approximately 8,000 students and 25,000 are projected at buildout.

3.4 MODEL CALIBRATION

The model was calibrated to the monitored DWF, considering weekday and weekend flow patterns. The calibrated DWF model was used to perform the wet weather calibration using data from monitored wet weather events. Calibration included modifying parameters such as flow distribution, Manning's n, and I/I parameters. Parameters were input to the hydraulic model on a trial basis and the routed flow hydrographs produced by the model at each flow monitoring site were compared to the observed monitored flow. The parameters were varied in a systematic manner within a reasonable range until an acceptable fit to the observed flow was obtained. Comparisons were made between modeled and monitored flow, depth, velocity, and volume. The calibration prioritized representing PWWF and total flow volume for each monitoring location, as these parameters are more indicative of potential capacity restrictions. Parameters for velocity and depth typically indicate significant differences between modeled and the physical state of the infrastructure, as field conditions such as sediment depth, minor defects and obstructions, and actual pipe slope in the vicinity of the flow monitor may vary from modeled conditions.

Initial Manning's n values were determined based on typical values for various pipe materials, pipe condition photos from the V&A site reports (included in Appendix A) and fitting calculated level vs. velocity curves to the observed depth and velocity data. It should be noted that the calibration resulted in relatively high roughness (Manning's N > 0.014) values for sewer within sewer-sheds 3, 4, 6, and 10, which drain to the 48-inch interceptor sewer. High roughness values reduce the available capacity of sewers to convey flow and increase surcharge in this portion of the system.

3.4.1 Data Quality Considerations

The flow monitoring data was evaluated to determine the overall data quality associated with each monitoring location, including a comparison with influent flow data observed at the WWTF to ensure overall consistency. Review of raw data from flow monitors indicated that quality of the flow data was not consistent between locations. In several instances, the flow monitor itself had erratic and unstable depth and velocity readings or complete velocity or level dropouts. The culmination of these issues is translated into the area-velocity computed flow, which can affect the PWWF and volume that are compared to the calibration simulation results. Interpretation of the flow monitoring data was required during calibration to assess the presence of outlier instantaneous spikes or dropouts, or inconsistencies between calibration and validation periods that could account for discrepancies. Despite variations in the quality of data between flow monitoring locations, the overall data quality was considered adequate for the purposes of calibration.

3.4.2 Calibration Challenges

Challenges encountered during model calibration included the impacts of system flow splits, error associated with subtracting flow from monitors in series, spatial variation of wastewater flows, and flow monitor data quality. Sewer networks often have various manholes with pipe bifurcation where flow may travel into two or more pipes. The exact contribution of flow to a downstream flow monitor is dependent on the characteristics of these flow splits and their response to varying levels of flow. The upstream sewer-sheds of flow monitoring Sites 7 and 8 (downtown area) have several instances of bifurcation, which added a degree of uncertainty to the development of calibrated parameters. Without several concurrent monitors in place capturing a large array of flow regimes, the assumed flow splits and physical layout of the model must be relied upon.

3.4.3 Calibration Summary

The DWF model was calibrated to measured flow, velocity, and depth at each monitoring location. An acceptable error of 15% between simulated and observed results was assumed for the calibration. The average and total flow volumes were calibrated to be within 3% of what had been observed during the flow monitoring study. Similarly, the peak dry weather flow was calibrated to be within 10% of what had been observed. The minimum flow at Sites 6, 8, and 9 were outside of the acceptable error range, but still within 20% of the observed values. Less effort is spent calibrating to minimum observed values as peak flows are used to assess system capacity. The simulated velocity and depth levels fell out of the acceptable error range at sites with poor data quality.

Two wet-weather events were selected from the flow monitoring data for wet-weather calibration. The second event was primarily used to calibrate the model and had a greater wet-weather response than Event 1, likely due to saturation from prior rainfall and limited initial abstraction. The simulated PWWF was calibrated to be within 15% of what had been observed during the flow monitoring study. Depth and velocity were not considered in the WWF calibration. This 15% PWWF accuracy is an industry standard typically accepted for models used in master planning efforts.

Comparison of the results of the calibration effort using flow monitoring data collected by V&A indicate that the model accurately represents system performance during the monitoring period. For purposes of this planning effort, the calibrated model is acceptable and is used in all subsequent evaluations of existing, interim, and buildout conditions. Calibration data and simulated vs. observed PWWF graphs are presented in **Appendix B** of this report.

4.0 MODEL RESULTS AND CAPACITY EVALUATION

The updated hydraulic model of the collection system was used to assess the residual capacity of the City's collection system under existing, interim, and buildout development conditions. The level of service (LOS) criteria used in the assessment corresponds to that presented in the City's Wastewater Collection System Master Plan (Stantec, 2017). LOS criteria used to assess capacity of sewers are summarized below.

4.1 DESIGN STORM

PWWFs simulated in the hydraulic model are used to evaluate the LOS of the collection system and provide recommendations for future servicing and improvement strategies. PWWFs are determined by computational models by simulating design rainfall events representing a reasonable worst-case condition. During rainfall conditions considered more severe than the input design storm, exceedances of LOS criteria would be expected to occur, which may result in sanitary sewer overflows (SSOs). The design storm selected for many Central Valley collection systems has a statistical 10-year return frequency and 24-hour duration. PWWFs in the collection system, originating from the existing sewer-sheds, were evaluated using a 10-year, 24-hour design storm with a Huff Distribution (distributing rainfall by hour). The 10-year, 24-hour design storm in the City of Merced has a total rainfall depth of 2.31 inches. PWWF contributing to proposed buildout infrastructure are calculated using the City's design standard, which applies a peaking factor of 2.3 to the projected ADWF.

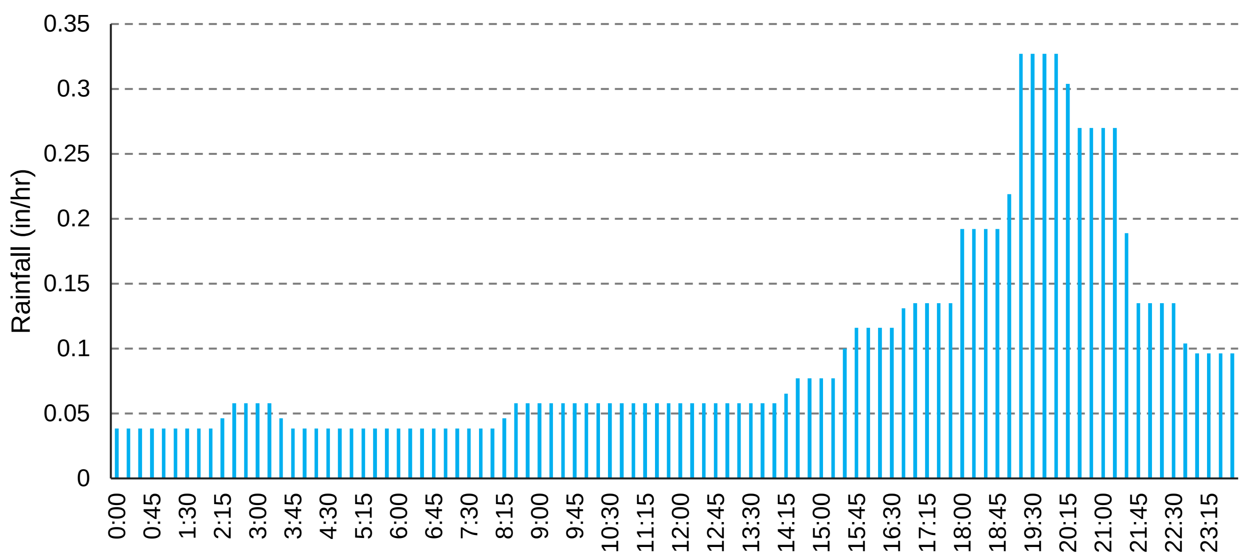


Figure 7 City of Merced 10-year, 24-hour Design Storm

4.2 CAPACITY EVALUATION CRITERIA

Capacity evaluation criteria used in the capacity assessment include:

- Level of manhole surcharging
- Sewer flow velocity
- Pipe capacity

4.2.1 Surcharging

Surcharging in a manhole is defined in terms of the distance between the top of the sewer pipe leaving the manhole (i.e., the pipe crown elevation) and the hydraulic grade line (HGL) of water flowing through the manhole. A manhole is considered to be surcharged when the HGL exceeds the exit pipe's crown elevation.

Two surcharging design criteria are applied during the sewer system capacity assessment:

- Manhole rim elevation is less than 8-feet above the exit pipe crown elevation:
  - No surcharging allowed
- Manhole rim elevation is greater than or equal to 8-feet above the exit pipe crown elevation:
  - 1-foot of surcharging is acceptable.

Proposed sewer improvements and new sewers are designed to have no surcharging allowed under peak design flow conditions.

4.2.2 Velocity

Gravity trunk sewers shall be designed to maintain a minimum flow velocity of 2.5 ft/s under dry weather flow conditions, and a maximum velocity of 7 ft/s under peak flow conditions. All existing trunk sewers that are predicted to have velocities outside of these criteria based on the results of the hydraulic model shall be identified.

Forcemains shall be designed to have a minimum flow velocity of 2 ft/s and a maximum flow velocity of 7 ft/s under the full range of pumping conditions. All existing trunk system forcemains that are predicted to have velocities outside of these criteria based on the results of the hydraulic model shall be identified.

4.2.3 Capacity

New gravity flow trunk sewers shall conform to the following capacity criteria under design peak flow conditions (where d = depth of flow in pipe, and D = pipe diameter):

- d/D shall be a maximum of 0.70 for gravity flow trunk sewers with diameters up to 24 inches.
- d/D shall be a maximum of 1.00 for gravity flow trunk sewers with diameters greater than 24 inches.

4.3 EXISTING SYSTEM RESULTS

The updated model of the trunk sewer system was used to evaluate the extent of hydraulic deficiencies within system under peak flow conditions. The updated model predicts a PWWF of 19.8 MGD at the WWTF under 10-year, 24-hour design storm conditions. This is slightly less than what had been predicted by the WCSMP ICM model, which was 23.4 MGD, but still within the range of peak observed flows recorded during significant historical storm events.

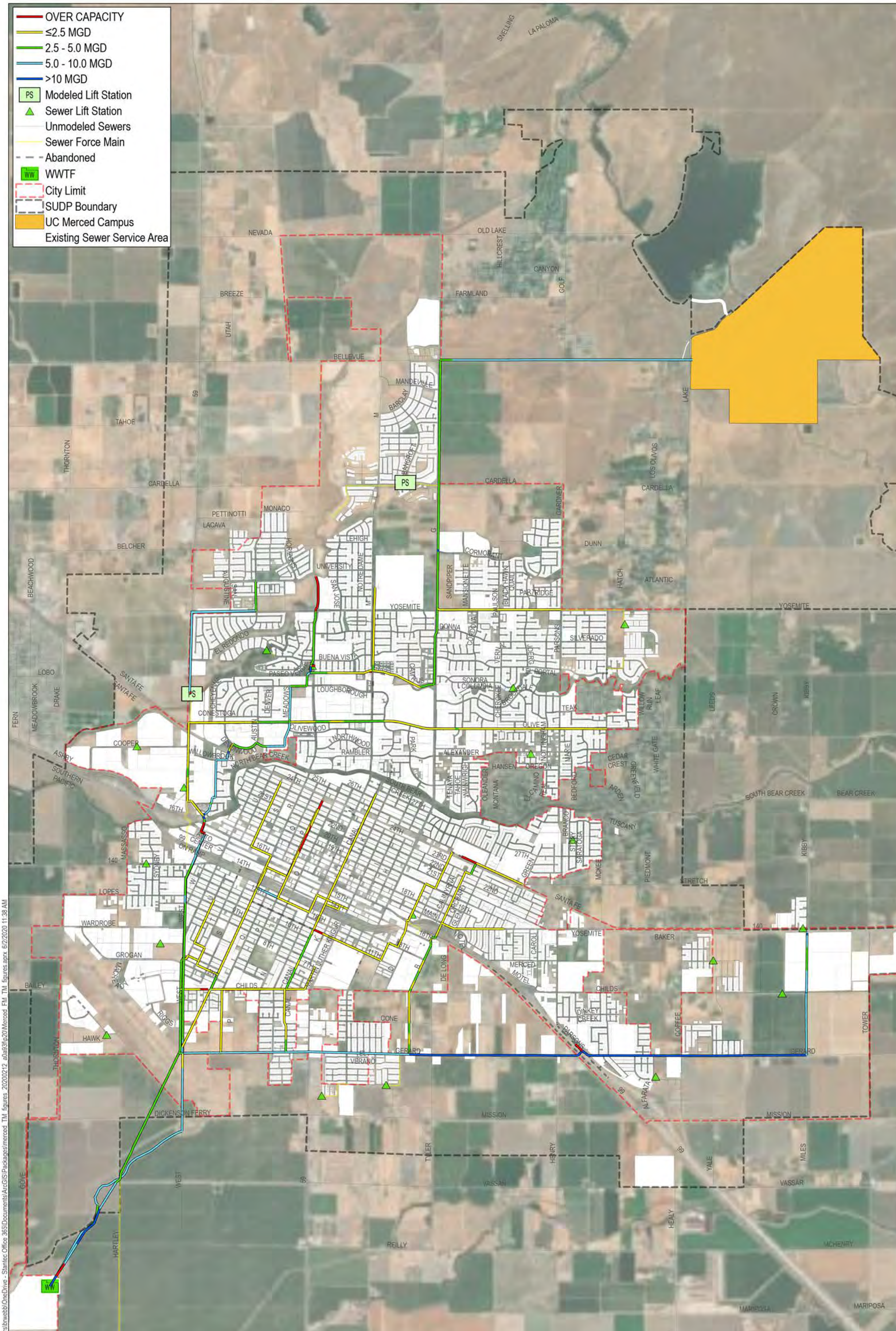
4.3.1 North Merced

There was only one sewer reach predicted to be nearing capacity in North Merced within the existing system model, however this may be a result of erroneous data on its actual diameter. This sewer is located along the H59PS Trunk in Hwy 59 just south of the H59PS discharge location and was also identified in the WCSMP as a potential issue. There are inconsistencies in the pipe sizes listed for sewers in this area between the previous system model, the City's GIS database, and those identified by V&A during the flow monitoring study. The pipe size ranges from 18 to 27-inches, the model currently assumes that one segment in this area is 24-inches based on the most recent GIS data provided by the City. If the actual diameter is 18-inches, it would be predicted to be nearing capacity under existing conditions. There was a deficiency predicted in Olive, near R, under design storm conditions in the WCSMP model. This deficiency is not predicted by the new model.

4.3.2 South Merced

Under existing conditions, the WCSMP identified two primary restrictions in South Merced within the "Old Part of Town"; the first at Canal Street and the second at R Street. As part of this model update, sewers within the City's GIS database identified during data review as abandoned were removed from the hydraulic model. Upstream pipelines and existing slopes within this part of the system were also added and updated within the model. These changes and the refined distribution of flow make it difficult to compare the two model simulations. The updated model shows that the trunk in 11th Street is nearing capacity at the Canal Street intersection, in the same vicinity of the constraints identified as surcharging in the WCSMP. No surcharging is predicted to occur at this location or anywhere within the updated existing system model.

The existing system model results, showing Residual Capacity are depicted in **Figure 8** and hydraulic profiles depicting the hydraulic grade line (HGL) within the primary trunk network are attached to this report as **Appendix C**.



Stantec

0 1.4 Miles

FIGURE 8
EXISTING SYSTEM SCENARIO RESULTS
COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

4.4 INTERIM SYSTEM RESULTS

The interim scenario simulates flow conditions in the existing sewer system after all the City's sewer service commitments have connected to the system without any improvements or new infrastructure. The projected flow from committed parcels and developments was added to the updated model of the existing trunk sewer system. The flow projected to be generated from entitled parcels will double the existing dry weather flow, adding approximately 7.2 MGD to the existing system. Approximately 60% of the committed flow is added within the North Merced service and planning area.

The interim model was used to evaluate the extent of hydraulic deficiencies within the system under peak flow conditions. The interim model predicts a PWWF of 33.9 MGD at the WWTF under 10-year, 24-hour design storm conditions. This is slightly more than what had been predicted by the WCSMP ICM model, which was 31.9 MGD.

The following should be considered when comparing the updated interim results with those presented in the WCSMP:

Physical System Updates:

Record drawings and updated GIS data for pipe size, activity status, slope, and other parameters were incorporated into the model, refining the physical parameters of the system.

New Flow Data and Calibration:

The calculated capacity of some trunk lines is reduced as a result of updated calibration and new flow monitoring data, which resulted in higher than typical roughness coefficients in sewer-sheds 3, 4, 6, and 10, primarily along the 48-inch interceptor and its main upstream trunks. These roughness coefficients were calibrated under ADWF flow conditions within the model. The crown, or top of sewer pipelines is typically smoother than the invert or bottom. Therefore, lower roughness coefficients may be warranted under PWWF conditions and full pipe flow. The model assumes the calibrated roughness coefficients in all scenarios.

Updated Land Use and Planning Information:

Including updating the existing service area to reflect only parcels with existing sewer accounts and exclude open space and vacant lots within city limits. The service area was only assumed based on the vicinity of the sewer system in the previous model. Land use planning and committed EDUs associated with committed parcels was updated to reflect the most recent planning information, including the addition of areas that were not previously considered, including vacant lots within the City. Updating this information changes the project flow from committed areas and its distribution within the existing system.

The interim system model results, showing Residual Capacity are depicted in **Figure 9** and hydraulic profiles depicting the hydraulic grade line (HGL) within the primary trunk network are attached to this report as **Appendix C**.

