CUPERTINO SANITARY DISTRICT
SANITARY BOARD MEETING
WEDNESDAY, AUGUST 3, 2022

AGENDA

The meeting will be held at 7:00 p.m. via teleconference [call 1 (866) 899 - 4679 Conference Access Code: 251566821] and anyone interested may also call in. The District Office at 20863 Stevens Creek Blvd, Suite 100, Cupertino is closed.

1. ROLL CALL

2. AB 361

The Board of Directors makes the following findings required by AB 361 in order to continue holding meetings by teleconferencing electronically: (1) the March 4, 2020 Governor's Proclamation of a State of Emergency is still in effect, (2) the County of Santa Clara positivity rate is over 14% and the County Health Officer continues to encourage social distancing and advises people to wear masks indoors, and (3) due to room capacity limitations, meeting in person would present imminent risks to the health or safety of attendees.

3. PUBLIC COMMENTS

This portion of the meeting is reserved for persons desiring to address the board on any matter not on the agenda. Speakers are limited to three (3) minutes.

All statements requiring a response will be referred to staff for further action. In most cases, state law will prohibit the board from making any decisions with respect to a matter not listed on the agenda.

4. CLOSED SESSION

A. CONFERENCE WITH LEGAL COUNSEL – EXISTING LITIGATION
in accordance with government code section Paragraph (1) of Subdivision (d) of Section 54956.9, existing litigation. Name of Case: County Sanitation District 2-3, West Valley Sanitation District, Cupertino Sanitary District, Burbank Sanitary District and the City of Milpitas v. The City of San Jose, The City of Santa Clara and Does 1 through 50 inclusive.

5. MINUTES

A. APPROVAL OF THE REGULAR MEETING MINUTES OF JULY 20, 2022

B. APPROVED MINUTES OF JUNE 15, 2022

C. APPROVED MINUTES OF JUNE 28, 2022

6. CORRESPONDENCE

NONE

7. MEETINGS

A. TELECONFERENCE MEETING OF THE SAN JOSE/SANTA CLARA TREATMENT PLANT TECHNICAL ADVISORY COMMITTEE (TAC) SCHEDULED TO BE HELD ON MONDAY, AUGUST 8, 2022

B. TELECONFERENCE MEETING OF THE SAN JOSE/SANTA CLARA TREATMENT PLANT ADVISORY COMMITTEE (TPAC) SCHEDULED TO BE HELD ON THURSDAY, AUGUST 11, 2022

C. CASA CONFERENCE TO BE HELD AUGUST 10-12, 2022 IN OLYMPIC VALLEY, CA

8. REPORTS

A. PEAK FLOW REDUCTION

9. UNFINISHED BUSINESS

A. COVID-19 UPDATES

10. NEW BUSINESS

A. ANNUAL RENEWAL GRANITENET SOFTWARE

B. CALIFORNIA MANDATORY RETIRMENT PLAN

11. STAFF REPORT

A. CURRENT DEVELOPMENT PROJECTS

12. CALENDAR ITEMS

A. NEXT REGULAR DISTRICT BOARD MEETING IS SCHEDULED TO BE HELD ON WEDNESDAY, AUGUST 17, 2022

13. ADJOURNMENT

CUPERTINO SANITARY DISTRICT BOARD MEETING
WEDNESDAY, JULY 20, 2022

The Sanitary Board of the Cupertino Sanitary District convened this date at 7:00 p.m. This meeting was conducted via teleconferencing in accordance with AB 361. The District office at 20863 Stevens Creek Blvd, Suite 100, Cupertino was closed.

1. ROLL CALL:

President Bosworth called the meeting to order, and the following proceedings were had to wit: Roll call was taken, with the following members in attendance:

Directors present: William A. Bosworth, Angela S. Chen, Taghi S. Saadati, and David A. Doyle. Patrick S. Kwok was on excused absence.

Staff present: District Manager Benjamin Porter, Deputy District Manager Robert Woodhouse, and Counsel Marc Hynes.

District Consultant: Richard K. Tanaka joined the meeting at 7:19 p.m.

Public: None

2. AB 361:

The Board of Directors makes the following findings required by AB 361 in order to continue holding meetings by teleconferencing electronically: (1) the March 4, 2020 Governor's Proclamation of a State of Emergency is still in effect, (2) the County of Santa Clara Health Officer announced on May 10, 2022 that COVID-19 cases are rising again to higher levels than last summer's surge and there is a rise in hospitalizations; she continues to encourage social distancing and advises people wear masks indoors, and (3) due to room capacity limitations, meeting in person would present imminent risks to the health or safety of attendees.

On a motion by President Bosworth, seconded by Director Saadati, by a vote of 4-0-0, the Board approved.

3. PUBLIC COMMENTS:

There were none.

4. CLOSED SESSION:

President Bosworth adjourned the regular meeting session and opened the closed session at 7:09 p.m. Manager Porter, and Deputy Manager Woodhouse were excused from the closed session.

A. Conference with legal counsel – Existing Litigation in accordance with government code section Paragraph (1) of Subdivision (d) of Section 54956.9, existing litigation. Name of Case: County Sanitation District 2-3, West Valley Sanitation District, Cupertino Sanitary District, Burbank Sanitary District, and the City of Milpitas v. The City of San Jose, The City of Santa Clara, and Does 1 through 50 inclusive.

   Board action: There was no reportable action.

President Bosworth adjourned the closed session at 7:15 p.m. and the regular meeting was called to order. District Manager Porter, and Deputy District Manager Woodhouse rejoined the regular meeting.

5. MINUTES & BILLS:

A. On a motion by Director Chen, seconded by Director Doyle, by a vote of 4-0-0, the minutes of special meeting held Wednesday, June 28, 2022, were approved.

B. On a motion by Director Chen, seconded by Director Doyle, by a vote of 4-0-0, the minutes of regular meeting held Wednesday, June 15, 2022, were approved.

C. By consensus, the Minutes of Monday, June 1, 2022, are to be Noted & Filed.

D. The Board reviewed May payable warrants and financial statements. On a motion by Director Saadati, seconded by Director Chen, by a vote of 4-0-0, the financial statements and payment of bills were approved as written.

E. Board members will submit their July timesheets to Manager Porter.

6. CORRESPONDENCE:

A. The Board reviewed correspondence from City of San Jose titled Revised 2022-2023 San Jose-Santa Clara Regional Wastewater Facility Operating and Maintenance Estimated Cost Distribution. It is to be Noted & Filed.

B. The Board reviewed emailed correspondence from the Rotary Club of Cupertino titled September 24 – Silicon Valley Fall Festival. It is to be Noted & Filed.

7. MEETINGS:

A. Manager Porter plans to attend the teleconference meeting of The San Jose/Santa Clara Treatment Plant Technical Committee (TAC) to be held on Monday, August 8, 2022.

B. Director Kwok plans to attend the teleconference meeting of The San Jose/Santa Clara Treatment Plant Advisory Committee (TPAC) to be held on Thursday, August 11, 2022.

C. CASA Annual Conference is to be held August 10-12, 2022 in Olympic Valley, CA.

8. REPORTS:

A. Director Chen reported on the CSRMA – Board of Directors meeting held June 23, 2022 via teleconference.

B. Deputy Manager Woodhouse reported on the CASSE teleconference held on Thursday, July 13, 2022.

C. Deputy Manager Woodhouse reported on the CASA Collection System Workgroup teleconference held on Wednesday, July 20, 2022.

D. The teleconference meeting of The San Jose/Santa Clara Treatment Plant Technical Advisory Committee (TAC) to be held on Monday, July 11, 2022 was canceled.

E. The teleconference meeting of The San Jose/Santa Clara Treatment Plant Advisory Committee (TPAC) to be held Thursday, July 14, 2022 was canceled.

9. UNFINISHED BUSINESS:

A. Manager Porter reported on COVID-19 updates.

10. NEW BUSINESS:

A. The Board discussed Ethics Training renewal.

11. STAFF REPORTS:

A. Manager Porter reported on Current Development Projects.

B. Manager Porter reported on the Monthly Maintenance Report.

12. CALENDAR ITEMS:

A. The next regular District Board meeting is scheduled to be held on Wednesday, August 3, 2022.

13. ADJOURNMENT:

On a motion properly made and seconded, at 8:15 p.m. the meeting was adjourned.

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Secretary of the Sanitary Board

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President of the Sanitary Board

CUPERTINO SANITARY DISTRICT
BOARD SPECIAL MEETING
TUESDAY, JUNE 28, 2022

The Sanitary Board of the Cupertino Sanitary District convened this date at 4:01 p.m. This meeting was conducted via teleconferencing in accordance with AB 361. The District office at 20863 Stevens Creek Blvd, Suite 100, Cupertino was closed.

1. ROLL CALL:

President Bosworth called the meeting to order, and the following proceedings were had to wit: Roll call was taken, with the following members in attendance:

Directors present: William A. Bosworth, Angela S. Chen, Taghi S. Saadati, David A. Doyle, and Patrick S. Kwok.

Staff present: District Manager Benjamin Porter and Associate Sanitary Engineer Abby Yung. Counsel Marc Hynes joined the meeting at 4:04pm.

Public: None

2. AB 361:

The Board of Directors makes the following findings required by AB 361 in order to continue holding meetings by teleconferencing electronically: (1) the March 4, 2020 Governor's Proclamation of a State of Emergency is still in effect, (2) over 1 million US residents have died from COVID and health officials continue to encourage social distancing, and (3) due to room capacity limitations, meeting in person would present imminent risks to the health or safety of attendees.

On a motion by President Bosworth, seconded by Director Doyle, by a vote of 5-0-0, the Board approved.

3. NEW BUSINESS:

The Board reviewed amendments to Resolution No. 1337, Consolidation of Elections. On motion by Director Kwok, seconded by Director Saadati, by a vote of 5-0-0, amendments to Resolution No. 1337 were approved.

4. ADJOURNMENT:

On a motion properly made and seconded, at 4:09 p.m. the meeting was adjourned.

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Secretary of the Sanitary Board President of the Sanitary Board

CUPERTINO SANITARY DISTRICT BOARD MEETING
WEDNESDAY, JUNE 15, 2022

The Sanitary Board of the Cupertino Sanitary District convened this date at 7:01 p.m. This meeting was conducted via teleconferencing in accordance with AB 361. The District office at 20863 Stevens Creek Blvd, Suite 100, Cupertino was closed.

1. ROLL CALL:

President Bosworth called the meeting to order, and the following proceedings were had to wit: Roll call was taken, with the following members in attendance:

Directors present: William A. Bosworth, Angela S. Chen, Taghi S. Saadati, David A. Doyle, and Patrick S. Kwok.

Staff present: District Manager Benjamin Porter, Deputy District Manager Robert Woodhouse, and Counsel Marc Hynes.

District Consultant: Richard K. Tanaka joined the meeting at 7:19 p.m.

Public: None

2. AB 361:

The Board of Directors makes the following findings required by AB 361 in order to continue holding meetings by teleconferencing electronically: (1) the March 4, 2020 Governor's Proclamation of a State of Emergency is still in effect, (2) over 1 million US residents have died from COVID and health officials continue to encourage social distancing, and (3) due to room capacity limitations, meeting in person would present imminent risks to the health or safety of attendees.

On a motion by President Bosworth, seconded by Director Saadati, by a vote of 5-0-0, the Board approved.

3. PUBLIC COMMENTS:

There were none.

4. PUBLIC HEARING

A. The Board conducted a public hearing on Proposed Sanitary Sewer Service Charge Increase for Fiscal Year 2022-2023.

   1. Manager Porter presented on the rate study.

   2. President Bosworth opened the public hearing at 7:03 p.m. The Board reviewed written protests. There were no public comments.

   3. President Bosworth closed the public hearing at 7:06 p.m.

   4. The Board discussed proposed new sewer rate increase of 5%.

5. On motion by Director Chen, seconded by Director Saadati, by a vote of 5-0-0, the Board approved Ordinance No. 129, Amending Sections 7301, 7302 and 7303 of Chapter VII of the Cupertino Sanitary District Operations Code Relating to Sewer Service Charges. The new sewer service rates will take effect, beginning July 1, 2022.

B. The Board conducted a public hearing on Accepting Report On Rates And Charges and Collection On Tax Roll for Fiscal Year 2022-2023.

1. Manager Porter presented on the Report on Rates and Charges.

2. President Bosworth opened the public hearing at 7:23 p.m. There were no public comments.

3. President Bosworth closed the public hearing at 7:24 p.m.

4. The Board discussed the Report on Rates and Charges and Collection on Tax Roll for Fiscal Year 2022-2023.

5. On motion by Director Chen, seconded by Director Saadati, by a vote of 5-0-0, the Board approved Resolution No. 1338, Confirming Report on Rates and Charges for Services and Facilities Furnished by the District and Delinquent Rates and Charges for the Cupertino Sanitary District for the Fiscal Year 2022-2023.

6. On motion by Director Chen, seconded by Director Saadati, by a vote of 5-0-0, the Board approved Resolution No. 1339, Providing for the Collection of Rates and Charges for Services and Facilities Furnished by the District and Delinquent Rates and Charges for Fiscal Year 2022-2023.

5. CLOSED SESSION:

President Bosworth adjourned the regular meeting session and opened the closed session at 7:45 p.m. Manager Porter, and Deputy Manager Woodhouse were excused from the closed session.

A. Conference with legal counsel – Existing Litigation in accordance with government code section Paragraph (1) of Subdivision (d) of Section 54956.9, existing litigation. Name of Case: County Sanitation District 2-3, West Valley Sanitation District, Cupertino Sanitary District, Burbank Sanitary District, and the City of Milpitas v. The City of San Jose, The City of Santa Clara, and Does 1 through 50 inclusive.

Board action: There was no reportable action.

President Bosworth adjourned the closed session at 7:52 p.m. and the regular meeting was called to order. District Manager Porter, and Deputy District Manager Woodhouse rejoined the regular meeting.

6. MINUTES & BILLS:

A. On a motion by Director Saadati, seconded by Director Chen, by a vote of 5-0-0, the minutes of Wednesday, June 1, 2022, were approved.

B. By consensus, the Minutes of Monday, May 18, 2022, are to be Noted & Filed.

C. The Board reviewed May payable warrants and financial statements. On a motion by Director Chen, seconded by Director Kwok, by a vote of 5-0-0, the financial statements and payment of bills were approved as written.

D. Board members will submit their June timesheets to Manager Porter.

7. CORRESPONDENCE:

A. The Board reviewed correspondence from Local Agency Formation Commission (LAFCO) Of Santa Clara County regarding LAFCO Budget for Fiscal Year 2022-2023. The notice is to be Noted & Filed.

B. The Board reviewed emailed correspondence from Nick Bailey regarding Cupertino Tertiary Water. It is to be Noted & Filed. Manager Porter will respond to Mr. Bailey.

8. MEETINGS:

A. The teleconference meeting of The San Jose/Santa Clara Treatment Plant Technical Committee (TAC) to be held on Monday, July 11, 2022 has been canceled.

B. The teleconference meeting of The San Jose/Santa Clara Treatment Plant Advisory Committee (TPAC) to be held on Thursday, July 14, 2022 has been canceled.

C. Director Chen plans to attend the CSRMA-Board of Directors meeting to be held June 23, 2022, via teleconference.

9. REPORTS:

A. Manager Porter reported on the teleconference meeting of The San Jose/Santa Clara Treatment Plant Technical Advisory Committee (TAC) held on Monday, June 6, 2022.

B. President Bosworth reported on The Santa Clara County Special Districts Association meeting held on Monday, June 6, 2022, via Zoom.

C. Deputy Manager Woodhouse reported on the CASSE teleconference held on Thursday, June 8, 2022.

D. Director Kwok reported on the teleconference meeting of The San Jose/Santa Clara Treatment Plant Advisory Committee (TPAC) held Thursday, June 9, 2022.

10. UNFINISHED BUSINESS:

A. The Board reviewed the District Audit for Fiscal Year 2020-2021. On motion by Director Saadati, seconded by Director Doyle, by a vote of 5-0-0, the Board approved the Audit Report as written

B. The Board previously approved the Sunnyvale Flow Transfer Agreement. The Board will sign the agreement tomorrow.

C. Manager Porter reported on COVID-19 updates.

11. NEW BUSINESS:

A. The Board reviewed the Fiscal Year 2022-2023 Budget. On motion by Director Chen, seconded by Director Kwok, by a vote of 5-0-0, the Board approved the budget as written.

B. The Board reviewed CASA sponsored Bill AB 2247. On motion by Director Chen, seconded by Director Kwok, by a vote of 5-0-0, the Board approved support of Bill AB 2247. Staff is to submit a letter of support to Senate Environmental Quality Committee and Local Assembly Member.

12. STAFF REPORTS:

A. Manager Porter reported on the City of Cupertino Notice to Owner - De Anza Boulevard at McClellan Road.

B. Manager Porter reported on Current Development Projects.

C. Manager Porter reported on the Monthly Maintenance Report.

13. CALENDAR ITEMS:

A. The next regular District Board meeting is scheduled to be held on Wednesday, July 6, 2022.

14. ADJOURNMENT:

On a motion properly made and seconded, at 8:30 p.m. the meeting was adjourned.

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Secretary of the Sanitary Board

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Acting President of the Sanitary Board

Cupertino Sanitary District

Memo

Item 8A

To: **Board of Directors**

From: **Benjamin T. Porter, District Manager-Engineer**

Date: **August 3, 2022**

Re: **V&A Consulting Engineering - Flow Monitoring Services Report**

V&A Consulting Engineers (V&A) has completed sanitary sewer flow monitoring and rainfall monitoring with inflow and infiltration (I/I) analysis within the Cupertino Sanitation District (District) collection system. Flow and rainfall monitoring were performed over a period of over 10 weeks from December 10, 2021, to February 22, 2022. Open-channel flow monitoring was performed at 28 sites.

- These 28 sites were previously monitored by V&A in 2016.
- 23 of the 28 sites were previously monitored by V&A in 2012/13.

This year's flow monitoring served as an update for the flow data that is used to calibrate the hydraulic model, an assessment of the smoke testing effectiveness, and a baseline for further I/I reduction activities. There were three general purposes of this study.

1. Establish the baseline sanitary sewer flows at the flow monitoring sites
2. Establish the peak flow condition during the rainfall events and estimate available sewer capacity.
3. Quantify inflow/ infiltration (I/I) at the applicable flow monitoring sites and develop synthetic I/I hydrographs for a design storm event.

V&A - Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. Master Plan and Model Implementation: The District is currently having a hydraulic model designed and/or updated to determine the overall needs of the District relative to I/I. Flow monitoring results should be incorporated and the changes over the years understood.
2. Verify Interconnections and Overflows: understanding the interconnections and overflows can help with the hydraulic model, basin isolation and I/I analysis.

3. Capacity Analysis: Sites 16 and 21 surcharged during the study; flow levels for these sites were less than one foot above the pipe crown when surcharged. The District may want to analyze the capacity constraints in the updated hydraulic model.
4. Determine I/I Reduction Program: The District should examine its I/I reduction needs to determine their needs and goals for a future I/I reduction program.

District Staff Recommendations

1. District staff will follow the recommendations of the V&A flow monitoring report.
2. District staff will update the I/I Peak Flow Reduction Plan that was presented to the Board in a memorandum dated October 7, 2020.

Attachment:

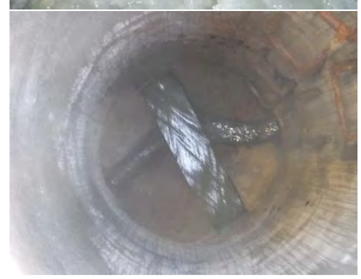
1. V&A Consulting Engineers - Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study 2021/2022

Item 8.A.
Attachment 1.

Cupertino Sanitary District

Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study 2021/2022





Prepared for:

Robert Woodhouse
Deputy District Manager
Mark Thomas
2833 Junction Ave. Suite 110
San Jose, CA 95134

Draft Report Date: 7/8/2022
Final Report Date:

Prepared by:

V&A consulting engineers

V&A Project No. 20-0045

Table of Contents

Tables

Figures

Photo Log

Abbreviations and Acronyms

Abbreviations/Acronyms	Definition
ADWF	Average Dry Weather Flow
AVG.	Average
CCTV	Closed-Circuit Television
CDEC	California Data Exchange Center
CIP	Capital Improvement Plan
CO	Carbon Monoxide
DIA.	Diameter
d/D	Depth/Diameter Ratio
FPS	Feet/Second
FT.	Feet
FM	Flow Monitor
GPD	Gallons per Day
GPM	Gallons per Minute
GWI	Groundwater Infiltration
H2S	Hydrogen Sulfide
IN.	Inch
I/I	Inflow and Infiltration
IDM	Inch-Diameter Mile
IDW	Inverse Distance Weighting
LEL	Lower Explosive Limit
MAX.	Maximum
MGD	Million Gallons per Day
MIN.	Minimum
NOAA	National Oceanic and Atmospheric Administration
N/A	Not applicable
PF	Peaking Factor
PS	Pump Station
PWS	Personal Weather Station
Q	Flow Rate
QAQC	Quality Assurance Quality Control
RDI	Rainfall-Dependent Infiltration
RG	Rain Gauge
SSO	Sanitary Sewer Overflow
V&A	V&A Consulting Engineers, Inc.
WEF	Water Environment Federation
WRCC	Western Regional Climate Center
WU	Weather Underground

Terms and Definitions

Term	Definition
Average dry weather flow (ADWF)	The average flow rate or pattern from days without noticeable inflow or infiltration response. ADWF usage patterns for weekdays and weekends differ and must be computed separately. ADWF is expressed as a numeric average and may include the influence of normal groundwater infiltration (not related to a rain event).
Basin	Sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. Also refers to the ground surface area near and enclosed by pipelines. A basin may refer to the entire collection system upstream from a flow meter or exclude separately monitored basins upstream.
Depth/diameter (*d/D*) ratio	Depth of water in a pipe as a fraction of the pipe's diameter. A measure of the fullness of the pipe used in the capacity analysis.
Design storm	A theoretical storm event of a given duration and intensity that aligns with historical frequency records of rainfall events. For example, a 10-year, 24-hour design storm is a storm event wherein the volume of rain that falls in a 24-hour period would historically occur once every 10 years. Design storm events are used to predict I/I response and are useful for modeling how a collection system will react to a given set of storm event scenarios.
Infiltration and inflow	**Infiltration and inflow (I/I)** rates are calculated by subtracting the ADWF flow curve from the instantaneous flow measurements taken during and after a storm event. Flow in excess of the baseline consists of inflow, rainfall-responsive infiltration, and rainfall-dependent infiltration. **Combined I/I** is the total sum in gallons of additional flow attributable to a storm event.
Infiltration, groundwater	**Groundwater infiltration (GWI)** is groundwater that enters the collection system through pipe defects. GWI depends on the depth of the groundwater table above the pipelines as well as the percentage of the system that is submerged. The variation of groundwater levels and subsequent groundwater infiltration rates are seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.
Infiltration, rainfall-dependent	**Rainfall-dependent infiltration (RDI)** is similar to groundwater infiltration but occurs as a result of storm water. The storm water percolates into the soil, submerges more of the pipe system, and enters through pipe defects. RDI is the slowest component of storm-related infiltration and inflow, beginning gradually and often lasting 24 hours or longer. The response time depends on the soil permeability and saturation levels.
Inflow	Inflow is defined as water discharged into the sewer system, including private sewer laterals, from direct connections such as downspouts, yard, and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins. Inflow creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Overflows are often attributable to high inflow rates.

Peak Wet Weather Flow	The highest daily flow during and immediately after a significant storm event. Includes sanitary flow, infiltration, and inflow.
Peaking factor (PF)	PF is the ratio of peak measured flow to average dry weather flow. This ratio expresses the degree of fluctuation in flow rate over the monitoring period and is used in the capacity analysis.
Surcharge	When the flow level is higher than the crown of the pipe, then the pipeline is said to be in a **surcharged** condition. The pipeline is surcharged when the *d/D* ratio is greater than 1.0.
Synthetic hydrograph	A set of algorithms has been developed to approximate the actual I/I hydrograph. The synthetic hydrograph is developed strictly using rainfall data and response parameters representing response time, recession coefficient and soil saturation.

Executive Summary

Scope and Purpose

V&A Consulting Engineers (V&A) has completed sanitary sewer flow monitoring and rainfall monitoring with inflow and infiltration (I/I) analysis within the Cupertino Sanitation District (District) collection system. Flow and rainfall monitoring were performed over a period of over 10 weeks from December 10, 2021, to February 22, 2022. Open-channel flow monitoring was performed at 28 sites.

These sites were previously monitored by V&A in 2016 (V&A Project Number 15-0305). 23 of these sites were previously monitored by V&A in 2012/13 (V&A Project Number 12-0139). This year's flow monitoring served as an update for the hydraulic model, an analysis of the smoke testing effectiveness, and a baseline for further I/I reduction activities. There were three general purposes of this study.

1. Establish the baseline sanitary sewer flows at the flow monitoring sites
2. Establish the peak flow condition during the rainfall events and estimate available sewer capacity.
3. Quantify inflow/ infiltration (I/I) at the applicable flow monitoring sites and develop synthetic I/I hydrographs for a design storm event.

Monitoring Sites

The flow monitoring site locations and rain gauge locations were selected and approved by Mark Thomas and the Cupertino Sanitary District and are listed in Table ES-1 and shown in Figure ES-1.

Table ES-1. List of Monitoring Sites

Monitoring Site	Manhole No.	Monitored Pipe	Measured Pipe Diameter (in)	Location
Site 1	L3-90	South Inlet	12	Wolfe Road north of Stevens Creek Boulevard
Site 2	L3-14	West Inlet	12	Stevens Creek Boulevard west of Vista Drive
Site 3A	T-139	South Inlet	15	Stelling Road at Stevens Creek Boulevard
Site 4A	CML-8	South Inlet	10	Florence Drive
Site 5	L1-46	South Inlet	10	Mary Avenue south of Lubec Street
Site 6	T-609	Southwest Inlet	10	Parking lot at 10040-10050 Bubb Road
Site 7	L1-54	West Inlet	8	Stevens Creek Boulevard west of Bubb Road
Site 9A	L2-256	West Inlet	6	Stevens Creek Boulevard at Camino Vista Drive
Site 9B	7099-3	West Inlet	6	Woodridge Court

Monitoring Site	Manhole No.	Monitored Pipe	Measured Pipe Diameter (in)	Location
Site 9C	5290-3	South Inlet	8	Foothill Boulevard north of Palm Avenue
Site 10	L2-228A	South Inlet	10	Foothill Boulevard at Alpine Drive
Site 11	L12-9	West Inlet	10	Creston Drive
Site 12[1]	L12-1	South Inlet	10[2]	10790 Peninsular Avenue, southeast of Barranca Drive
Site 14	T-239	South Inlet	10.5	Tantau Avenue
Site 15	T-695	West Inlet	8	Easement at north end of Festival Drive
Site 16	T-617	West Inlet	14	Festival Drive at November Drive
Site 18	L4-12	West Inlet	8	Prospect Road
Site 19	T-225	Southwest Inlet	10	Arroyo De Arguello
Site 20	T-420	South Inlet	8	Saratoga Sunnyvale Road at Gordon Court
Site 21	L4-84	Northeast **OUTLET**[3]	6.5	De Sanka Avenue
Site 22	L13-18	Southwest Inlet	8	Pierce Road east of Chalet Clotilde Drive
Site 24	L4-56	South Inlet	8	Bubb Road
Site 25	L10-5	West Inlet	8	Brandywine Drive north of Apollo Way
Site 26	L15-1	South Inlet	8	Woodmont Drive
Site 27	T-701	East Inlet	7.75[4]	Prospect Road at Covina Court
Site 28	HUD3-27	West Inlet	15	Corner of Noranda Drive and Noranda Court
Site 29	4510-1	West Inlet	8	Lucille Avenue west of Villa de Anza Avenue
Site 30	T-182	South Inlet	18	Walkway south of 10631 Becker Lane
Flume	N/A	West Inlet	18-inch Parshall Flume	E Homestead Road & Swallow Dr

[1] Moved 1 manhole upstream from 2016 (corner of Peninsular Avenue and Barranca Drive) due to possibility of parked car. 2021 was same location as 2013.
[2] There was a plastic liner of inside diameter 10-inch, within the host clay pipe of 13.5-inch diameter.
[3] Site 21 was first installed in the southwest 8-inch inlet, similar to previous years. It was realized there is a flow split immediately upstream and the inlet often has stagnant flow. The sensor was changed to the northeast 6.5-inch outlet on December 29, 2021 and alternatives were explored but not found. The smaller outlet diameter collected rags and debris. V&A visited multiple times for maintenance, but overall the data quality was poor.
[4] Plastic pipes tend to have non-integer inside-diameter, even though the nominal diameter is 8-inches. Measuring the inside diameter accurately is important for flow calculations.