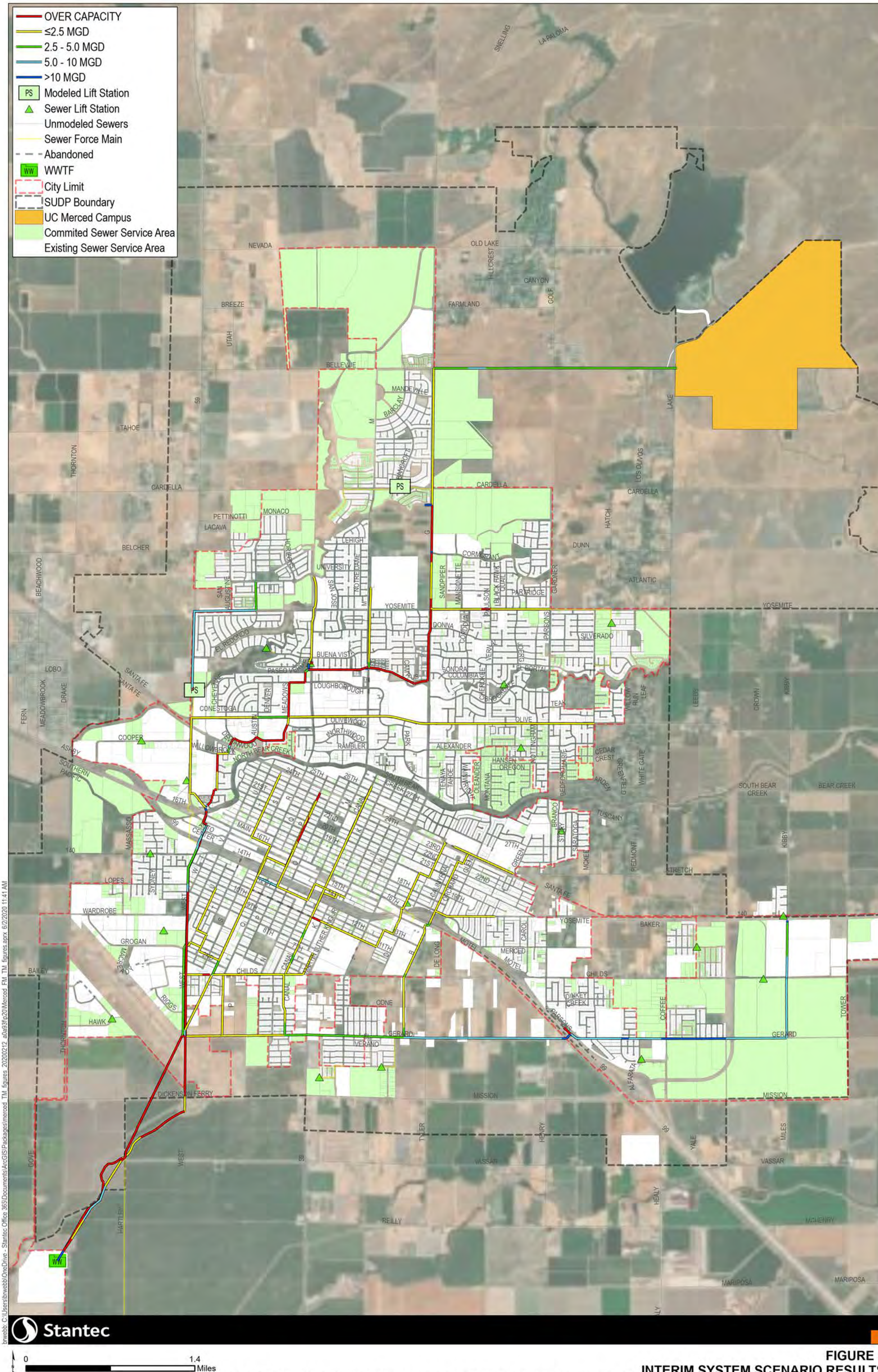


FIGURE 9
INTERIM SYSTEM SCENARIO RESULTS
COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

4.4.1 North Merced

Approximately 60% of the flow added to the existing system under interim conditions is in the North Merced service area. This adds approximately 4.4 MGD to the existing North Merced ADWF (3.6 MGD) equating to a total ADWF of approximately 8.1 MGD under interim conditions.

The WCSMP identified the Yosemite, G Street, H59PS, Black Rascal, West Ave, and 48-inch Interceptor trunks as having LOS deficiencies under interim conditions. It was noted that the WCSMP interim results were within the City's acceptable LOS criteria because the predicted level of surcharge remains 8-feet below the ground surface.

The results of the updated interim PCSWMM model predict capacity deficiencies in the same portion of the system, in addition to those identified under existing conditions. Surcharging and capacity limitations projected from the updated model are more severe than what had been presented in the WCSMP. Despite increased surcharge depths, no SSOs are predicted to occur within the system under interim conditions.

Hydraulic Constraints

Trunks with hydraulic capacity constraints, where the peak simulated flow exceeds the pipe's calculated flow capacity, include:

- G Street Trunk
- Black Rascal Trunk (Part 1, North)
- Black Rascal Trunk (Part 2, South)
- North Merced West Ave Trunk
- 48-inch Interceptor

The largest hydraulic constraint predicted in the interim system model is along the Black Rascal Trunk (Part 2, South) immediately upstream of the railroad crossing where it crosses under Bianchi Lane from its alignment in Loughborough Drive/Devonwood Drive. The 42-inch sewer is projected to flow at approximately 170% of pipe capacity. The sewer has a slope of 0.0002 ft/ft based on data within the model database and was calibrated to a roughness of 0.016, limiting its capacity to approximately 7.0 MGD. The actual slope and condition of this pipe should be verified by the City during the pre-design of any system capacity improvements based on these results. The projected peak flow the sewer needs to convey to meet LOS criteria under interim conditions is approximately 13.0 MGD, assuming no impacts from upstream improvements.

Two sewer segments were calculated to be 150% over capacity along the 48-inch interceptor sewer. The first segment is at the approximate location of flow monitoring site 10 and the other is in the last segment before the trunk reaches the WWTF junction structure near the WWTF.

Pipes within sewer-shed 10 have less capacity than previously projected due to their calibrated roughness of 0.017. This value is reduced from 0.02, which was determined using the flow monitoring data due to data quality concerns. The slope of the 48-interceptor further limits its capacity, averaging approximately 0.0003 ft/ft within the model. Large amounts of sediment were noted during installation of flow monitoring equipment, which also indicates sewers are likely to flow at low flows, have shallow slopes, and/or high roughness. The City is aware that this trunk is in poor condition. The high roughness coefficients were validated upon review of pipe condition photos provided by V&A, pipe material data, and discussions with City Staff, who indicated hydrogen sulfide accumulation and pipeline deterioration exist in this portion of the system.

The other most notable hydraulic restriction predicted in the interim system model exists along the Black Rascal Trunk (Part 1, North) between G Street and M Street, where it parallels Black Rascal Creek/ Campus Drive. These segments of the trunk are calculated at more than 150% full and its overall capacity is approximately 5.1 MGD. The 30-inch sewer has an average slope of approximately 0.0006 ft/ft, with a minimum 0.0003 ft/ft. Sewer-shed 4 was also calibrated to a high roughness value (0.016) further reducing capacity. The projected peak flow these sewers need to convey to meet LOS criteria under interim conditions is approximately 9.5 MGD, assuming no impacts from upstream improvements. The entire Black Rascal (Part 1, North) trunk line and the portion of the G Street Trunk immediately upstream to Yosemite Drive are projected to be hydraulically constrained, flowing between 100-150% of their current capacity. The entire North Merced West Ave Trunk is also projected to flow between 100-130% of its capacity under interim conditions.

Backwater Surcharging

The minimum freeboard is predicted to be less than 8-feet below the ground surface along the Yosemite, G Street, Black Rascal (Part 1, North), and H59PS trunks under interim conditions. Trunks that are surcharged due to backwater effects caused by increased HGL and hydraulic capacity constraints in the downstream system, include:

- Yosemite Trunk
- West Olive Ave Trunk
- H59PS Trunk

The Yosemite Trunk is currently surcharged as a result of the capacity constraints immediately downstream in the Black Rascal (Part 1, North) trunk line and the G Street Trunk. The maximum surcharge depth is predicted to reach 4.4 feet at the downstream end of Yosemite Trunk near its connection to the G Street Trunk.

Minimum freeboard is less than 6-feet below the ground surface in the downstream end of the West Olive Avenue Trunk near its connection to the H59PS Trunk. The predicted surcharging is a result of backwater effects that occur due to capacity constraints in the downstream North Merced West Avenue Trunk, backwater effects propagate up along the H59PS Trunk. The H59PS trunk has limited residual capacity (0.2 MGD). Under higher flow conditions where the H59PS trunk exceeds its capacity, an SSO would be most likely to occur between Austin Avenue and Hwy 59 in Olive Avenue - at the manhole located two upstream of the intersection of W Olive Avenue and Loughborough Drive (identified as junction 1782 within the model). The risk of SSOs at this location is reduced as a result of the upstream flow split. The flow from sewer-shed 5 is conveyed through the East Olive Avenue Trunk, which splits between the West Olive Avenue Trunk and the Black Rascal Trunk (Part 2, South), at the intersection of Olive and Meadows Avenue. Data within the hydraulic model suggests that approximately 2.0-feet of freeboard exist between the invert of this flow split and the rim elevation of junction 1782. This freeboard allows flow to be diverted to the Black Rascal Trunk before resulting in an SSO along the West Olive Avenue Trunk.

A summary of key parameters and results for each trunk sewer under interim conditions is presented in **Table 9** and **Table 10**.

Table 9 North Merced - Interim System Scenario Results, Part 1

Parameter	Bellevue Trunk	G Street Trunk	Yosemite Trunk	Black Rascal Trunk (Part 1, North)	East Olive Ave Trunk
Cause of Surcharge	NA	Hydraulic Capacity	Backwater Effects	Hydraulic Capacity	NA
Sewershed(s)	2	2	1	4	5
Roughness (n)	0.013	0.013	0.013	0.016	0.011
Max Surcharge (ft)	0	3.4	4.4	2.6	0
Min Freeboard (ft)	7.3	5.3	5.7	6.8	2.7 (shallow MH)
Max Surcharge MH ID	NA	2081	976	2073	NA
Min Freeboard MH ID	NA	3008	975	2068	1265
Min Trunk Capacity (MGD)	5.5	5.6	1.9	5.1	0.8
Peak Flow @ Min Capacity (MGD)	2.6	6.1	1.9	8.5	0.4
Max Trunk Peak Flow (MGD)	2.6	8.0	2.3	11.7	1.2
Min Residual Trunk Capacity (MGD)	2.9	-1.6	0.0	-3.5	0.4

Table 10 North Merced - Interim System Scenario Results, Part 2

Parameter	West Olive Ave Trunk	Black Rascal Trunk (Part 2, South)	H59PS Trunk (downstream of LS)	North Merced West Ave Trunk	48-inch Interceptor
Cause of Surcharge	Backwater Effects	Hydraulic Capacity	Backwater Effects	Hydraulic Capacity	Hydraulic Capacity
Sewershed(s)	3 & 5	6	3 & 6	10	NA
Roughness (n)	0.015 & 0.011	0.016	0.015 & 0.016	0.017	0.013 (assumed)
Max Surcharge (ft)	0.5	1.5	2.5	3.1	<0.1
Min Freeboard (ft)	4.5	7.8	3.7	10.2	5.8
Max Surcharge MH ID	696	704	696	2055	2040
Min Freeboard MH ID	1782	703	696	2043	2036
Min Trunk Capacity (MGD)	1.7	7.5	4.0	12.0	10.0
Peak Flow @ Min Capacity (MGD)	1.6	12.6	3.4	16.5	16.6
Max Trunk Peak Flow (MGD)	2.2	12.8	4.5	16.7	16.7
Min Residual Trunk Capacity (MGD)	0.5	-5.1	0.2	-4.6	-6.6

4.4.2 South Merced

Approximately 40% of the City's flow commitments exist within the South Merced service area. Approximately 2.8 MGD was added to the existing ADWF (3.6 MGD) that originates from South Merced, equating to a total ADWF of approximately 6.4 MGD under interim conditions.

The WCSMP does not identify any new hydraulic constraints in South Merced as a result of added flow under interim conditions. The focus of the interim model in the WCSMP was on North Merced, which is why additional analysis of the southern service area and recommended future South Trunk are included as part of this report. Hydraulic constraints identified within the WCSMP, under interim conditions, exist in the Old Town trunks within the system in South Merced and were also identified under existing conditions.

The only new LOS deficiency identified as part of this update exists at the confluence of the Gerard and West Avenue Trunk lines and immediately downstream, along the 42-inch WWTF Trunk near the location of FM 7. Deficiencies identified in the old part of town under existing conditions are also predicted in the interim model. These impacts are not significantly impacted despite the addition of flow from vacant development.

Hydraulic Constraints

Trunks with hydraulic capacity constraints, where the peak simulated flow exceeds the pipe's calculated flow capacity, include:

- West Gerard Trunk
- 42-inch WWTF Trunk

There is insufficient capacity in the sewer immediately downstream of the location of flow monitoring Site 8 along the West Gerard Trunk. This 36-inch sewer is predicted to flow at approximately 110% of its capacity under interim conditions. The capacity of this sewer is approximated as roughly 14.4 MGD and would require a capacity of approximately 15.5 MGD to meet LOS criteria, assuming there are no impacts from upstream improvements.

The sewers immediately downstream, along the 42-inch WWTF Trunk are also predicted to exceed their capacity under interim conditions. These sewers have a slope of approximately 0.0006 ft/ft based on data stored within the hydraulic model, the shallowest slope along this trunk line. The capacity of these sewers is currently around 15.4 MGD and would require a capacity of approximately 18.0 MGD in order to meet LOS criteria.

Backwater Surcharging

Surcharging in the South Merced system is not predicted as a result of backwater effects. Surcharge depths in trunks with hydraulic constraints is limited to less than half a foot above the pipe crown. Much of the South Merced system was constructed at shallow depths, limiting the available freeboard depth to less than 8-feet below the ground surface, without surcharging. Surcharging is not predicted to occur in the East Gerard Trunk, which has sufficient capacity to convey PWWF under interim conditions. The South Merced West Ave Trunk is also not predicted to be surcharged under interim conditions but would likely become surcharged if the HGL at the downstream confluence were to increase under higher flow conditions.

A summary of key parameters and results for each trunk sewer under interim conditions is presented in **Table 11**.

Table 11 South Merced - Interim System Scenario Results

Parameter	East Gerard Trunk	West Gerard Trunk	South Merced West Ave Trunk	42-inch WWTF Trunk
Cause of Surcharge	NA	Hydraulic Capacity	NA	Hydraulic Capacity
Sewer-shed(s)	9	8	7	NA
Roughness (n)	0.013	0.013	0.013	0.013 (assumed)
Max Surcharge (ft)	0	0.4	0	<0.1
Min Freeboard (ft)	2.9 (shallow MH)	2.9 (shallow MH)	4.1 (shallow MH)	4.6 (shallow MH)
Max Surcharge MH ID	NA	1872	NA	768
Min Freeboard MH ID	9372	2427	764	22351
Min Trunk Capacity (MGD)	5.0	13.6	4.5	10.7
Peak Flow @ Min Capacity (MGD)	0.8	11.0	0.5	17.8
Max Trunk Peak Flow (MGD)	8.0	15.4	2.5	17.9
Min Residual Trunk Capacity (MGD)	4.0	-1.0	2.8	-7.2

4.5 BUILDOUT MODEL RESULTS

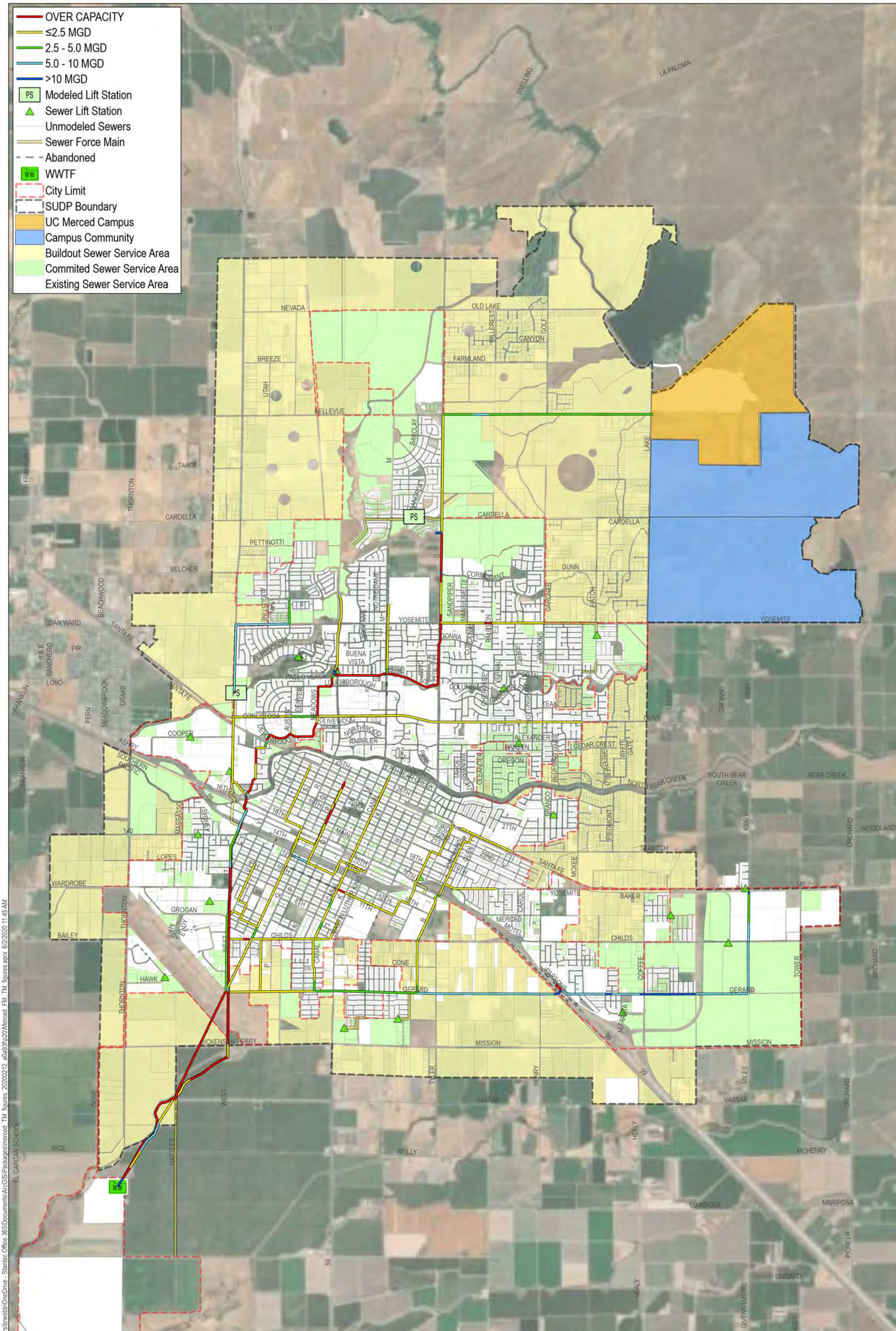
The interim model was expanded to include buildout system flows and infrastructure proposed in the WCSMP. Flow projections for buildout development areas were updated as previously described in this report. The flow generated from future developments will increase the total average dry weather flow to 31.1 MGD, adding approximately 16.7 MGD to the interim system. The peak inflow to the WWTF is predicted to reach 74.6 MGD during a 10-year, 24-hour design storm under buildout development conditions. The updated buildout model results show that surcharging depths are less than 1-foot above pipe crown.. The results, showing Residual Capacity of the buildout model are presented in **Figure 10**. The results depicted in Figure 10 do not reflect the adjustments to pipe sizes discussed below.

The updated buildout model results show that portions of the future system proposed in the WCSMP are under capacity and some portions have excess capacity.

The updated model results indicate that the sizing of the proposed South Merced Trunk could be reduced and is discussed further in the Alternatives Analysis section of this report.

Conversely, several locations in the North Merced Service Area were found to be under capacity. The updated model results indicate that the following trunk sewers should be upsized to accommodate the redistribution of flow in North Merced:

- The WCSMP 24-inch sewer diverting flow from the existing Bellevue Trunk to the new trunk in Cardella Road is now projected to require a 30-inch sewer (~5,300 LF).
- The WCSMP 21-inch sewer diverting flow from the existing H59PS to the new North Merced Pump Station (~10,350 LF) is now projected to require at least a 27-inch sewer to match upstream pipe sizing (i.e., avoid smaller sized sewers in the downstream) depending on slope.
- The WCSMP 24-inch sewer in Cardella between Hatch Road and N. Gardner Avenue is now projected to require a 27-inch sewer (~2,600 LF)



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Stantec

FIGURE 10
BUILDOUT SYSTEM SCENARIO RESULTS
COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

4.6 GERARD TRUNK CAPACITY

The residual capacity under buildout conditions within the existing Gerard Trunk was determined and evaluated. The updated buildout model results were compared to the WCSMP results to assess the required design capacity of the South Trunk. **Table 12** compares the updated buildout model results with the previous results from the WCSMP.