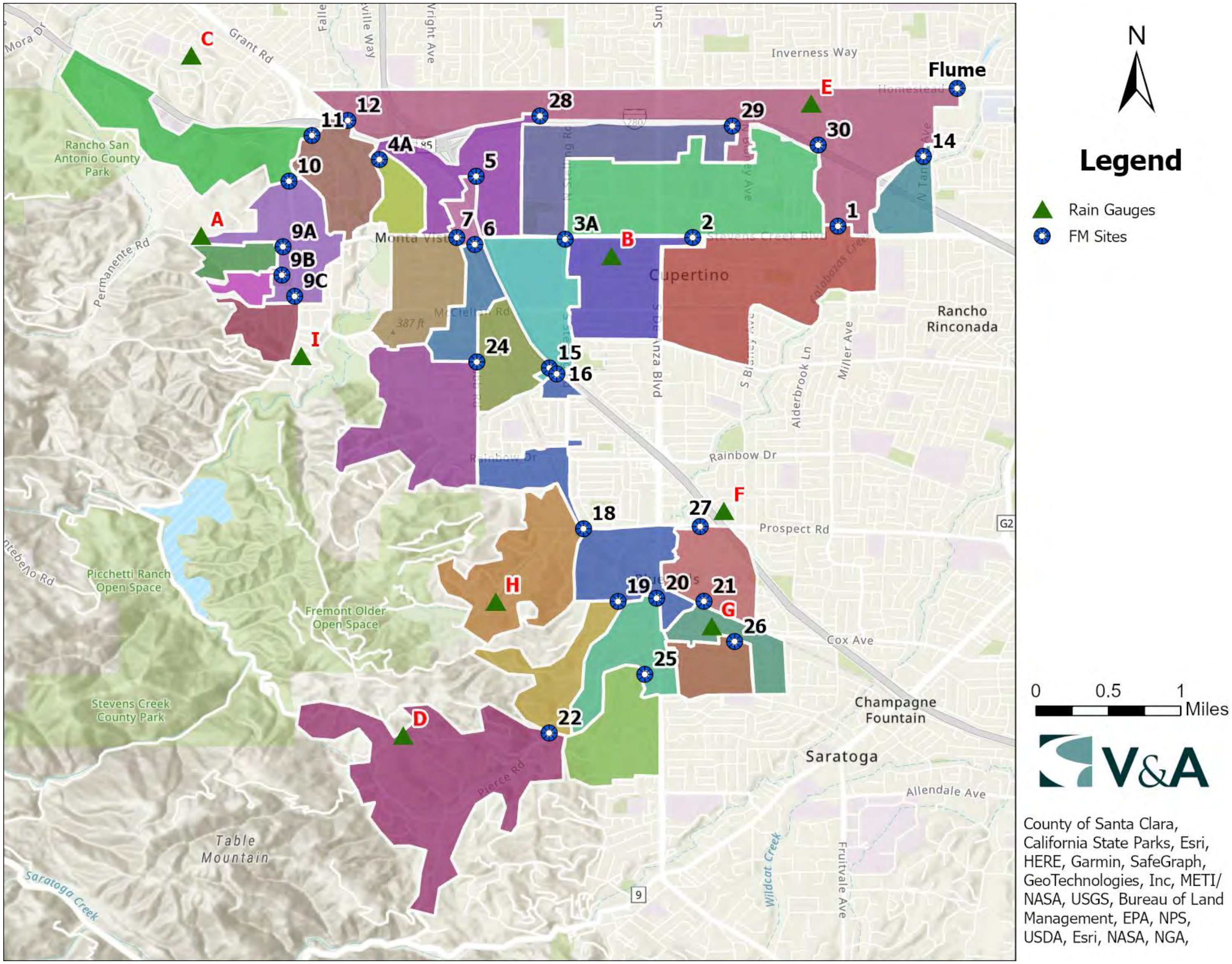


Figure ES-1. Map of Flow Monitoring Sites, Rain Gauges, and Flow Basins

Rainfall Monitoring

The cumulative precipitation over the flow monitoring period was **24% higher** than the historical average. Two rainfall events were defined as shown in Figure ES-2, noting the following items:

- Event 1 from December 12, 2021 to December 16, 2021 was classified as a 2- to 5-year, 1-day rainfall event.
- Event 2 from December 21, 2021 to December 30, 2021 was classified as a less than 1-year rainfall event.
- The precipitation was the greatest in the south and the hills, with less precipitation falling to the north.

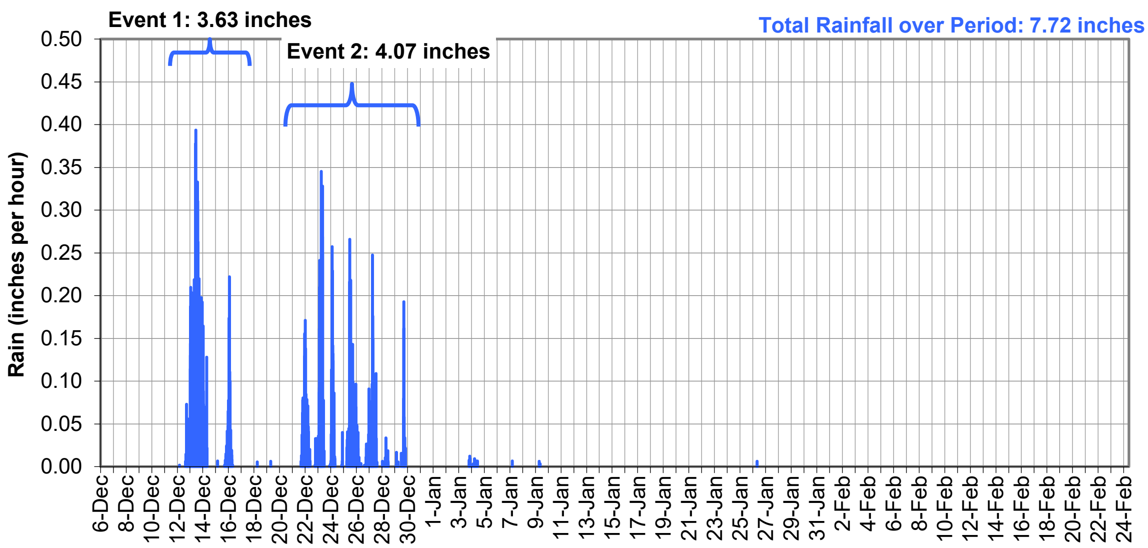


Figure ES-2. Rainfall Over Monitoring Period – Triangulated to District Centroid

The following items are noted relevant to the storm events used for I/I analyses:

- Events 1 and 2 elicited I/I responses in this study.
- The rain occurred earlier than typical and during holidays; then the rest of the season was dry. The sites were installed as fast as possible. 10 sites were prioritized where smoke testing and rehab work from smoke testing results have been performed. These 10 sites were installed on December 10, 2021, and caught Event 1. The remaining 18 sites were installed between December 16 and 20, 2021.
- Synthetic Hydrographs were used to model the I/I response so that all sites could be compared with each other and the 2016 I/I response.

Site Flow Monitoring and Capacity Results

Peak measured flows and the hydraulic grade line data (flow depths) are essential to understanding the capacity limitations of a collection system. The following capacity analyses terms are defined as follows:

- Peaking Factor: Peaking factor is defined as the peak measured flow divided by the average dry weather flow (ADWF). Peaking factors are influenced by many factors including size and topography of the tributary area, flow attenuation, flow restrictions, characteristics of I/I entering the collection system, and hydraulic features such as pump stations.

- For this report, peaking factors are reported and PF >5 are highlighted in ***RED***[5]; however, the District should refer to District standards when evaluating peaking factors. Peaking factor data should be used at the discretion of the District Engineer.
- **d/D Ratio**: The d/D ratio is the peak measured depth of flow (d) divided by the pipe diameter (D). The d/D ratio for each site was computed based on the maximum depth of flow for the study. Standards for d/D ratio vary from agency to agency, but typically range between d/D ≤ 0.5 and d/D ≤ 0.75
- For this report, d/D ratios > 0.75 are highlighted in ***RED***; however, the District should refer to District standards when evaluating d/D ratios, to be used at the discretion of the District Engineer.

Table ES-2 summarizes the peak recorded flows, levels, d/D ratios, and peaking factors per site during the flow monitoring period. Capacity analysis data is presented on a site-by-site basis and represents the hydraulic conditions only at the site locations; hydraulic conditions in other areas of the collection system will differ.

Table ES-2. Capacity Analysis Summary

Monitoring Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D (IN)*	Peak Measured Depth	*Max d/D Ratio*	Surcharge above pipe crown (FT)
Site 1	0.310	0.57	1.8	12	5.78	0.48	-
Site 2	0.137	0.46	3.3	12	2.89	0.24	-
Site 3A	0.629	1.80	2.9	15	14.88	0.99	-
Site 4A	0.152	0.42	2.8	10	4.98	0.50	-
Site 5	0.304	0.64	2.1	10	3.69	0.37	-
Site 6	0.123	0.27	2.2	10	4.02	0.40	-
Site 7	0.093	0.24	2.6	8	2.47	0.31	-
Site 9A	0.003	0.08	24.1	6	1.53	0.25	-
Site 9B	0.002	0.02	10.2	6	1.60	0.27	-
Site 9C	0.042	0.09	2.1	8	1.80	0.22	-
Site 10	0.263	0.71	2.7	10	4.53	0.45	-
Site 11	0.336	0.73	2.2	10	4.02	0.40	-
Site 12	0.138	0.41	3.0	10	5.94	0.59	-
Site 14	0.090	0.29	3.2	10.5	4.15	0.40	-
Site 15	0.057	0.21	3.2	8	2.62	0.34	-
Site 16	0.572	1.61	2.8	14	17.79	1.27	0.32
Site 18	0.051	0.42	8.3	8	6.10	0.76	-
Site 19	0.078	0.43	5.5	10	5.67	0.57	-
Site 20	0.127	0.42	3.3	8	5.55	0.69	-

[5] WEF Manual of Practice FD-6 and ASCE Manual No. 62 suggests typical peaking factor ratios range between 3 and 4, with higher values possibly indicative of pronounced I/I flows.

Monitoring Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D* *(IN)*	Peak Measured Depth	*Max d/D Ratio*	Surcharge above pipe crown (FT)
Site 21	0.052	0.16 [6]	3.0	6.5	7.32	**1.13**	**0.07**
Site 22	0.029	0.31	**10.7**	8	4.58	0.57	-
Site 24	0.097	0.22	2.3	8	3.64	0.45	-
Site 25	0.042	0.27	**6.4**	8	3.77	0.47	-
Site 26	0.021	0.06	3.0	8	1.56	0.19	-
Site 27	0.083	0.27	3.2	7.75	5.39	0.70	-
Site 28	0.836	1.46	1.7	15	6.92	0.46	-
Site 29	0.213	0.47	2.2	8	5.29	0.66	-
Site 30	0.938	1.99	2.1	18	11.94	0.66	-
Flume	3.583	7.13	2.0	n/a [7]	17.84	n/a[8]	-

The following capacity analysis results are noted:

- Peaking Factors:
  - Sites 9A, 9B, 18, 19, 22 and 25 all had peaking factors greater than 6. Site 9A had the largest peaking factor of all sites at 24.1; however, this value may be partially skewed due to the low AWDWF, like Site 9B.
- d/D Ratio:
  - Sites 16 and 21 surcharged during the study; flow levels for these sites were less than one foot above the pipe crown when surcharged. Site 3A nearly reached a surcharged condition (less than 0.2 inch) during the study.

Figure ES-3 shows a schematic diagram of the peak measured flows with peak flow levels.

[6] Site 21 was first installed in the southwest 8-inch inlet, similar to previous years. It was realized there is a flow split immediately upstream and the inlet often has stagnant flow. The sensor was changed to the northeast 6.5-inch outlet on December 29, 2021. The peak flows and depth are from post December 29, 2021. However, there were no rain events after December 29, 2021 to the end of the flow monitoring period. One would expect the peak flows and depth were probably higher during rain event 1 and 2.
[7] Homestead Flume is an 18-inch Parshall Flume
[8] The maximum rated head for an 18-inch Parshall Flume is 30 inches, so d/max d = 0.59 for this flow monitoring period.

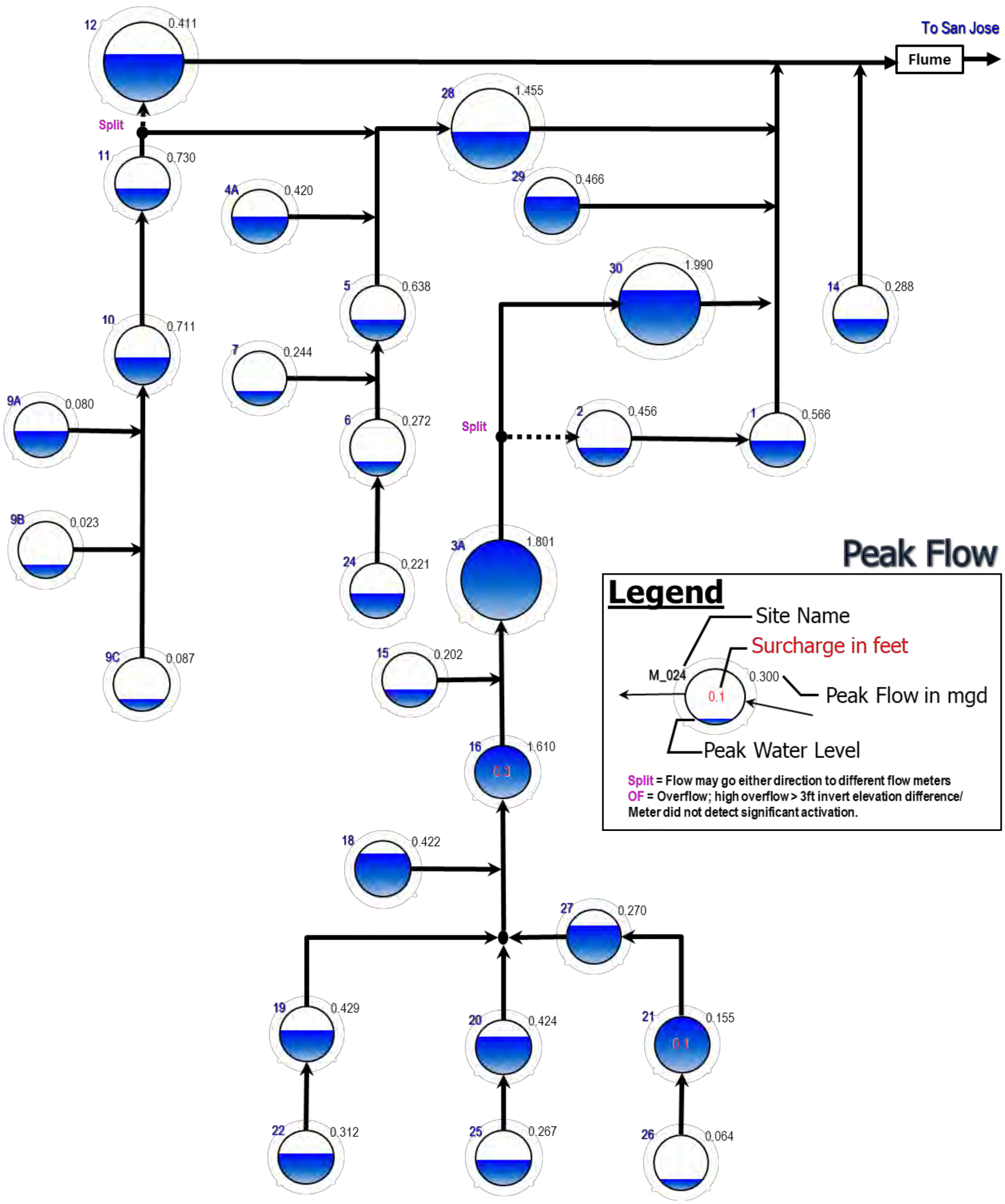


Figure ES-3. Peak Measured Flow (Flow Schematic)

Infiltration and Inflow Analysis

Flow monitoring basins are localized areas of a sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. The basin refers to the ground surface area near and enclosed by the pipelines. A basin may refer to the entire collection system upstream from a flow meter or may exclude separately monitored basins upstream. I/I analysis in this report will be conducted on a basin-by-basin basis. For this study subtraction of flows was required to isolate the drainage areas of some flow monitoring basins. The flow monitoring basins and basin isolation equations used to define the limits of the basin boundaries are listed in Table ES-3.

Table ES-3. Basin Flow Isolation Summary

Isolated Basin	Flow Isolation Calculation	Area (Acres)	Pipe Length (IDM)
Basin 1	$= Q_{1} - Q_{2}$	464	128.6
Basin 2	$= Q_{2}$	228	53.6
Basin 3A	$= Q_{3A} - Q_{15} - Q_{16}$	199	35.9
Basin 4A	$= Q_{4}$	76	21.5
Basin 5	$= Q_{5} - Q_{6} - Q_{7}$	37	14.3
Basin 6	$= Q_{6} - Q_{24}$	101	17.5
Basin 7	$= Q_{7}$	185	34.9
Basin 9A	$= Q_{9A}$	59	17.8
Basin 9B	$= Q_{9B}$	37	9.2
Basin 9C	$= Q_{9C}$	86	16.5
Basin 10	$= Q_{10} - Q_{9A} - Q_{9B} - Q_{9C}$	200	53.7
Basin 11	$= Q_{11} - Q_{10}$	314	37.4
Basin 12	$= Q_{12}$	165	37.5
Basin 14	$= Q_{14}$	94	11.7
Basin 15	$= Q_{15}$	128	30.2
Basin 16	$= Q_{16} - Q_{18} - Q_{19} - Q_{20} - Q_{21} - Q_{27}$	294	106.6
Basin 18	$= Q_{18}$	293	41.9
Basin 19	$= Q_{19} - Q_{22}$	153	22.8
Basin 20	$= Q_{20} - Q_{25}$	164	29.4
Basin 21	$= Q_{21} - Q_{26}$	104	17.3
Basin 22	$= Q_{22}$	587	62.3
Basin 24	$= Q_{24}$	339	68.4
Basin 25	$= Q_{25}$	195	39.4
Basin 26	$= Q_{26}$	101	21.5
Basin 27	$= Q_{27} - Q_{21}$	162	34.5
Basin 28	$= Q_{28} - Q_{11} - Q_{4A} - Q_{5}$	232	55.7
Basin 29	$= Q_{29}$	260	48.6
Basin 30	$= Q_{30} - Q_{3A}$	502	122.6
Flume	$=Q_{flume} - Q_{1} - Q_{12} - Q_{14} - Q_{28} - Q_{29} - Q_{30}$	806	199.2

Event 1 was the highest classified and most intensive short-term rainfall event, however, V&A only had time to install flow meters for the prioritized basins (Basins 4A, 9A, 9B, 9C, 18, 19 ,20, 22, 25, and 27). Therefore, the I/I analysis will be presented based on both rain events respectively (See Table ES-4 and Table ES-5). The "Top 3" basins for each category have been shaded in ***RED***. Please refer to the I/I Methods section for more information on inflow and infiltration analysis methods and ranking methods.

Table ES-4. I/I Analysis Summary (Rain Event 1)

Monitoring Basin	ADWF (mgd)	Peak Inflow Rate (mgd)	RDI Rate (mgd)	Combined I/I (gallons)	Overall Inflow Rank	Overall RDI Rank	Combined I/I Rank	Evidence of high GWI?
Basin 4A	0.152	0.244	0.011	101730	**2**	**3**	**1**	
Basin 9A	0.003	0.074	Negl.	14865	**3**	8	6	
Basin 9B	0.002	0.011	Negl.	Negl.	9	8	9	
Basin 9C	0.042	0.042	0.008	38697	6	4	5	**Yes**
Basin 18	0.051	0.359	0.014	203663	**1**	5	**3**	
Basin 19	0.049	0.006	Negl.	Negl.	10	8	9	
Basin 20	0.085	0.076	0.024	70773	7	**1**	7	
Basin 22	0.029	0.268	0.04	345364	5	**2**	**2**	
Basin 25	0.042	0.172	0.01	141063	4	6	4	
Site 27 (Basin 27+21+26)	0.083	0.149	0.001	42118	8	7	8	
Flume	N/A	2.661	0.492	4,033,892	N/A	N/A	N/A	

Table ES-5. I/I Analysis Summary (Rain Event 2)

Monitoring Basin	ADWF (mgd)	Peak Inflow Rate (mgd)	RDI Rate (mgd)	Combined I/I (gallons)	Overall Inflow Rank	Overall RDI Rank	Combined I/I Rank	Evidence of high GWI?
Basin 1	0.173	Negl.	0.018	119,849	24	14	20	
Basin 2	0.137	0.287	0.004	112,556	8	19	14	
Basin 3A	0.000	Negl.	Negl.	Negl.	24	21	25	
Basin 4A	0.152	0.302	0.005	141,727	1	15	10	
Basin 5	0.088	0.104	Negl.	190,903	3	21	2	
Basin 6	0.026	0.004	0.01	7,862	22	8	23	
Basin 7	0.093	0.055	Negl.	17,598	20	21	22	
Basin 9A	0.003	0.018	0.002	10,497	13	13	17	
Basin 9B	0.002	0.01	Negl.	5,364	14	21	19	
Basin 9C	0.042	0.034	0.002	16,563	18	17	21	Yes
Basin 10	0.216	0.317	0.031	456,883	4	9	6	
Basin 11	0.073	Negl.	0.036	101,109	24	3 (tie)	12	
Basin 12	0.138	0.214	0.048	521,867	7	2	1	
Basin 14	0.09	0.116	0.004	30,947	4	11	15	
Basin 15	0.057	0.125	0.024	301,640	10	5	3	
Basin 16	0.233	0.02	0.005	288,863	23	20	11	
Basin 18	0.051	0.193	Negl.	100,874	9	21	16	
Basin 19	0.049	0.163	0.039	336,132	2	1	4	
Basin 20	0.085	0.069	0.025	260,821	17	6	7	
Basin 21	0.039	Not avail.	Not avail.	Not avail.	Not avail.	Not avail.	Not avail.	Yes
Basin 22	0.029	0.16	0.029	358,892	12	7	9	
Basin 24	0.097	0.114	0.012	168,311	19	12	12	
Basin 25	0.042	0.186	0.03	317,640	6	3 (tie)	5	
Basin 26	0.021	0.021	0.001	Negl.	21	18	25	
Basin 27 + Basin 21	0.062	0.153	0.006	97,522	11	16	18	
Basin 28	0.043	Negl.	Negl.	Negl.	24	21	25	
Basin 29	0.213	0.122	Negl.	Negl.	15	21	25	
Basin 30	0.309	Negl.	Negl.	Negl.	25	21	25	
Flume	1.059	0.486	0.061	1,276,902	16	10	8	

The following inflow/infiltration analysis results are noted:

- **Rain Event 1**:
  - **Inflow:** Basins 18, 4A, and 9A ranked top 3 highest for normalized inflow contribution amongst the 10 monitored priority basins.
  - **Rainfall-Dependent Infiltration:** Basins 20, 22, and 4A ranked top 3 highest for normalized RDI contribution amongst the 10 monitored priority basins.
  - **Combined I/I:** Basins 4A, 22 and 18 ranked top 3 highest for normalized combined I/I inflow contribution amongst the 10 monitored priority basins.
- **Rain Event 2**:
  - **Inflow:** Basins 4A, 19 and 5 ranked top 3 highest for normalized inflow contribution amongst all 28 monitored basins and basin flume.
  - **Rainfall-Dependent Infiltration:** Basins 19, 12, 11 and 25 ranked top 3 highest for normalized RDI contribution
  - **Combined I/I:** Basins 12, 5 and 15 ranked top 3 highest for normalized combined I/I inflow contribution
  - **Groundwater Infiltration**: Basins 9C and 21 showed evidence of GWI rates that were above the WEF typical low-to-average ratio.

Figure ES-4 to Figure ES-10 illustrate temperature maps that summary of the I/I results.

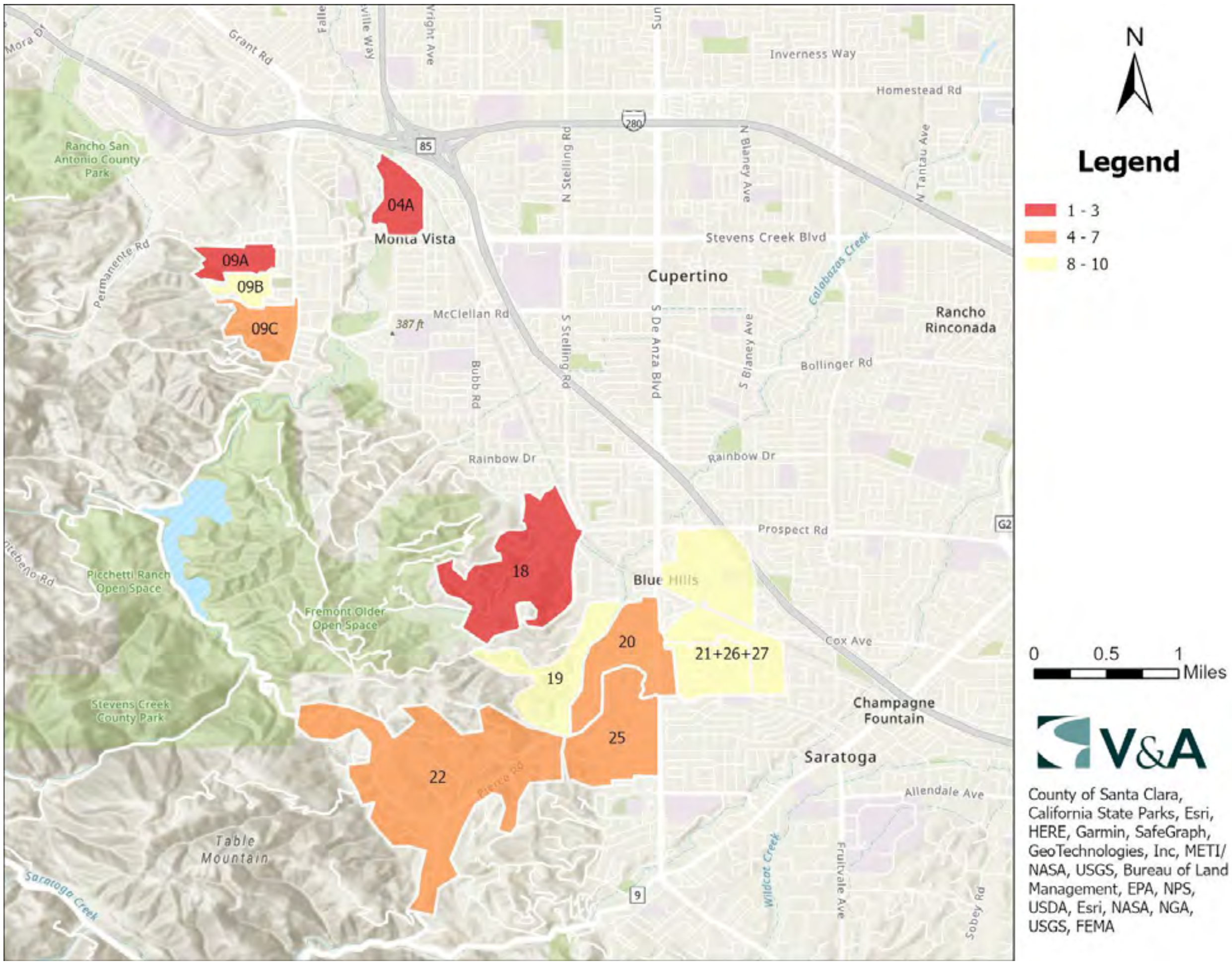


Figure ES-4. Temperature Map: Inflow Final Basin Rankings Based on Rain Event 1

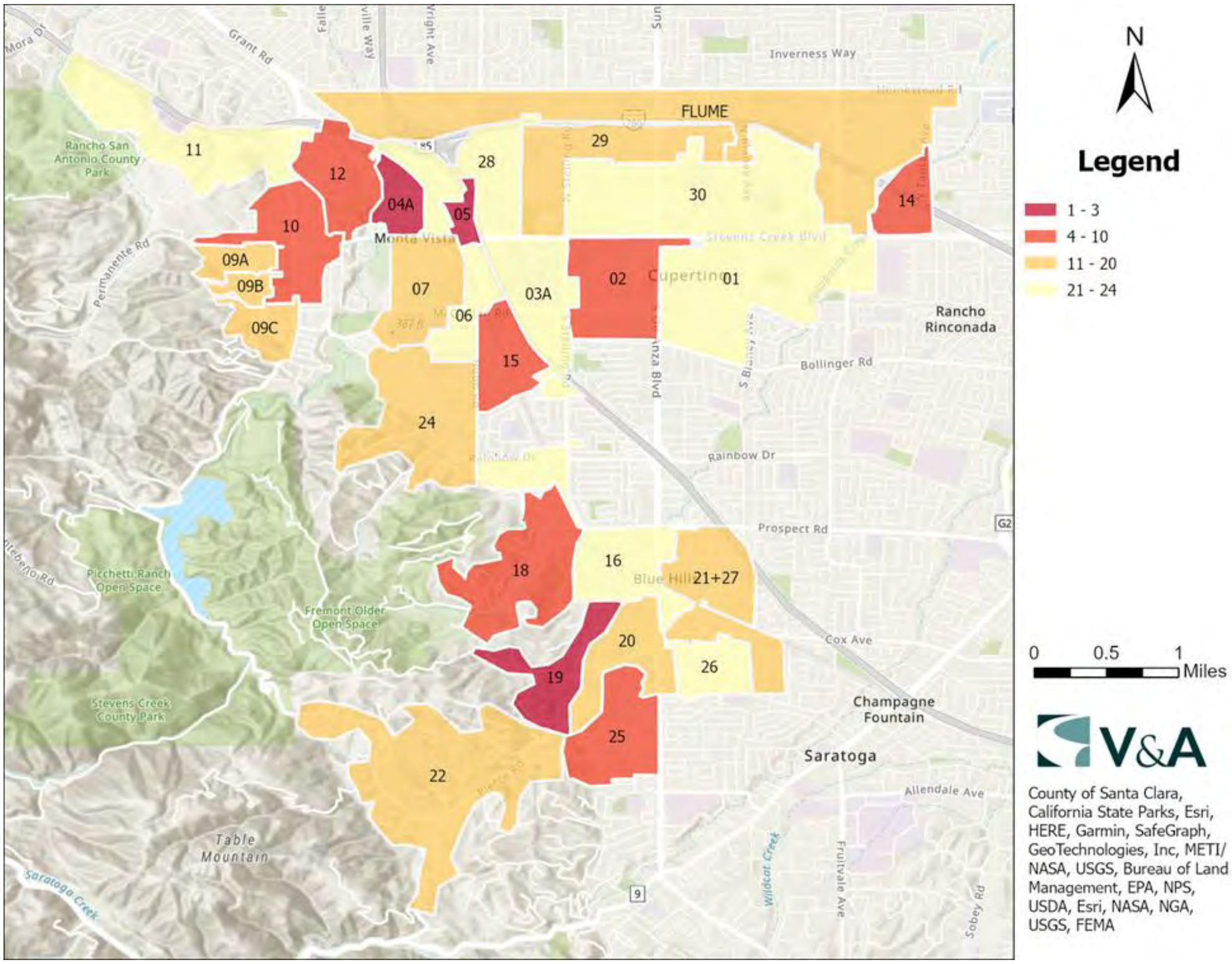


Figure ES-5. Temperature Map: Inflow Final Basin Rankings Based on Rain Event 2

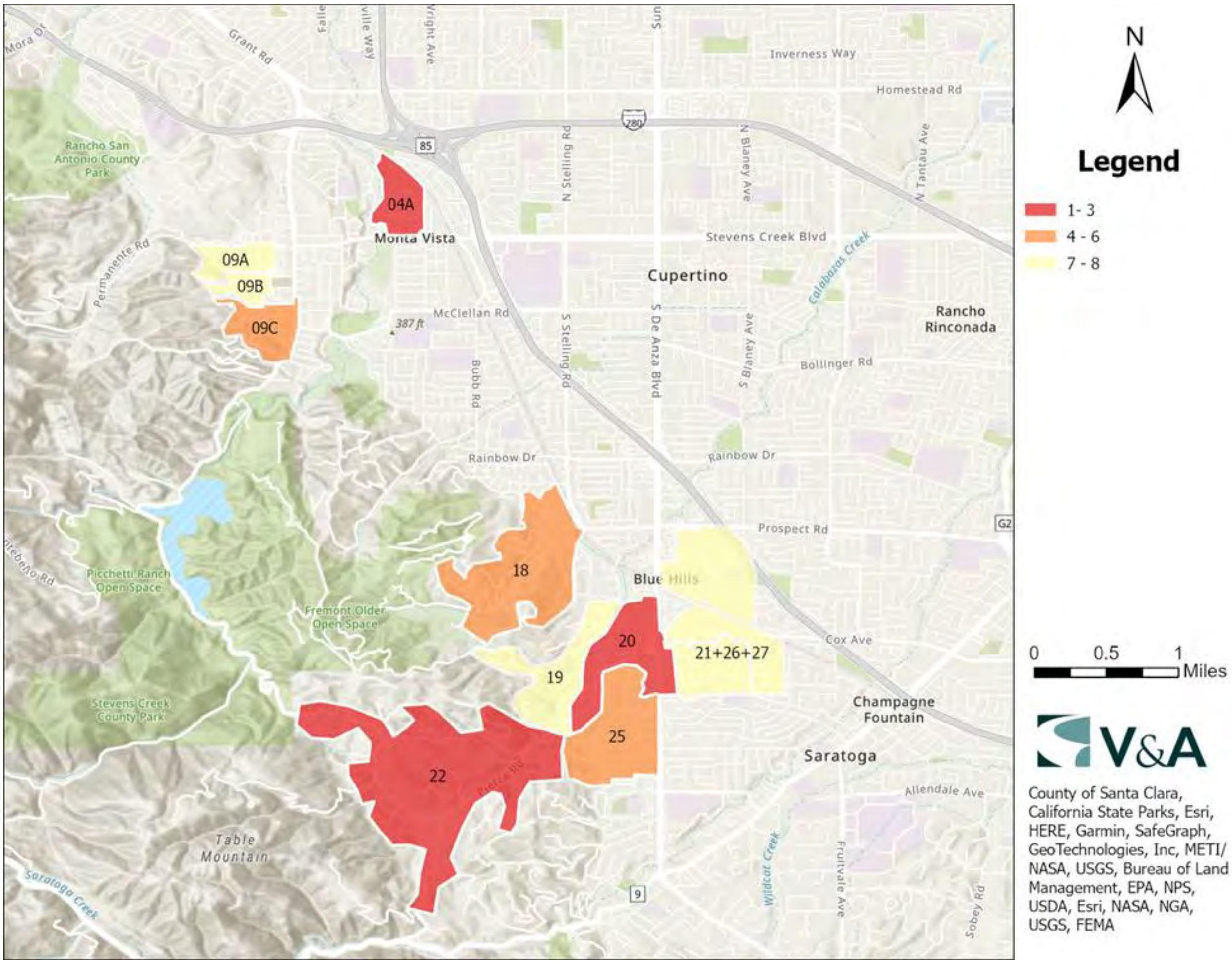


Figure ES-6. Temperature Map: RDI Final Basin Rankings Based on Rain Event 1

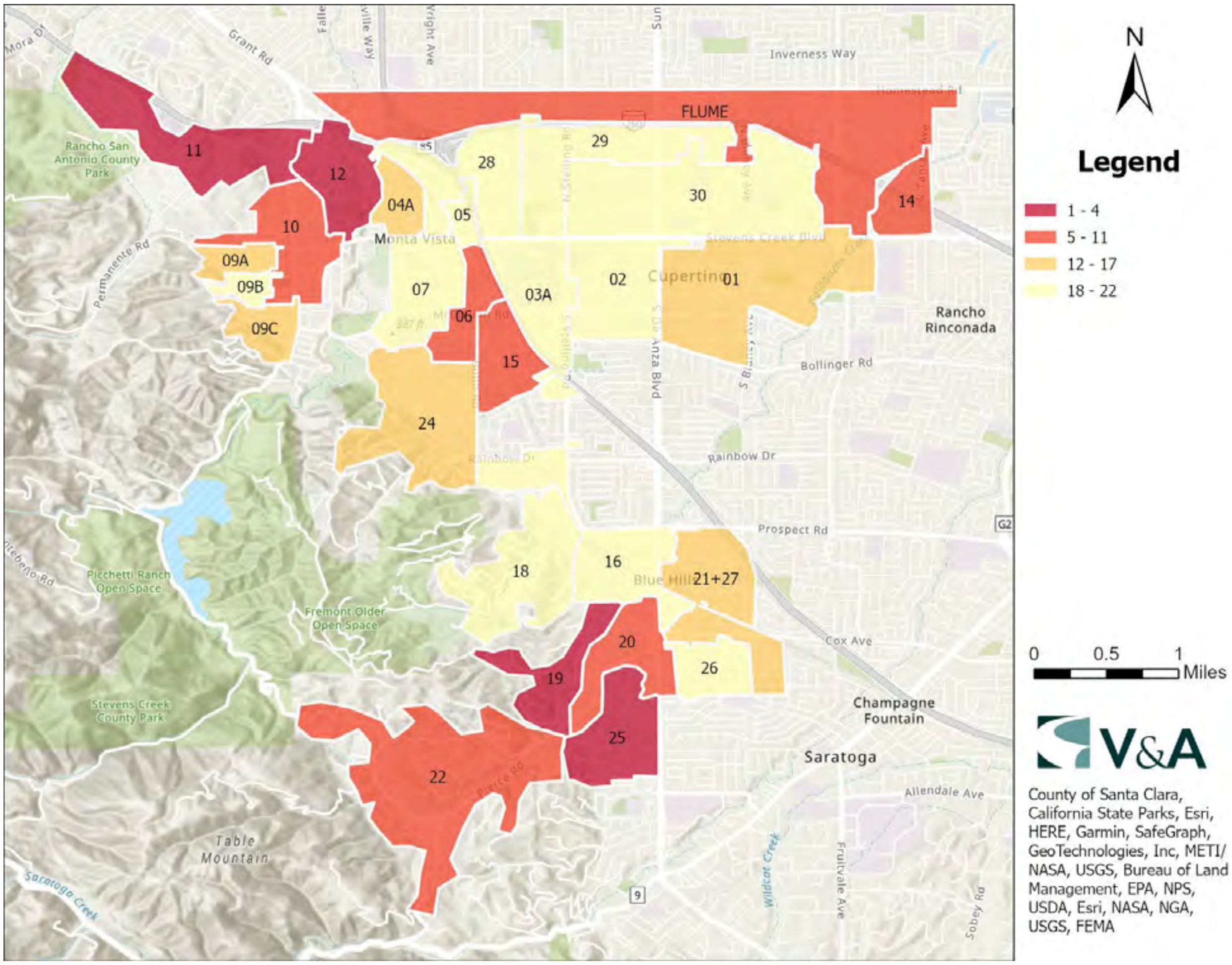


Figure ES-7. Temperature Map: RDI Final Basin Rankings Based on Rain Event 2

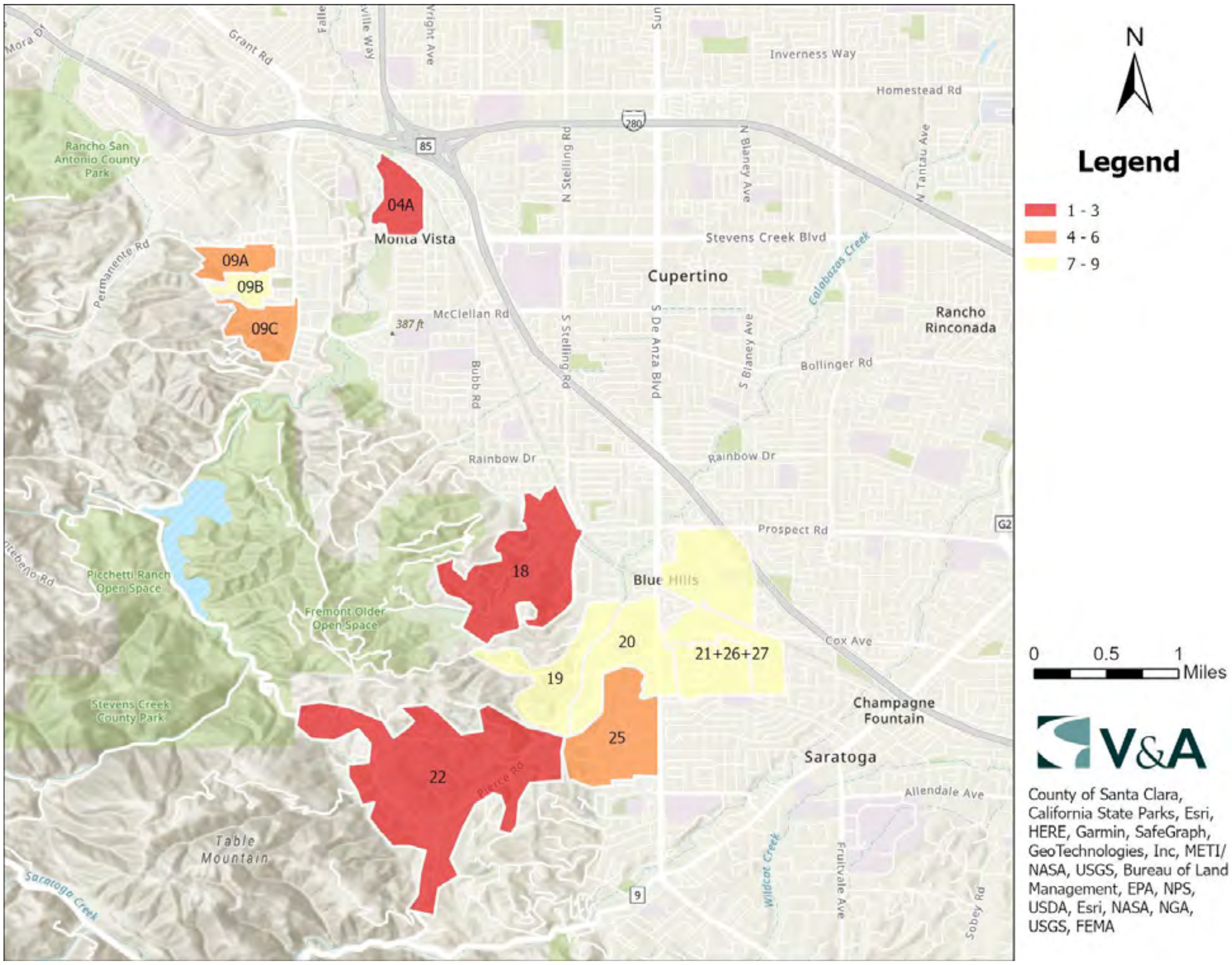


Figure ES-8. Temperature Map: Combined I/I Final Basin Rankings Based on Rain Event 1

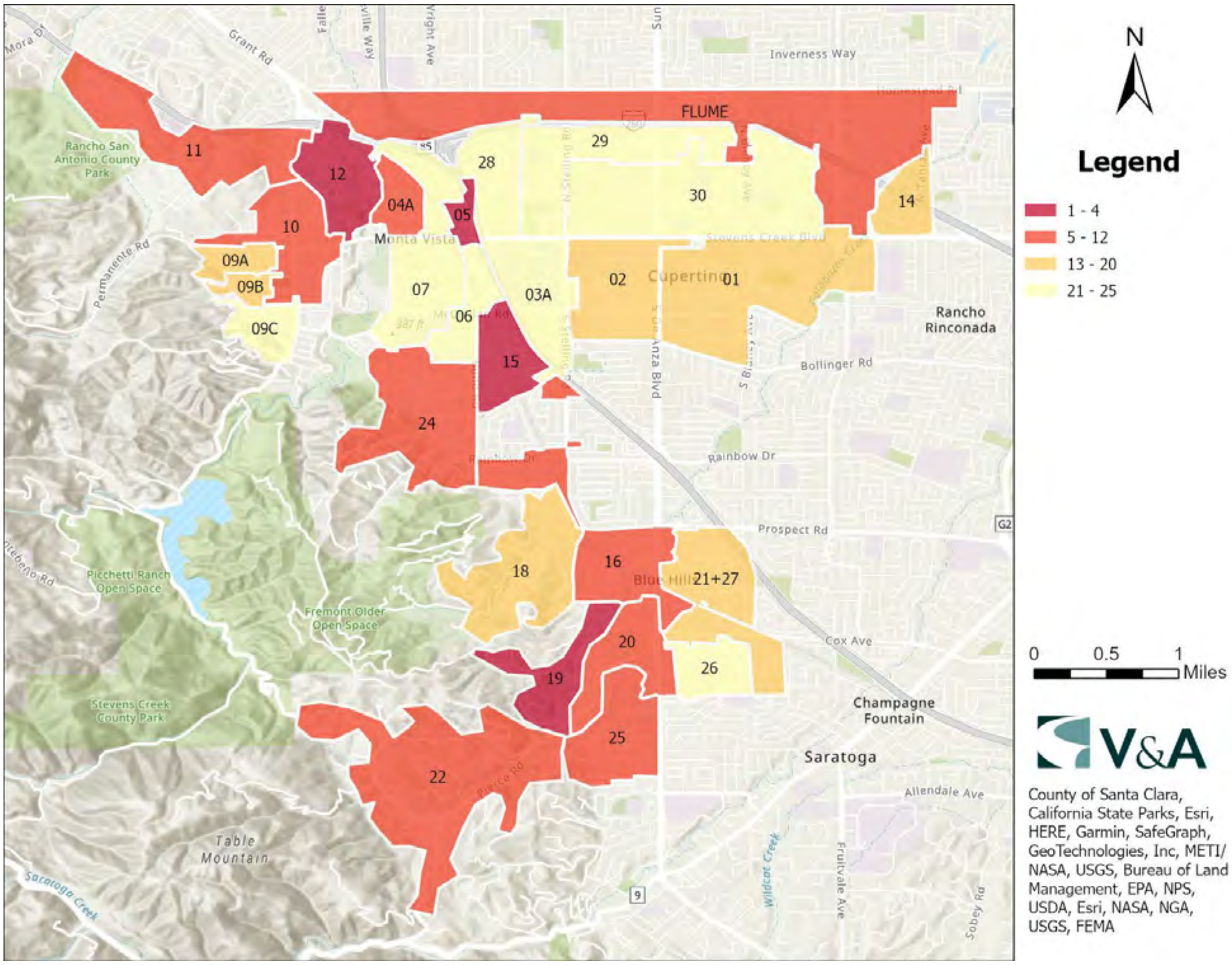


Figure ES-9. Temperature Map: Combined I/I Final Basin Rankings Based on Rain Event 2

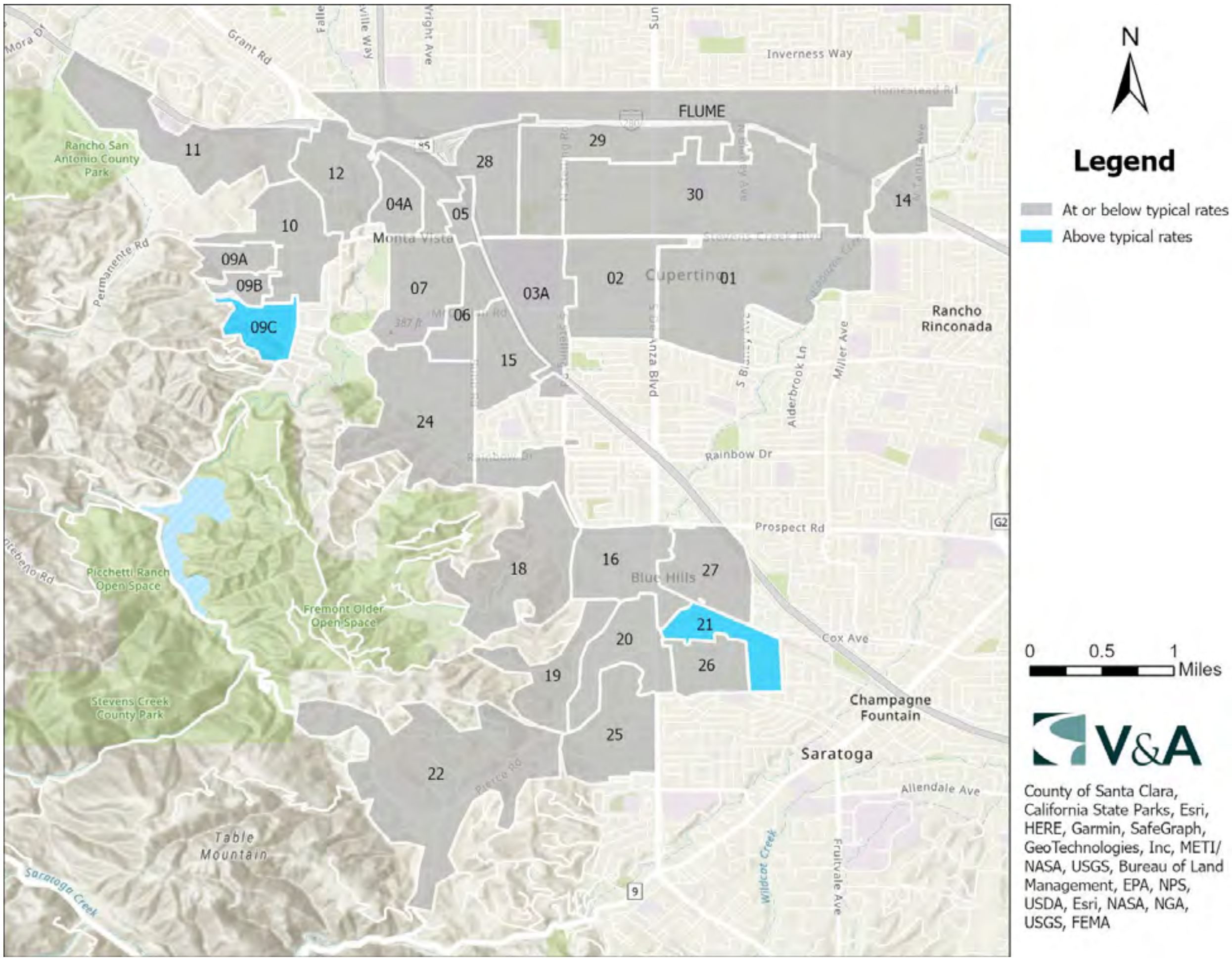


Figure ES-10. Temperature Map: GWI Final Basin Rankings

Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Master Plan and Model Implementation**: The District is currently having a hydraulic model designed and/or updated to determine the overall needs of the District relative to I/I. Flow monitoring results should be incorporated and the changes over the years understood.
2. **Verify Interconnections and Overflows**: understanding the interconnections and overflows can help with the hydraulic model, basin isolation and I/I analysis.
3. **Capacity Analysis**: Sites 16 and 21 surcharged during the study; flow levels for these sites were less than one foot above the pipe crown when surcharged. The District may want to analyze the capacity constraints in the updated hydraulic model.
4. **Determine I/I Reduction Program**: The District should examine its I/I reduction needs to determine their needs and goals for a future I/I reduction program.

   Since peak flows are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest normalized inflow occurs in Basins 4A, 19, and 5. Basins 4A and 19 have already been smoke tested. Night-time I/I reconnaissance may be attempted. Night-time reconnaissance work occurs between 12am to 4am after a rain event to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution. CCTV systematic review and analysis can also be attempted.

1 Introduction

1.1 Scope and Purpose

V&A Consulting Engineers (V&A) has completed sanitary sewer flow monitoring and rainfall monitoring with I/I analysis within the Cupertino Sanitation District (District) collection system. Flow and rainfall monitoring were performed over a period of over 10 weeks from December 10, 2021, to February 22, 2022. Open-channel flow monitoring was performed at 28 sites.

The sites were previously monitored by V&A in 2016 (V&A Project Number 15-0305). 23 of these sites were previously monitored by V&A in 2012/13 (V&A Project Number 12-0139). This year's flow monitoring served as an update for the hydraulic model, an analysis of the smoke testing effectiveness, and a baseline for the further I/I reduction activities. There were three general purposes of this study.

1. Establish the baseline sanitary sewer flows at the flow monitoring sites
2. Establish the peak flow condition during the rainfall events and estimate available sewer capacity.
3. Quantify inflow/ infiltration (I/I) at the applicable flow monitoring sites and develop synthetic I/I hydrographs for a design storm event.

1.2 Flow Monitoring Sites

Flow monitoring sites are defined as the manholes where flow monitors are secured and the pipelines in which flow sensors are placed. Capacity analysis and flow rate information is presented on a site-by-site basis.

The flow monitoring sites were selected and approved by Mark Thomas and the Cupertino Sanitary District. The flow monitoring site locations were similar to the sites monitored in 2016 by V&A[9]. Information regarding the flow monitoring locations is listed in Table 1-1 and illustrated in Figure-1-1. Detailed descriptions of the individual flow monitoring sites, including photographs, are included in Appendix A.

Table 1-1. List of Monitoring Locations

Monitoring Site	Manhole No.	Monitored Pipe	Measured Pipe Diameter (in)	Location
Site 1	L3-90	South Inlet	12	Wolfe Road north of Stevens Creek Boulevard
Site 2	L3-14	West Inlet	12	Stevens Creek Boulevard west of Vista Drive
Site 3A	T-139	South Inlet	15	Stelling Road at Stevens Creek Boulevard
Site 4A	CML-8	South Inlet	10	Florence Drive
Site 5	L1-46	South Inlet	10	Mary Avenue south of Lubec Street
Site 6	T-609	Southwest Inlet	10	Parking lot at 10040-10050 Bubb Road

[9] V&A project no. 15-0305 "Cupertino Sanitary District Sewer FM and I/I Study" submitted September 2016.

Monitoring Site	Manhole No.	Monitored Pipe	Measured Pipe Diameter (in)	Location
Site 7	L1-54	West Inlet	8	Stevens Creek Boulevard west of Bubb Road
Site 9A	L2-256	West Inlet	6	Stevens Creek Boulevard at Camino Vista Drive
Site 9B	7099-3	West Inlet	6	Woodridge Court
Site 9C	5290-3	South Inlet	8	Foothill Boulevard north of Palm Avenue
Site 10	L2-228A	South Inlet	10	Foothill Boulevard at Alpine Drive
Site 11	L12-9	West Inlet	10	Creston Drive
Site 12[10]	L12-1	South Inlet	10[11]	10790 Peninsular Avenue, southeast of Barranca Drive
Site 14	T-239	South Inlet	10.5	Tantau Avenue
Site 15	T-695	West Inlet	8	Easement at north end of Festival Drive
Site 16	T-617	West Inlet	14	Festival Drive at November Drive
Site 18	L4-12	West Inlet	8	Prospect Road
Site 19	T-225	Southwest Inlet	10	Arroyo De Arguello
Site 20	T-420	South Inlet	8	Saratoga Sunnyvale Road at Gordon Court
Site 21	L4-84	Northeast **OUTLET**[12]	6.5	De Sanka Avenue
Site 22	L13-18	Southwest Inlet	8	Pierce Road east of Chalet Clotilde Drive
Site 24	L4-56	South Inlet	8	Bubb Road
Site 25	L10-5	West Inlet	8	Brandywine Drive north of Apollo Way
Site 26	L15-1	South Inlet	8	Woodmont Drive
Site 27	T-701	East Inlet	7.75[13]	Prospect Road at Covina Court
Site 28	HUD3-27	West Inlet	15	Corner of Noranda Drive and Noranda Court
Site 29	4510-1	West Inlet	8	Lucille Avenue west of Villa de Anza Avenue
Site 30	T-182	South Inlet	18	Walkway south of 10631 Becker Lane
Flume	n/a	West Inlet	18-inch Parshall Flume	E Homestead Road & Swallow Dr

[10] Moved 1 manhole upstream from 2016 (corner of Peninsular Avenue and Barranca Drive) due to possibility of parked car. 2021 was same location as 2013.
[11] There was a plastic liner of inside diameter 10-inch, within the host clay pipe of 13.5-inch diameter.
[12] Site 21 was first installed in the southwest 8-inch inlet, similar to previous years. It was realized there is a flow split immediately upstream and the inlet often has stagnant flow. The sensor was changed to the northeast 6.5-inch outlet on December 29, 2021 and alternatives were explored but not found. The smaller outlet diameter collected rags and debris. V&A visited multiple times for maintenance, but overall the data quality was poor.
[13] Plastic pipes tend to have non-integer inside-diameter, even though the nominal diameter is 8-inches. Measuring the inside diameter accurately is important for flow calculations.

1.3 Flow Monitoring Basins

Flow monitoring site data may include the flows of one or many drainage basins. Flow monitoring basins are localized areas of a sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. The basin refers to the ground surface area near and enclosed by the pipelines. A basin may refer to the entire collection system upstream from a flow meter or may exclude separately monitored basins upstream, requiring basin isolation (subtraction of upstream flows). The I/I analysis results will be presented on an isolated basin basis. The basins, basin attributes, and basin isolation equations are listed in Table 1-2. Rain gauge locations in relation to the drainage basins are also shown in Figure-1-1.

Table 1-2. Isolated Flow Monitoring Basin Characteristics

Isolated Basin	Flow Isolation Calculation	Area (Acres)	Inch-Diameter-Mile (IDM)
Basin 1	$= Q_1 – Q_2$	464	128.6
Basin 2 [14]	$= Q_2$	228	53.6
Basin 3A	$= Q_{3A} – Q_{15} – Q_{16}$	199	35.9
Basin 4A	$= Q_4$	76	21.5
Basin 5	$= Q_5 - Q_6 - Q_7$	37	14.3
Basin 6	$= Q_6 - Q_{24}$	101	17.5
Basin 7	$= Q_7$	185	34.9
Basin 9A	$= Q_{9A}$	59	17.8
Basin 9B	$= Q_{9B}$	37	9.2
Basin 9C	$= Q_{9C}$	86	16.5
Basin 10	$= Q_{10} - Q_{9A} - Q_{9B} - Q_{9C}$	200	53.7
Basin 11	$= Q_{11} - Q_{10}$	314	37.4
Basin 12[15]	$= Q_{12}$	165	37.5
Basin 14	$= Q_{14}$	94	11.7
Basin 15	$= Q_{15}$	128	30.2
Basin 16	$= Q_{16} - Q_{18} - Q_{19} - Q_{20} - Q_{21} - Q_{27}$	294	106.6
Basin 18	$= Q_{18}$	293	41.9
Basin 19	$= Q_{19} - Q_{22}$	153	22.8
Basin 20	$= Q_{20} - Q_{25}$	164	29.4
Basin 21	$= Q_{21} - Q_{26}$	104	17.3
Basin 22	$= Q_{22}$	587	62.3
Basin 24	$= Q_{24}$	339	68.4
Basin 25	$= Q_{25}$	195	39.4
Basin 26	$= Q_{26}$	101	21.5
Basin 27	$= Q_{27} - Q_{21}$	162	34.5
Basin 28 [10]	$= Q_{28} - Q_{11} - Q_{4A} - Q_5$	232	55.7
Basin 29[16]	$= Q_{29}$	260	48.6
Basin 30 [9]	$= Q_{30} - Q_{3A}$	502	122.6
Flume	$=Q_{flume} - Q_1 - Q_{12} - Q_{14} - Q_{28} - Q_{29} - Q_{30}$	806	199.2

[14] There is a flow split upstream of Basin 2 whereby Site 3A flows can flow to Site 2 in addition to Site 30. From the flow monitoring data it appears this flow split was not activated this season.

[15] In previous years and according to the GIS and as-builts, Site 11 flowed to Site 12. However, this year Site 12 had lower flows than Site 11, leading us to believe Site 11 flows somehow flows to Site 28, or flows somehow bypass Site 12. V&A field reconned after flow monitoring and could not find the point of split or bypass.

[16] On 12/30/2021 to 1/21/2022, Site 29 had much lower flows with very clear cutoffs. One possibility would be an overflow to Basins 30 or 28. It was difficult to tell from the flow data as Sites 28 and 30 had much larger flows than Site 29. Another possibility is a temporary diversion, but this would have been during holidays.

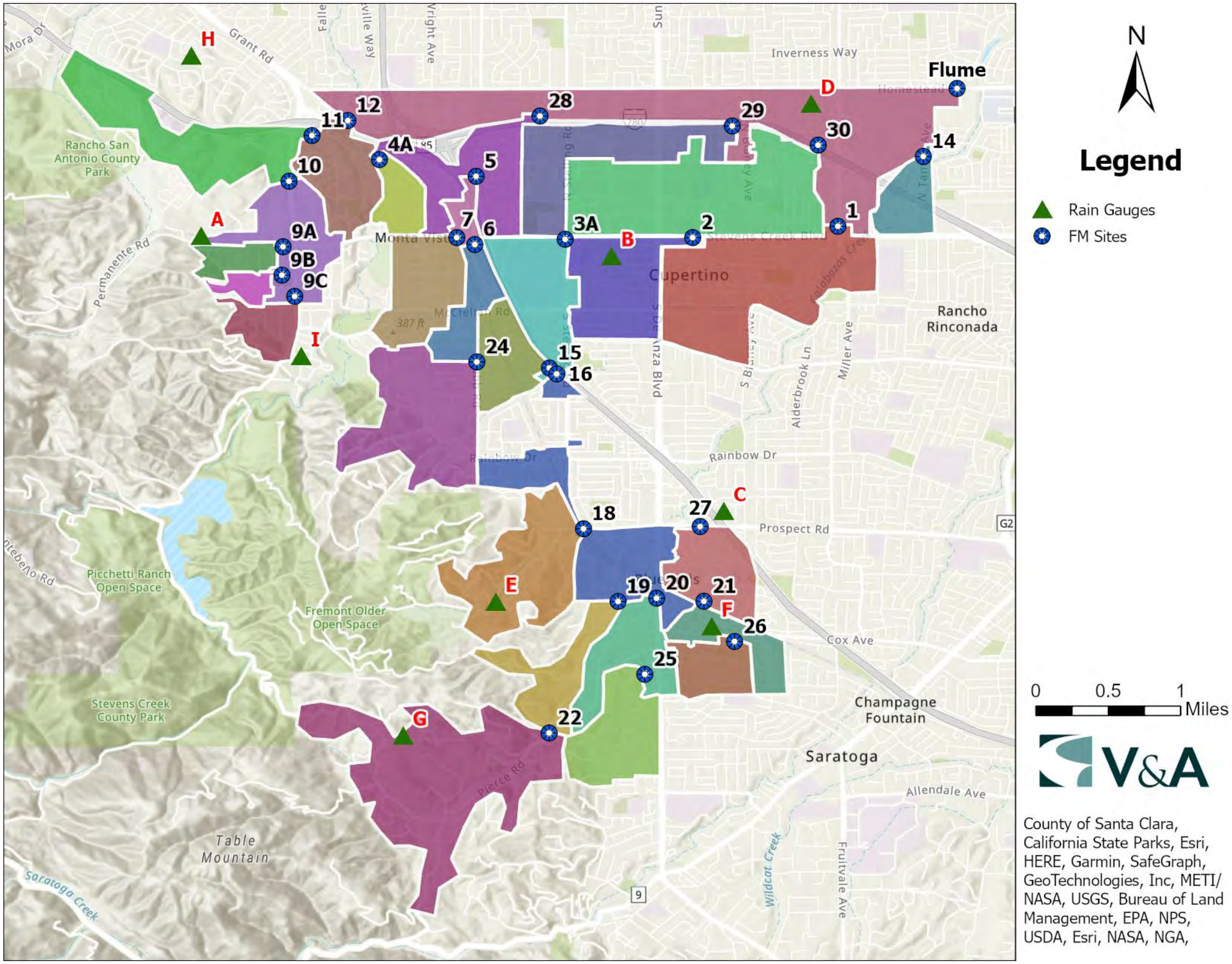


Figure-1-1. Map of Flow Monitoring Sites, Rain Gauges, and Flow Basins

2 Methods and Procedures

2.1 Confined Space Entry

A confined space (Photo 2-1) is defined as any space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5% to 23.5%), and the presence of hydrogen sulfide (H_2S) gas, carbon monoxide (CO) gas, and lower explosive limit (LEL) levels. A typical confined space entry crew has members with OSHA-defined responsibilities of Entrant, Attendant, and Supervisor. The Entrant is the individual performing the work. He or she is equipped with the necessary personal protective equipment needed to perform the job safely, including a personal four-gas monitor (Photo 2-2). If it is not possible to maintain line-of-sight with the Entrant, then more Entrants are required until line-of-sight can be maintained. The Attendant is responsible for maintaining contact with the Entrants to monitor the atmosphere using another four-gas monitor and maintaining records of all Entrants if there is more than one. The Supervisor is responsible for developing the safe work plan for the job at hand prior to entering.