Table 12 Buildout Service Area Wastewater Flow Estimates

Future Development Area	UPDATED MODEL Buildout ADWF (MGD)	WCSMP MODEL Buildout ADWF (MGD)
North Merced Service Area	13.4	14.0 to 15.0
South Merced (future South Trunk)	2.2	5.0 to 6.0
Infill in South Merced (existing system)	1.1	
Total [(1)]	16.7	20.0

1. The total flow excludes existing and interim flow and is only the incremental flow estimate for the future service area.

The updated buildout system model predicts that there will be available residual capacity in the existing East Gerard Avenue Trunk and in the upstream end of the Gerard Avenue Trunk. The West Gerard Avenue Trunk is predicted to be over capacity between G Street and the proposed location connecting it to the new South Trunk as outlined in the WCSMP. This capacity constraint was not identified in the WCSMP and is due to the additional details for the redistribution of existing and interim flows completed in this update. The capacity and PWWF simulated within the updated buildout model for each segment of the new South Trunk, along with the residual capacity in the parallel segment of the Gerard Trunk are presented in **Table 13**.

Table 13 South Trunk Capacity & Gerard Trunk Residual Capacity

Recommended South Trunk Sewer Segment	South Trunk Flow Capacity (MGD)	Parallel Residual Capacity Gerard Trunk (MGD) Downstream & Upstream		PWWF Model (MGD)
Diversion/relief Sewer	6.7	NA	NA	5.3
South Trunk Segment 1	1.3	NA	NA	0.9
South Trunk Segment 2	2.2	4.5	12.2	0.9
South Trunk Segment 3	4.8	7.5	9.2	0.9
South Trunk Segment 4	12.5	-2.9	4.3	4.5
South Trunk Segment 5	12.7	NA	NA	10.2

5.0 SOUTH MERCED TRUNK SEWER ALTERNATIVES

The City's WCSMP presents planning level infrastructure concepts required to provide wastewater collection service to the City's General Plan area under buildout development conditions. The proposed infrastructure needed to serve the South Merced service area at buildout is referred to as the South Trunk sewer. The development of the WCSMP was primarily focused on the North Merced service area as a majority of on-going and planned development was and still is in the vicinity of the UC Merced Campus which is served by the North Merced trunk system.

Given the model revisions and results presented in this report, it was prudent to re-evaluate the previously proposed South Trunk and evaluate alternatives that further consider maximizing the available residual capacity in the existing collection system. The updated hydraulic model was used to re-evaluate the sizing of the WCSMP South Trunk Improvements and present an alternative that leverages available residual capacity.

The City noted plans to replace the 48-inch Interceptor Sewer and the 42-inch WWTF Trunk due to their failing condition. The alternatives to the WCSMP South Trunk improvements assessed in this report assume that the existing downstream 42-inch and 48-inch trunk sewers are upsized during their replacement.

5.1 WCSMP SOUTH TRUNK IMPROVEMENTS

The original WCSMP South Trunk was proposed as an 18 to 36-inch trunk sewer extending 2.8 miles northeast from the WWTF to West Dickenson Ferry Road before splitting north to divert flow from the existing system and east to collect flow from future development areas. The northern leg was considered a relief sewer and diverts flow from the Gerard Avenue Trunk approximately a half mile north of Dickenson Ferry Road. The proposed alignment head east for approximately 4.5 miles in Dickenson Ferry Road/Mission Avenue until it meets Miles Road, where it turns north and follows the alignment of the upstream end of the Gerard Avenue Trunk for approximately 2 miles. This concept provides capacity to support the addition of approximately 5 to 6 MGD in the South Merced service area as projected in the WCSMP.

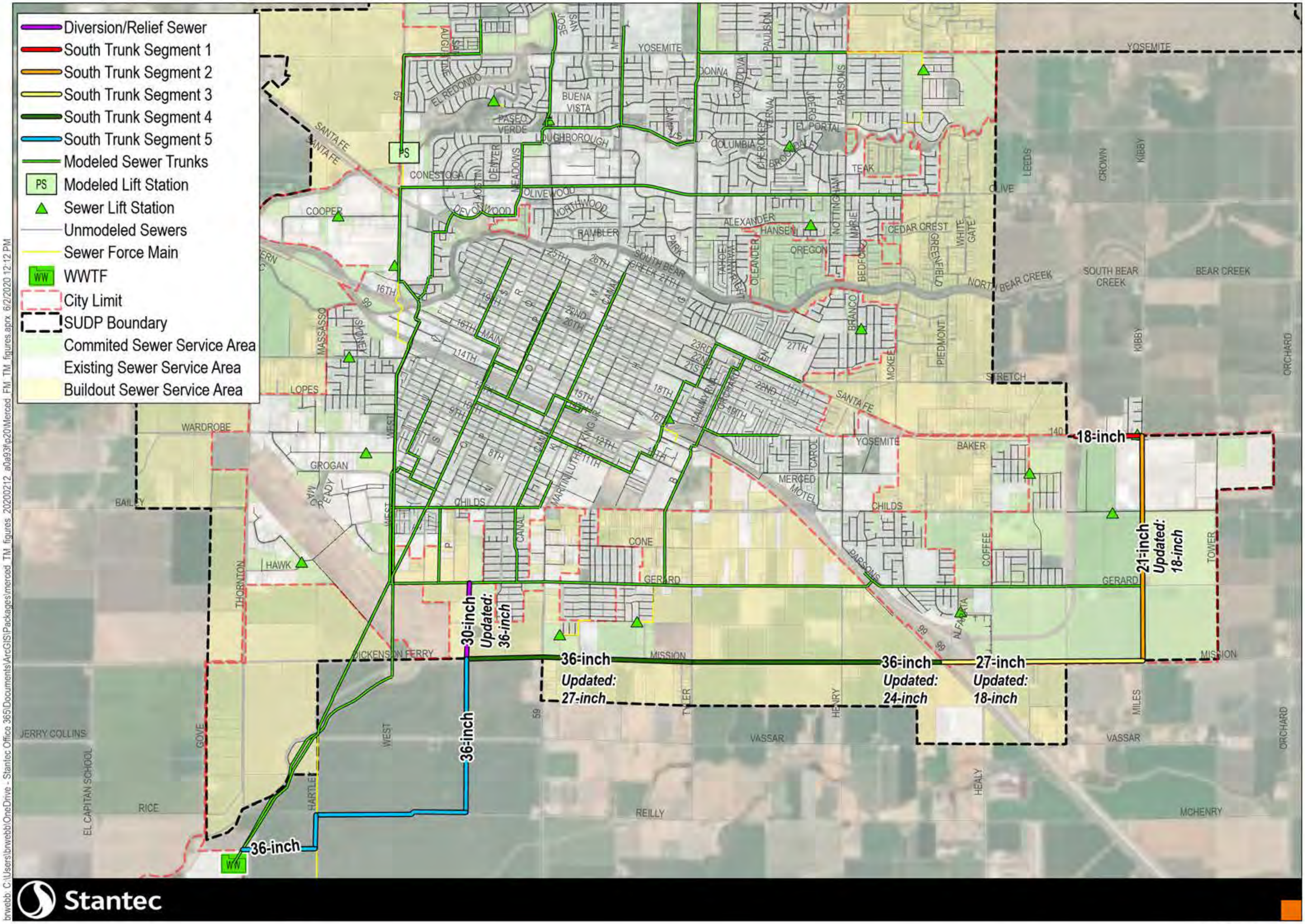
The updated buildout model results completed in this assessment determined that this concept was oversized and does not take advantage of remaining residual capacity in the existing network.

The WCSMP South Trunk is presented in **Figure 11** and the required improvements and preliminary opinion of probable costs from the WCSMP are summarized in **Table 14**.

Table 14 WCSMP South Trunk Improvements Summary

Recommended New South Trunk Sewer Segment	Size (in)	Length (LF)	Opinion of Capital Cost [(1)]
Diversion/relief Sewer: from West Gerard Ave Trunk to the new South Trunk, from Gerard Avenue to W. Dickenson Ferry Road	30	2,700	$741,282
South Trunk Segment 1: from the end of Baker Drive to Kibby Road	18	2,300	$422,187
South Trunk Segment 2: along Kibby Road from CA Hwy 140 to Mission Avenue	21	8,000	$1,914,098
South Trunk Segment 3: along Mission Avenue from Kibby Road to Miles Road	27	7,200	$2,016,994
South Trunk Segment 4: along Mission Avenue from Miles Road to approximately 0.5 miles west of Hwy 59	36	16,700	$4,472,605
South Trunk Segment 5: along Dickenson Ferry Road to WWTF	36	15,000	$4,321,334
Subtotal (rounded):			**$13,889,000**
5% Mobilization/Demobilization			$731,000
Estimated Construction Subtotal:			**$14,620,000**
30% Contingencies for Unknown Conditions			$4,386,000
Estimated Construction Cost:			**$19,006,000**
ROW/ Easement Acquisition			
20% Engineering, Environmental, & Admin			$3,802,000
Total Project Cost:			**$22,808,000**

1. Based on ENR-CCI (20 Cities Index) = 10,703, June 2017.



0 1.7 Miles

FIGURE 11

ALTERNATIVE 1 - WCSMP SOUTH TRUNK

COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

5.2 ALTERNATIVE 1 – REVISIONS TO WCSMP CONCEPT

Alternative 1 refines the South Trunk alignment as it was presented in the WCSMP eliminating excess capacity by adjusting recommended pipes and slopes. This alternative considers refinement of the proposed South Trunk to eliminate excess capacity that now exists due to the refined flow distribution within the model. The alignment is the same, but pipe sizes and slopes were adjusted to eliminate excess capacity within the proposed sewers while maintaining ground elevations along the proposed alignment.

The upstream half of segment 4 is now recommended to be 24-inches (~8,800 LF) while the downstream end is recommended to be 27-inches (~7,900 LF).

The proposed Alternative 1 infrastructure for the future South Merced service area is summarized in **Table 15**.

Table 15 Alternative 1 Infrastructure Summary

Recommended New Sewer Segment	WCSMP Size (in)	Updated Size (in)	Updated Slope (ft/ft)
Diversion/relief Sewer: from West Gerard Ave Trunk to the new South Trunk, from Gerard Avenue to W. Dickenson Ferry Road	30	36	0.0012
South Trunk Segment 1: from the end of Baker Drive to Kibby Road	18	18	0.0012
South Trunk Segment 2: along Kibby Road from CA Hwy 140 to Mission Avenue	21	18	0.0012
South Trunk Segment 3: along Mission Avenue from Kibby Road to Miles Road	27	18	0.0012
South Trunk Segment 4: along Mission Avenue from Miles Road to approximately 0.5 miles west of Hwy 59	36	24/27	0.0008/0.0007
South Trunk Segment 5: along Dickenson Ferry Road to WWTF	36	36	0.0010

5.3 ALTERNATIVE 2 – MINIMIZE NEW INFRASTRUCTURE WITH EXISTING SYSTEM IMPROVEMENTS

Alternative 2 considers collection system improvements the City intends on implementing in the near-term and limits the extent of new infrastructure by taking advantage of residual capacity in the existing system.

This alternative requires changes to where future flows are discharged:

- The majority of the re-routed service area required for this alternative is redirected to the existing Gerard Avenue Trunk.
- The service area north of Bear Creek is rerouted to the Olive Trunk.
- To accommodate flows routed to the existing system the diversion/relief sewer was adjusted to connect to the Gerard Trunk at the intersection of Gerard Avenue and Tyler Road.

The proposed South Merced Trunk under Alternative 2 is reduced to approximately 2.5 miles of 36-inch sewer and connects to the existing 48-inch interceptor sewer at the intersection of W Dickenson Ferry Road and S West Avenue.

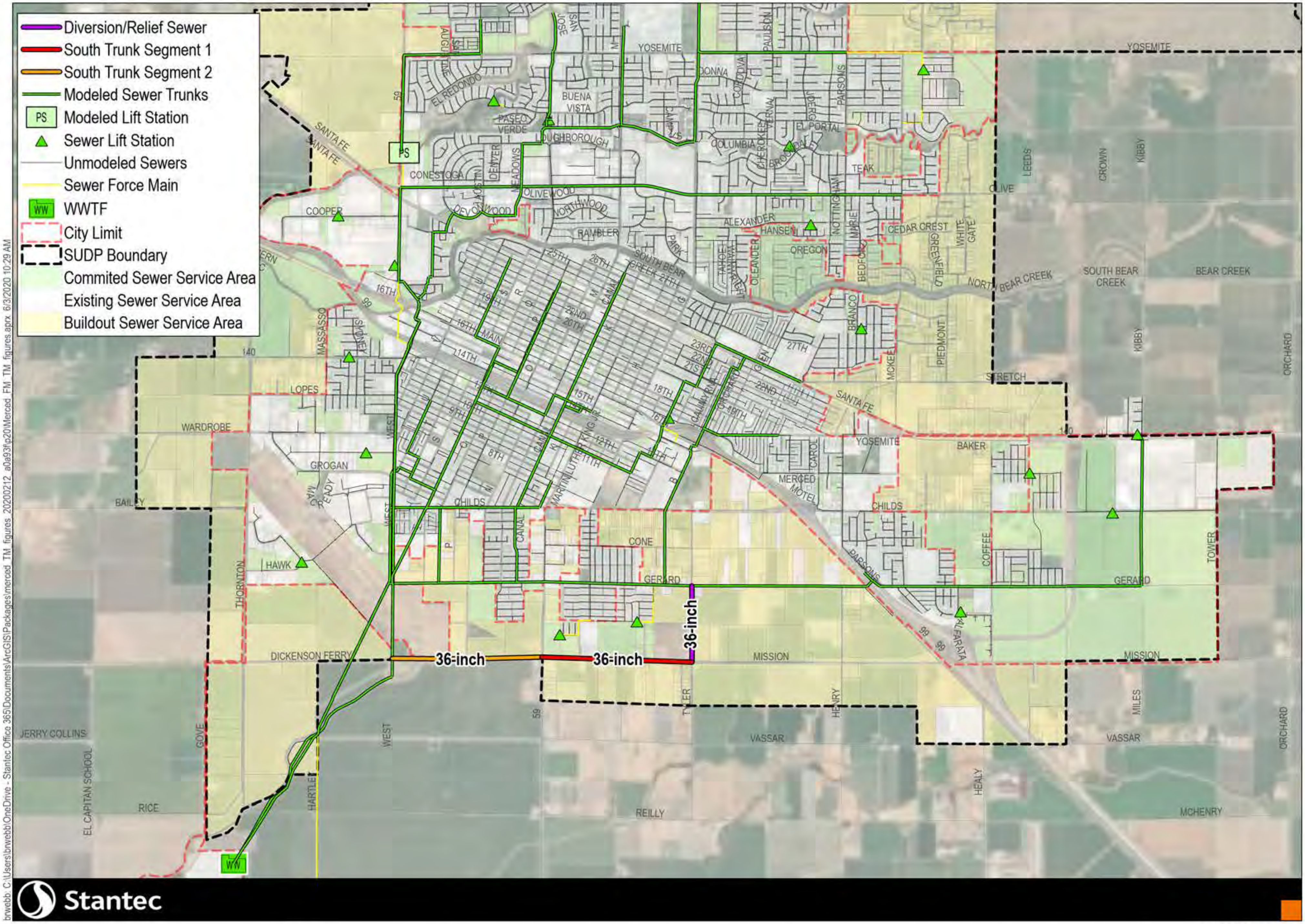
The proposed improvements provide a parallel relief trunk for the downstream end of the Gerard Trunk and take advantage of additional capacity that will be provided by City planned improvements to address concerns with the condition (hydrogen sulfide damage) of the existing 48-inch and 42-inch Trunks which deliver influent to the WWTF.

The Alternative 2 alignment, flow routing, and existing system improvements are shown on **Figure 12**. The proposed Alternative 2 infrastructure for the future South Merced service area is summarized in **Table 16**.

Table 16 Alternative 2 Infrastructure Summary

Recommended New Sewer Segment	Length (LF)	Size (in)	Slope (ft/ft)
Diversion/Relief Sewer: Along Tyler Road, from West Gerard Ave Trunk to the new South Trunk, from Gerard Avenue to W. Dickenson Ferry Road	2,700	36	≥0.0019
South Trunk Segment 1: Along E Mission Avenue, from Tyler Road to Hwy 59	5,300	36	0.0010
South Trunk Segment 2: Along W Dickenson Ferry Road, from Hwy 59 to S West Avenue	5,300	36	0.0010

It is important that the Diversion/Relief Sewer is designed to ensure that sufficient flow volume is diverted from the Gerard Trunk to free-up capacity downstream. This could be accomplished with a stop-log or weir-type diversion structure to send flows to the south.



0 1.7
Miles

FIGURE 12

ALTERNATIVE 2 - MINIMIZE NEW INFRASTRUCTURE WITH EXISTING SYSTEM IMPROVEMENTS

COLLECTION SYSTEM HYDRAULIC MODEL CONVERSION & SOUTH TRUNK SEWER SERVICE ALTERNATIVES ANALYSIS

5.4 OPINION OF PROBABLE COSTS

This section presents budget level opinions of probable costs (OPC) that are intended to establish planning level budget estimates for scenario comparisons. It is expected that once a preferred solution is identified, a detailed design will be developed, and survey data will be collected to confirm the proposed pipe slopes and sizes.

Estimates of the capital costs associated with the trunk improvement project alternatives developed and presented herein are order of magnitude estimates only. An order of magnitude estimate is one that is made without detailed engineering data and uses techniques such as cost curves and scaling factors from similar projects. The same unit costs used to develop cost estimates presented in the WCSMP were used to develop alternative cost estimates presented herein. The WCSMP unit costs have been adjusted from a “20-Cities” Engineering News Record Construction Cost Index (ENR-CCI) of 10,703 (June 2017), to a value of 11,496 (February 2020).

Budget level opinions of probable costs were developed for both alternatives. Cost estimates include construction costs, a 5% allowance for mobilization, a 30% contingency for unforeseen conditions, and a 20% allowance for design, construction management, and environmental documentation. Costs associated with obtaining rights of way (ROW) have not been included in these estimates.

Costs from the WCSMP for the South Merced Trunk were updated to reflect the refined pipe sizes of Alternative 1 – WCSMP South Trunk Alternative.

5.4.1 Alternative 1 OPC

The preliminary opinion of probable costs for the proposed improvements associated with Alternative 1 are summarized in **Table 17**.