Photo 2-1. Confined Space Entry

Photo 2-2. Typical Personal Four-Gas Monitor

2.2 Flow Meter Installation

V&A installed mostly ISCO 2150 and some HACH 904 area-velocity flow meters for temporary monitoring within the collection system.

ISCO 2150 and HACH 904 meters use submerged sensors with a pressure transducer to collect depth readings, and an ultrasonic Doppler sensor to determine the average fluid velocity. The ultrasonic sensor emits high-frequency sound waves, which are reflected by air bubbles and suspended particles in the flow. The sensor receives the reflected signal and determines the Doppler frequency shift, which indicates the estimated average flow velocity. The sensor is typically mounted at a manhole inlet to take advantage of smoother upstream flow conditions. The sensor may be offset to one side of the pipe to lessen the chances of fouling and sedimentation where these problems are expected to occur. Manual level and velocity measurements were taken during the installation of the flow meters, and again when they were removed, and compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. Figure 2-1 shows a typical installation for a flow meter with a submerged sensor.

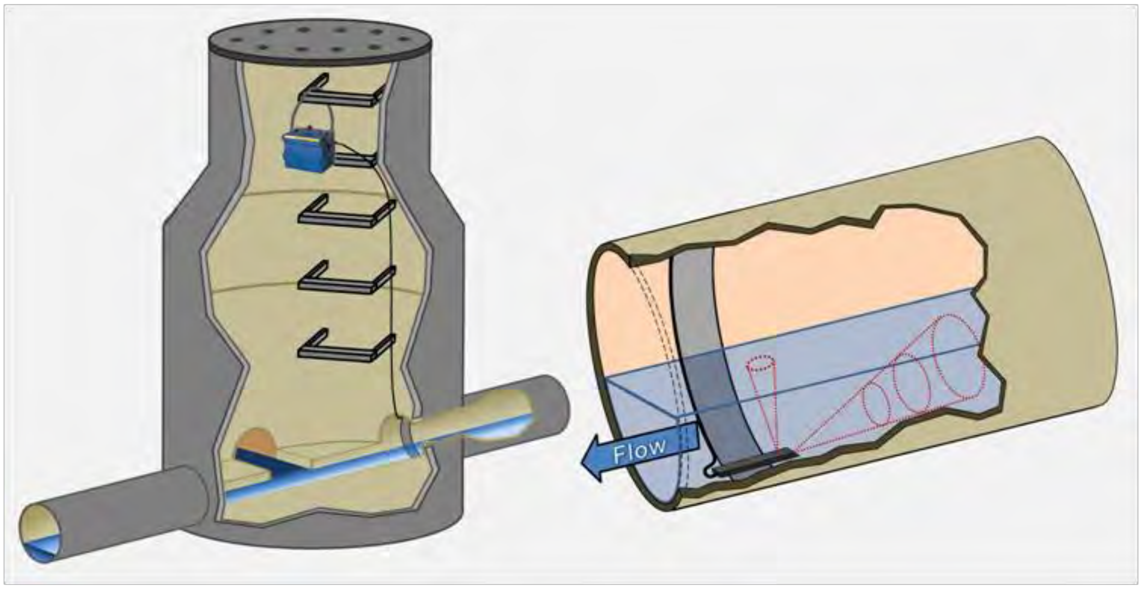


Figure 2-1. Typical Installation for ISCO 2150 Flow Meter with Submerged Sensor

2.3 Flow Calculation

Data retrieved from the flow meters is placed into a spreadsheet program for analysis. Data analysis includes comparison to field calibration measurements as well as necessary geometric adjustments as required for sediment (sediment reduces the pipe's wetted cross-sectional area available to carry flow). Area-velocity flow metering uses the continuity equation,

$$Q = v \cdot A = v \cdot (A_T - A_S)$$

where Q: volume flow rate

v: average velocity as determined by the ultrasonic sensor

A: cross-sectional area available to carry the flow

A_T: total cross-sectional area with both wastewater and sediment

A_S: cross-sectional area of sediment

For circular pipe,

$$A_T = \left[\frac{D^2}{4} \cos^{-1}\left(1 - \frac{2d_W}{D}\right) \right] - \left[\left(\frac{D}{2} - d_W\right)\left(\frac{D}{2}\right) \sin\left(\cos^{-1}\left(1 - \frac{2d_W}{D}\right)\right)\right]$$

$$A_S = \left[\frac{D^2}{4} \cos^{-1}\left(1 - \frac{2d_S}{D}\right) \right] - \left[\left(\frac{D}{2} - d_S\right)\left(\frac{D}{2}\right) \sin\left(\cos^{-1}\left(1 - \frac{2d_S}{D}\right)\right)\right]$$

where d_W: distance between wastewater level and pipe invert

d_S: depth of sediment

D: pipe diameter

2.4 Measurement Error and Uncertainty

For traditional engineering applications, measurement "error" is explained as a difference between a computed, estimated, or measured value and the generally accepted true or theoretically correct value. It can also be thought of as a difference between the desired and the actual performance of equipment. For equipment, an error is usually expressed as a percentage relative to accuracy (i.e., "…the velocity sensor has an accuracy of ±2% of the reading…").

However, for this study and flow monitoring applications, the cause of the measurement difference is important, and a distinction will be made between the equipment not performing to industry standards ("error") and expected inaccuracies ("uncertainty") associated with monitoring technology limitations.

Gauging **"error"** occurs when the equipment is not performing to industry standards. This can occur as a result of the following common categories of conditions that can be encountered at a wastewater monitoring site.

- Malfunctioning equipment (i.e. a sensor is damaged, battery life ends, or a desiccant canister becomes saturated)
- Improper equipment choice or maintenance (i.e. the selected gauging equipment technologies are incompatible with hydraulic conditions within the sewer, or excessive gravel deposits are allowed to accumulate around the sensors without being removed)
- Improper equipment calibration (i.e. depth and/or velocity measurements are incorrectly taken within the sewer, or equipment is allowed to drift out of calibration)
- Field conditions within the sewer, (i.e. foaming at the water surface that "blinds" an ultrasonic depth sensor, or toilet paper catching and accumulating on a combination sensor, blinding the acoustic Doppler velocity meter)

For flow monitoring applications, gauging **"uncertainty"** is used to describe and quantify the expected inaccuracies that result from the limitations of the technologies that utilize indirect measurements to quantify wastewater flow.

It is important to try and install flow meters in "ideal" flow conditions. Ideal flow conditions are generally defined as laminar flow in a straight-through, constant-slope pipeline with no disturbances (elbows, tees, hydraulic shifts, etc.) 10 diameters upstream and 5 diameters downstream from the flow monitoring location. If ideal flow conditions are met, then an expected uncertainty of final flow calculation from an open-channel flow meter may be approximately ±5%. For many situations, ideal flow conditions cannot be met, and uncertainties increase.

2.4.1 Flow Addition versus Flow Subtraction

Due to the uncertainties involved in subtracting flows of similar magnitudes, the addition of flows at multiple monitoring sites is usually preferred over subtraction of flows. Subtraction becomes an issue especially when the flow difference from the subtraction falls within the measurement uncertainty range of the two larger flow data sets (i.e. subtracting a large flow from another large flow to obtain a small difference).

This concept is best demonstrated by the following example:

Meter A measures 2.00 MGD of flow and has an expected uncertainty of ±5%, thus the uncertainty range of the flow measurement is ±0.10 MGD.

Meter B measures 2.50 MGD of flow and has an expected uncertainty of ±6%, thus the uncertainty range of the flow measurement is ±0.15 MGD.

Meter C measures 0.50 MGD of flow and has an expected uncertainty of ±8%, thus the uncertainty range of the flow measurement is ±0.04 MGD.

- Scenario 1 – Flow Addition
    - Meter A + Meter B = 2.00 MGD (±0.10) + 2.50 MGD (±0.15) = 4.50 MGD (±0.25)
    - Overall uncertainty = ±0.25 / 4.50 = ±5.6%
    - For flow addition, the final uncertainty is essentially a weighted average of the component uncertainties.

- Scenario 2 – Flow Subtraction, Large Flow less Small Flow
    - Meter B - Meter C = 2.50 MGD (±0.15) - 0.50 MGD (±0.04) = 2.00 MGD (±0.19)
    - Overall uncertainty = ±0.19 / 2.00 = ±9.5%
    - For flow subtraction, the final uncertainty will always be greater than the component uncertainties.
    - When subtracting a small flow from a large flow, the resulting uncertainties can still be manageable.

- Scenario 3 – Flow Subtraction, Large Flow less a similarly Large Flow
    - Meter B - Meter A = 2.50 MGD (±0.15) – 2.00 MGD (±0.10) = 0.50 MGD (±0.25)
    - Overall uncertainty = ±0.25 / 0.50 = ±50%
    - When subtracting similarly sized flow rates, the resulting uncertainties may not be manageable. In this example, an uncertainty of ±50% may be considered unacceptable for confident analyses.

Scenario 3 is a very “real-world” situation. The uncertainties for Meter A and Meter B are extremely reasonable (indeed, most flow monitoring service providers would be extremely pleased with true meter uncertainties of ±5% to ±6%). However, the reality of the math is clear, and the above example demonstrates the concept of flow subtraction and compounding or inflating uncertainty ranges.

The following points are emphasized in relation to the items of this section:

- For subtraction of flows, the overall uncertainty can be an inflated value that far exceeds the component uncertainties.
- The smaller the resultant flow from the subtraction equation, the larger the percentage uncertainty.
- Whenever possible, basins flows should be directly measured, rather than calculated as a subtraction of two or more flow meters.
- If flow subtraction cannot be avoided, it is better to have the magnitudes of the component flows be as dissimilar as possible.

2.5 Average Dry Weather Flow Determination

For this study, four distinct average dry weather flow curves were established for each site location:

- Mondays – Thursdays
- Fridays
- Saturdays
- Sundays

Flows for many sites differ on Friday evenings compared to Mondays through Thursdays. Starting around 7 pm, the flows are often decreased (compared to Monday through Thursday). Similarly, flow patterns for Saturday and Sunday were also separated due to their unique evening flow pattern. This type of differentiation can be important when determining I/I response, especially if a rain event occurs on a Friday, Saturday or Sunday evening.

Figure 2-2 illustrates a sample of varying flow patterns within a typical dry week[17].

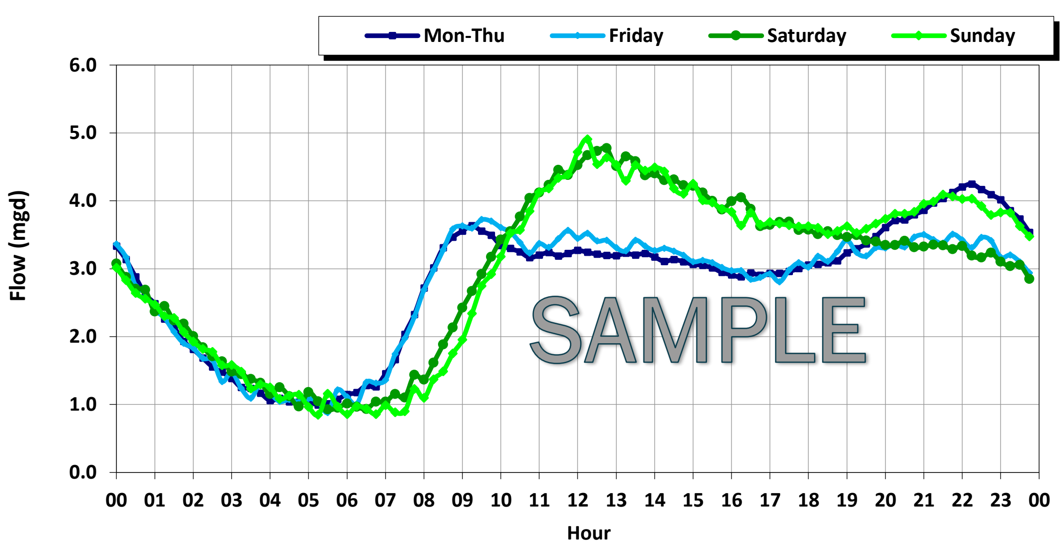


Figure 2-2. Sample ADWF Diurnal Flow Patterns

[17] Holiday flows can be extremely variable. Christmas flows are different from Thanksgiving flows and different from MLK Day flows. See Section **Error! Reference source not found.** for details on whether holiday ADWF curves were established for this project's I/I analysis.

ADWF curves are taken from “Dry Days” when RDI had the least impact on the baseline flow. The overall average dry weather flow (ADWF) is calculated using the following equation:

$$ADWF = \left(ADWF_{Mon-Thu} \times \frac{4}{7}\right) + \left(ADWF_{Fri} \times \frac{1}{7}\right) + \left(ADWF_{Sat} \times \frac{1}{7}\right) + \left(ADWF_{Sun} \times \frac{1}{7}\right)$$

2.6 Holiday Season Average Dry Weather Flow Determination

For the following sites an additional two distinct average dry weather flow curves were established for the holiday season of December 10, 2021, to January 17, 2022:

- Site 1
- Site 4A
- Site 5
- Site 6
- Site 7
- Site 10
- Site 11
- Site 14
- Site 25
- Site 29

These additional average dry weather flow curves were labelled “alternate weekday” and “alternate weekend” curves as flows were noticeable different shaped and lower than post January 17, 2022. For example, Figure 2-3 shows the ADWF curves for Site 1. Holiday weekdays have a much less distinct peak at around 8am to 9am.

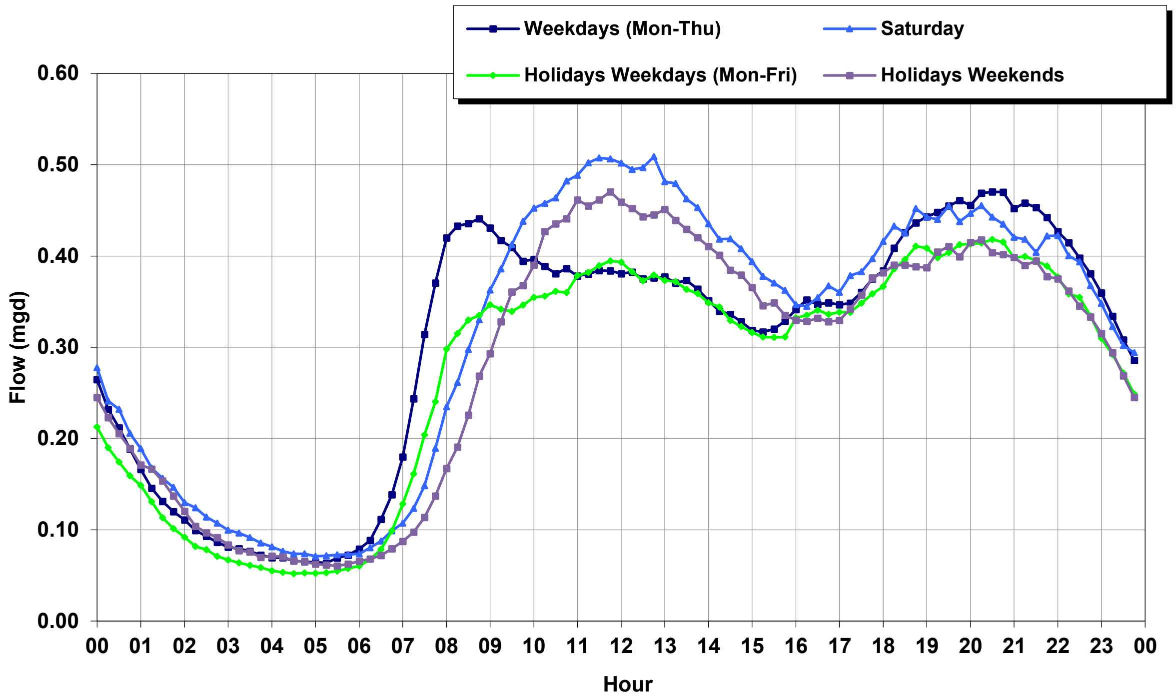


Figure 2-3. Site 1 ADWF Diurnal Flow Patterns – Holidays vs post 1/17/2022

The rain events occurred during holidays, with rain event 2 exactly during Christmas, making I/I analysis challenging as the base flow curve was probably different due to holiday activities. Establishing holiday flow patterns for December 10, 2021 to January 17, 2022 helped but did not fully alleviate this issue.

2.7 Flow Attenuation

Flow attenuation in a sewer collection system is the natural process of the reduction of the peak flow rate through redistribution of the same volume of flow over a longer period of time. This occurs as a result of friction (resistance), internal storage and diffusion along the sewer pipes. Fluids are constantly working towards equilibrium. For example, a volume of fluid poured into a static vessel with no outside turbulence will eventually stabilize to a static state, with a smooth fluid surface without peaks and valleys. Attenuation within a sanitary sewer collection system is based upon this concept. A flow profile with a strong peak will tend to stabilize towards equilibrium, as shown in Figure 2-4.

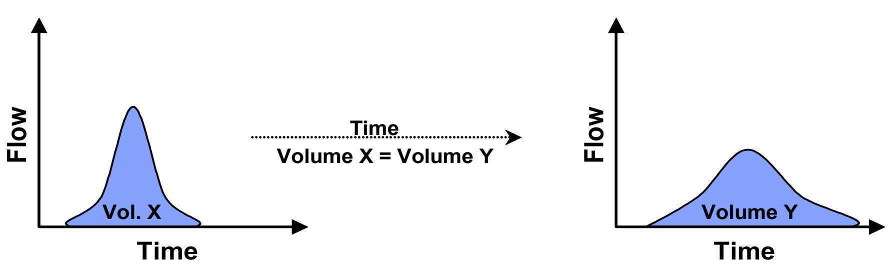


Figure 2-4. Attenuation Illustration

Within a sanitary sewer collection system, each individual basin will have a specific flow profile. As the flows from the basins combine within the trunk sewer lines, the peaks from each basin will not necessarily coincide at the same time, and peak flows may attenuate prior to reaching the treatment facility due to the length and time of travel through the trunk sewers. The sum of the peak flows of the individual basins within a collection system will usually be greater than the peak flows observed at the treatment facility.

2.8 Inflow / Infiltration Analysis: Definitions and Identification

Inflow and infiltration (I/I) consists of storm water and groundwater that enters the sewer system through pipe defects and improper storm drainage connections and is defined as follows:

- **Inflow**: Storm water inflow is defined as water discharged into the sewer system, including private sewer laterals, from direct connections such as downspouts, yard and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins.
- **Infiltration**: Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes.

Figure 2-5 illustrates the possible sources and components of I/I.

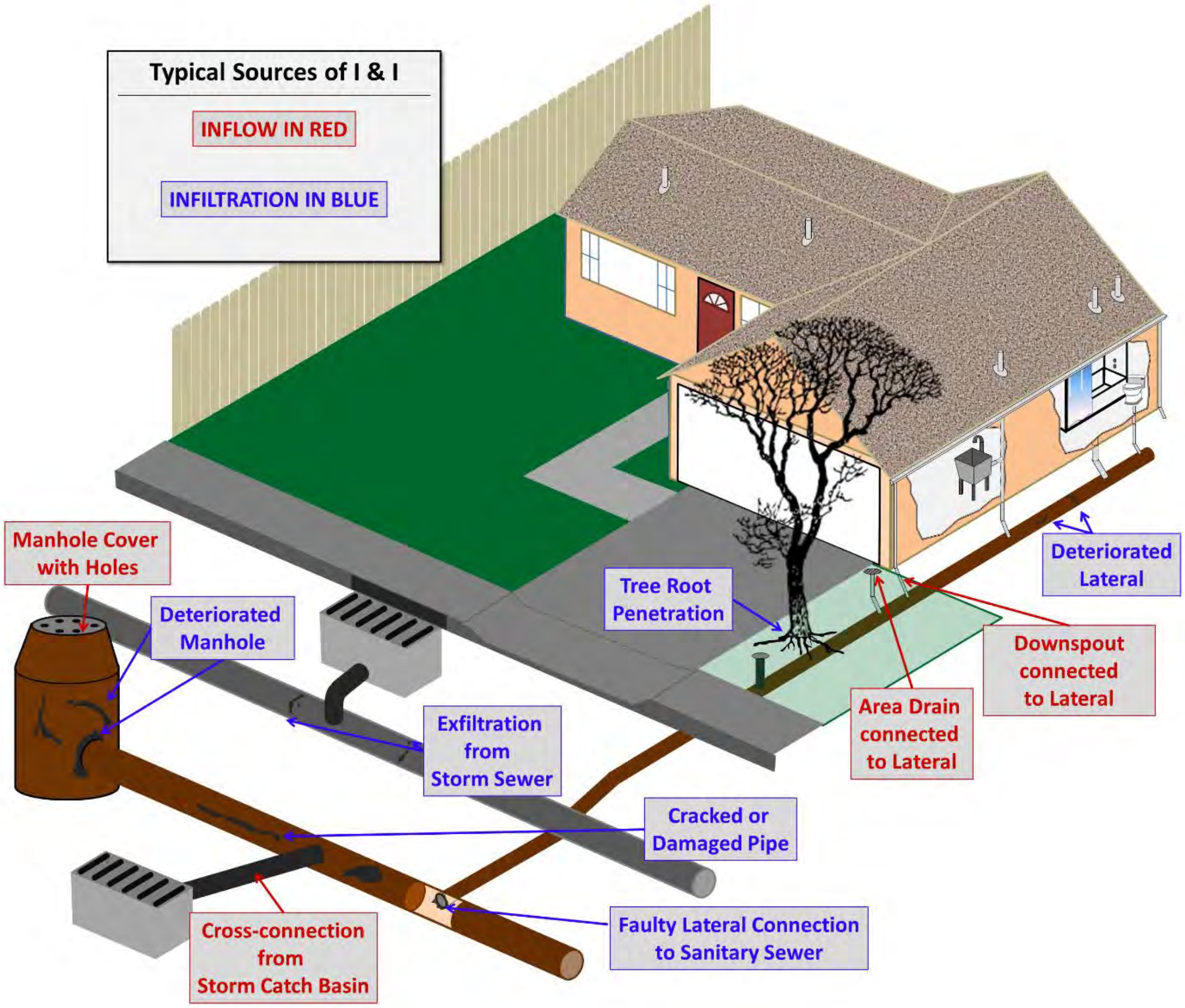


Figure 2-5. Typical Sources of Infiltration and Inflow

2.8.1 Infiltration Components

Infiltration can be further subdivided into components as follows:

- **Groundwater Infiltration**: Groundwater infiltration depends on the depth of the groundwater table above the pipelines as well as the percentage of the system submerged. The variation of groundwater levels and subsequent groundwater infiltration rates are seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.
- **Rainfall-Dependent Infiltration**: This component occurs as a result of storm water and enters the sewer system through pipe defects, as with groundwater infiltration. The storm water first percolates directly into the soil and then migrates to an infiltration point. Typically, the time of concentration for rainfall-related infiltration may be 24 hours or longer, but this depends on the soil permeability and saturation levels.
- **Rainfall-Responsive Infiltration** is storm water which enters the collection system indirectly through pipe defects, but normally in sewers constructed close to the ground surface such as private

laterals. Rainfall-responsive infiltration is independent of the groundwater table and reaches defective sewers via the pipe trench in which the sewer is constructed, particularly if the pipe is placed in impermeable soil and is bedded and backfilled with a granular material. In this case, the pipe trench serves as a conduit similar to a French drain, conveying storm drainage to defective joints and other openings in the system. This type of infiltration can have a quick response and graphically can look very similar to inflow.

2.8.2 Impact and Cost of Source Detection and Removal

- Inflow:
  - Impact: Inflow creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Because the response and magnitude of inflow are tied closely to the intensity of the storm event, the short-term peak instantaneous flows may result in surcharging and overflows within a collection system. Severe inflow may result in sewage dilution, resulting in upsetting the biological treatment (secondary treatment) at the treatment facility.
  - Cost of Source Identification and Removal: Inflow locations are usually less difficult to find and less expensive to correct. These sources include direct and indirect cross-connections with storm drainage systems, roof downspouts, and various types of surface drains. Generally, the costs to identify and remove sources of inflow are low compared to potential benefits to public health and safety or the costs of building new facilities to convey and treat the resulting peak flows.
- Infiltration:
  - Impact: Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).
  - Cost of Source Detection and Removal: Infiltration sources are usually harder to find and more expensive to correct than inflow sources. Infiltration sources include defects in deteriorated sewer pipes or manholes that may be widespread throughout a sanitary sewer system.

2.8.3 Graphical Identification of I/I

Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event. Infiltration is often recognized graphically by a gradual increase in flow after a wet-weather event. The increased flow typically sustains for a period after rainfall has stopped and then gradually drops off as soils become less saturated and as groundwater levels recede to normal levels. Real-time flows are plotted against ADWF to analyze the I/I response to rainfall events. Figure 2-6 illustrates a sample of how this analysis is conducted and some of the measurements that are used to distinguish infiltration and inflow. Similar graphs have been generated for the individual flow monitoring sites and can be found in Appendix A.

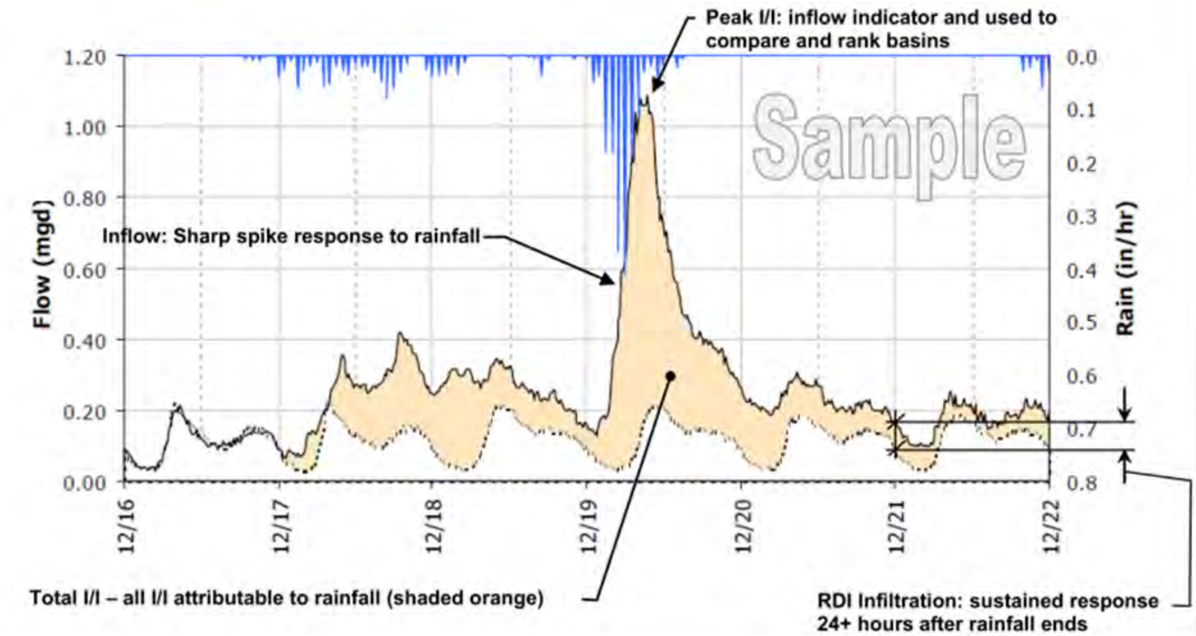


Figure 2-6. Sample Infiltration and Inflow Isolation Graph

2.8.4 Analysis Metrics

After differentiating I/I flows from ADWF flows, various calculations can be made to determine which I/I component (inflow or infiltration) is more prevalent at a particular site and to compare the relative magnitudes of the I/I components between drainage basins and between storm events:

- **Inflow – Peak I/I Flow Rate**: Inflow is characterized by sharp, direct spikes occurring during a rainfall event. Peak I/I rates are used for inflow analysis. [18]
- **Groundwater Infiltration (GWI)**: GWI analysis is conducted by looking at minimum dry weather flow to average dry weather flow ratios and comparing them to established standards to quantify the rate of excess groundwater infiltration.
- **Rainfall-Dependent Infiltration (RDI)**: RDI Analysis is conducted by looking at the infiltration rates at set periods after the conclusion of a storm event. Depending on the particular collection system and the time required for flows to return to ADWF levels, different periods may be examined to determine the basins with the greatest or most sustained rainfall-dependent infiltration rates.
- **Combined I/I**: The combined inflow and infiltration is measured in gallons per site and per storm event. Because it is based on combined I/I volume, it is used to identify the overall volumetric influence of I/I within the monitoring basin.

2.8.5 Normalization Methods

There are three ways to *normalize* the I/I analysis metrics for an "apples-to-apples" comparison among the different drainage basins:

[18] I/I flow rate is the real time flow less the estimated average dry weather flow rate. It is an estimate of flows attributable to rainfall. By using peak measured flow rates (inclusive of ADWF), the I/I flow rate would be skewed higher or lower depending on whether the storm event I/I response occurs during low-flow or high-flow hours.

- **per-ADWF**: The metric is divided by the established average dry weather flow rate and typically expressed as a ratio. Peaking Factors are examples of using ADWF to normalize data from different sites.
- **per-IDM**: The metric is divided by the length of pipe (IDM [inch-diameter mile]) contained within the upstream basin. Final units typically are gallons per day (gpd) per IDM.
- **per-ACRE**: The metric is divided by the acreage of the upstream basin. Final units typically are gallons per day (gpd) per ACRE.

The infiltration and inflow indicators were normalized by the per-IDM, per-ADWF and per-ACRE methods in this report and these results will be shown in the following I/I analysis results sections. For the purposes of basin rankings, the following weighting decisions are given:

- **per**-ADWF**:** It is noted that abnormal waste usage could result in low ADWF values, which could skew results and lend for possible misinterpretation of data. Per-ADWF values are known and valid and will be assigned 30% weighting towards final rankings.
- **per-IDM:** Per-IDM values are known and valid and will be assigned 40% weighting towards final rankings. Capital improvement projects are often bid per pipe length, a reason to weight IDM metrics higher.
- **per-ACRE:** Many of the basins were in hilly areas and did not have many sewage pipes that may collect the I/I from the hills. Many basins were comprised of open land that may capture a disproportionate amount of rain compared to the pipe system size. Per-ACRE values are known and valid and will be assigned 30% weighting towards final rankings.

3 Results and Analysis

3.1 Rainfall Monitoring

3.1.1 Rain Gauge Locations

V&A analyzed rainfall data from a total of 9 publicly available private weather stations (PWS) on Weather Underground[19], allowing for solid coverage over the collection system which has a diverse range of topographical features. Figure 3-1 illustrates the locations and labeling convention used for the 9 rain gauges.

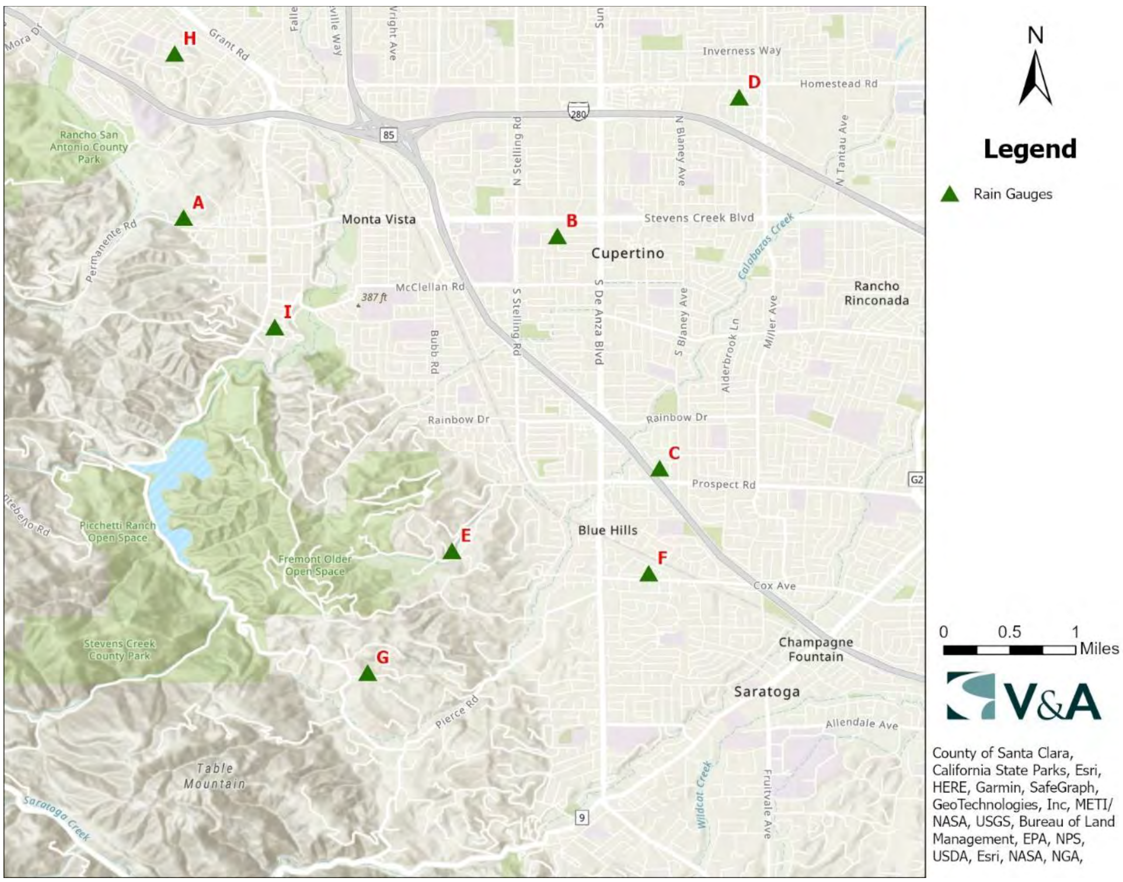


Figure 3-1. Location of Rain Gauges

[19] Weather Underground (wunderground.com) collects data from 180,000+ weather stations across the country, including Automated Surface Observation System (ASOS) at airports, personal weather stations (PWS), and Meteorological Assimilation Data Ingest System (MADIS) managed by the National Oceanic and Atmospheric Administration (NOAA). While V&A has no direct control over the rain gauges, V&A performs additional QA/QC on the data to ensure its suitability for use.

3.1.2 Flow Study Rainfall Data

The two main rainfall events that elicited a solid I/I response over the flow monitoring period are illustrated in Figure 3-2.

Table 3-1 shows the duration and precipitation of each rainfall event for each rain gauge. Figure 3-3 shows the rain accumulation plot of the period rainfall, as well as the historical average rainfall[20] triangulated to the district centroid during this project duration. The cumulative precipitation for the average of the rain gauges was **24% higher** than the historical precipitation for the duration of the flow monitoring.

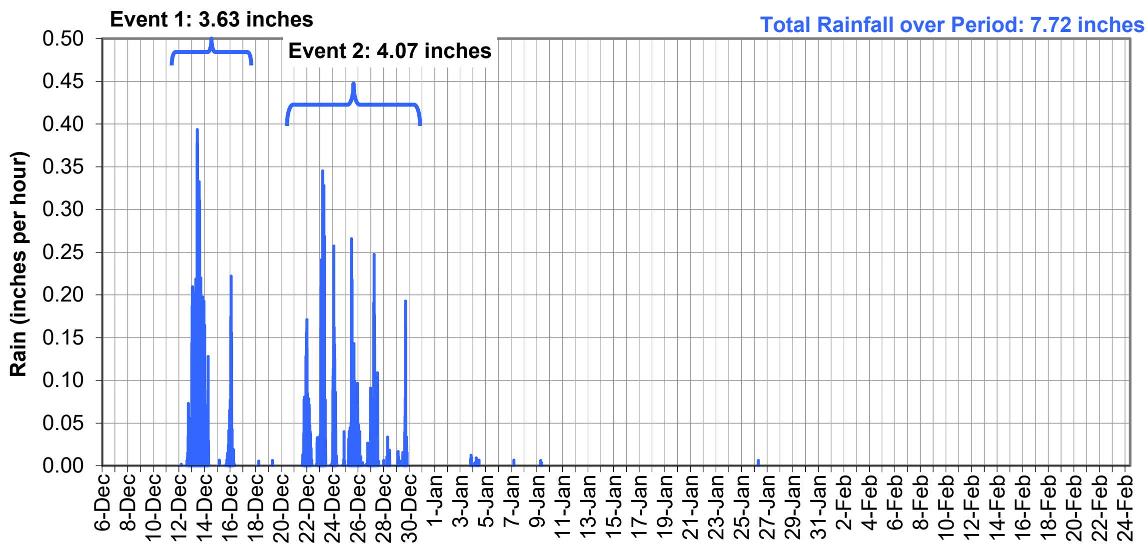


Figure 3-2. Rainfall Monitoring – Triangulated to District Centroid

Table 3-1. Summary of Rainfall Data

Rain Gauge	Rain Event 1 Dec 12 – 16, 2021	Rain Event 2 Dec 21 – 30, 2021	Monitoring Period Total
A	3.16	3.31	6.83
B	3.26	3.04	6.31
C	3.93	3.59	7.54
D	2.82	2.81	5.65
E	5.16	4.38	10.01
F	4.64	4.27	8.95
G	5.85	4.38	10.29
H	3.22	3.42	6.66
I	4.19	5.04	9.29
Average	4.03	3.81	7.95

[20] Historical data taken from the WRCC (Station 47912 in Santa Clara, Station 46646 in Palo Alto and Station 47821 in San Jose triangulated to district centroid): http://www.wrcc.dri.edu/summary/climsmnca.html

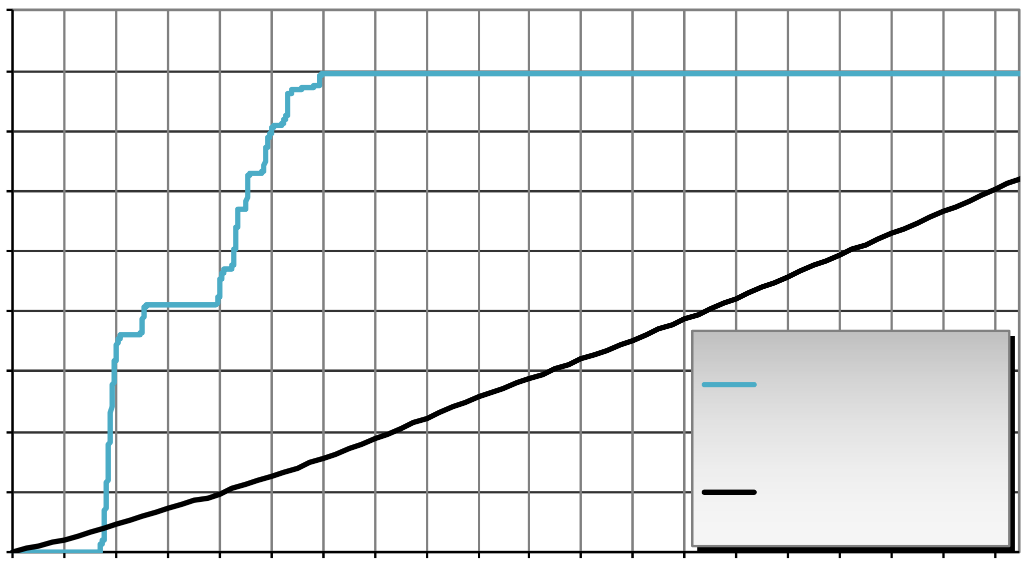


Figure 3-3. Rainfall Accumulation Plot –Rain Gauges triangulated to district centroid

3.1.3 Regional Rainfall Event Classification

It is important to classify the relative size of a major storm event that occurs over the course of a flow monitoring period[21]. Rainfall events are classified by intensity and duration. Based on historical data, frequency contour maps for storm events of given intensity and duration have been developed by the NOAA for all areas within the continental United States (Figure 3-4).

[21] Sanitary sewers are often designed to withstand I/I contribution to sanitary flows for specific-sized "design" storm events.

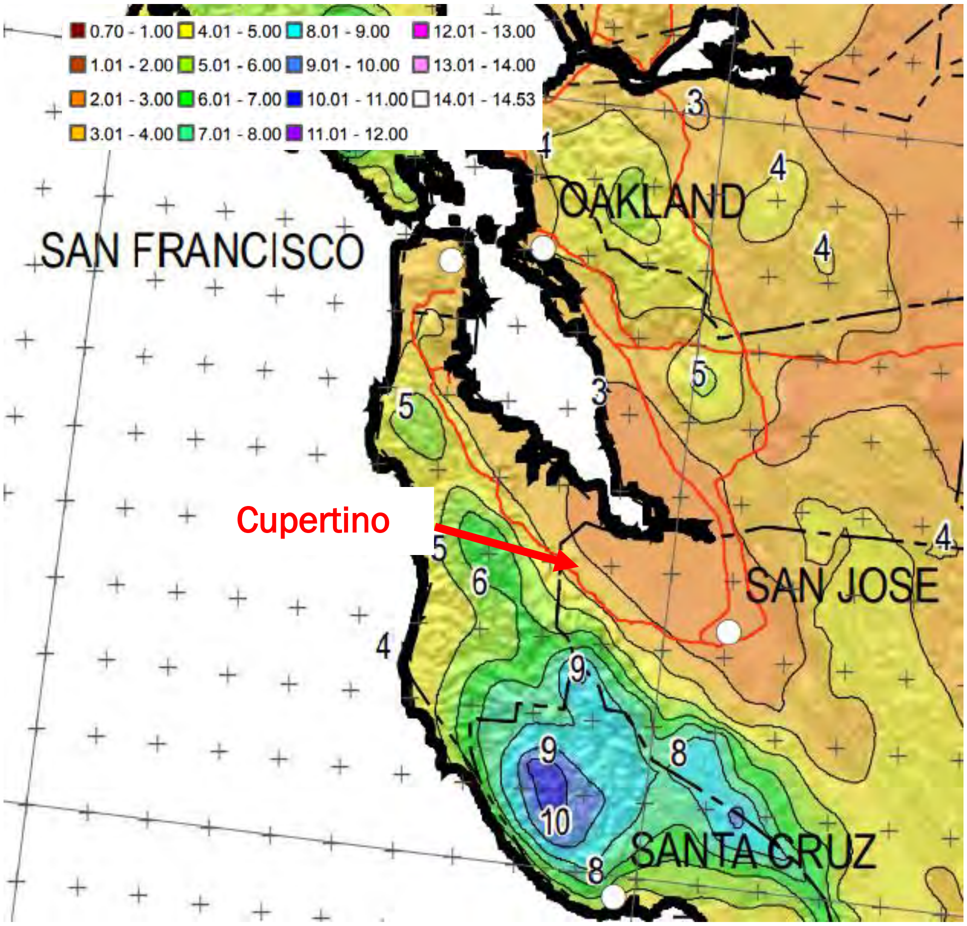


Figure 3-4. NOAA Northern California Rainfall Frequency Map

For example, the NOAA Rainfall Frequency Atlas[22] classifies a 10-year, 24-hour storm event at the rain gauge location F as **4.60** inches. This means that in any given year, at this specific location, there is a 10% chance that 4.60 inches of rain will fall in any 24-hour period.

From the NOAA frequency maps, for a specific latitude and longitude, the rainfall densities for period durations ranging from 1 hour to 20 days are known for rain events ranging from 1-year to 10-year intensities. These are plotted to develop a rain event frequency map specific to each rainfall monitoring site. Superimposing the peak measured densities for the rainfall events on the rain event frequency plot determines the classification of the rainfall event. Table 3-2 shows the peak classifications for each rain event at each rain gauge location. Figure 3-5 illustrate the rain event classification plot at gauge location Outer SSE as an example. The following items are noted:

- Event 1 was the highest classified rainfall event during this study, ranging between a 2 and 5 year, 24-hour storm event.
- Event 2 was classified as less than 1-Yr event by all rain gauges.
- The precipitation was the greatest in the south and the hills, with less precipitation falling to the north.

[22] NOAA Western U.S. Precipitation Frequency Maps Atlas 14, Volume 6, 2011: ftp://hdsc.nws.noaa.gov/pub/hdsc/data/sw/ca10y24h.pdf

Table 3-2. Rainfall Events Classification

Rain Gauge	Rain Event #1 Classification	Rain Event #2 Classification
A	2-Yr, 1-Day	<1-Yr, 7-Day
B	4-Yr, 1-Day	<1-Yr, 7-Day
C	3-Yr, 1-Day	<1-Yr, 7-Day
D	3-Yr, 1-Day	<1-Yr, 7-Day
E	5-Yr, 1-Day	<1-Yr, 7-Day
F	4-Yr, 1-Day	<1-Yr, 7-Day
G	3-Yr, 1-Day	<1-Yr, 7-Day
H	3-Yr, 1-Day	<1-Yr, 7-Day
I	3-Yr, 1-Day	<1-Yr, 7-Day

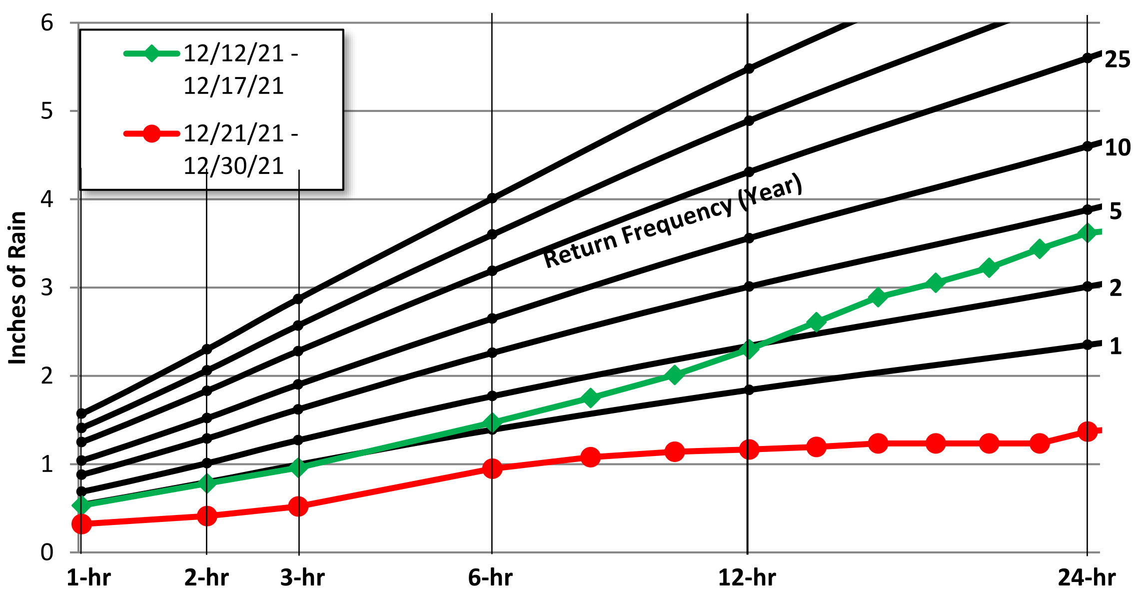


Figure 3-5. Rainfall Event Classification – 24-Hour Period (Rain Gauge F)

3.1.4 Rain Gauge Triangulation Distribution

The rainfall affecting the sanitary sewer collection system basins must be calculated based on the proximity to the rain gauge locations. The mean precipitation for each site's upstream basin was calculated by taking data from the rain gauges and using the inverse distance weighting (IDW) method. IDW is an interpolation method that assumes the influence of each rain gauge location diminishes with distance. The center of an upstream basin[23] is identified, and a weighted triangulated average is taken of the precipitation data from nearby rain gauge locations.

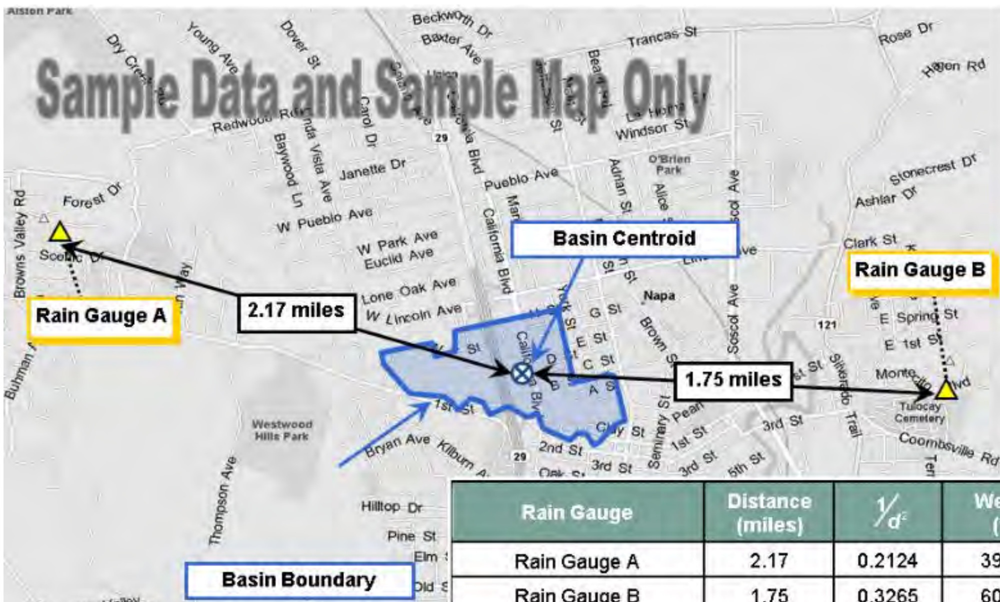
The IDW function is as follows:

$$weight(d) = \frac{1/d^p}{\sum 1/d^p},$$

where: d = distance
p = power ($p > 0$)

The value of p is user defined. The most common choice for hydrological studies of watershed areas is $p = 2$.

Figure 3-6 illustrates the IDW method with sample data. The rain gauge distribution as calculated for each flow monitoring basin is shown in Table 3-3.



Rain Gauge	Distance (miles)	$1/d^2$	Weight (%)
Rain Gauge A	2.17	0.2124	39.4%
Rain Gauge B	1.75	0.3265	60.6%
Totals		**0.5389**	**100%**

Figure 3-6. Rainfall Inverse Distance Weighting Method

[23] Note that the full basin upstream of the site was used instead of the isolated basins as the rain data will be compared to the flow at each site

Table 3-3. Rain Gauge Distribution per Monitoring Site

Monitoring Site	RG A	RG B	RG C	RG D	RG E	RG F	RG G	RG H	RG I
Site 01	2.45%	60.52%	9.07%	13.40%	3.34%	4.03%	1.69%	1.88%	3.61%
Site 02	*0.76%*	92.62%	1.48%	1.52%	*0.79%*	*0.71%*	*0.37%*	*0.51%*	1.25%
Site 03A	1.61%	8.98%	11.16%	1.25%	23.53%	22.91%	26.19%	*0.89%*	3.47%
Site 04A	25.12%	20.83%	4.05%	5.66%	3.96%	2.71%	2.31%	13.82%	21.53%
Site 05	11.05%	18.70%	6.66%	3.59%	9.98%	4.44%	4.01%	4.51%	37.06%
Site 06	8.95%	15.70%	7.61%	3.15%	12.53%	5.13%	4.76%	3.59%	38.57%
Site 07	15.52%	21.52%	4.78%	3.97%	5.09%	3.08%	2.58%	5.92%	37.55%
Site 09A	84.47%	1.23%	*0.52%*	*0.47%*	*0.69%*	*0.40%*	*0.45%*	2.62%	9.14%
Site 09B	56.10%	2.54%	1.12%	*0.92%*	1.57%	*0.86%*	1.01%	3.95%	31.93%
Site 09C	12.20%	1.63%	*0.80%*	*0.55%*	1.22%	*0.61%*	*0.61%*	1.72%	80.66%
Site 10	52.02%	3.16%	1.17%	1.10%	1.52%	*0.88%*	*0.92%*	5.06%	34.17%
Site 11	41.74%	2.85%	1.09%	1.19%	1.36%	*0.83%*	*0.88%*	28.82%	21.23%
Site 12	40.73%	4.45%	1.43%	1.74%	1.68%	1.06%	1.07%	27.32%	20.52%
Site 14	2.79%	15.22%	7.56%	58.77%	3.31%	4.33%	2.00%	2.56%	3.45%
Site 15	7.79%	32.19%	10.64%	4.61%	9.65%	5.79%	3.85%	3.74%	21.72%
Site 16	*0.96%*	1.77%	11.80%	*0.78%*	26.34%	25.95%	29.97%	*0.56%*	1.86%
Site 18	*0.63%*	1.08%	3.75%	*0.41%*	85.01%	4.24%	3.10%	*0.33%*	1.46%
Site 19	*0.76%*	*0.97%*	2.94%	*0.50%*	14.94%	6.29%	71.78%	*0.45%*	1.37%
Site 20	1.40%	2.31%	10.84%	1.21%	22.13%	43.78%	15.00%	0.86%	2.47%
Site 21	*0.31%*	*0.64%*	5.00%	*0.35%*	3.05%	88.36%	1.57%	*0.20%*	0.53%
Site 22	*0.64%*	*0.72%*	1.71%	*0.39%*	6.35%	2.96%	85.77%	*0.37%*	1.10%
Site 24	8.40%	10.72%	7.94%	2.73%	14.37%	5.50%	5.30%	3.24%	41.79%
Site 25	1.70%	2.68%	10.79%	1.45%	22.72%	35.82%	20.84%	1.06%	2.94%
Site 26	*0.42%*	*0.85%*	6.10%	*0.46%*	4.34%	84.56%	2.27%	*0.27%*	0.73%
Site 27	*0.41%*	*0.98%*	20.60%	*0.49%*	3.81%	71.11%	1.62%	*0.26%*	0.72%
Site 28	12.91%	23.51%	5.97%	5.03%	8.05%	3.95%	3.46%	6.79%	30.32%
Site 29	4.96%	56.90%	4.05%	17.45%	2.66%	2.39%	1.50%	4.51%	5.58%
Site 30	1.83%	16.59%	10.00%	5.89%	19.84%	19.34%	21.86%	1.17%	3.49%
Flume	8.83%	22.03%	7.01%	15.25%	10.81%	9.99%	10.63%	5.81%	9.66%

3.2 Flow Monitoring

3.2.1 Average Flow Analysis

Average dry weather flow (ADWF) curves were established during dry days when I/I had the least impact on the baseline flow. Table 3-4 summarizes the dry weather flow data measured for this study. ADWF curves for each site can be found in Appendix A. Figure 3-7 shows a flow schematic of the average

Table 3-4. Dry Weather Flow

Monitored Site	Sediment (in.)	Mon-Thu ADWF (MGD)	Friday ADWF (MGD)	Saturday ADWF (MGD)	Sunday ADWF (MGD)	Overall ADWF (MGD)
Site 1	0	0.304	0.312	0.316	0.324	0.310
Site 2	0	0.135	0.135	0.141	0.140	0.137
Site 3A	0.5	0.625	0.621	0.634	0.647	0.629
Site 4A	0	0.149	0.148	0.157	0.165	0.152
Site 5	0	0.302	0.299	0.307	0.317	0.304
Site 6	0	0.124	0.117	0.123	0.127	0.123
Site 7	0	0.091	0.090	0.098	0.097	0.093
Site 9A	0	0.003	0.003	0.003	0.004	0.003
Site 9B	0	0.002	0.002	0.003	0.003	0.002
Site 9C	0	0.041	0.040	0.043	0.043	0.042
Site 10	0	0.260	0.265	0.264	0.271	0.263
Site 11	0	0.332	0.333	0.346	0.342	0.336
Site 12	0	0.140	0.139	0.135	0.136	0.138
Site 14	0	0.091	0.093	0.091	0.083	0.090
Site 15	0	0.057	0.055	0.056	0.056	0.057
Site 16	2	0.570	0.575	0.571	0.579	0.572
Site 18	0	0.051	0.051	0.054	0.048	0.051
Site 19	0	0.077	0.077	0.079	0.079	0.078
Site 20	0	0.127	0.127	0.128	0.128	0.127
Site 21	0	0.052	0.053	0.054	0.052	0.052
Site 22	0	0.029	0.029	0.029	0.029	0.029
Site 24	0	0.095	0.098	0.099	0.100	0.097
Site 25	0	0.043	0.042	0.040	0.041	0.042
Site 26	0	0.022	0.021	0.020	0.020	0.021
Site 27	0	0.084	0.082	0.082	0.085	0.083
Site 28	0	0.830	0.821	0.835	0.874	0.836
Site 29	0	0.213	0.211	0.212	0.215	0.213
Site 30	0	0.936	0.926	0.939	0.954	0.938
Flume	0	3.582	3.545	3.585	3.626	3.583

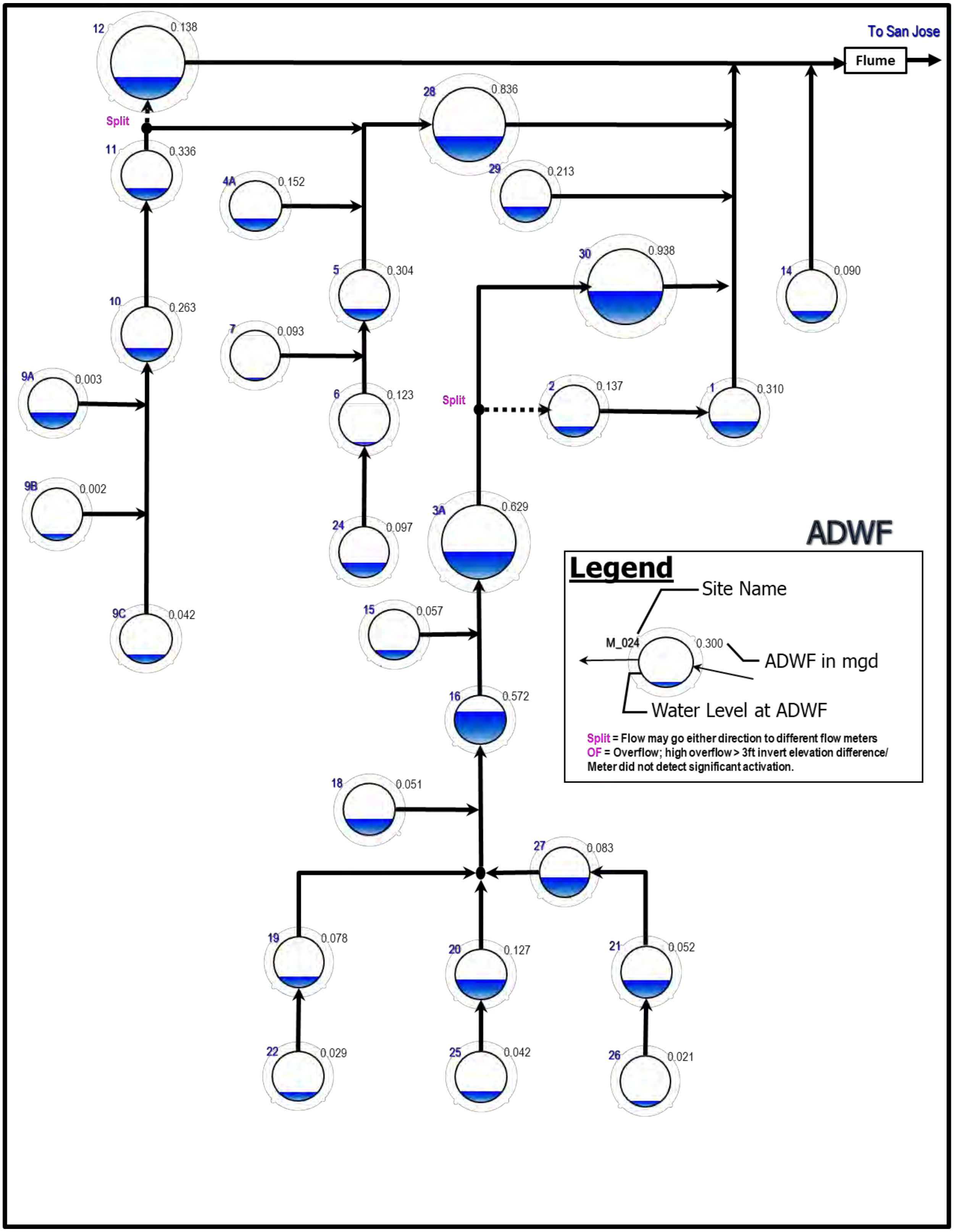


Figure 3-7. Average Dry Weather Flow (Flow Schematic)

3.2.2 Peak Measured Flows and Pipeline Capacity Analysis

Peak measured flows and the hydraulic grade line data (flow depths) are important to understanding the capacity limitations of a collection system. The peak flows and flow levels are the peak measurements as taken across the entirety of the flow monitoring period. Peak flows and levels may not correspond to a rainfall event or occur at the same time.