Table 17 Alternative 1 - WCSMP South Trunk Opinion of Probable Costs

Recommended Improvement	Size (in)	Length (LF)	Opinion of Capital Cost [1]
Diversion/Relief Sewer: from West Gerard Ave Trunk to the new South Trunk, from Gerard Avenue to W. Dickenson Ferry Road	36	2,700	$835,471
South Trunk Segment 1: from the end of Baker Drive to Kibby Road	18	2,300	$453,467
South Trunk Segment 2: along Kibby Road from CA Hwy 140 to Mission Avenue	18	8,000	$1,577,278
South Trunk Segment 3: along Mission Avenue from Kibby Road to Miles Road	18	7,200	$1,419,550
South Trunk Segment 4: along Mission Avenue from Miles Road to approximately 0.5 miles west of Hwy 59	27	16,700	$5,024,928
South Trunk Segment 5: along Dickenson Ferry Road to WWTF	36	15,000	$4,641,508
Subtotal (Rounded):			**$13,953,000**
5% Mobilization/Demobilization			$735,000
Estimated Construction Subtotal:			**$14,688,000**
30% Contingencies for Unknown Conditions			$4,407,000
Estimated Construction Cost:			**$19,095,000**
ROW/ Easement Acquisition			2
20% Engineering, Environmental, & Admin			$3,819,000
Total Project Cost:			**$22,914,000**

1. Based on ENR-CCI (20 Cities Index) = 11,496, February 2020.
2. Not included. Additional assessment of required ROW and associated costs should be completed as well. Final determination of the best alternative will be made when these costs are better understood.

5.4.2 Alternative 2 OPC

The preliminary opinion of probable costs for the proposed improvements associated with Alternative 2 are summarized in **Table 18**.

Table 18 Alternative 2 – Minimize New Infrastructure with Existing System Improvements Opinion of Probable Costs

Recommended Improvement	Size (in)	Length (LF)	Opinion of Capital Cost [1]
Diversion/Relief Sewer: Along Tyler Road, from West Gerard Ave Trunk to the new South Trunk, from Gerard Avenue to W. Dickenson Ferry Road	36	2,700	$835,471
South Trunk Segment 1: Along E Mission Avenue, from Tyler Road to Hwy 59	36	5,300	$1,639,999
South Trunk Segment 2: Along W Dickenson Ferry Road, from Hwy 59 to S West Avenue	36	5,300	$1,639,999
Subtotal (Rounded):			**$4,115,000**
5% Mobilization/Demobilization			$217,000
Estimated Construction Subtotal:			**$4,332,000**
30% Contingencies for Unknown Conditions			$1,300,000
Estimated Construction Cost:			**$5,632,000**
ROW/ Easement Acquisition			[2]
20% Engineering, Environmental, & Admin			$1,126,000
Total Project Cost:			**$6,758,000**

1. Based on ENR-CCI (20 Cities Index) = 11,496, February 2020.
2. Not included. Additional assessment of required ROW and associated costs should be completed as well. Final determination of the best alternative will be made when these costs are better understood.

5.4.3 Non-Monetary Factors

Non-monetary factors considered for each alternative include construction risks, potential environmental constraints, potential for phasing, interim service capacity impacts, and ROW or easement acquisition.

5.4.3.1 Construction Risks

Construction risks associated with Alternative 1 include construction within an already developed area, which would entail designing around or relocating existing utilities within the ROW, specifically where the proposed alignment parallels the existing Gerard Trunk line. Construction risks associated with Alternative 2 include those associated with Alternative 1 but are reduced extent.

5.4.3.2 Environmental Constraints

Each of the improvement alternatives include constraints due to sensitive environmental resources located nearby, or directly impacted by a sewer alignment. The alternatives analysis did not include a detailed assessment of environmental constraints, however there are a number of canals, highway, and creek crossings which any future construction will need to consider. Alternative 1 would require approximately eight canal or stream crossings, two railroad crossings, and two highway crossings. Alternative 2 would require approximately two canal or stream crossings and one highway crossing. Alternative 1 poses a larger environmental impact than Alternative 2, due to the extent of the proposed improvements. Replacing the sewers in place would be categorically exempt from the CEQA process.

5.4.3.3 Phasing Potential and Interim Conditions

Ideally, the construction of buildout system improvements is done in phases to accommodate the sequence and location of future developments. Many portions of the South Merced Service Area consist of County residential areas currently served by septic systems. When and if these areas will ever connect to the City sewer system is unknown. Planning and sequencing of development is more defined within the North Merced Service Area, as future and immediate development is most likely to occur in the vicinity of the UC Merced campus.

Improvements to the existing collection system to provide capacity for the City's existing and committed service area under interim conditions is the City's most immediate need. The updated interim system model identified the 48-inch Interceptor Sewer and 42-inch WWTRF Trunk as being hydraulically constrained under PWWF conditions.

Alternative 2 provides service to the future South Merced Service Area by implementing existing system CIPs, which is considered the more favorable phasing approach. Constructing these CIPs prior to the remaining improvements will provide interim capacity for both the North and South Service Area commitments before the construction of the major system improvements required to serve buildout development in North Merced. A phased overall system improvement and expansion plan should be developed by the City as the City continues to expand.

5.4.3.4 ROW Acquisition

The City will have to acquire right of way for the proposed improvements in the form of easements or land acquisitions. It has been assumed that the City will need to obtain ROW where the trunk alignments fall outside of an existing roadway. The City should also consider ROW impacts associated with crossing or overlapping those of Merced Irrigation District (MID) canals.

Alternative 1 will require that the City have or obtain ROW along the entire Diversion/Relief Sewer and South Trunk Segment 5, as well as portions of South Trunk Segments 2 and 4. In addition, the South Trunk Segment 1 sewer runs along Highway 140. Constructing utilities within a California Department of Transportation (CalTrans) ROW is not desirable, and not typically allowed by CalTrans.

The alignment of Alternative 2 is entirely within existing roadways. The Diversion/Relief Sewer was adjusted to run along Tyler Road and the remaining portion of the alignment in in E Mission Ave and Dickenson Ferry Road.

5.5 SUMMARY AND RECOMMENDATIONS

The following two alternatives were considered in the South Merced Trunk Sewer Service analysis:

Alternative 1 – WCSMP South Trunk

Alternative 1 refines the South Trunk alignment as it was presented in the WCSMP eliminating excess capacity by adjusting recommended pipes and slopes. This alternative considers refinement of the proposed South Trunk to eliminate excess capacity now predicted to exist due to the refined flow distribution within the model.

Alternative 2 – Minimize New Infrastructure with Existing System Improvements

Alternative 2 considers collection system improvements the City intends to implement in the near-term and limits the extent of new infrastructure by taking advantage of residual capacity in the existing system. A summary of the opinions of probable costs and the non-monetary factors considered for each alternative is presented as **Table 19**. The best apparent alternative to providing service to the future South Merced Service Area was selected based on the opinion of probable cost, non-monetary factors, and discussions with City staff.

Alternative 2 – Minimize New Infrastructure with Existing System Improvements is the recommended sewer servicing alternative. The proposed Alternative 2 improvements consist of the 36-inch Diversion/Relief sewer in Tyler Road and the 36-inch South Trunk in E Mission Ave/Dickenson Ferry Road connecting it to the upsized 48-inch Interceptor sewer. Alternative 2 requires that the City upsize its two primary trunk lines, increasing the 42-inch WWTF Trunk to 48-inches and the 48-inch Interceptor Trunk to 54-inches. This alternative minimizes the extent and cost of future system improvements, provides an interim phasing strategy considering interim conditions, and takes advantage of residual capacity in the existing collection system.

Table 19 South Merced Trunk Sewer Service Alternatives Summary

Parameter	Alternative 1	Alternative 2
OPINION OF PROBABLE COSTS		
New Construction	$22,914,000	$6,758,000
NON-MONETARY FACTORS		
Construction Risks	Working in existing utility corridors	Replacement Risks (CIPs)
Environmental Constraints	Larger area of Impact	Reduced area of impact
Phasing Potential	Cannot be phased with interim improvements	Can be phased with interim improvements
Interim Capacity	Does not provide interim capacity	Provides interim capacity
ROW	Extensive ROW acquisition	No ROW acquisition

APPENDICES

Appendix A V&A FLOW MONITORING SITE REPORTS

Appendix B MODEL CALIBRATION DATA AND GRAPHS

PROJECT: Merced Model Update
TASK: Model Re-calibration Dry Weather
DATE: 3/13/2020
JOB NUMBER: 184031243
PREPARED BY: BEW
CLIENT: Merced
CHECKED BY: DWP

Dry Weather Period: *DWF Event 1*
Duration: *7 days*
Start: *12/14/2019 0:00*
End: *12/21/2019 0:00*

FLOW

Site	Average Flow (MGD)		
Site	Modeled	Observed	Error
1	0.39	0.39	0.21%
2	1.05	1.04	0.87%
3	0.86	0.88	-2.88%
4	1.50	1.52	-1.44%
5	0.68	0.68	0.77%
6	3.45	3.43	0.73%
7	3.45	3.43	0.64%
8	2.77	2.72	1.80%
9	0.56	0.55	2.00%
10	3.48	3.44	1.25%

Site	Maximum Flow (MGD)		
Site	Modeled	Observed	Error
1	0.62	0.60	3.16%
2	1.50	1.56	-4.16%
3	1.27	1.38	-8.17%
4	2.10	2.33	-9.82%
5	1.06	1.10	-4.26%
6	4.87	5.25	-7.16%
7	5.40	5.19	4.07%
8	4.44	4.66	-4.68%
9	1.00	1.00	-0.30%
10	4.88	4.78	2.22%

Site	Minimum Flow (MGD)		
Site	Modeled	Observed	Error
1	0.13	0.14	-1.48%
2	0.49	0.44	12.51%
3	0.40	0.40	0.95%
4	0.73	0.69	5.47%
5	0.29	0.27	4.38%
6	1.77	1.51	17.12%
7	1.64	1.72	-5.05%
8	1.26	1.08	16.48%
9	0.22	0.19	18.16%
10	1.80	1.74	3.10%

Site	Total Flow (MG)		
Site	Modeled	Observed	Error
1	2.72	2.71	0.22%
2	7.32	7.26	0.84%
3	6.00	6.18	-2.87%
4	10.51	10.67	-1.50%
5	4.77	4.73	0.76%
6	24.18	24.00	0.75%
7	24.14	23.98	0.67%
8	19.38	19.04	1.79%
9	3.93	3.85	2.00%
10	24.36	24.05	1.29%

VELOCITY

Site	Average Velocity (fps)		
Site	Modeled	Observed	Error
1	1.61	1.23	30.93%
2	1.40	1.47	-4.97%
3	1.58	1.49	5.99%
4	1.15	1.00	14.61%
5	2.11	2.06	2.58%
6	2.34	2.30	2.09%
7	1.90	1.96	-2.81%
8	1.83	1.97	-6.76%
9	1.62	1.56	3.92%
10	1.45	1.10	32.12%

Site	Maximum Velocity (fps)		
Site	Modeled	Observed	Error
1	1.87	1.68	11.19%
2	1.55	1.75	-11.49%
3	1.78	1.74	2.36%
4	1.26	1.27	-0.79%
5	2.47	2.54	-2.95%
6	2.60	2.86	-9.27%
7	2.17	2.35	-7.62%
8	2.14	2.47	-13.44%
9	1.97	2.13	-7.65%
10	1.62	1.28	26.72%

Site	Minimum Velocity (fps)		
Site	Modeled	Observed	Error
1	1.20	0.56	113.75%
2	1.14	1.07	6.54%
3	1.26	1.09	15.23%
4	0.94	0.66	42.42%
5	1.61	1.50	7.07%
6	1.96	1.45	35.45%
7	1.55	1.42	9.37%
8	1.47	1.43	2.45%
9	1.19	0.88	35.45%
10	1.18	0.86	37.67%

Calibrated N	
Site	Roughness
1	0.013
2	0.013
3	0.015
4	0.016
5	0.011
6	0.016
7	0.013
8	0.013
9	0.013
10	0.017

DEPTH

Site	Average Depth (ft)		
Site	Modeled	Observed	Error
1	0.39	0.50	-23.08%
2	0.70	0.70	0.99%
3	0.71	0.69	3.48%
4	0.90	1.01	-10.63%
5	0.45	0.45	-1.31%
6	1.02	1.04	-1.44%
7	1.15	1.12	2.59%
8	1.08	1.19	-9.73%
9	0.38	0.38	-0.97%
10	1.53	1.75	-12.53%

Site	Maximum Depth (ft)		
Site	Modeled	Observed	Error
1	0.50	0.59	-15.23%
2	0.86	0.88	-2.42%
3	0.90	0.89	1.24%
4	1.09	1.17	-7.42%
5	0.56	0.57	-2.63%
6	1.24	1.26	-1.74%
7	1.47	1.36	8.62%
8	1.39	1.48	-5.81%
9	0.50	0.48	5.88%
10	1.79	2.06	-12.97%

Site	Minimum Depth (ft)		
Site	Modeled	Observed	Error
1	0.23	0.39	-40.52%
2	0.48	0.48	0.27%
3	0.48	0.46	5.27%
4	0.63	0.77	-18.34%
5	0.30	0.30	-0.36%
6	0.73	0.78	-6.31%
7	0.79	0.86	-8.19%
8	0.73	0.85	-14.46%
9	0.25	0.27	-7.14%
10	1.17	1.30	-10.48%

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PROJECT: Merced Model Update **TASK:** Model Re-calibration Wet Weather **DATE:** 3/18/2020

JOB NUMBER: 184031243 **PREPARED BY:** BEW

CLIENT: Merced **CHECKED BY:** DWP

Wet Weather Period: *WWF Event 1*
Duration: *72 hours*
Start: *11/30/2019 11:35*
End: *12/3/2019 11:35*

FLOW

Site	Average Flow (MGD)		
	Modeled	Observed	Error
1	0.62	0.53	18.47%
2	1.45	1.21	19.79%
3	1.14	1.10	3.82%
4	2.12	1.78	19.35%
5	0.84	0.81	3.23%
6	4.56	3.99	14.35%
7	4.93	4.43	11.19%
8	4.15	3.69	12.40%
9	0.99	0.71	38.15%
10	4.62	4.16	11.04%

Site	Maximum Flow (MGD)		
	Modeled	Observed	Error
1	1.13	1.12	0.90%
2	2.18	2.34	-7.01%
3	1.77	1.89	-6.29%
4	3.19	3.15	1.21%
5	1.36	1.42	-4.30%
6	6.68	6.59	1.40%
7	8.45	7.29	15.85%
8	7.21	6.00	20.24%
9	1.75	1.37	27.17%
10	6.77	6.71	0.94%

Site	Minimum Flow (MGD)		
	Modeled	Observed	Error
1	0.21	0.21	0.39%
2	0.62	0.52	19.54%
3	0.49	0.46	6.44%
4	0.94	0.76	22.60%
5	0.34	0.29	18.88%
6	2.21	2.03	8.85%
7	2.18	1.84	18.34%
8	1.73	1.61	7.27%
9	0.34	0.22	53.74%
10	2.24	2.19	2.19%

Site	Total Flow (MG)		
	Modeled	Observed	Error
1	1.87	1.58	18.46%
2	4.36	3.64	19.73%
3	3.43	3.30	3.85%
4	6.37	5.33	19.35%
5	2.52	2.44	3.23%
6	13.67	11.95	14.39%
7	14.79	13.30	11.20%
8	12.46	11.08	12.45%
9	2.96	2.14	38.15%
10	13.85	12.47	11.07%

Wet Weather Period: *WWF Event 2* **Primary Calibration Period*
Duration: *36 hours*
Start: *12/4/2019 0:10*
End: *12/5/2019 12:10*

FLOW

Site	Average Flow (MGD)		
	Modeled	Observed	Error
1	0.47	0.46	1.82%
2	1.18	1.18	-0.17%
3	0.93	0.98	-4.87%
4	1.72	1.65	4.24%
5	0.70	0.68	2.28%
6	3.75	3.87	-3.25%
7	3.66	3.81	-3.78%
8	2.99	3.13	-4.35%
9	0.58	0.67	-13.08%
10	3.78	3.86	-2.02%

Site	Maximum Flow (MGD)		
	Modeled	Observed	Error
1	1.06	1.07	-1.12%
2	2.07	2.10	-1.76%
3	1.64	1.58	3.80%
4	2.98	2.86	4.24%
5	1.28	1.22	4.67%
6	5.97	6.00	-0.52%
7	6.20	6.79	-8.58%
8	5.24	5.10	2.72%
9	1.17	1.18	-0.34%
10	5.97	5.84	2.17%

Site	Minimum Flow (MGD)		
	Modeled	Observed	Error
1	0.18	0.20	-7.14%
2	0.57	0.55	2.48%
3	0.46	0.44	5.90%
4	0.88	0.71	23.10%
5	0.32	0.29	11.16%
6	2.10	2.00	5.06%
7	2.03	1.72	18.19%
8	1.57	1.50	4.60%
9	0.26	0.26	1.94%
10	2.13	2.08	2.41%

Site	Total Flow (MG)		
	Modeled	Observed	Error
1	0.71	0.69	1.82%
2	1.77	1.77	-0.11%
3	1.39	1.46	-4.85%
4	2.58	2.48	4.24%
5	1.05	1.03	2.24%
6	5.62	5.81	-3.27%
7	5.49	5.71	-3.77%
8	4.49	4.69	-4.35%
9	0.87	1.00	-13.08%
10	5.67	5.79	-2.02%

UNIT HYDROGRAPH R-T-K PARAMETERS

Site	Short-Term		
	R	T	K
1	0.0106	1.74	0.64
2	0.0061	0.50	1.00
3	0.0067	1.40	1.96
4	0.0075	1.22	1.27
5	0.0035	0.58	1.52
6	0.0042	1.00	0.50
7	0.0100	0.34	0.50
8	0.0080	0.25	0.25
9	0.0090	0.63	1.85
10	0.0422	1.00	1.00

Site	Medium-Term		
	R	T	K
1	0.0036	2.84	0.95
2	0.0020	3.30	2.00
3	0.0091	1.86	3.96
4	0.0046	3.51	2.00
5	0.0023	1.27	3.26
6	0.0014	3.39	3.98
7	0.0030	1.50	1.25
8	0.0037	1.06	2.00
9	0.0060	2.50	3.50
10	0.0422	3.00	2.00

Site	Long-Term		
	R	T	K
1	0.0080	8.02	2.60
2	0.0047	8.20	5.88
3	0.0067	7.85	4.47
4	0.0042	4.00	3.00
5	0.0011	7.10	4.29
6	0.0014	9.70	6.00
7	0.0010	5.10	4.83
8	0.0060	5.00	6.00
9	0.0040	5.28	4.24
10	0.0422	5.00	3.00