The following capacity analysis definitions will be used:

- **Peaking Factor (PF)** is defined as the peak measured flow divided by the average dry weather flow (ADWF). Peaking factors are influenced by many factors including size and topography of tributary area, flow attenuation, flow restrictions, characteristics of I/I entering the collection system, and hydraulic features such as pump stations.
  - For this report, peaking factors are reported and PF > 5 are highlighted in ***RED***[24]; however, the District should refer to District standards when evaluating peaking factors. Peaking factor data should be used at the discretion of the District Engineer
- **d/D Ratio** is the peak measured depth of flow (d) divided by the pipe diameter (D). The d/D ratio for each site is computed based on the maximum depth of flow for the study. Standards for d/D ratio vary from agency to agency, but typically range between d/D ≤ 0.5 and d/D ≤ 0.75
  - For this report, d/D ratios > 0.75 are highlighted in RED; however, the District should refer to District standards when evaluating d/D ratios, to be used at the discretion of the District Engineer.

Table 3-5 summarizes the peak recorded flows, levels, *d/D* ratios, and peaking factors per site during the flow monitoring period. Results of note have been shaded in RED. Capacity analysis data are presented on a site-by-site basis and represents the hydraulic conditions only at the site locations; hydraulic conditions in other areas of the collection system will differ.

Table 3-5. Capacity Analysis Summary

Monitoring Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D (IN)*	Peak Measured Depth	*Max d/D Ratio*	Surcharge above pipe crown (FT)
Site 1	0.310	0.57	1.8	12	5.78	0.48	-
Site 2	0.137	0.46	3.3	12	2.89	0.24	-
Site 3A	0.629	1.80	2.9	15	14.88	**0.99**	-
Site 4A	0.152	0.42	2.8	10	4.98	0.50	-
Site 5	0.304	0.64	2.1	10	3.69	0.37	-
Site 6	0.123	0.27	2.2	10	4.02	0.40	-
Site 7	0.093	0.24	2.6	8	2.47	0.31	-
Site 9A	0.003	0.08	**24.1**	6	1.53	0.25	-
Site 9B	0.002	0.02	**10.2**	6	1.60	0.27	-
Site 9C	0.042	0.09	2.1	8	1.80	0.22	-
Site 10	0.263	0.71	2.7	10	4.53	0.45	-

[24] WEF Manual of Practice FD-6 and ASCE Manual No. 62 suggests typical peaking factor ratios range between 3 and 4, with higher values possibly indicative of pronounced I/I flows.

Monitoring Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D* *(IN)*	Peak Measured Depth	*Max d/D Ratio*	Surcharge above pipe crown (FT)
Site 11	0.336	0.73	2.2	10	4.02	0.40	-
Site 12	0.138	0.41	3.0	10	5.94	0.59	-
Site 14	0.090	0.29	3.2	10.5	4.15	0.40	-
Site 15	0.057	0.21	3.2	8	2.62	0.34	-
Site 16	0.572	1.61	2.8	14	17.79	**1.27**	**0.32**
Site 18	0.051	0.42	**8.3**	8	6.10	**0.76**	-
Site 19	0.078	0.43	**5.5**	10	5.67	0.57	-
Site 20	0.127	0.42	3.3	8	5.55	0.69	-
Site 21	0.052	0.16 [25]	3.0	6.5	7.32	**1.13**	**0.07**
Site 22	0.029	0.31	**10.7**	8	4.58	0.57	-
Site 24	0.097	0.22	2.3	8	3.64	0.45	-
Site 25	0.042	0.27	**6.4**	8	3.77	0.47	-
Site 26	0.021	0.06	3.0	8	1.56	0.19	-
Site 27	0.083	0.27	3.2	7.75	5.39	0.70	-
Site 28	0.836	1.46	1.7	15	6.92	0.46	-
Site 29	0.213	0.47	2.2	8	5.29	0.66	-
Site 30	0.938	1.99	2.1	18	11.94	0.66	-
Flume	3.583	7.13	2.0	n/a [26]	17.84	n/a[27]	-

The following capacity analysis results are noted:

- Peaking Factors:
  - Sites 9A, 9B, 18, 19, 22 and 25 all had peaking factors greater than 5. Site 9A had the largest peaking factor of all sites at 24.1; however, this value may be partially skewed due to the low ADWF, like Site 9B.
- d/D Ratio:
  - Sites 16 and 21 surcharged during the study; flow levels for these sites were less than one foot above the pipe crown when surcharged. Site 3A nearly reached a surcharged condition (less than 0.2 inch) during the study.

[25] Site 21 was first installed in the southwest 8-inch inlet, similar to previous years. It was realized there is a flow split immediately upstream and the inlet often has stagnant flow. The sensor was changed to the northeast 6.5-inch outlet on December 29, 2021. The peak flows and depth are from post December 29, 2021. However there were no rain events after December 29, 2021 to the end of the flow monitoring period. One would expect the peak flows and depth were probably higher during rain event 1 and 2.
[26] Homestead Flume is an 18-inch Parshall Flume
[27] The maximum rated head for an 18-inch Parshall Flume is 30 inches, so d/max d = 0.59.

Figure 3-8 and Figure 3-9 show bar graph summaries of the peaking factors and d/D ratios, respectively. Figure 3-10 shows the schematic diagram of the peak measured flows in each section with peak flow levels.

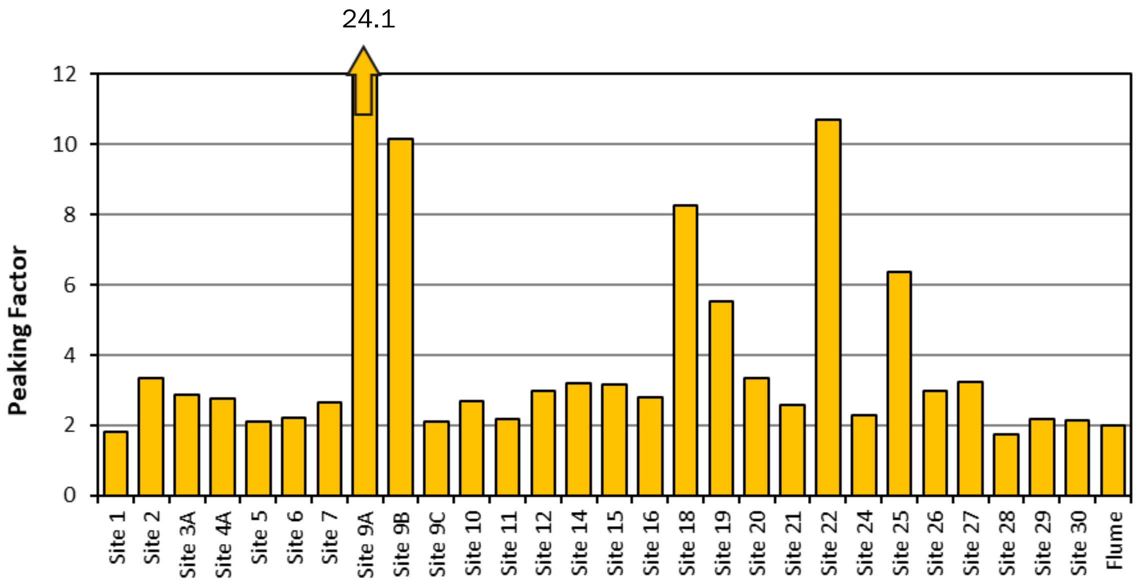


Figure 3-8. Peaking Factors

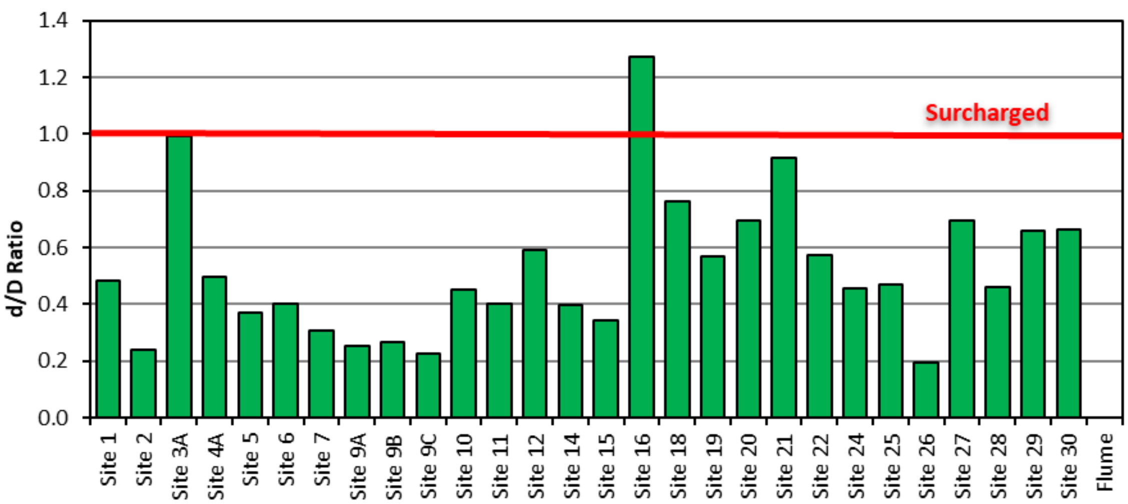


Figure 3-9. Capacity Summary: Max d/D Ratios

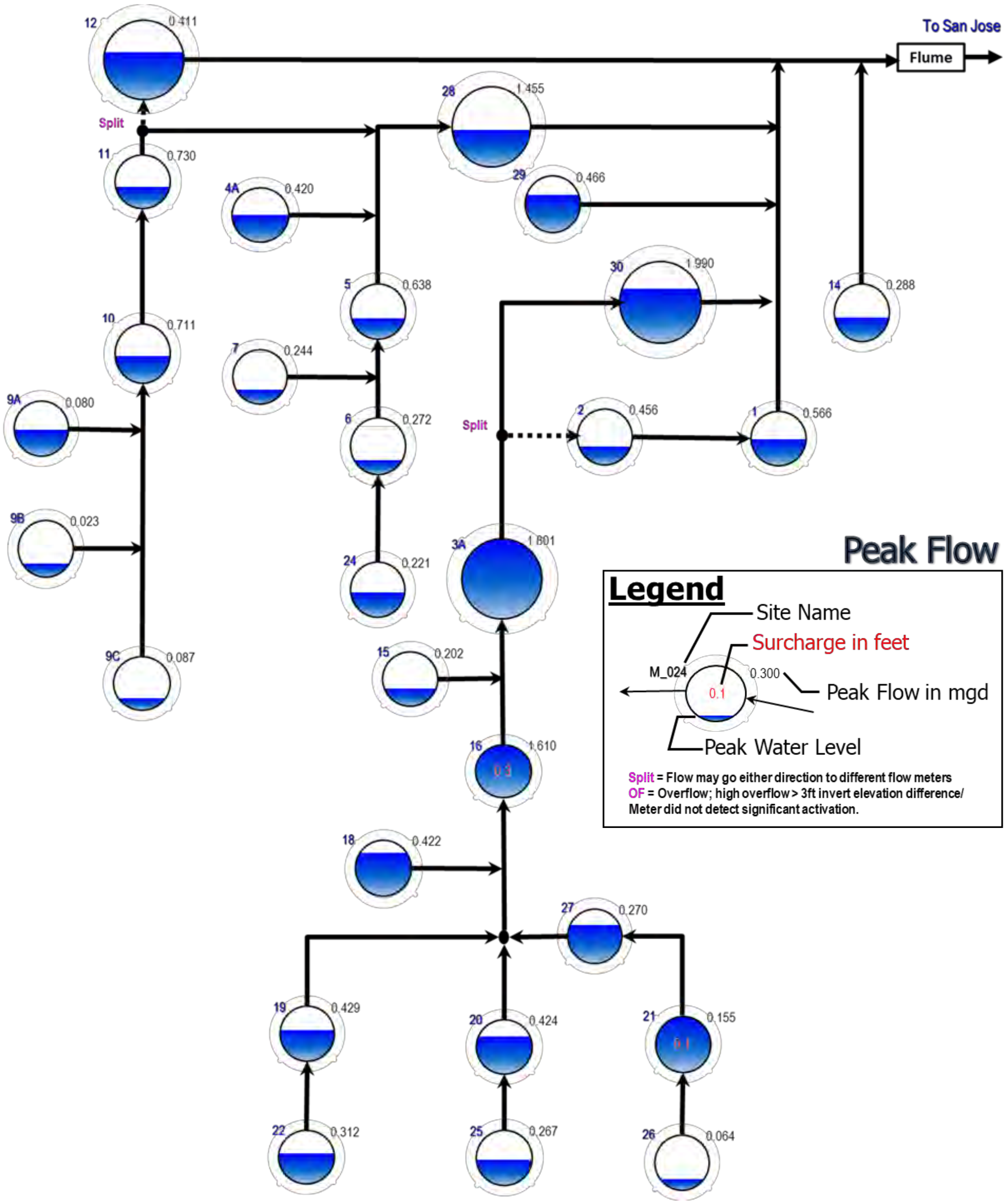


Figure 3-10. Peak Measured Flow (Flow Schematic)

3.3 Inflow and Infiltration

3.3.1 Preface

Even though rain event 1 was the larger rain event, V&A was only able to install flow meters for the priority sites (Sites 4A, 9A, 9B, 9C, 18, 19, 20, 22, 25, and 27) due to the limited time frame. Therefore, I/I analysis are presented for both rain events. For rain event 1, Basin 27 cannot be isolated as Site 21 was not installed. Basin 27+Basin 21+Basin 26 is analyzed as a whole basin for rain event 1. For rain event 2, Site 21 was installed but unbeknownst downstream of a flow split and the inlet often has stagnant flow. The sensor was changed to the northeast 6.5-inch outlet on December 29, 2021. However, there were no rain events after December 29, 2021 to the end of the flow monitoring period, so Site 21 rain response was not captured. Basin 27+Basin 21 is analyzed as a whole basin for rain event 2. Items relevant to the analysis in this study are noted below and referenced in Figure 3-11:

I/I Isolation: The I/I flow rate is the real-time flow less the estimated average dry weather flow rate (shown below as the RED line).

Inflow: Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event. The peak inflow rate is the highest spike in the isolated I/I hydrograph immediately following the evaluated rainfall event.

RDI: RDI is typically taken as the average I/I flow rate measured approximately 24 to 36 hours after the rainfall event has concluded. For this study, the RDI rate used for comparative analysis was measured as the average I/I rate from December 14 at 12:00 noon to December 15, 2021 at 12:00 noon for rain event 1; December 27 at 14:00 to December 29 at 14:00 for rain event 2. Systemwide, flows returned to near-baseline levels within 48 hours.

Combined I/I: the totalized volume (in gallons) of both inflow and RDI over the course of a rainfall event (shown below as the orange area).

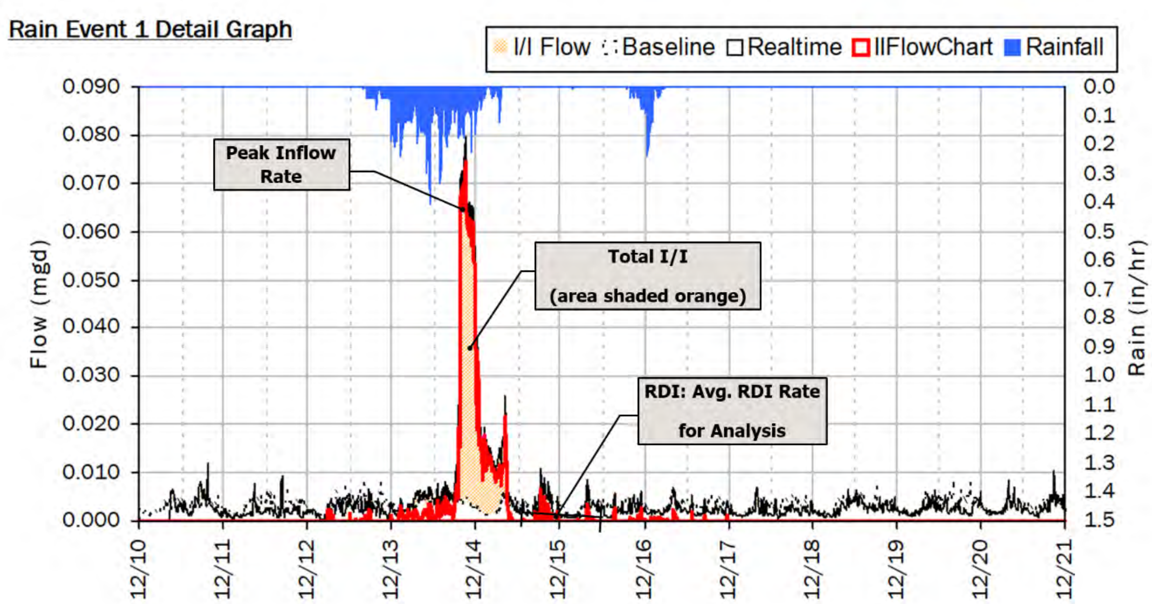


Figure 3-11. I/I Isolation, Site 9A

3.3.2 Inflow Results Summary

Inflow is storm water discharged into the sewer system through direct connections such as downspouts, area drains, cross-connections to catch basins, etc. These sources transport rain water directly into the sewer system and the corresponding flow rates are tied closely to the intensity of the storm. This component of I/I often causes a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows.

For rain event 1, Table 3-6 and Figure 3-12 summarizes the peak measured inflow and inflow analysis results for the relevant flow monitoring basins; the top 3 ranked basins have been shaded RED. shows a temperature map summary of the inflow analysis results per basin. The results for rain event 2 were presented in Table 3-7, Figure 3-14 and Figure 3-15.

The following inflow results are noted:

- **Rain Event 1**:
  - Basins 18, 4A, and 9A had the highest normalized peak I/I rates amongst the 10 basins, an indicator of high inflow within the flow monitoring basins.
- **Rain Event 2**:
  - Basins 4A, 19 and 5 had the highest normalized peak I/I rates, an indicator of high inflow within the flow monitoring basins. Among them, Basins 4A was isolated basins and did not require flow subtraction.
  - Basins 1, 3A, 11, 28 and 30 had negligible (negl.) flows after subtracting the upstream flows.

Attenuation: this inflow analysis accounts for attenuation (see Section 2.7). There were often long lengths of pipes between sites or even pump stations that can help attenuate peak I/I.

Table 3-6. Results and Rankings of Inflow Analysis Based on Rain Event 1

Basins	Basin IDM	Basin Acre	Basin ADWF (mgd)	Inflow Rate (mgd)	Peak I/I per IDM (gpd/IDM)	Peak I/I per Acre (gpd/Acre)	Peak I/I per ADWF Ratio	Final Inflow Ranking
Basin 4A	21.5	76	0.152	0.244	11,340	3,211	1.6	**2**
Basin 9A	17.8	59	0.003	0.074	4,180	1,259	22.5	**3**
Basin 9B	9.2	37	0.002	0.011	1,230	303	4.9	9
Basin 9C	16.5	86	0.042	0.042	2,541	490	1.0	6
Basin 18	41.9	293	0.051	0.359	8,573	1,227	7.0	**1**
Basin 19	85.1	153	0.049	0.006	275	41	0.1	10
Basin 20	68.8	164	0.085	0.076	2,586	463	0.9	7
Basin 22	62.3	587	0.029	0.268	4,296	456	9.2	5
Basin 25	39.4	194	0.042	0.172	4,369	884	4.1	4
Site 27 (Basin 27+21+26)	73.3	368	0.083	0.149	2,035	406	1.8	8
Flume[28]	N/A	N/A	N/A	2.661	N/A	N/A	N/A	N/A

[28] The Flume's inflow rate as a *site* is shown here for reference. The basin rate is not calculated for rain event 1 as there were insufficient upstream sites installed for flow subtraction.

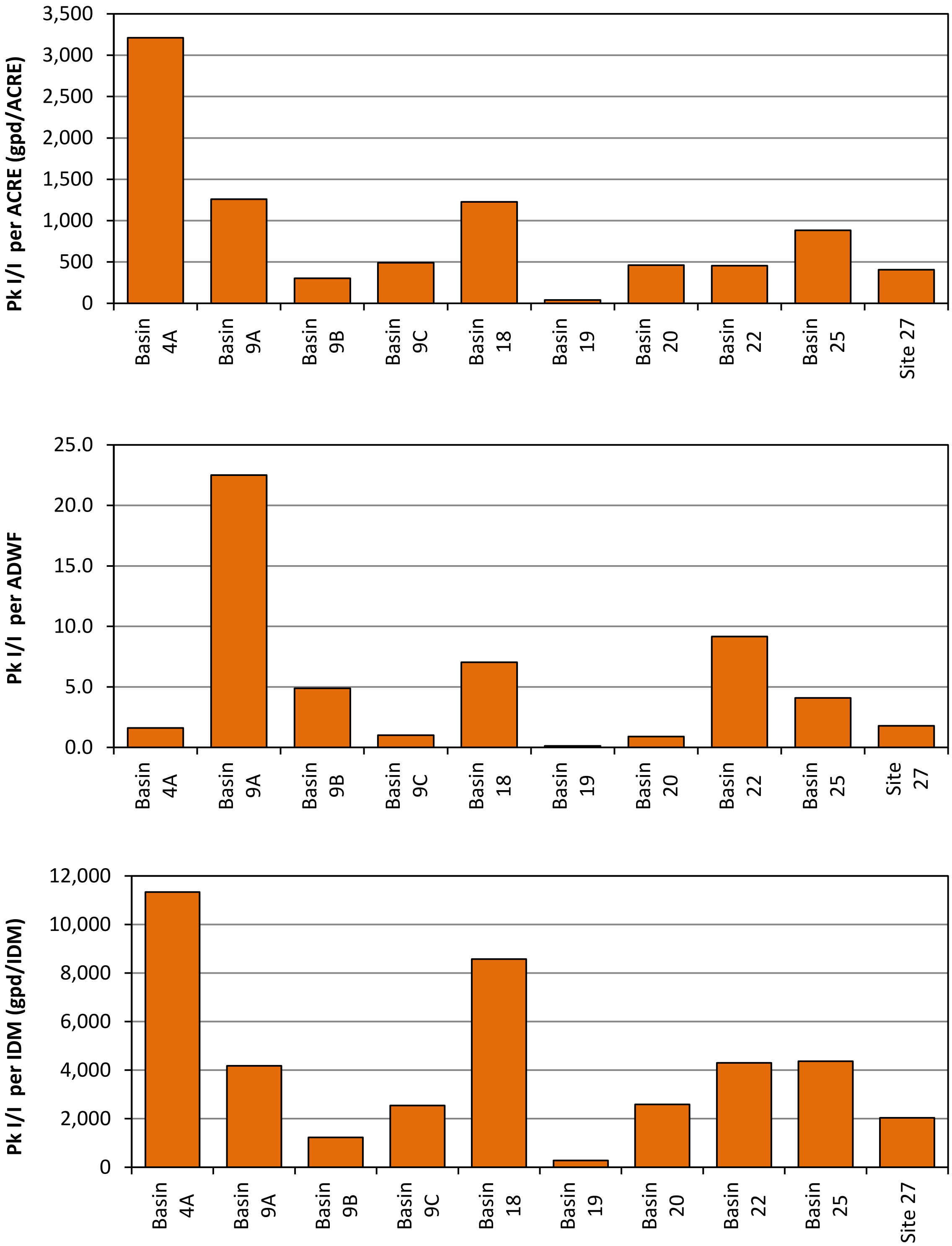


Figure 3-12. Bar Graph: Inflow Summary Based on Rain Event 1

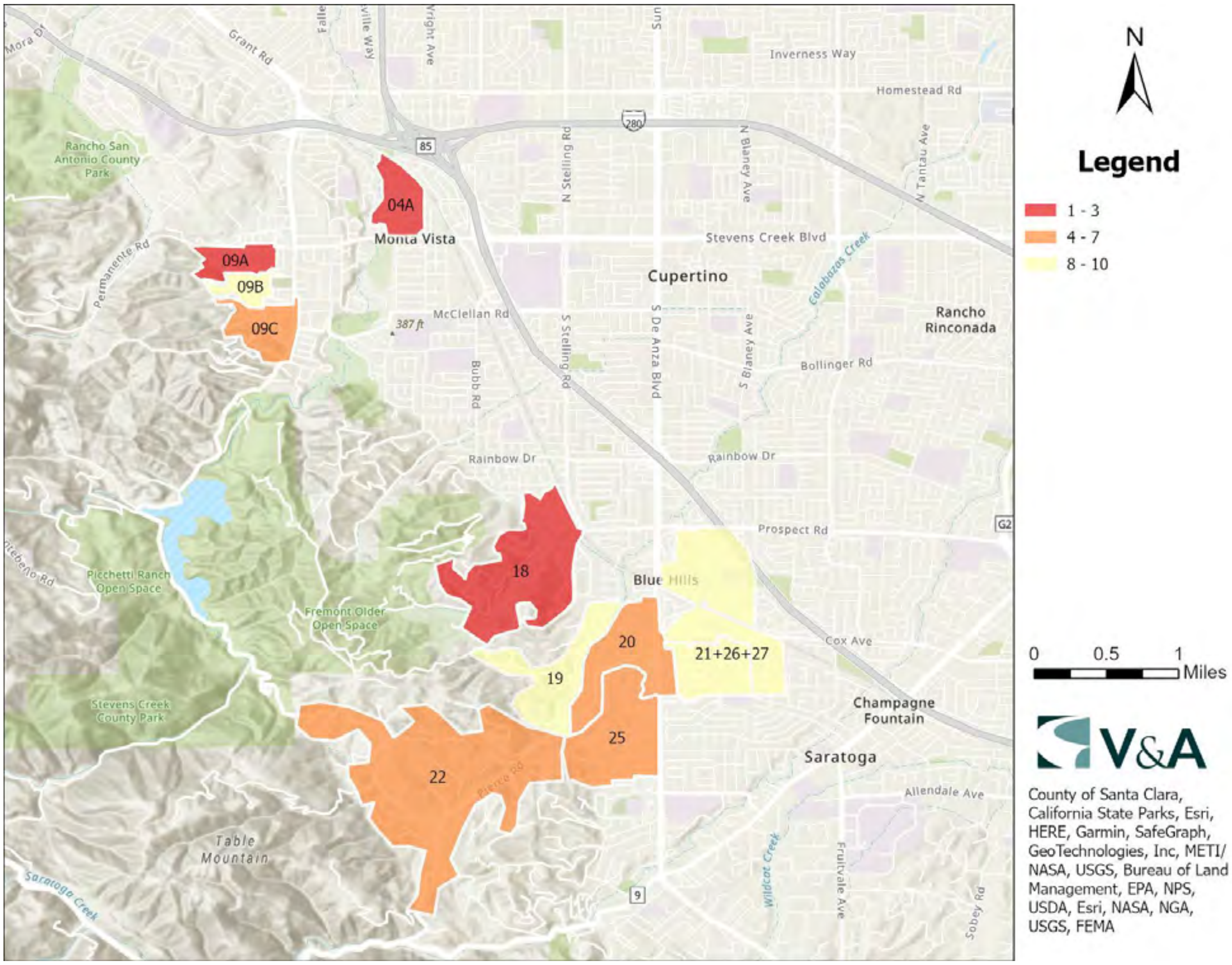


Figure 3-13. Temperature Map: Inflow Final Basin Rankings Based on Rain Event 1

Table 3-7. Results and Rankings of Inflow Analysis Based on Rain Event 2

Basins	Basin IDM	Basin Acre	Basin ADWF (mgd)	Inflow Rate (mgd)	Peak I/I per IDM (gpd/IDM)	Peak I/I per Acre (gpd/Acre)	Peak I/I per ADWF Ratio	Final Inflow Ranking
Basin 1	128.6	464	0.173	Negl.	Negl.	Negl.	Negl.	24
Basin 2	53.6	228	0.137	0.287	5,351	1,259	2.1	8
Basin 3A	35.9	199	0.000	Negl.	Negl.	Negl.	Negl.	24
Basin 4A	21.5	76	0.152	0.302	14,030	3,973	2.0	1
Basin 5	14.3	37	0.088	0.104	7,260	2,822	1.2	3
Basin 6	17.5	101	0.026	0.004	256	44	0.2	22
Basin 7	34.9	185	0.093	0.055	1,579	298	0.6	20
Basin 9A	17.8	59	0.003	0.018	1,022	308	5.5	13
Basin 9B	9.2	37	0.002	0.010	1,066	263	4.2	14
Basin 9C	16.5	86	0.042	0.034	2,069	399	0.8	18
Basin 10	53.7	200	0.216	0.317	5,915	1,591	1.5	4
Basin 11	37.4	314	0.073	Negl.	Negl.	Negl.	Negl.	24
Basin 12	37.5	165	0.138	0.214	5,704	1,296	1.5	7
Basin 14	11.7	94	0.090	0.116	9,909	1,232	1.3	4
Basin 15	30.2	128	0.057	0.125	4,138	972	2.2	10
Basin 16	106.6	294	0.233	0.020	190	69	0.1	23
Basin 18	41.9	293	0.051	0.193	4,593	657	3.8	9
Basin 19	22.8	153	0.049	0.163	7,157	1,067	3.4	2
Basin 20	29.4	164	0.085	0.069	2,351	421	0.8	17
Basin 21	17.3	104	0.039	Not avail.	Not avail.	Not avail.	Not avail.	Not avail.
Basin 22	62.3	587	0.029	0.160	2,576	273	5.5	12
Basin 24	68.4	339	0.097	0.114	1,661	335	1.2	19
Basin 25	39.4	195	0.042	0.186	4,723	956	4.4	6
Basin 26	21.5	101	0.021	0.021	980	209	1.0	21
Basin 27 + Basin 21	51.8	267	0.062	0.153	2,965	576	2.5	11
Basin 28	55.7	231.75	0.043	Negl.	Negl.	Negl.	Negl.	24
Basin 29	48.6	260	0.213	0.122	2,516	471	0.6	15
Basin 30	122.6	502	0.309	Negl.	Negl.	Negl.	Negl.	25
Flume	199.2	231.75	1.059	0.486	2,438	603	0.5	16

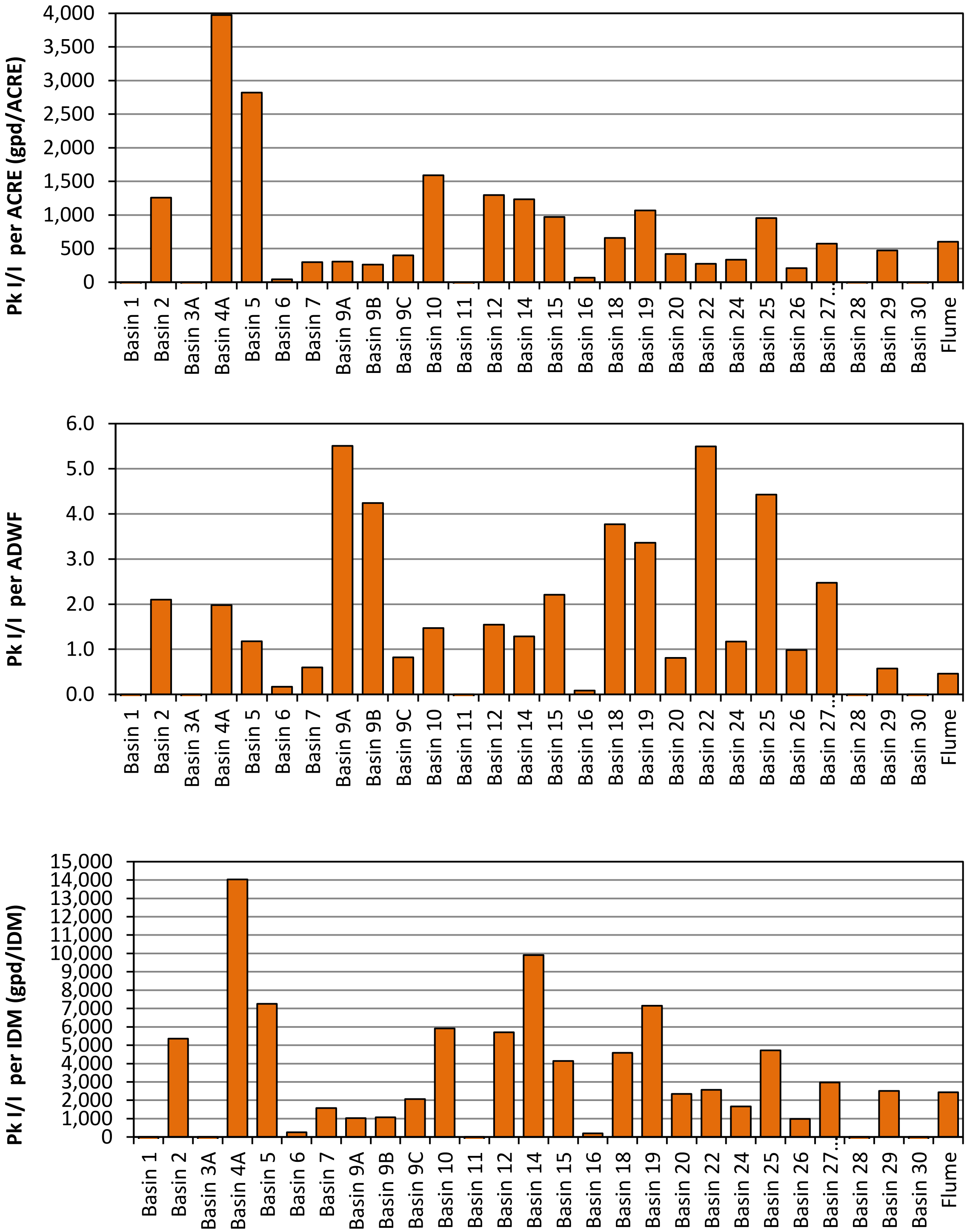


Figure 3-14. Bar Graph: Inflow Summary Based on Rain Event 2

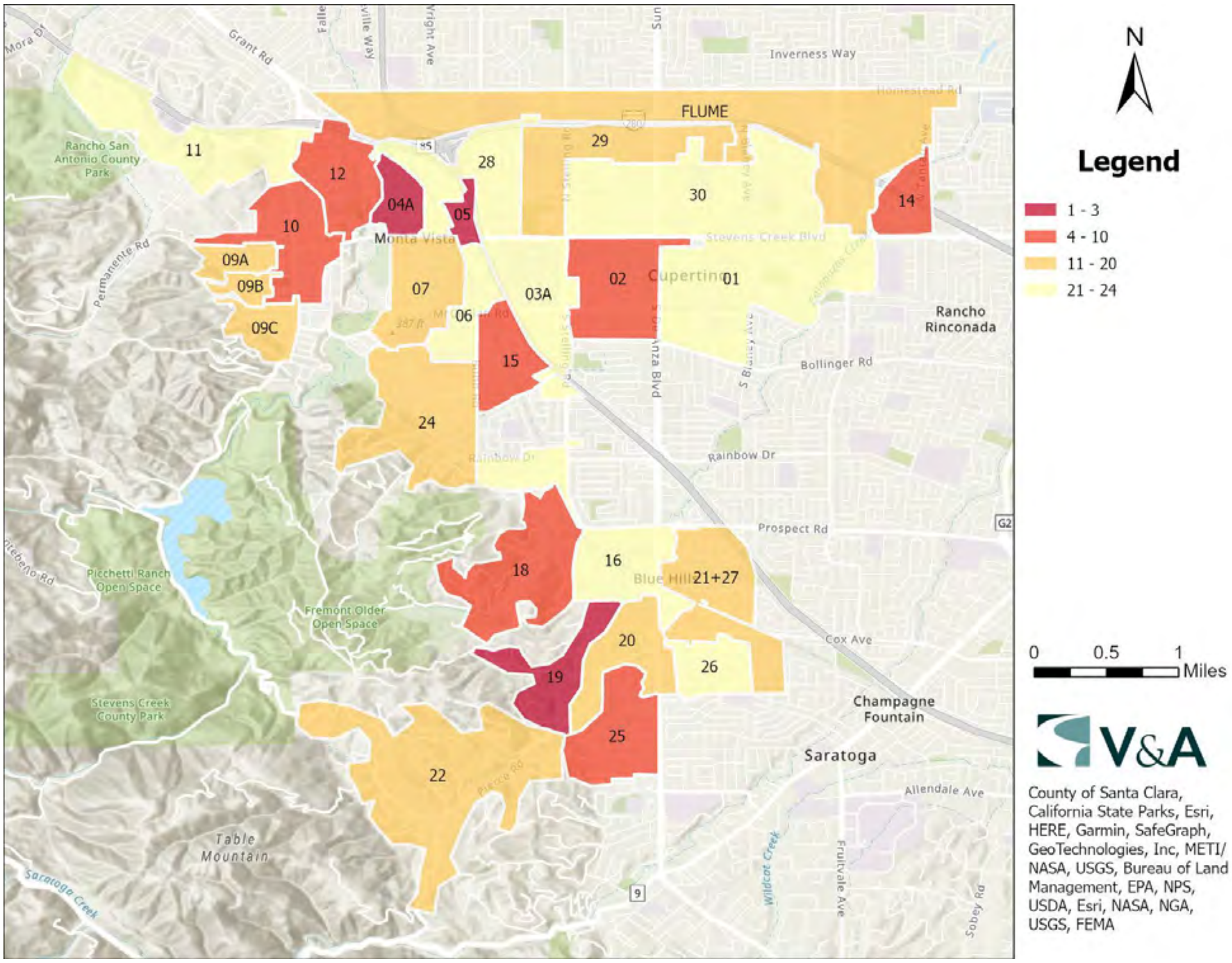


Figure 3-15. Temperature Map: Inflow Final Basin Rankings Based on Rain Event 2

3.3.3 Rainfall Dependent Infiltration Results Summary

Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes. Increased flows into the sanitary sewer system are usually tied to groundwater levels and soil saturation levels. Infiltration sources transport rain water into the system indirectly; flow levels in the sanitary system increase gradually, are typically sustained for a period after rainfall has stopped, and then gradually decrease as soils become less saturated and as groundwater levels recede to normal.

Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).

For rain event 1, Table 3-8 and Figure 3-16 summarize the captured RDI flow rates. The "Top 3" basins for each category have been shaded in RED. Figure 3-17 shows a temperature map. The results for rain event 2 were presented in Table 3-9, Figure 3-18 and Figure 3-19. The following RDI results are noted:

- **Rain Event 1**:
  - Basins 20, 22, and 4A had the highest normalized RDI rates amongst the 10 basins, an indicator of high infiltration within the flow monitoring basins.
  - Basins 9A and 9B showed negligible amount of RDI and were isolated basins. Basin 19 had negligible response after subtracting the upstream flows.
- **Rain Event 2**:
  - Basins 19, 12, 11, and 25 had the highest normalized RDI rates, an indicator of high infiltration within the flow monitoring basins.
  - Basins 7, 9B, 18, and 29 showed negligible amount of RDI and were isolated basins. Basins 3A, 5, 21, 28, and 30 had negligible response after subtracting the upstream flows.

Table 3-8. Results and Rankings of RDI Analysis Based on Rain Event 1

Basins	Basin IDM	Basin Acre	ADWF (mgd)	RDI Rate (mgd)	RDI per IDM (gpd/IDM)	RDI per Acre (gpd/Acre)	RDI per ADWF Ratio	Final RDI Ranking
Basin 4A	21.5	76	0.152	0.011	489	139	0.07	3
Basin 9A	17.8	59	0.003	Negl.	Negl.	Negl.	Negl.	8
Basin 9B	9.2	37	0.002	Negl.	Negl.	Negl.	Negl.	8
Basin 9C	16.5	86	0.042	0.008	487	94	0.19	4
Basin 18	41.9	293	0.051	0.014	335	48	0.27	5
Basin 19	85.1	153	0.049	Negl.	Negl.	Negl.	Negl.	8
Basin 20	68.8	164	0.085	0.024	804	144	0.28	1
Basin 22	62.3	587	0.029	0.040	637	68	1.36	2
Basin 25	39.4	194	0.042	0.010	246	50	0.23	6
Site 27 (Basin 27+21+26)	73.3	368	0.083	0.001	16	3	0.02	7
Flume [29]	N/A	N/A	N/A	0.492	N/A	N/A	N/A	N/A

[29] The Flume's RDI rate as a *site* is shown here for reference. The basin rate is not calculated for rain event 1 as there were insufficient upstream sites installed for flow subtraction.

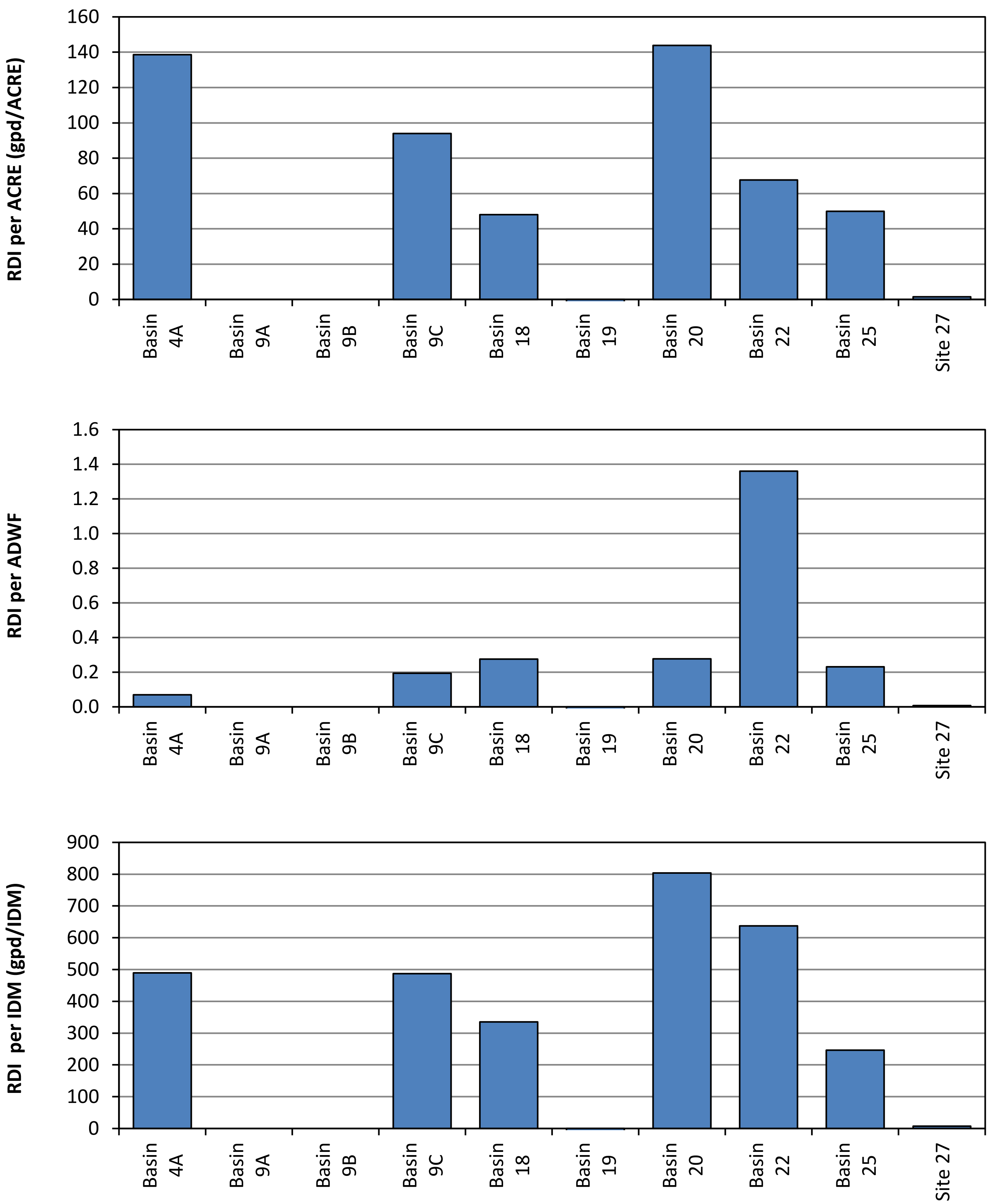


Figure 3-16. Bar Graphs: RDI Analysis Summary Based on Rain Event 1

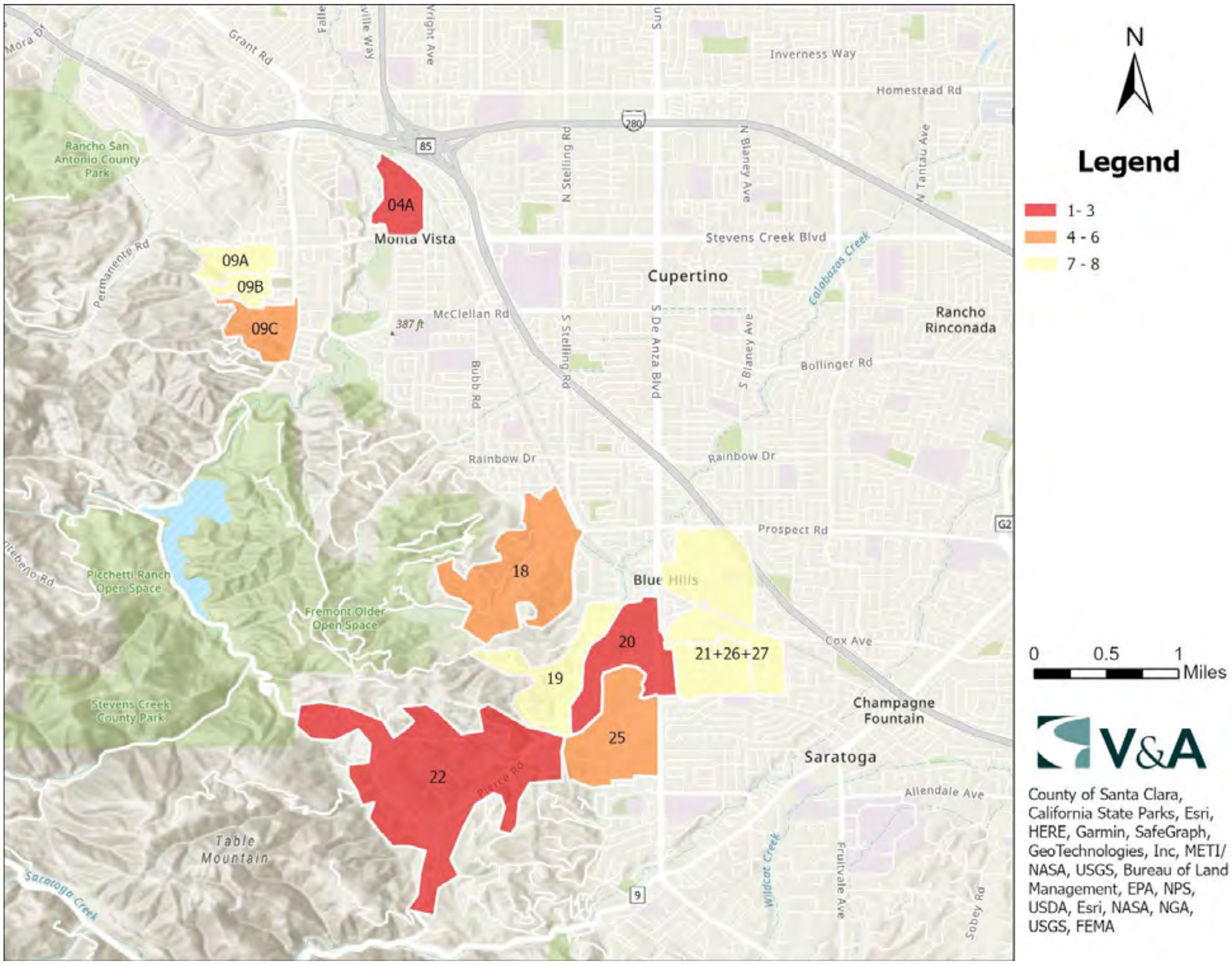


Figure 3-17. Temperature Map: RDI Final Basin Rankings Based on Rain Event 1

Table 3-9. Results and Rankings of RDI Analysis Based on Rain Event 2

Basins	Basin IDM	Basin Acre	Basin ADWF (mgd)	RDI Rate (mgd)	RDI per IDM (gpd/IDM)	RDI per Acre (gpd/Acre)	RDI per ADWF Ratio	Final RDI Ranking
Basin 1	128.6	464	0.173	0.018	140	39	0.1	14
Basin 2	53.6	228	0.137	0.004	72	17	0.0	19
Basin 3A	35.9	199	0.000	Negl.	Negl.	Negl.	Negl.	21
Basin 4A	21.5	76	0.152	0.005	226	64	0.0	15
Basin 5	14.3	37	0.088	Negl.	Negl.	Negl.	Negl.	21
Basin 6	17.5	101	0.026	0.010	571	99	0.4	8
Basin 7	34.9	185	0.093	Negl.	Negl.	Negl.	Negl.	21
Basin 9A	17.8	59	0.003	0.002	92	28	0.5	13
Basin 9B	9.2	37	0.002	Negl.	Negl.	Negl.	Negl.	21
Basin 9C	16.5	86	0.042	0.002	107	21	0.0	17
Basin 10	53.7	200	0.216	0.031	569	153	0.1	9
Basin 11	37.4	314	0.073	0.036	961	114	0.5	3
Basin 12	37.5	165	0.138	0.048	1282	291	0.3	2
Basin 14	11.7	94	0.090	0.004	343	43	0.0	11
Basin 15	30.2	128	0.057	0.024	790	186	0.4	5
Basin 16	106.6	294	0.233	0.005	49	18	0.0	20
Basin 18	41.9	293	0.051	Negl.	Negl.	Negl.	Negl.	21
Basin 19	22.8	153	0.049	0.039	1698	253	0.8	1
Basin 20	29.4	164	0.085	0.025	856	153	0.3	6
Basin 21	17.3	104	0.039	Not avail.	Not avail.	Not avail.	Not avail.	Not avail.
Basin 22	62.3	587	0.029	0.029	465	49	1.0	7
Basin 24	68.4	339	0.097	0.012	177	36	0.1	12
Basin 25	39.4	195	0.042	0.030	770	156	0.7	3
Basin 26	21.5	101	0.021	0.001	47	10	0.0	18
Basin 27 + Basin 21	51.8	267	0.062	0.006	107	21	0.1	16
Basin 28	55.7	231.75	0.043	Negl.	Negl.	Negl.	Negl.	21
Basin 29	48.6	260	0.213	Negl.	Negl.	Negl.	Negl.	21
Basin 30	122.6	502	0.309	Negl.	Negl.	Negl.	Negl.	21
Flume	199.2	231.75	1.059	0.061	307	76	0.1	10

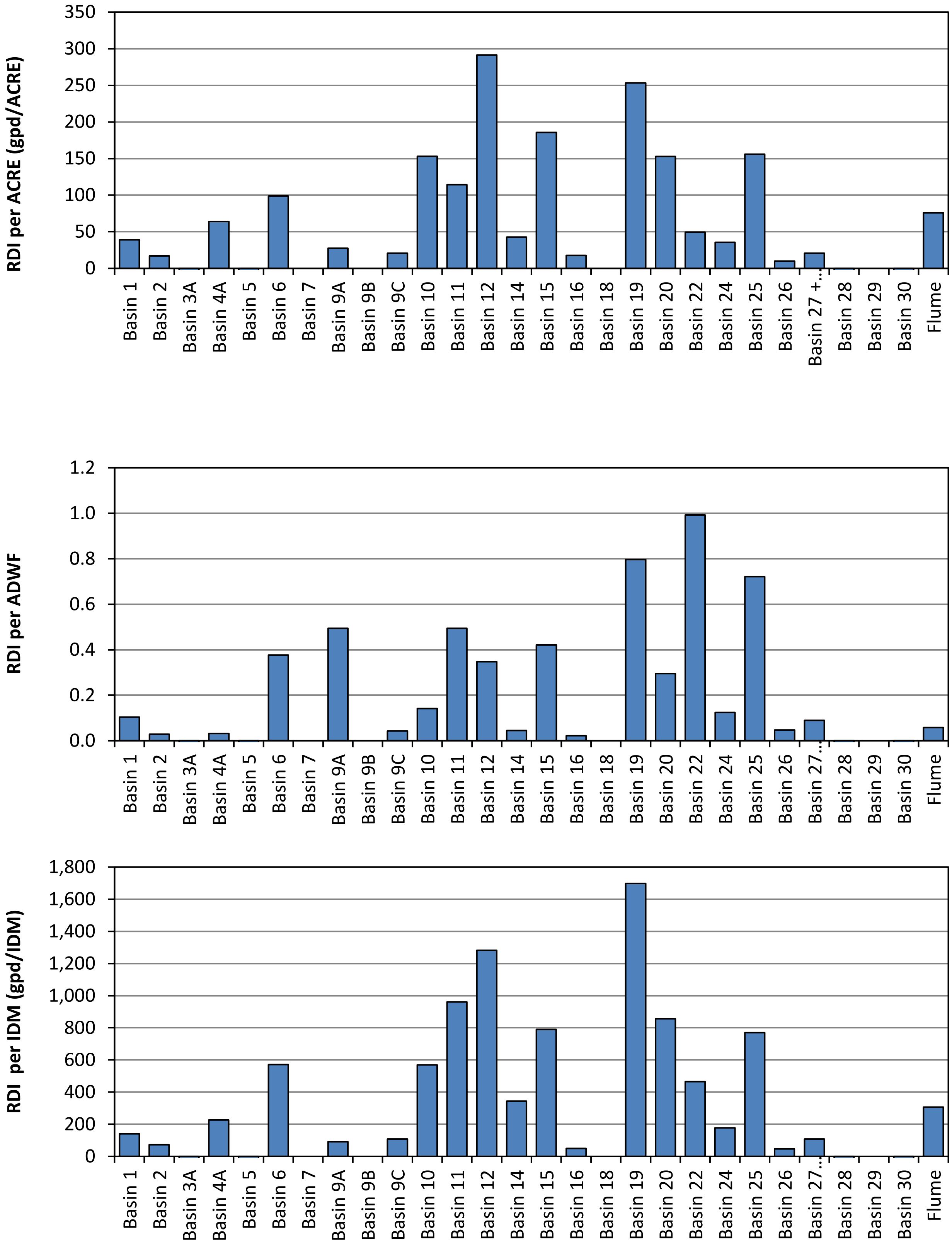


Figure 3-18. Bar Graphs: RDI Analysis Summary Based on Rain Event 2

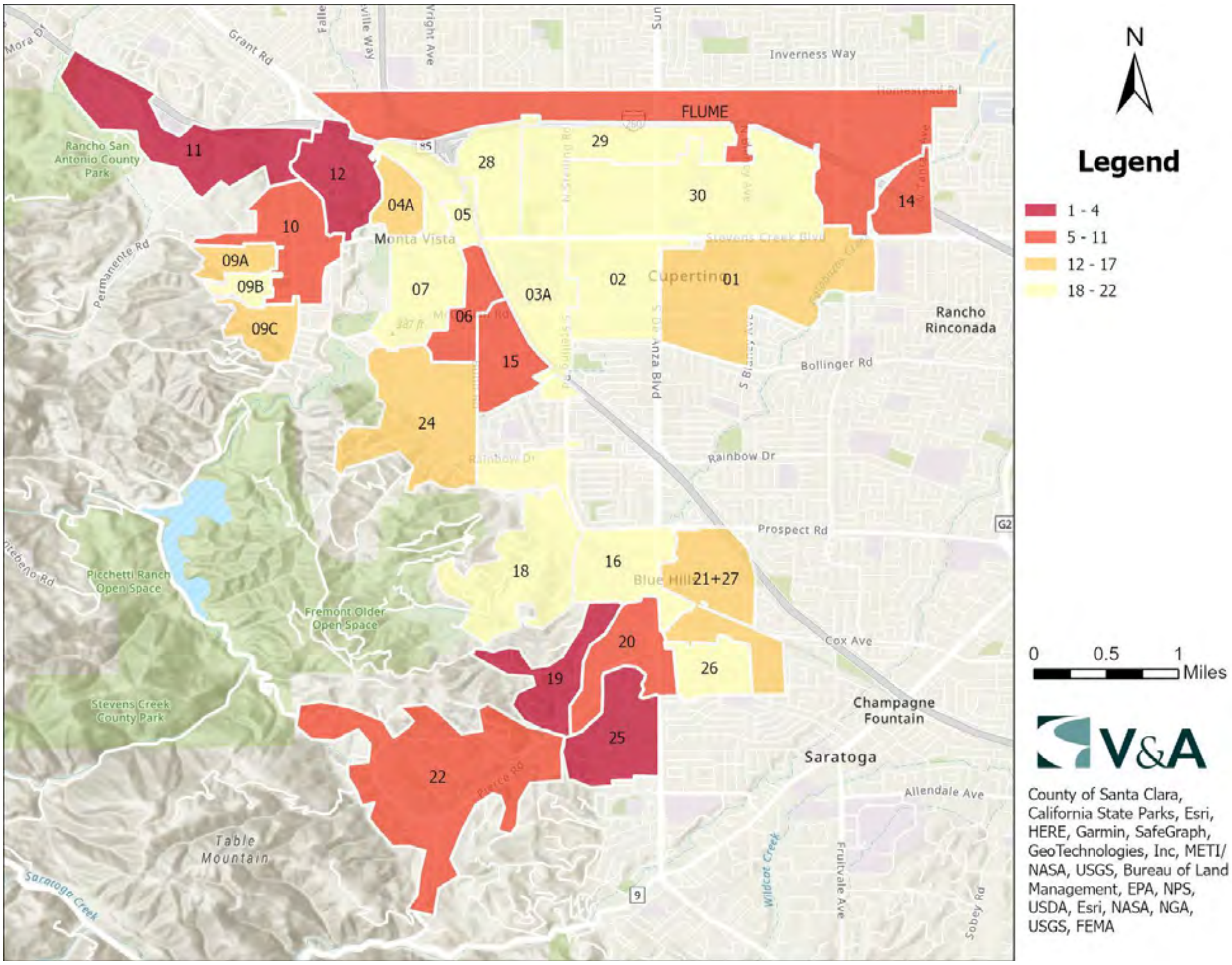


Figure 3-19. Temperature Map: RDI Final Basin Rankings Based on Rain Event 2

3.3.4 Combined I/I Results Summary

Combined I/I analysis considers the totalized volume (in gallons) of both inflow and rainfall-dependent infiltration over the course of a storm event.

For rain event 1, Table 3-10 and Figure 3-20 summarize the captured RDI flow rates. The "Top 3" basins for each category have been shaded in RED. Figure 3-21 shows a temperature map. The results for rain event 2 were presented in Table 3-11, Figure 3-22 and Figure 3-23.

The following total I/I results are noted:

- Rain Event 1:
  - Basins 4A, 22 and 18 had the highest normalized combined I/I rates, an indicator of high infiltration within the flow monitoring basins.
  - Basin 9B showed negligible amount of combined I/I and was an isolated basin. Basin 19 had negligible response after subtracting the upstream flows.
- Rain Event 2:
  - Basins 12, 5 and 15 had the highest normalized combined I/I rates, an indicator of high infiltration within the flow monitoring basins.
  - Basins 26 and 29 showed negligible amount of combined I/I and were an isolated basin. Basins 3A, 28, and 30 had negligible amount of combined I/I after subtracting the upstream flows.