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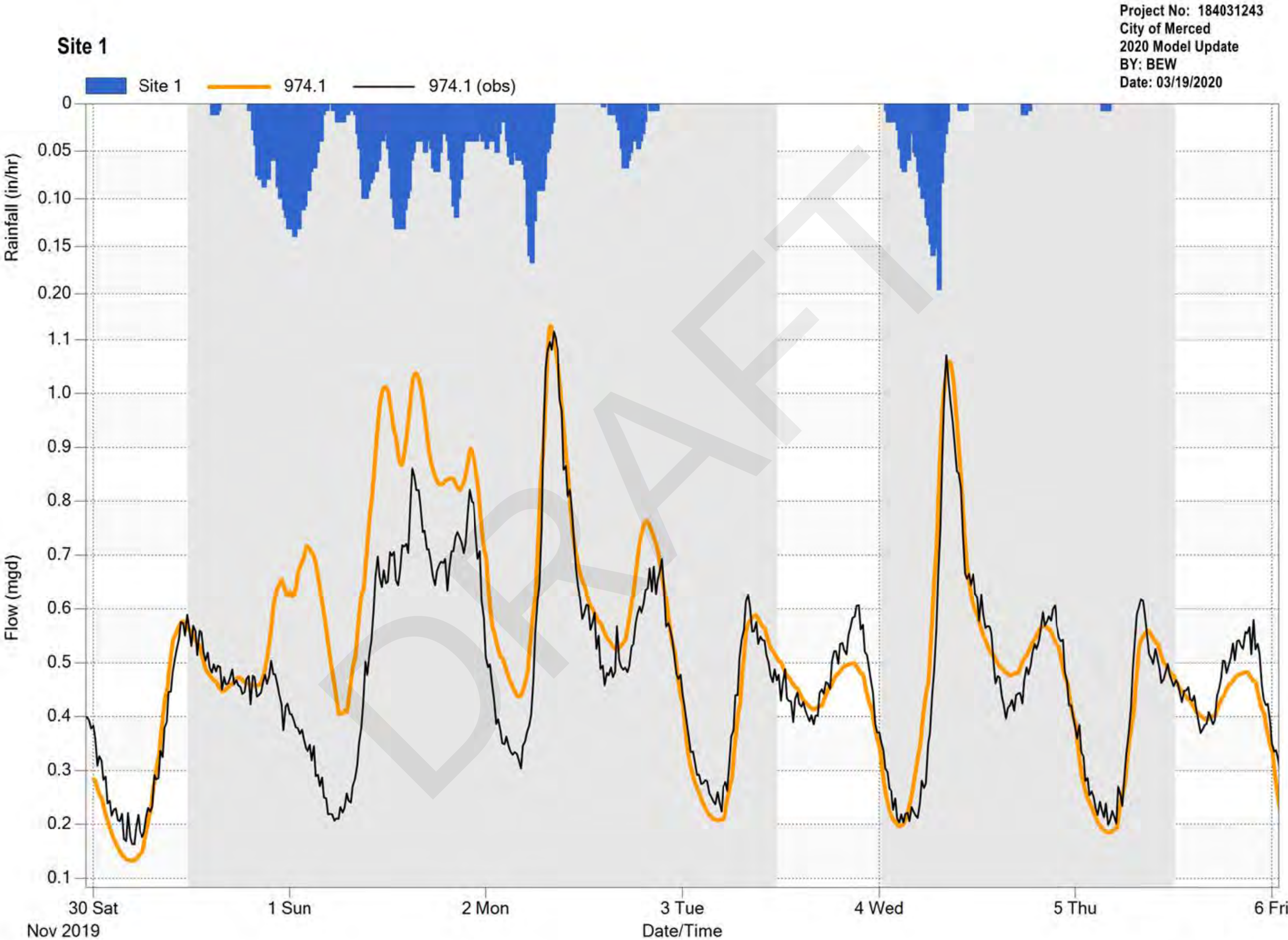
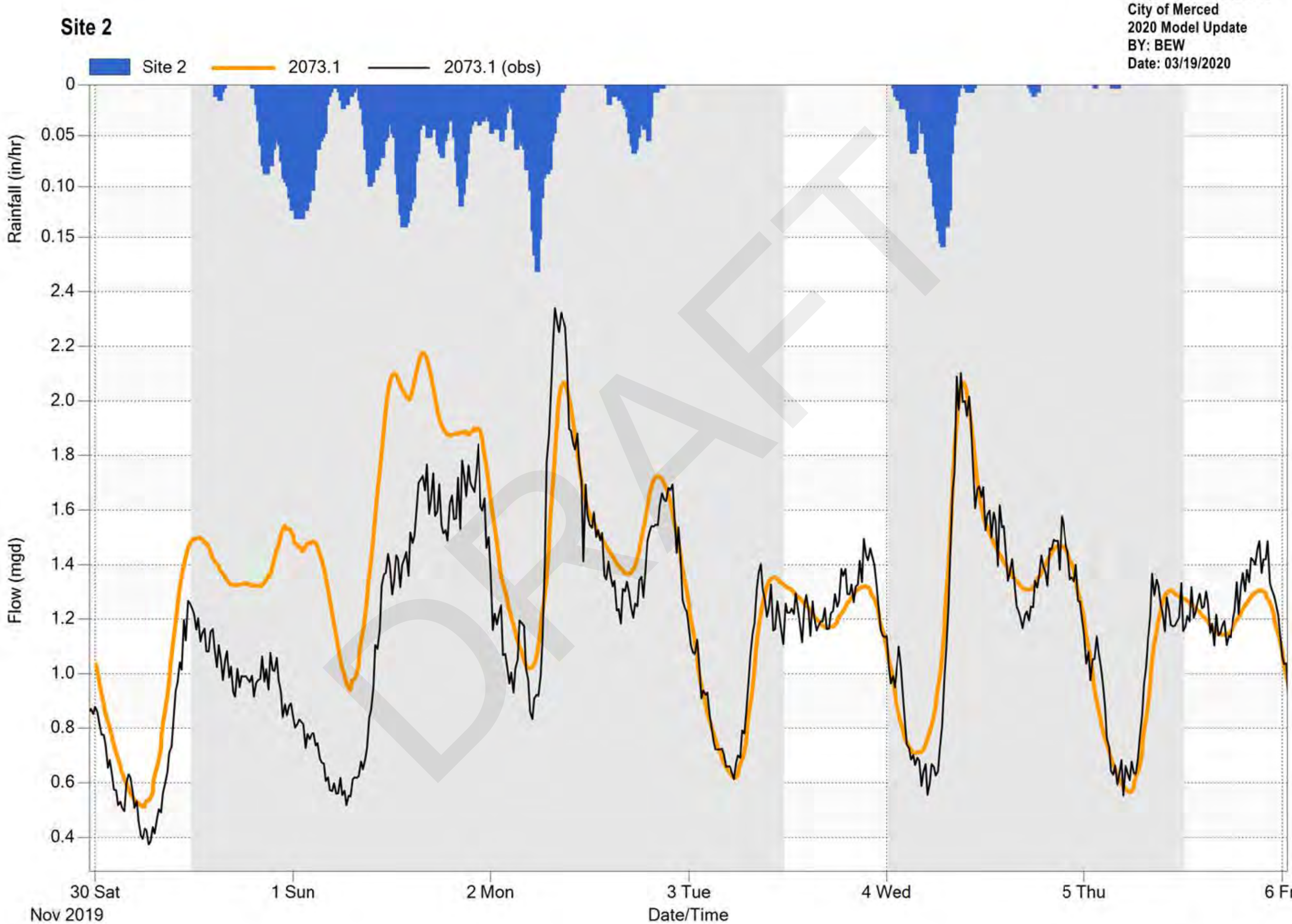


City of Merced - WWF Calibration

Project No: 184031243
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020



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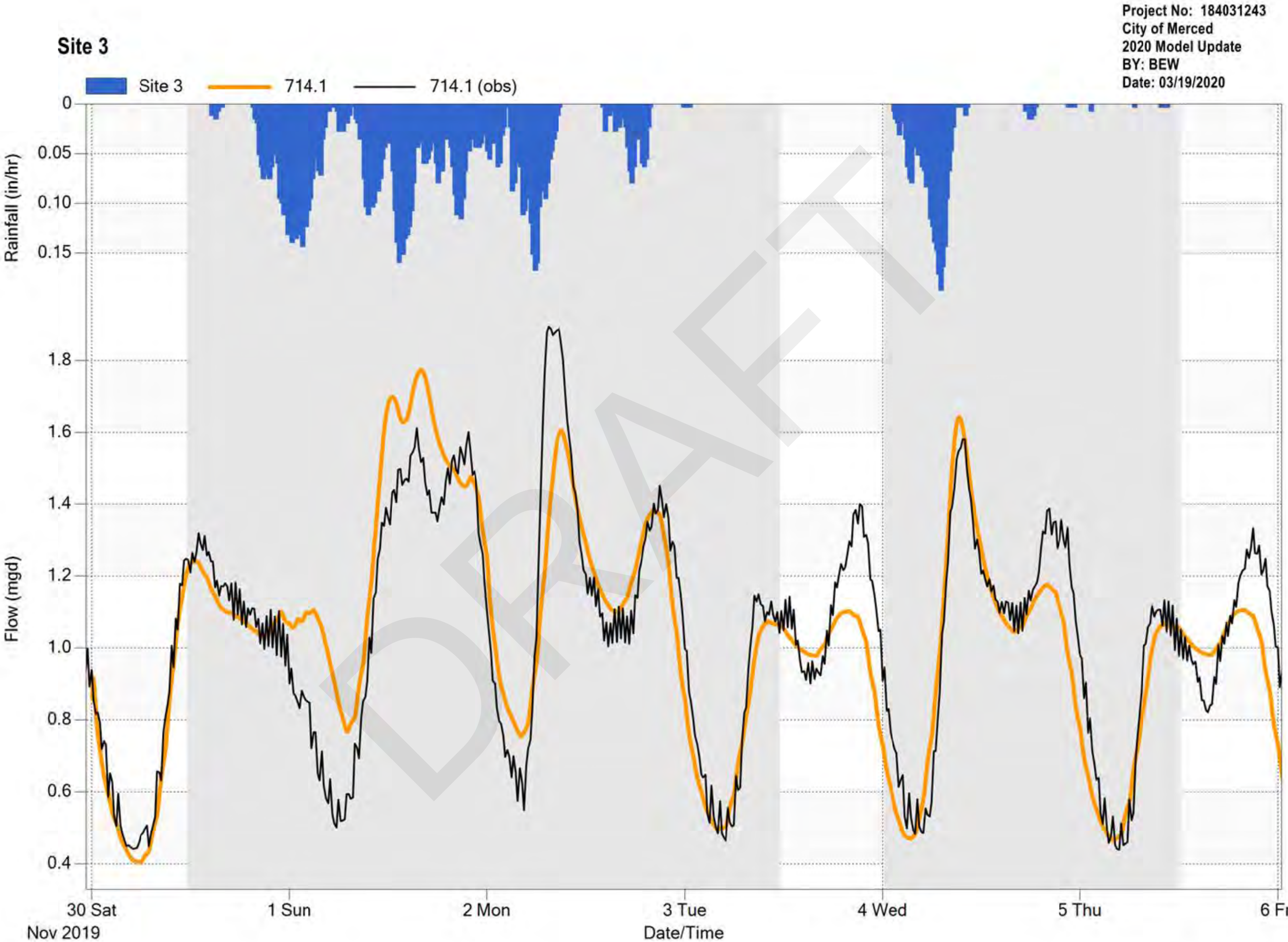

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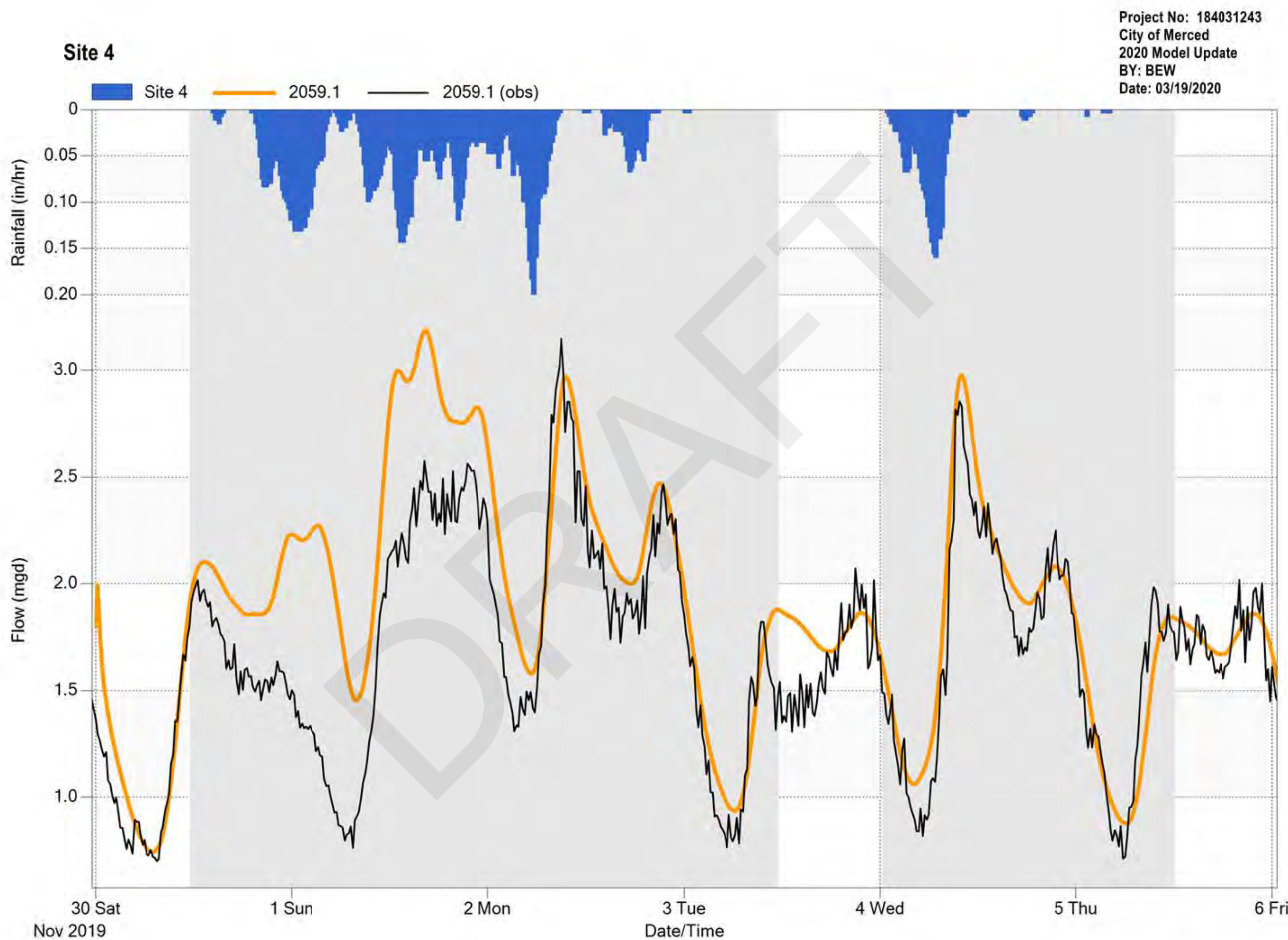

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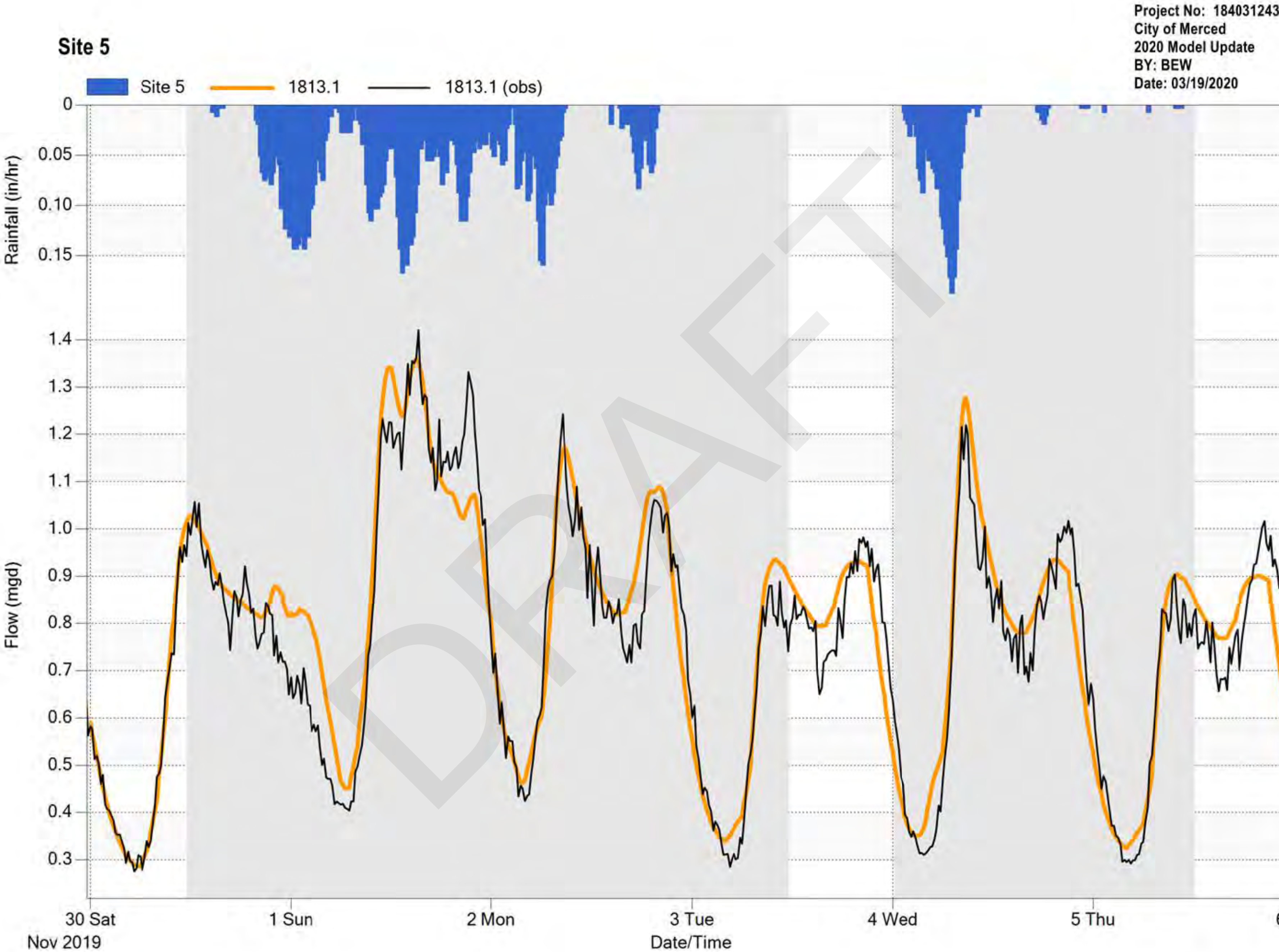
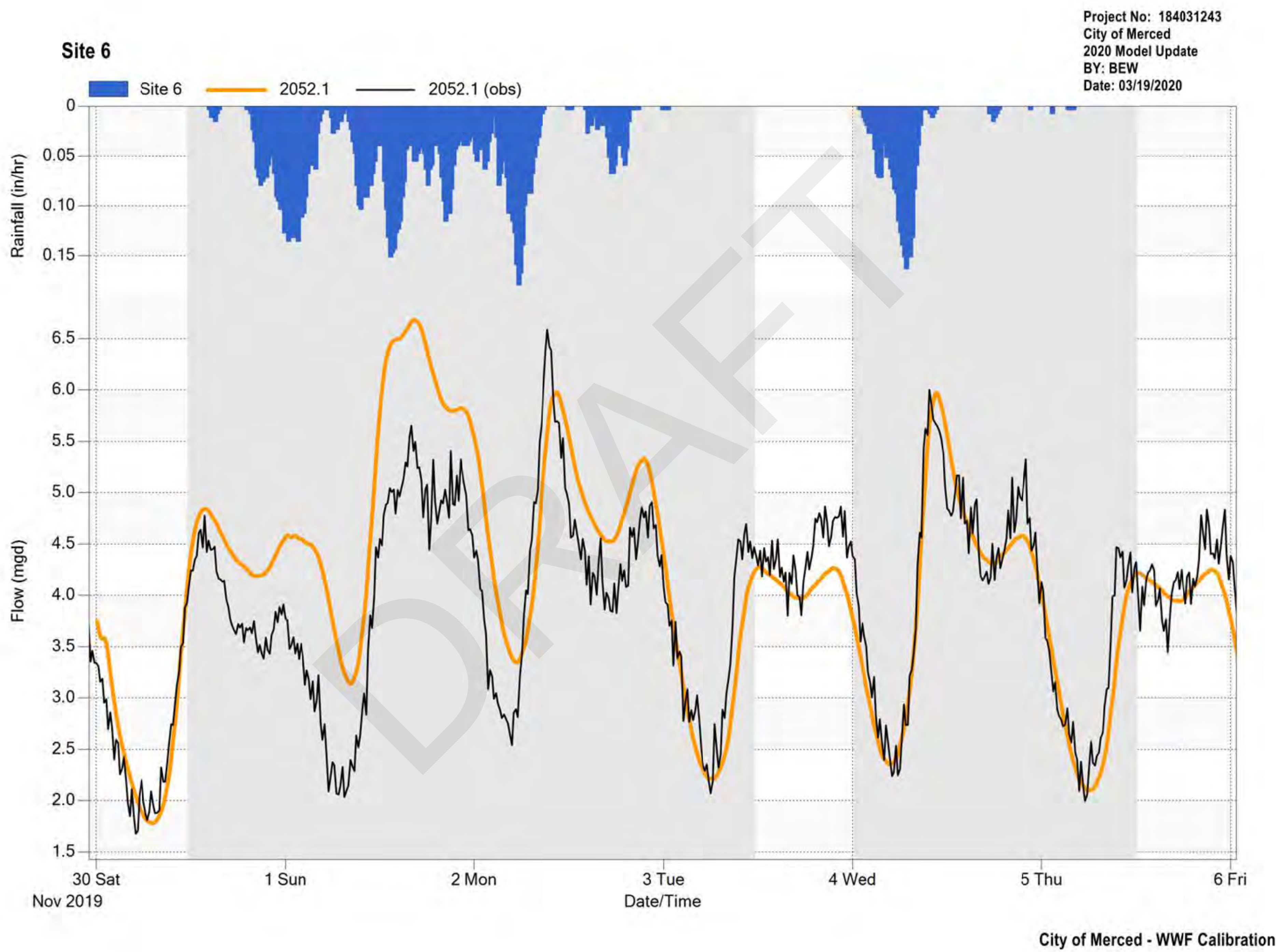
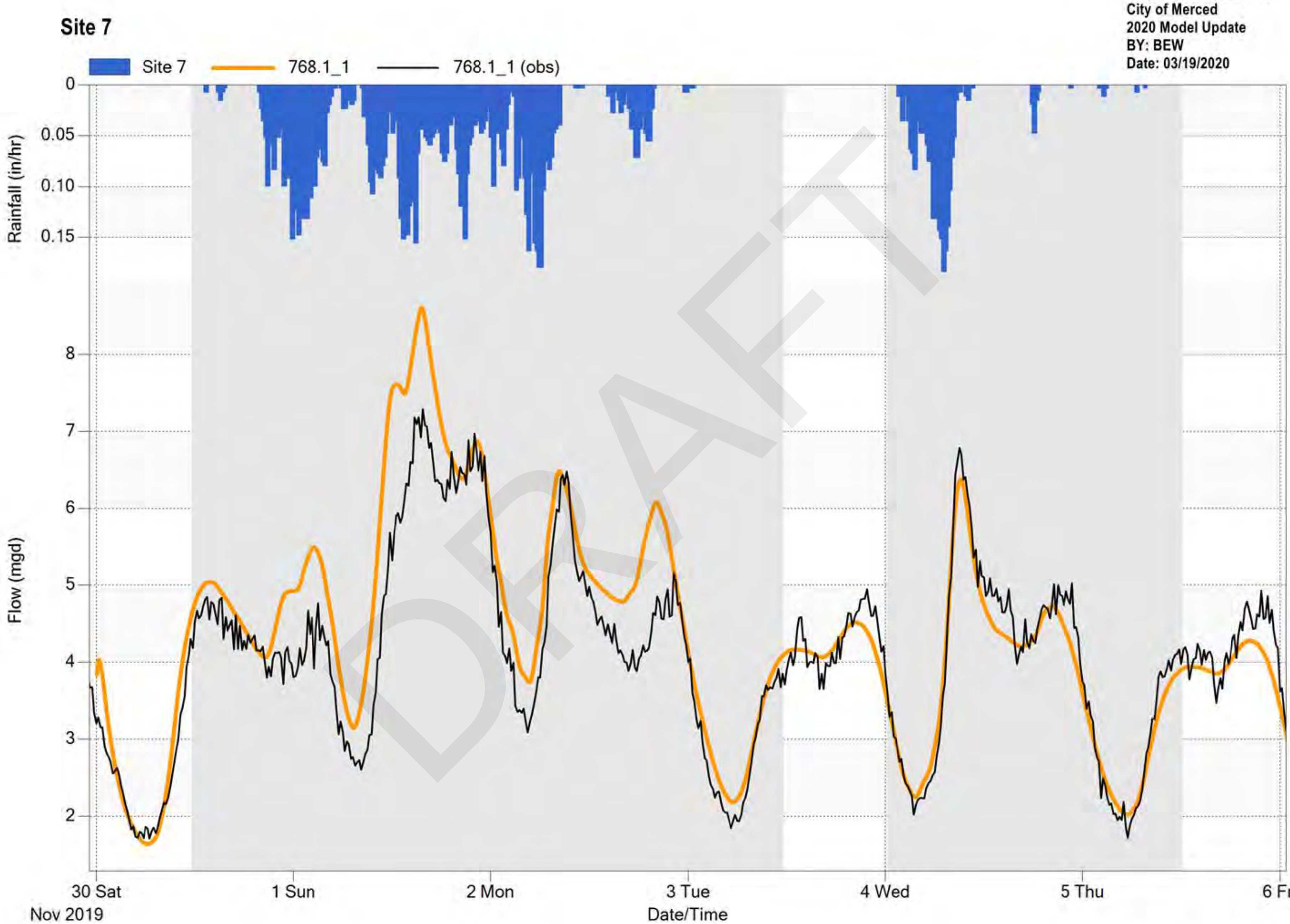


City of Merced - WWF Calibration



Project No: 184031243
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020
Site 6
Site 6
2052.1
2052.1 (obs)
Rainfall (in/hr)
0
0.05
0.10
0.15
Flow (mgd)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
30 Sat
Nov 2019
1 Sun
2 Mon
3 Tue
4 Wed
5 Thu
6 Fri
Date/Time
DRAFT
City of Merced - WWF Calibration

Project No: 184031243
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020



City of Merced - WWF Calibration

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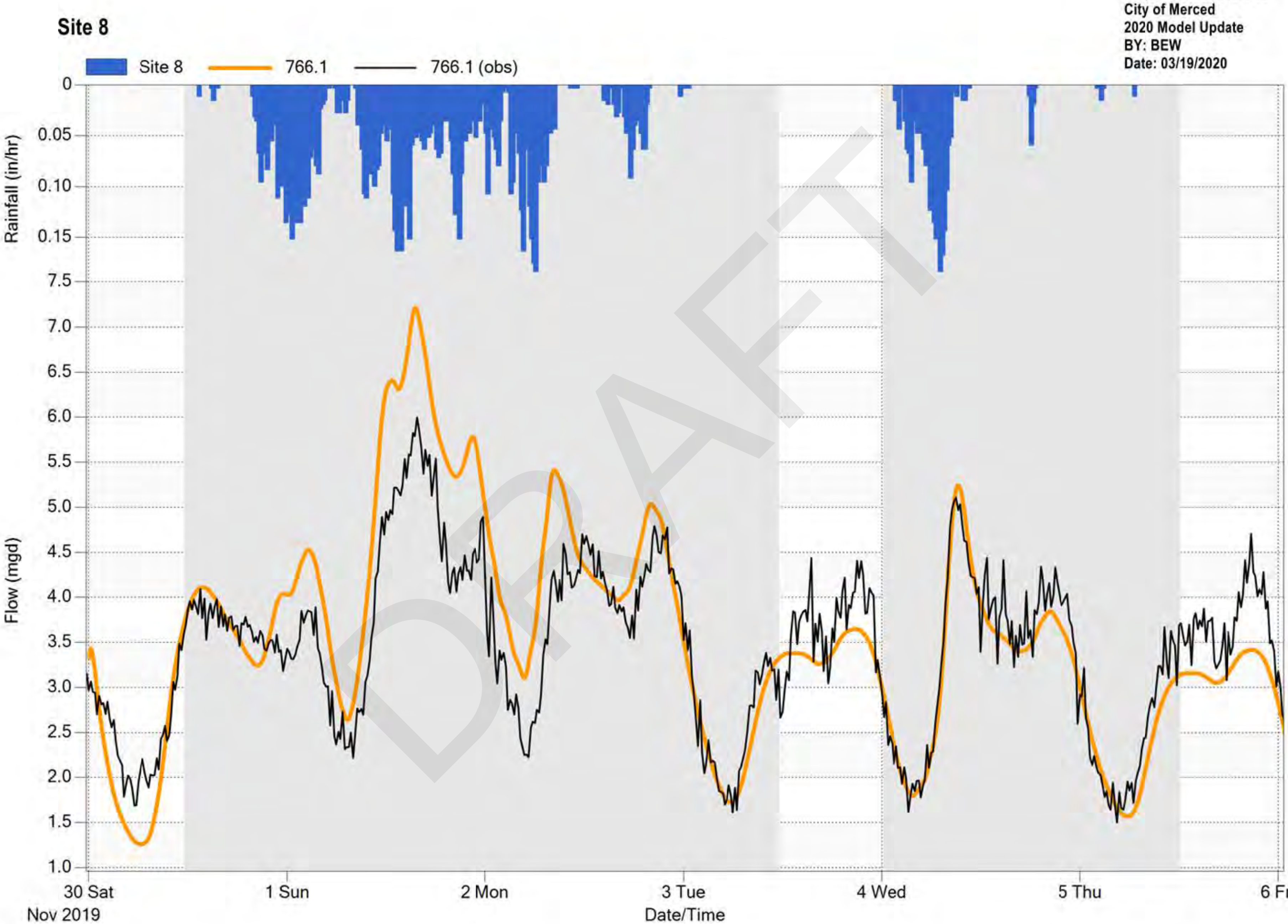
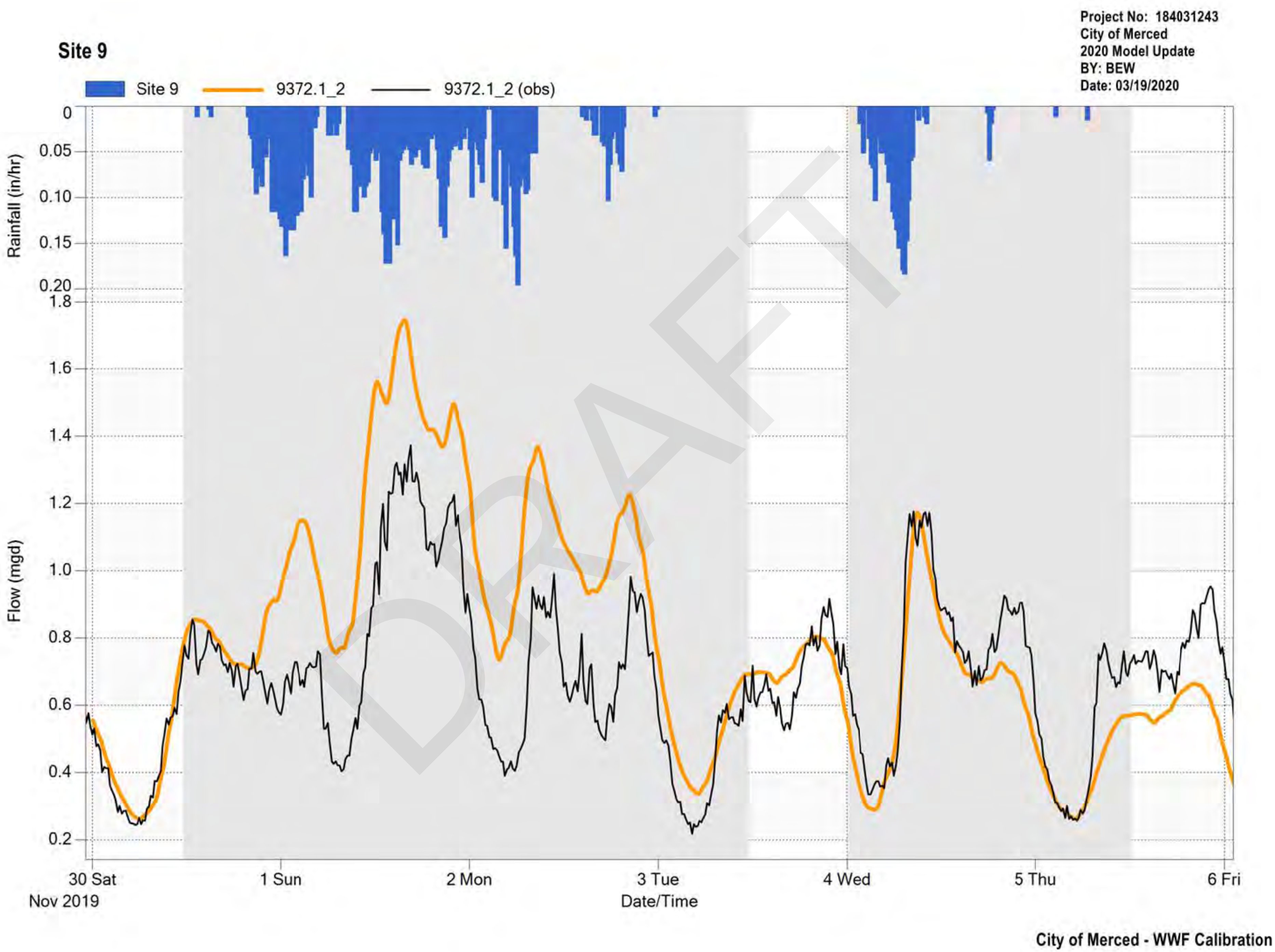
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020

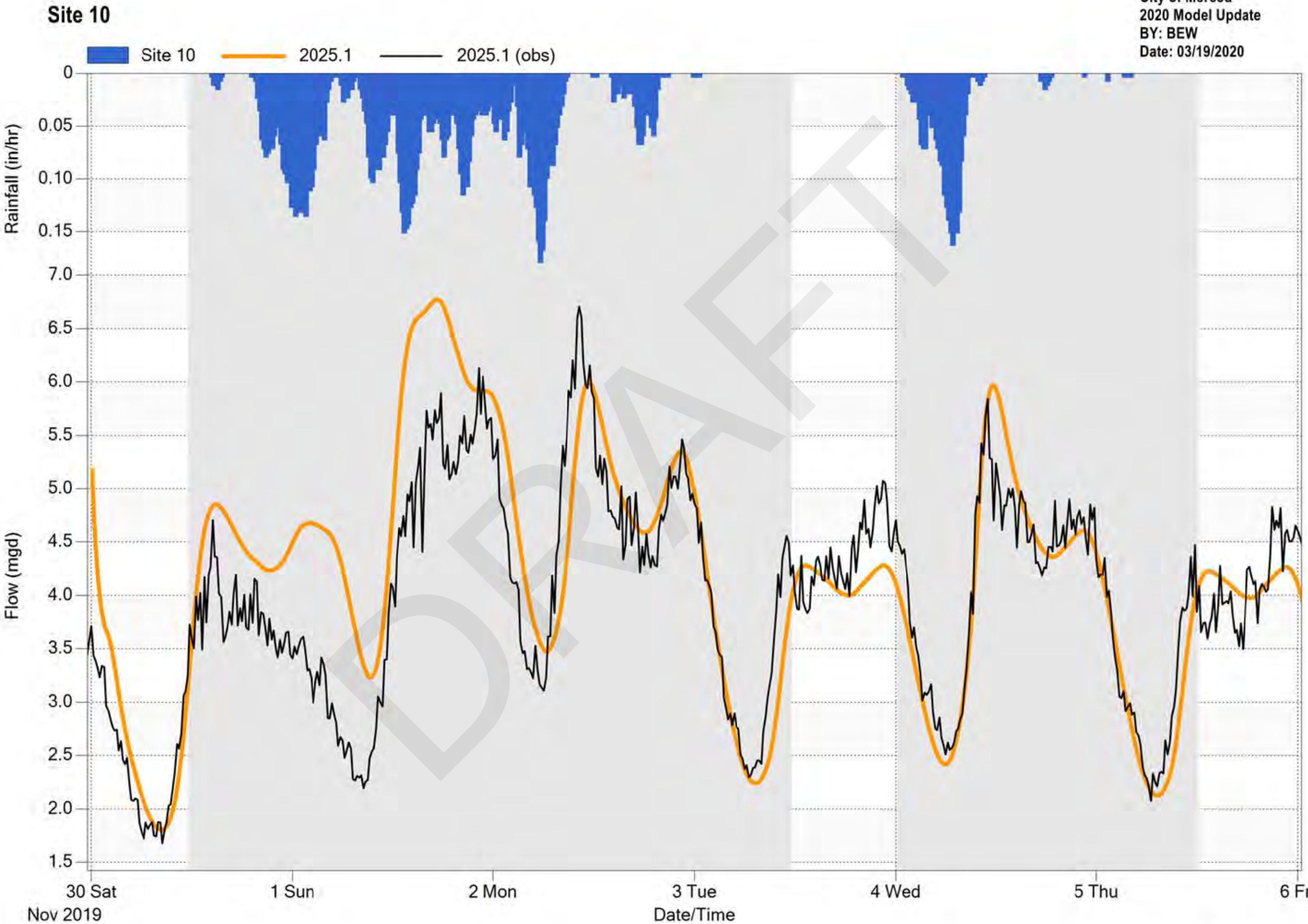


City of Merced - WWF Calibration



Project No: 184031243
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020
Site 9
Site 9
9372.1_2
9372.1_2 (obs)
Rainfall (in/hr)
0
0.05
0.10
0.15
0.20
Flow (mgd)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
30 Sat
Nov 2019
1 Sun
2 Mon
3 Tue
Date/Time
4 Wed
5 Thu
6 Fri
DRAFT
City of Merced - WWF Calibration

Project No: 184031243
City of Merced
2020 Model Update
BY: BEW
Date: 03/19/2020



City of Merced - WWF Calibration

Appendix C TRUNK SEWER PROFILES

City of Merced
Wastewater Collection System
Master Plan

Stantec

Prepared for:
City of Merced

Prepared by:
Stantec Consulting Services Inc.

December 15, 2017

Sign-off Sheet

This document entitled City of Merced Wastewater Collection System Master Plan was prepared by Stantec Consulting Services Inc. ("Stantec") for the City of Merced (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any changes that may have occurred since that time. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____
(signature)

Brett LaPlante, P.E.

Reviewed by ____
(signature)

Dave Price, P.E.

Stantec

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Executive Summary

The City of Merced (City) Vision 2030 General Plan (2030 General Plan) discusses City growth that may occur by the year 2030. Much of that growth requires construction of new infrastructure that is to be funded by the proponents of growth needing public services which the City provides. Key infrastructure needs relevant to this Wastewater Collection System Master Plan (WCS Master Plan) include the wastewater collection system, itself; wastewater treatment, disposal, and reuse facilities; and various potable and non-potable water needs for the growing areas of the City. This WCS Master Plan is focused on wastewater collection system (aka, sewer system) needs and planning. However, wastewater collection system planning is driven by 1) where the wastewater is generated (i.e., collected from), and 2) where it is conveyed to receive treatment, and then subsequent disposal or reuse of the treated wastewater, which is termed "effluent". The siting of wastewater treatment facilities is driven by many factors including land use/zoning, how/where the treated wastewater is to be disposed/reused, and overall life cycle costs. The City is in the process of updating its master plan for wastewater treatment needs and recently updated a draft of its water master plan (AECOM, 2015 draft). This WCS Master Plan is believed to integrate the intent and objectives expressed by City staff relevant to these related infrastructure planning efforts. The most important concept coming out of these concurrent planning efforts is that the City is not planning to implement extensive effluent reuse (i.e. the City is not planning to install a "purple pipe" distribution system) in the North Merced area. This WCS Master Plan considers the collection system needs of the existing City as well as future needs of the Specific Urban Development Plan (SUDP) identified in the 2030 General Plan, see **Figure ES-1**.

Because wastewater collection systems are designed to have an effective service life of over 50 years and can be expected to be in service up to 75 or 100 years, such systems are designed and constructed based on best professional judgement of wastewater collection system needs under "reasonable build-out" conditions, not just City growth envisioned in the 2030 General Plan (which has a mandated 20-year planning horizon). The City's collection system is to be designed and constructed to serve "reasonable build-out" of the General Plan SUDP depicted in **Figure ES-1**. "Reasonable build-out" conditions (hereinafter, simply "build-out", or "build-out conditions") are City growth and wastewater flow estimates based on development density assumptions outlined in Section 5.0 of this WCS Master Plan. Application of maximum densities on all properties within the 2030 General Plan SUDP could result in higher flow estimates than presented herein. Planning for maximum densities is unrealistic for a city like Merced (versus "land-locked" cities like San Francisco). Consequently, this WCS Master Plan is based on reasonable build-out of the City utilizing current development trends and judgment of City staff. Prior to actual design and construction of infrastructure improvements, developers should be given the opportunity to fund maximum density sewer capacity, if that is their desire.

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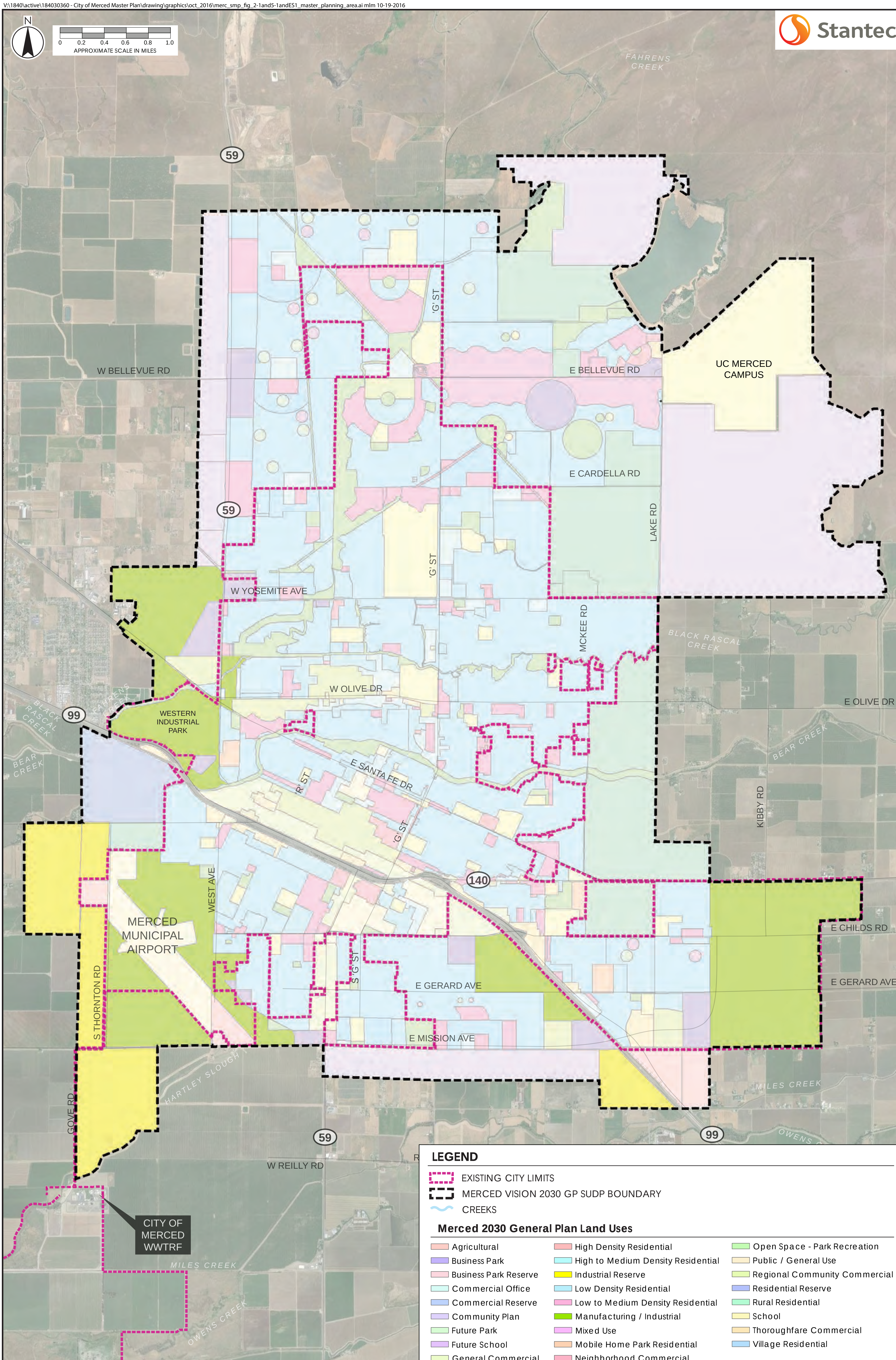

Figure ES-1
Master Planning Area

Because wastewater collection systems flow to wastewater treatment plant sites and related effluent disposal/reuse facilities, these plant sites and effluent facilities must also be evaluated conceptually for function/viability under "build-out" flow conditions. The importance of this concept of planning infrastructure for build-out conditions becomes evident from the forecasts of current (2017), 2030 General Plan, and build-out design wastewater flows presented in **Table ES-1**.

Table ES-1 Design Wastewater ADWFs for the City of Merced [(a)]

Time Frame	Entire City	North Merced [(b)]	Rest of City [(c)]
	ADWF, Mgal/d	ADWF, Mgal/d	ADWF, Mgal/d
Current (2017) [(d)]	~ 8	--	--
2030 General Plan	~ 16 to 17	~ 4 to 5	~ 12
Build-out	~ 34 to 35	~ 14 to 15	~ 20

(a) Design flow= expected flow for design purposes, not actual flow which can vary materially from year-to-year. ADWF = average dry weather flow.

(b) Represents new flow from the North Merced service area requiring new trunk sewers and additional wastewater treatment and effluent disposal/reuse capacity.

(c) Represents flow to the existing trunk sewer system, including some flow (about 4 Mgal/d) from proposed projects entitled to connect to the existing trunk sewer system.

(d) Current flows include a mix of wastewater from both North Merced (including UC Merced) and the rest of the existing City.

Like collection systems, wastewater treatment plants are master planned to serve "reasonable build-out", but construction of these facilities can be more cost effectively phased. Collection system sewer lines, particularly large trunk sewers, are often located within roadways. This WCS Master Plan has identified locations for trunk sewers which are consistent with the Vision 2030 General Plan Circulation Plan. Trunk sewers require deep excavations and are most cost effectively installed prior to, or concurrent with construction of major roadway and other surface improvements. Replacing sewers or putting in parallel sewers after the fact is disruptive to the public and very expensive.

Treatment plants, when properly sited have generous buffers to limit exposure of commercial and residential land uses to objectionable odors, noise and visual impacts associated with them. Thus, construction activities occurring on treatment plant sites do not involve significant traffic disruptions like trunk sewers and typically result in less exposure of the general public to noise and other potential impacts. So, although treatment plants must be planned for "reasonable build-out" to ensure these generous buffers are in place, they allow for construction of capacity expansions to be phased to keep pace with population growth and take advantage of advances in treatment process technology and consideration of regulatory requirements.

This WCS Master Plan, after consideration of many alternatives, describes two basic plans for building the wastewater collection system infrastructure needed to serve 2030 General Plan growth projections and City forecasts of reasonable "build-out" conditions. All flow capacities referred to in the following bullets are design, ADWF (Average Dry Weather Flow) capacities.

- Plan A: Under Plan A, the collection system takes all municipal wastewater to the City's existing 12 Mgal/d capacity wastewater treatment and reclamation facility (WWTRF) located southwest of the City, as shown in **Figure ES-2**. The existing WWTRF would be expanded, as needed, to handle 2030 General Plan flows. The effluent disposal and reuse facilities needed by the planned expansions largely exist; however, developers still need to buy their fair shares of all existing City facilities they use, including the land on which that infrastructure is located. The existing WWTRF site is believed to have sufficient land and disposal potential to serve "reasonable build-out" design flow estimates of 34 to 35 Mgal/d, if/when needed.

- Plan B: Under Plan B, the collection system takes most municipal wastewater generated by growth in North Merced to a new North Merced WWTRF (NMWWTRF) located on industrially zoned land west of the intersection of W. Yosemite Avenue and Highway 59 (aka, Snelling Highway), see **Figure ES-3**. The NMWWTRF site would be planned for 2030 General Plan and build-out capacities of approximately 4 to 5 Mgal/d, and 14 to 15 Mgal/d, respectively. The existing WWTRF would serve the remainder of the City and its growth, and would have approximate planned capacities for 2030 General Plan, and build-out conditions of 12 Mgal/d and 20 Mgal/d, respectively. Both the new NMWWTRF and existing WWTRF would be built and expanded in stages, or phases, as needed. The NMWWTRF would also need new effluent disposal and reuse facilities master planned for its 2030 General Plan and build-out flow conditions. This is because there are no existing effluent facilities or related effluent discharge permits for the NMWWTRF site, at this time, whereas they do exist at the WWTRF site.

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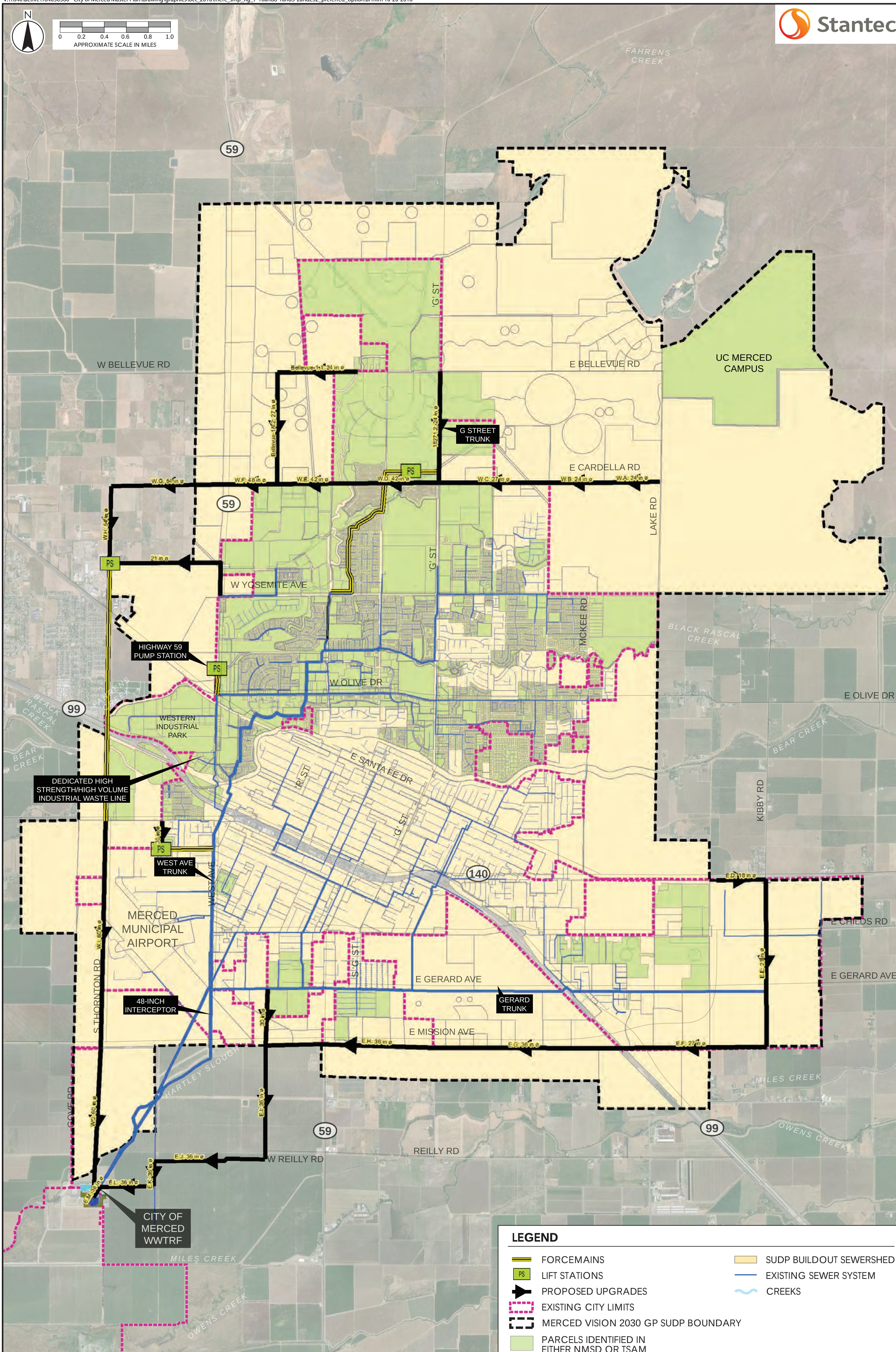

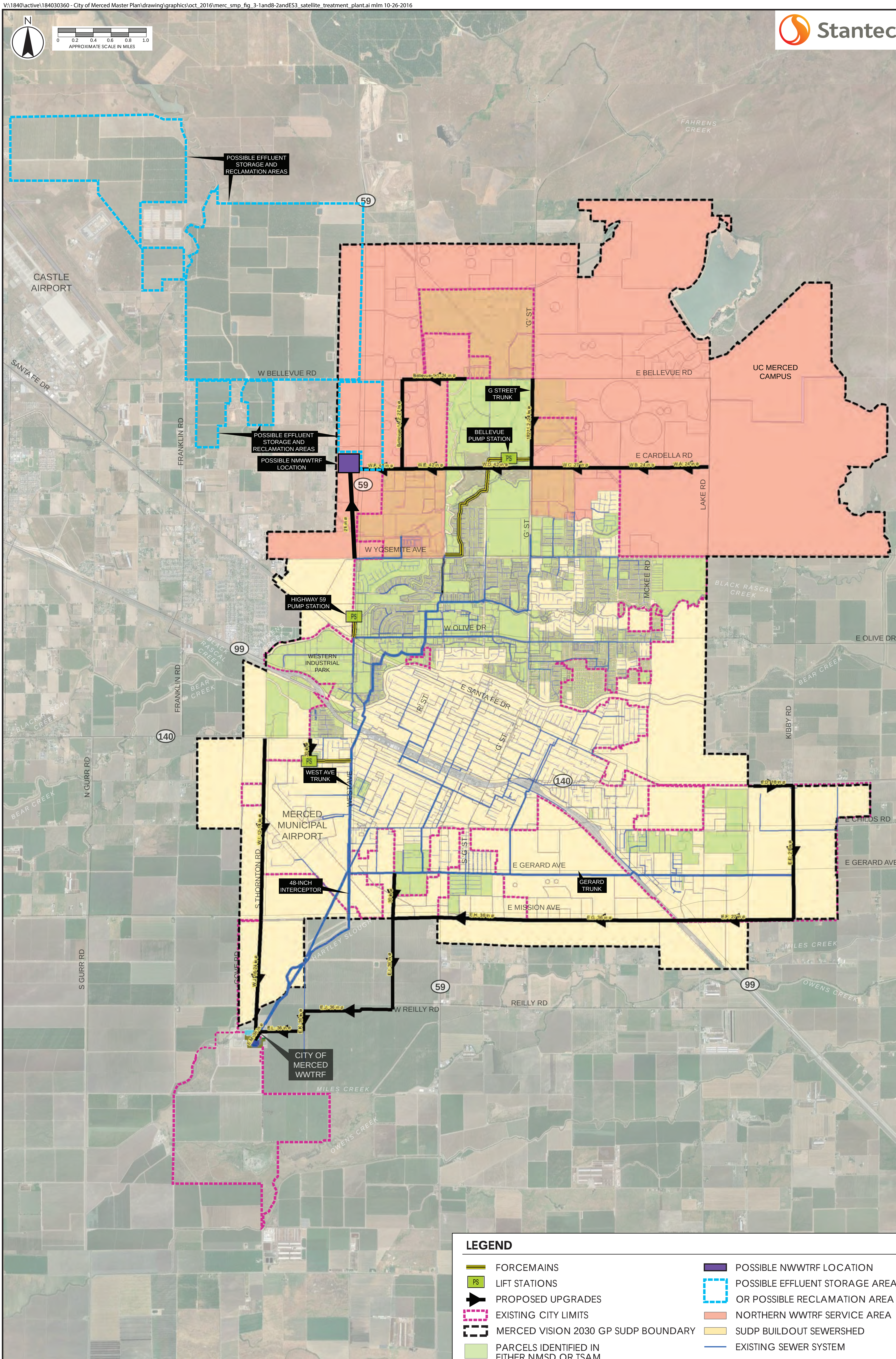

N
0 0.2 0.4 0.6 0.8 1.0
APPROXIMATE SCALE IN MILES
Stantec
FAHRENS CREEK
POSSIBLE EFFLUENT STORAGE AND RECLAMATION AREAS
59
CASTLE AIRPORT
SANTA FE DR
'G' ST
W BELLEVUE RD
E BELLEVUE RD
UC MERCED CAMPUS
G STREET TRUNK
BELLEVUE PUMP STATION
POSSIBLE EFFLUENT STORAGE AND RECLAMATION AREAS
POSSIBLE NMWWTRF LOCATION
E CARDELLA RD
LAKE RD
FRANKLIN RD
W YOSEMITE AVE
MCKEE RD
BLACK RASCAL CREEK
HIGHWAY 59 PUMP STATION
W OLIVE DR
E OLIVE DR
99
WESTERN INDUSTRIAL PARK
BEAR CREEK
E SANTA FE DR
R' ST
'G' ST
140
KIBBY RD
N GURR RD
WEST AVE TRUNK
WEST AVE
MERCED MUNICIPAL AIRPORT
E CHILDS RD
E GERARD AVE
S 'G' ST
GERARD TRUNK
48-INCH INTERCEPTOR
S THORNTON RD
E MISSION AVE
HARTLEY SLOUGH
MILES CREEK
S GURR RD
COVE RD
W REILLY RD
REILLY RD
OWENS CREEK
CITY OF MERCED WWTRF
LEGEND
FORCEMAINS
LIFT STATIONS
PROPOSED UPGRADES
EXISTING CITY LIMITS
MERCED VISION 2030 GP SUDP BOUNDARY
PARCELS IDENTIFIED IN EITHER NMSD OR TSAM
POSSIBLE NWWTRF LOCATION
POSSIBLE EFFLUENT STORAGE AREA OR POSSIBLE RECLAMATION AREA
NORTHERN WWTRF SERVICE AREA
SUDP BUILDOUT SEWERSHED
EXISTING SEWER SYSTEM
CREEKS

When comparing wastewater collection system needs under Plan A (**Figure ES-2**) to the wastewater collection system needs under Plan B (**Figure ES-3**), it becomes evident that there is one major similarity and four major differences between these two plans, as summarized below.

Similarities:

S-1. The wastewater collection systems servicing North Merced and the rest of the City are the same under both plans except that under Plan A the North Merced sewer system leads to a pump station conveying the wastewater to the existing WWTRF, whereas under Plan B, the North Merced sewer system leads to a pump station (in essentially the same location as Plan A) lifting the wastewater into the new NMWWTRF.

Differences:

D-1. Plan A builds a pipeline between the North Merced pump station (see S-1, above) and the existing WWTRF, whereas Plan B does not.

D-2. Plan A expands the existing WWTRF, whereas Plan B builds a new NMWWTRF on industrially zoned land adjacent to the North Merced pump station (see S-1, above).

D-3. Plan A expands effluent disposal capacity at the existing WWTRF, whereas Plan B builds a new effluent disposal facility in the greater North Merced area. The new effluent disposal/reuse area could occupy up to approximately 3,800 acres of land under build-out conditions. Effluent reuse is envisioned to entail irrigation of agricultural crops in this WCS Master Plan in the absence of there being any other plan for NMWWTRF effluent, at this time.

D-4. Plan B facilitates effluent reuse in the North Merced area, and therefore has the potential to reduce agricultural use of groundwater in the area, which has been over-utilized historically.

Because actual wastewater collection system needs under Plan A and Plan B are very similar, a comparison of Plan A and Plan B is presented in **Table ES-2** to help avoid confusion as to the major and material differences between these two plans.

Because the wastewater collection system improvements needed under Plans A and B are virtually identical except as noted under "D-1" of Table ES-2, the City Council's decision regarding which wastewater collection system plan to implement will be based more on wastewater treatment and disposal/reuse issues (and associated costs) than on wastewater collection issues (and associated costs). Besides these differences and their costs, the City Council's decision will also be based on many other considerations including recommendations from City staff, City consultants, the general public, and various special interest groups; water resource planning considerations; economics; political considerations; specific service area needs/objectives; etc.

Table ES-2 Differences Between Plan A and Plan B

Major Differences	Plan A	Plan B
D-1. Raw sewage pipeline from North Merced to existing WWTRF	Approximately 2.5 miles of dual 24 and 36-inch forcemains and approximately 3 miles of 60-inch diameter gravity sewer	Not required.
D-2. WWTRF Needs	Expand existing WWTRF to approximately 34 Mgal/d, as needed.	Build new approximately 14 Mgal/d NMWWTRF, and expand existing WWTRF to approximately 20 Mgal/d, both as needed.
D-3. Effluent disposal needs a. Land b. Storage c. Conveyance pipe	 a. None b. None c. None	 a. Up to ~3,800 acres b. Up to ~750 acres c. Approximately 2 miles to ag land north of Bellevue Road and west of Highway 59
D-4. Effluent reuse potential	Indirect via MID (Merced Irrigation District)	Indirect via MID and direct from NMWWTRF to ag land in/near North Merced area

An important consideration in the City Council's final decision regarding Plan A and Plan B is cost and cost differences between A and B. As will be discussed, the costs and cost differences between Plan A and Plan B are dependent on many factors, including whether the City plans to implement extensive effluent reuse via agricultural irrigation in the North Merced area to reduce agricultural use of the North Merced groundwater resource. This groundwater resource serving the City, agriculture, and other uses in the greater Merced area is currently heavily utilized. Extensive agricultural reuse of effluent in the North Merced area could potentially reduce agricultural use of the groundwater resource, and possibly play a role in helping sustain the City's potable water supply.

When put in those terms, without benefit of a more complete understanding of City water resource planning, it may seem irresponsible to not implement Plan B and associated effluent reuse in North Merced. However, the City has engaged in extensive water resource planning to help achieve the goal of making the City's potable water supply more sustainable and reliable. The most significant planning relative to this WCS Master Plan is between the City and Merced Irrigation District (MID) to swap effluent water from the existing WWTRF for Merced River water to be used to 1) recharge the area's groundwater resource, and 2) irrigate parks and other City landscaping (in place of using groundwater).

In summary, not implementing effluent reuse in the North Merced area does not mean the City is ignoring groundwater resource issues. It means the City is attempting to address the issue via different means involving use of lower salinity and lower nitrogen content Merced River water rather than tertiary-treated effluent. This is important because the two most common contaminants of concern in groundwater resources are salinity and nitrogen. With this insight, one may ask, "Why even consider effluent reuse in North Merced when better quality water is available?" The answer is reliability. The City has greater control over an effluent reuse program than over a water swap program involving MID and parties impacted by changes in Merced River flows and/or diversions. This is why the City continues to consider effluent reuse in the North Merced area and throughout the City.

In so far as Plan A and Plan B both include effluent reclamation and groundwater resource considerations, the choice between Plan A and Plan B is primarily a matter of economics from an engineering perspective. Specifically, is the overall life cycle cost of Plan A more or less than the overall life cycle cost of Plan B? Life cycle costs cover the upfront cost of building the infrastructure (the primary concern of developers, who typically pay this bill when assessment districts are not involved), and the present worth of the on-going annual costs necessary to operate, maintain, and ultimately rebuild the infrastructure (the primary concern of businesses and residents, who pay these bills after occupying the developers' projects). The desires for low, up-front construction costs versus low, long-term annual costs are generally competing interests. The City's objective is to act as the fair deal broker between these two special interest groups, who are both essential to City growth.

Stantec's reconnaissance opinion of probable total project costs to plan, design and construct Plan A and Plan B (to serve "reasonablel build-out", or ~34 Mgal/d, ADWF) reflects a difference of approximately 15 to 20 percent, with Plan B having the higher expected cost. Detailed breakdowns of the estimated costs for Plan A and Plan B are presented in Section 8.0 of this WCS Master Plan, along with discussion of the anticipated process and facility components associated with each. Major uncertainties (known to exist, at this time) associated with each plan are presented in **Table ES-3**. Schematics of the relative locations of infrastructure needs for Plan A and Plan B are shown in **Figure ES-2** and **Figure ES-3**, respectively.

Table ES-3 Major Uncertainties Associated with Plan A and Plan B

Uncertainties	
Plan A	• Will water swap with MID occur and be a long-term proposition?
Plan B	• Does the City wish to devote 35 acres of industrially zoned land for the new NMWWTRF? Will the presence of a major WWTRF in the industrial park discourage other industries from locating there, particularly food processing industries? • Which agricultural lands in the greater North Merced area will become part of the NMWWTRF effluent reclamation system, and how/when will those lands be secured for City use under build-out conditions? • Will CEQA analyses and/or Regional Water Board permitting present any roadblocks to implementing Plan B either near-term or long term? • Will Plan B help or hinder maintenance of the quantity and/or quality of the City's groundwater potable water supply?

Under Plan A, wastewater treatment, disposal, and reuse are expansions in-kind of existing facilities and permits. Much of the effluent is planned to be swapped for Merced River water, as described previously. Under Plan B, effluent disposal from the new NMWWTRF is envisioned to entail dry season effluent irrigation of agricultural land under City ownership (effluent disposal facilities should be as permanent [i.e., secure] as the developments they serve), wet season storage of effluent for subsequent use during the following dry season, and possibly wet season effluent discharges to Fahrens Creek under very wet conditions when Fahrens Creek is both below flood stage, and has adequate flow to dilute effluent discharged to it (if realistic under CEQA and permitted by the Regional Water Board). As to whether effluent produced by the NMWWTRF under Plan B could be swapped for MID surface water (as is proposed under Plan A) is unknown at this time. Plan B should reduce use of North Merced area groundwater for agricultural purposes, but this is not an established fact at this time because the agricultural lands that would be used for effluent reclamation have not been identified by the City, let alone acquired by the City. Because the actual types, locations, and feasibilities of the new NMWWTRF effluent facilities have not been developed by the City, subjected to CEQA analyses, permitted by the Regional Water Board, etc., the estimated higher total project costs for Plan B NMWWTRF effluent facilities are based solely on Stantec's judgement and experience with somewhat similar facilities in the Central Valley.

Plan A is believed to have a total project cost and fewer uncertainties than Plan B. Plan A's effluent is proposed to be swapped by the City for MID surface water; Plan B's effluent may not have this potential benefit. Plan A is well precedented by similar sized cities throughout the Central Valley, and is in concert with Regional Water Board policy to regionalize WWTRFs to the extent feasible rather than have multiple WWTRFs servicing geographically contiguous areas. Based on available information, Stantec's recommendation is to implement Plan A, primarily for cost and water resource planning reasons. In other words, Stantec's preliminary recommendation is to pipe all municipal wastewater to the existing WWTRF for treatment, disposal, reuse, and water swapping.

In making that preliminary recommendation, Stantec believes both Plan A and Plan B are viable. Merced-sized cities with two WWTRFs are relatively rare in the Central Valley, but do exist. A good example of such a city is Roseville, California. Roseville elected to build a second WWTRF (the Pleasant Grove Creek facility: ADWF= 18 Mgal/d) just under 5 miles northwest from its existing Dry Creek facility (ADWF= 12 Mgal/d) to serve new growth that was occurring primarily in this northwesterly area. The two Cities (Roseville and Merced) face different circumstances relative to land use planning. The driving force behind Roseville's decision to bifurcate treatment and disposal was the reality that development had encroached upon the Dry Creek facility, surrounding it and making expansion in that location impractical. The City of Merced, in contrast, has large agricultural and industrial land use buffers surrounding its existing WWTRF making such conflicts far less likely in the future.

When considering the contents of this WCS Master Plan, likely questions are "Why not recommend this approach…or that approach?" A very brief discussion of some collection system options raised by special interests that have not been carried forward in this WCS Master Plan as being feasible for the City on a long-term, permanent basis are presented below.

1. *Why not install wastewater flow equalization basins in the collection system to utilize the existing sewers more efficiently, and more cost effectively?*

   Such basins are possible, but storing raw sewage for flow equalization purposes, in practice, is almost entirely limited to WWTRF sites. Such basins are rare in developed areas because they are ugly, are a potential nuisance, and are maintenance headaches. Such basins have aeration equipment (to minimize smells), have automatic wash-down systems (to scour "solids" from the basin when not in use), and may need a cover or other visual screening, noise attenuation, and/or odor scrubbing equipment (depending on situation-specific factors). Raw sewage equalization basins should not be a planned permanent component of a wastewater collection system (except in rare situations not applicable to Merced); however, such basins may be considered on a temporary basis (with specific closure criteria and financial guarantees) in specific situations authorized by the City Council. The entire cost of such a basin, if approved by the City Council, should be borne and bonded by the basin proponent, and in no way reduces proponent's fees for building the permanent wastewater collection system, which will be exactly the same regardless of whether the City Council permits temporary use of such a basin to expedite a specific development that otherwise would be on hold until sewer system capacity is built to meet the development's needs.

2. *Why not allow larger, planned community developments to build their own wastewater collection, treatment, and effluent reuse systems? We could save the cost of those big trunk sewers, implement effluent reuse, and expedite development all at the same time*

   This approach to implementing wastewater infrastructure reduces upfront construction costs (paid by developers) and increases long-term annual costs (paid by residents and businesses) because of loss of economy of scale on at least operations and maintenance, if not also construction when total construction costs are considered. As an example of total construction costs, such systems need places to store effluent within the planned communities through 100-year rainfall seasons. In this example, each planned community may plan to build an ornamental lake for seasonal tertiary effluent storage, but problems with such lakes are manifold. The lake's water level must be able to rise and fall seasonally because the only lake volume that counts as 100-year effluent storage is the volume of the lake that is empty each autumn. Algae that naturally grow in tertiary effluent lakes can be chronically problematic. The lake may need aeration, circulation, and chemical controls. Following construction and filling of ornamental lakes, midge populations can explode to nuisance levels until the natural ecology of the lake has time to develop (typically in a year or two). Such small, project-specific wastewater systems are difficult to permit with the Regional Water Board because they run contrary to Board policy, which was developed because the long-term track record of multiple small systems has been relatively poor. If/when such systems fail, the City will be responsible for correcting the failure. This is because the development is within the City, and the City permitted it to occur. Because the wastewater collection system was not planned for these "self-sufficient" planned community developments, the City will either reconstruct the wastewater collection system, or continue to rebuild and operate the small systems to prevent the planned community development from being condemned for health and safety reasons. However, as with the raw sewage equalization basins, temporary small wastewater systems (with specific closure criteria and financial guarantees) could be authorized by the City Council in specific situations to address specific development needs. The entire cost of the temporary system should be borne and bonded by the system proponent. The proponent still pays upfront for proponent's share of the permanent wastewater collection system and treatment facilities. The proponent still designs the development's collection system to tie into the permanent City trunk sewer by gravity flow when that trunk sewer reaches the development. Because the City has General Plan Policy UE-1.2 to maintain development in a compact urban form, any proposal for a temporary, development-specific wastewater treatment and reuse system should be located on the perimeter of existing City-served developments with the only hindrance to connecting to the City system being lack of capacity in the existing City wastewater collection system at the time the development desires to move forward.

The Regional Water Board is not expected to approve any small systems unless they are operated by the City, and are temporary (with specific and enforceable closure criteria and financial guarantees). Because of the poor economy of scale of operating and maintaining small WWTRFs, the annual costs (as reflected by monthly sewer use fees) for users of these small systems will be higher than normal City wastewater fees. As a matter of policy, the City Council (when approving any such temporary system) will need to decide whether the businesses and residents served by the temporary system pay higher monthly sewer use fees, or whether they pay the City's normal use fee with the system proponent covering the cost difference until the businesses and residents connect to the permanent City system.

Raw sewage equalization basins and development-specific WWTRFs are suggestions put forth by developers to reduce their infrastructure costs and/or to facilitate implementation of their developments that are on-hold because of the need for City wastewater infrastructure. Neither suggestion is recommended as a permanent facility; therefore, neither suggestion impacts the design or cost of Plan A, or Plan B. However, the City Council may wish to consider allowing developer use of temporary raw sewage equalization basins and/or development-specific WWTRFs on a project-specific basis for situation-specific reasons, e.g., to facilitate development critically needed by the community. If the City Council desires to consider temporary means to facilitate critically needed development, then Stantec recommends that the City develop an Implementation Plan describing use of and design criteria for temporary facilities.

Finally, this Executive Summary concludes with a list (see **Table ES-5**) of recommended trunk sewer projects:

- Improvements to existing trunk sewers (common to Plans A and B).
- New trunk sewers to serve new growth in SUDP (common to Plans A and B).
- New pump station, forcemain, and gravity sewer connecting North Merced area trunk sewers to the existing WWTRF (unique to Plan A).

Table ES-4 includes reconnaissance opinions of probable capital costs for each trunk sewer project.

Table ES-4 Recommended Trunk Sewer Improvements & Opinions of Probable Cost [(a)]

Service Area	Construction Cost [(a)]	Engineering, CM, Admin (20%)	Contingency (30%)	Total Project Costs (rounded)
Address Existing Deficiencies	$3,417,000	$683,000	$1,230,000	$5,330,000
North Merced SUDP (Plan A)	$67,139,000	$13,428,000	$24,171,000	$104,738,000
South Merced SUDP	$14,620,000	$2,924,000	$5,264,000	$22,808,000

(a) ENR CCI = 10703, June 2017. Costs presented do not include acquisition of additional right-of-way, environmental or permitting costs.

The improvement projects to address existing deficiencies identified in **Table ES-4** do not include repair and replacement (R&R) of City facilities. A robust R&R program is a key element of any properly managed public infrastructure system. The City's R&R program for the sewer utility includes an annual expenditure for the replacement of older, aging infrastructure. To replace all the facilities in the City's sewer enterprise would require a significant sum of money. An annual R&R allocation is recommended to reduce the impact of repairing and replacing critical portions of the City's sewer collection system by stretching them out over time.

Implementation of Plan A and the necessary improvements to convey wastewater to the existing City WWTRF site would require the construction of additional treatment capacity as needed. The City, as described previously and in more detail in Section 8.0 of this WCS Master Plan, intends to expand those facilities either in one 8 Mgal/d, ADWF phase, or in two 4 Mgal/d phases up to 20 Mgal/d. This would be sufficient to provide treatment and disposal capacity for the projected flows anticipated in 2030 (~16 to 17 Mgal/d, ADWF) as summarized in **Table ES-1**. **Table ES-5** summarizes the expected cost of those WWTRF improvements.

Table ES-5 An Estimate of Improvements Needed to Provide Capacity at Existing WWTRF to Serve 2030 Population Projections [(a)]

WWTRF Improvements	Opinion of Capital Costs to Expand Existing WWTRF to 20 Mgal/d [(b)]
Headworks and Primary Treatment Facilities	$2,474,000
Secondary Treatment	$21,901,000
Tertiary Treatment	$3,065,000
Disinfection System	$0
Effluent Disposal Facilities	$0
Solids Handling Facilities	$21,835,000
Miscellaneous Structures	$677,000
Subtotal 1	**$49,952,000**
Mobilization, Bonds, Insurance, Startup, Misc.	$6,808,000
Sitework	$6,152,000
Site Piping	$4,922,000
Electrical and Instrumentation	$10,663,000
Subtotal 2	**$78,497,000**
Contingencies @ 30%	$23,549,000
Subtotal 3	**$102,046,000**
Engineering and Administration @ 20%	$20,409,000
Total Project Cost	**$122,455,000**

a) 20 Mgal/d, ADWF is estimated to be sufficient to serve the 2030 population projected in the City's General Plan.
b) Based on ENR-CCI (20 Cities Index) = 10703, June 2017.

At this time, the City is planning to budget $600,000 to $800,000 annually for repair and replacement of collection system assets. Prioritization of R&R projects will be done within the typical five-year CIP timeframe, updated accordingly, but the City also recognizes that unforeseen incidents may require adjustments in the specific projects identified in any particular year. Further discussion of the City's R&R program is provided in Sections 7.0 and 8.0 of this WCS Master Plan.