Table 3-10. Combined I/I Analysis Summary (Event 1)

Basins	Basin IDM	Basin Acre	ADWF (mgd)	Combined I/I (mgd)	Combined I/I per IDM (gpd/IDM)	Combined I/I per Acre (R-Value)	Combined I/I per ADWF Ratio	Final Combined I/I Ranking
Basin 4A	21.5	76	0.152	101730	1277	1.3%	0.18	1
Basin 9A	17.8	59	0.003	14865	234	0.3%	1.26	6
Basin 9B	9.2	37	0.002	Negl.	Negl.	Negl.	Negl.	9
Basin 9C	16.5	86	0.042	38697	571	0.4%	0.23	5
Basin 18	41.9	293	0.051	203663	897	0.5%	0.74	3
Basin 19	85.1	153	0.049	Negl.	Negl.	Negl.	Negl.	9
Basin 20	68.8	164	0.085	70773	503	0.3%	0.17	7
Basin 22	62.3	587	0.029	345364	976	0.4%	2.08	2
Basin 25	39.4	194	0.042	141063	729	0.5%	0.68	4
Site 27 (Basin 27+21+26)	73.3	368	0.083	42118	279	0.2%	0.41	8
Flume [30]	N/A	806.33	N/A	4,033,892	N/A	N/A	N/A	N/A

[30] The Flume's combined I/I rate as a *site* is shown here for reference. The basin rate is not calculated for rain event 1 as there were insufficient upstream sites installed for flow subtraction.

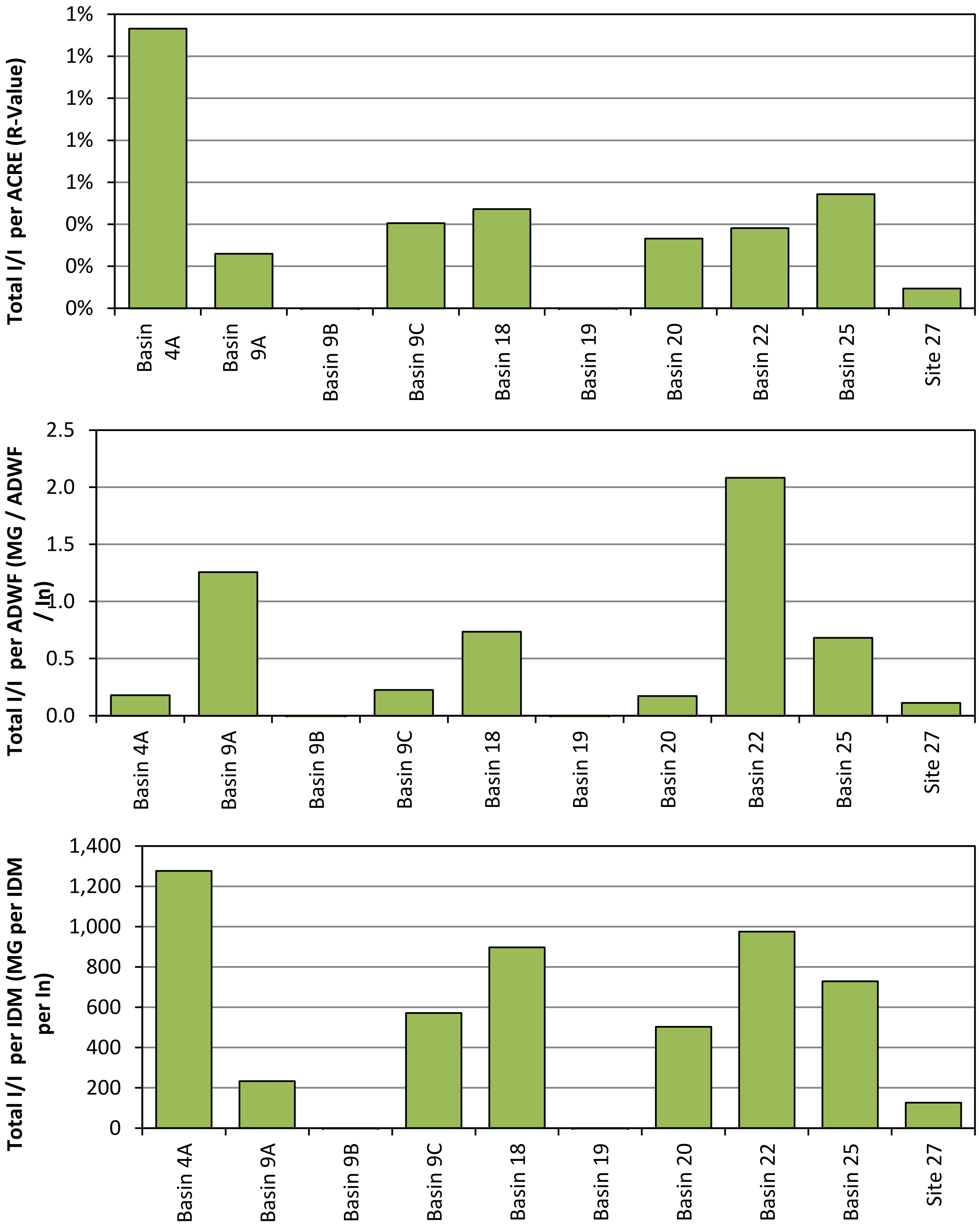


Figure 3-20. Bar Graphs: Combined I/I Analysis Summary Based on Rain Event 1

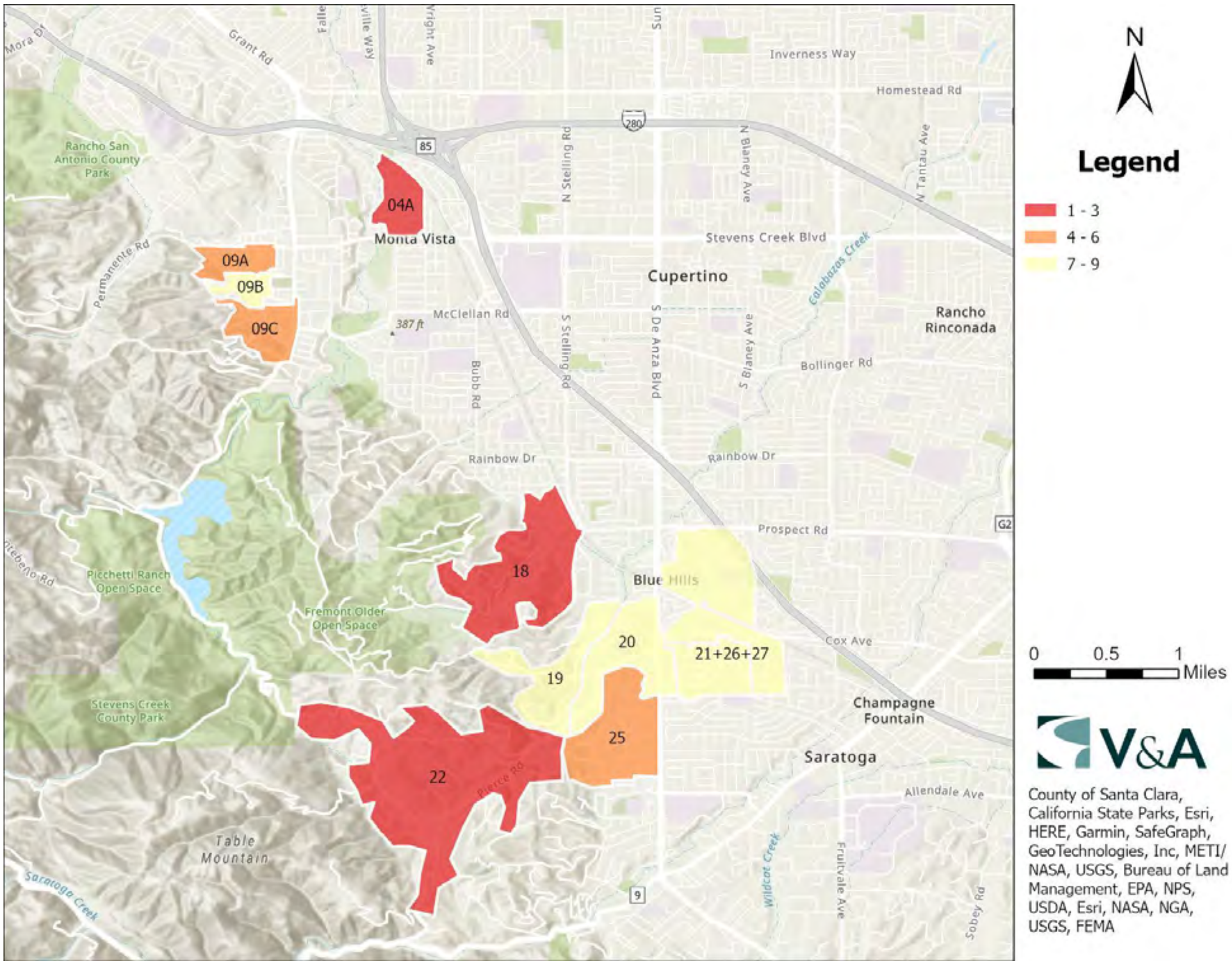


Figure 3-21. Temperature Map: Combined I/I Final Basin Rankings Based on Rain Event 1

Table 3-11. Combined I/I Analysis Summary (Event 2)

Basins	Basin IDM	Basin Acre	Basin ADWF (mgd)	Combined I/I (mgd)	Combined I/I per IDM (gpd/IDM)	Combined I/I per Acre (R-Value)	Combined I/I per ADWF Ratio	Final Combined I/I Ranking
Basin 1	128.6	464	0.173	119,849	279	0.3%	0.21	20
Basin 2	53.6	228	0.137	112,556	677	0.6%	0.27	14
Basin 3A	35.9	199	0.000	Negl.	Negl.	Negl.	Negl.	25
Basin 4A	21.5	76	0.152	141,727	1773	1.8%	0.25	10
Basin 5	14.3	37	0.088	190,903	3737	5.3%	0.61	2
Basin 6	17.5	101	0.026	7,862	117	0.1%	0.08	23
Basin 7	34.9	185	0.093	17,598	126	0.1%	0.05	22
Basin 9A	17.8	59	0.003	10,497	169	0.2%	0.91	17
Basin 9B	9.2	37	0.002	5,364	150	0.1%	0.60	19
Basin 9C	16.5	86	0.042	16,563	212	0.2%	0.08	21
Basin 10	53.7	200	0.216	456,883	2285	2.3%	0.57	6
Basin 11	37.4	314	0.073	101,109	774	0.3%	0.40	12
Basin 12	37.5	165	0.138	521,867	3791	3.2%	1.03	1
Basin 14	11.7	94	0.090	30,947	839	0.4%	0.11	15
Basin 15	30.2	128	0.057	301,640	2623	2.3%	1.40	3
Basin 16	106.6	294	0.233	288,863	675	0.9%	0.31	11
Basin 18	41.9	293	0.051	100,874	556	0.3%	0.46	16
Basin 19	22.8	153	0.049	336,132	3466	1.9%	1.63	4
Basin 20	29.4	164	0.085	260,821	2118	1.4%	0.73	7
Basin 21	17.3	104	0.039	Not avail.	Not avail.	Not avail.	Not avail.	Not avail.
Basin 22	62.3	587	0.029	358,892	1325	0.5%	2.83	9
Basin 24	68.4	339	0.097	168,311	575	0.4%	0.41	12
Basin 25	39.4	195	0.042	317,640	1926	1.4%	1.81	5
Basin 26	21.5	101	0.021	Negl.	Negl.	Negl.	Negl.	25
Basin 27 + Basin 21	51.8	267	0.062	97,522	473	0.3%	0.39	18
Basin 28	55.7	231.75	0.043	Negl.	Negl.	Negl.	Negl.	25
Basin 29	48.6	260	0.213	Negl.	Negl.	Negl.	Negl.	25
Basin 30	122.6	502	0.309	Negl.	Negl.	Negl.	Negl.	25
Flume	199.2	231.75	1.059	1,276,902	2127	1.9%	0.40	8

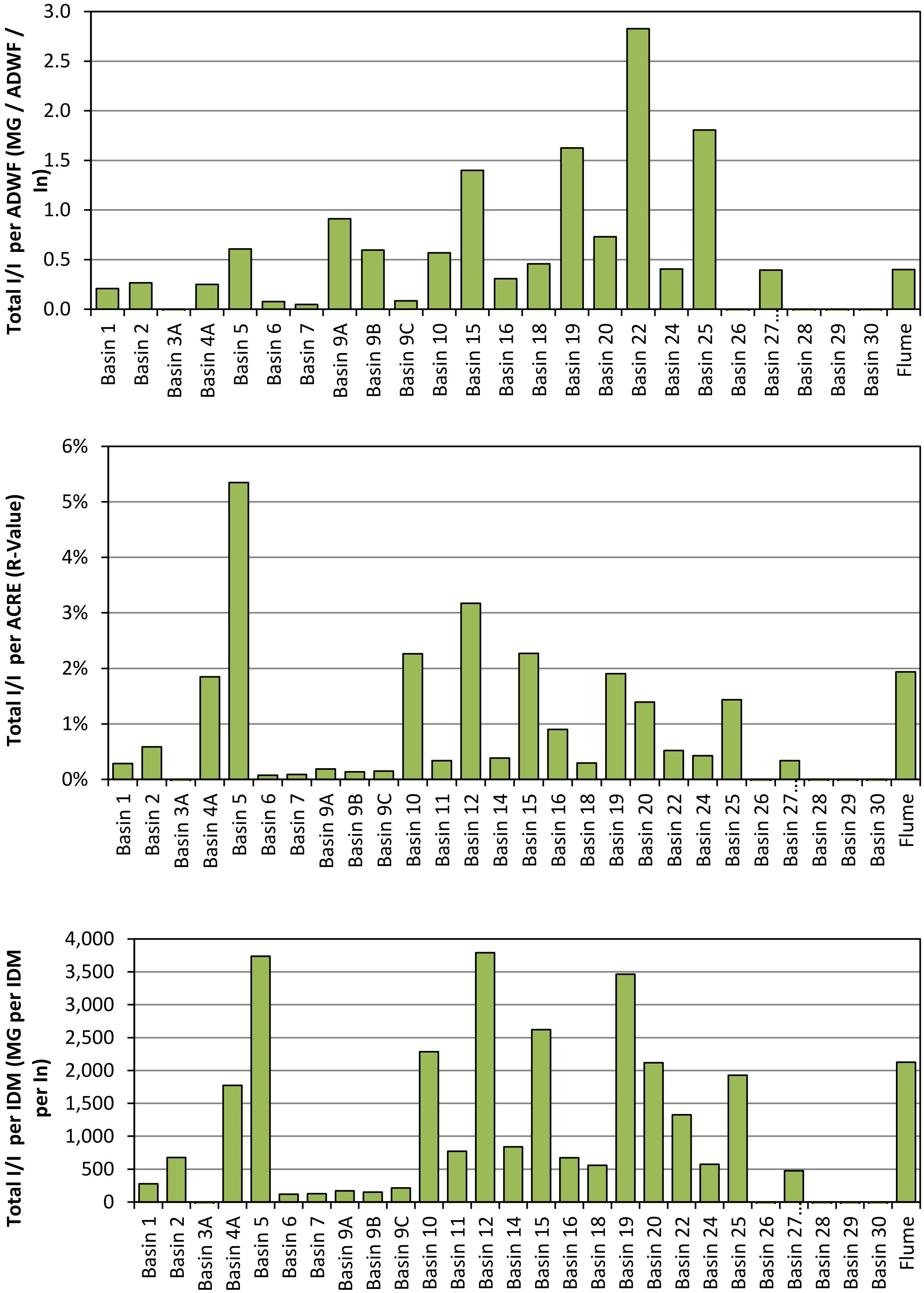


Figure 3-22. Bar Graphs: Combined I/I Analysis Summary Based on Rain Event 2

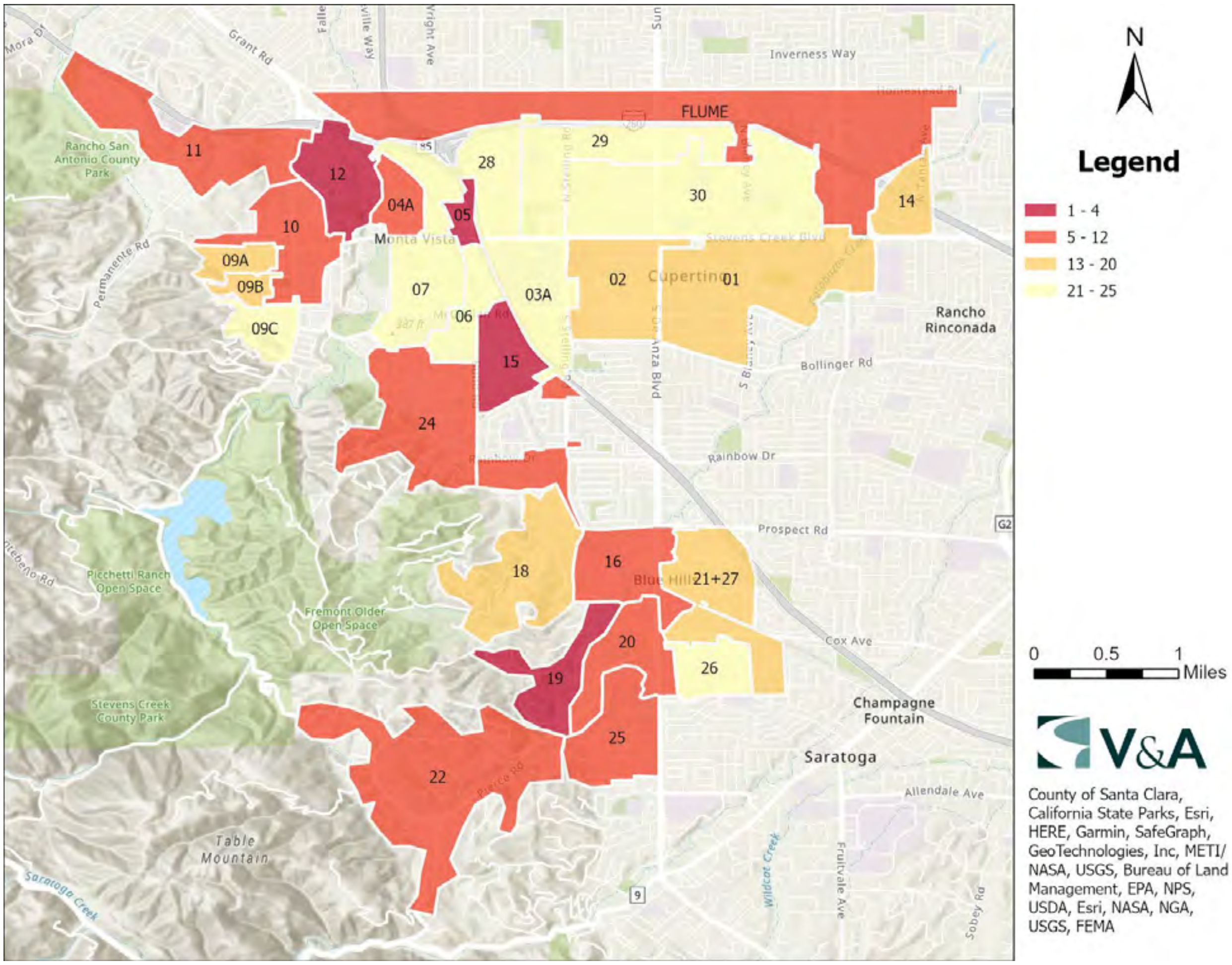


Figure 3-23. Temperature Map: Combined I/I Final Basin Rankings Based on Rain Event 2

3.3.5 Groundwater Infiltration Results Summary

Dry weather (ADWF) flow can be expected to have a predictable diurnal flow pattern. While each site is unique, experience has shown that, given a reasonable volume of flow and typical loading conditions, the daily flows fall into a predictable range when compared to the daily average flow. If a site has a large percentage of groundwater infiltration occurring during the periods of dry weather flow measurement, the amplitudes of the peak and low flows will be dampened[31]. Figure 3-24 shows a sample of two flow monitoring sites, both with nearly the same average daily flow, but with considerably different peak and low flows. In this *sample* case, Site B1 may have a considerable volume of groundwater infiltration.

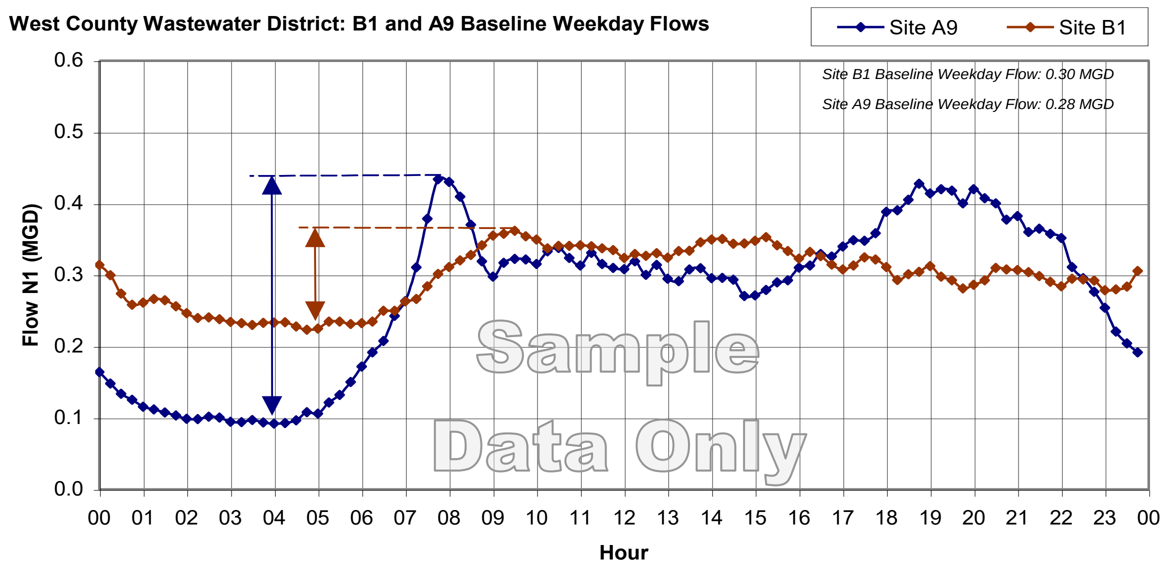


Figure 3-24. Groundwater Infiltration Sample Figure

It can be useful to compare the low-to-ADWF flow ratios for the flow monitoring sites. A site with abnormal ratios, and with no other reasons to suspect abnormal flow patterns (such as proximity to a pump station, treatment facilities, etc.), has a possibility of higher levels of groundwater infiltration in comparison to the rest of the collection system.

Figure 3-25 plots the low-to-ADWF flow ratios[32] against the ADWF flows for the relevant flow monitoring sites. The brown dashed line shows "typical" low-to-ADWF ratios per the Water Environment Federation (WEF). Figure 3-26 shows a color-coded map of the basins with rates of groundwater infiltration considerably above typical groundwater infiltration standards (as set forth by WEF).

[31] In an extreme case, perhaps 0.2 mgd of ADWF flow and 2.0 mgd of groundwater infiltration, the peaks and lows would be barely recognizable; the ADWF flow would be nearly a straight line.
[32] The Minimum to Average flow ratio is calculated by taking the minimum flow and dividing by the ADWF value (using the Mon-Thu ADWF curve).

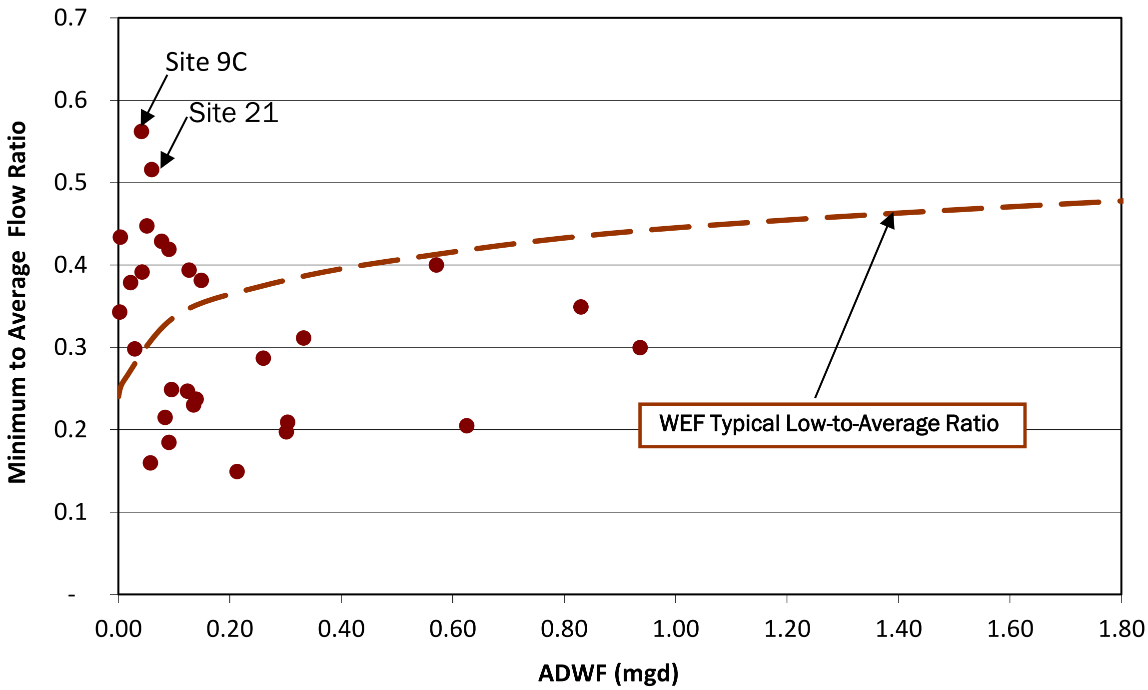


Figure 3-25. Minimum Flow Ratios vs ADWF[33]

The following GWI results are noted:

- Basins 9C and 21 had GWI rates higher-than typical standards

[33] Due to attenuation, it should be expected that sites with larger flow volumes should not have quite the peak-to-average and low-to-average flow ratios as sites with lesser flow volumes. This is why the WEF typical trend line's slope is closer to 1.0 as the ADWF increases, as shown in the figure.

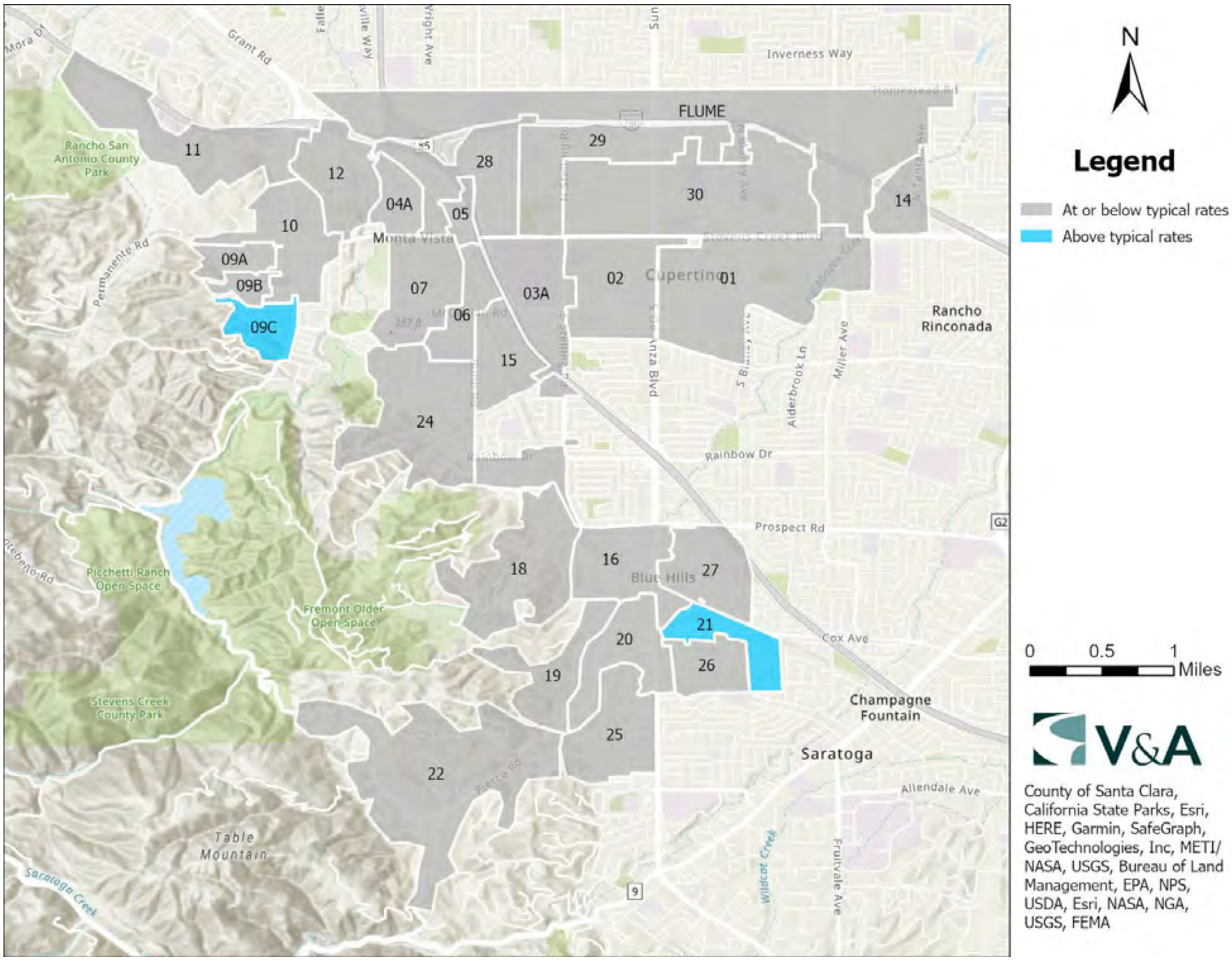


Figure 3-26. Basins with Groundwater Infiltration

3.4 Model Design Storm Results

3.4.1 Synthetic I/I Hydrograph Development

In order to model the I/I response to the provided rainfall event, synthetic hydrographs were developed to approximate the actual RDI hydrograph shape in terms of the time to the peak and the recession coefficient. The actual RDI hydrograph was best matched with a synthetic hydrograph by separating the synthetic hydrograph into seven volume components (R1 through R7). The seven components represent different response times to the rainfall event and, therefore, different infiltration or inflow paths into the sewer system. R1 is characterized by a short response time (inflow) and R7 represents slower response and longer recession times (RDI). Levels of soil saturation are also considered. Using synthetic hydrograph analysis, appropriate time and recession parameters were estimated by a trial-and-error procedure until a good match was obtained. For example, the hydrograph and its component hydrographs for rain event 2, for Site 22 are shown in Figure 3-27.

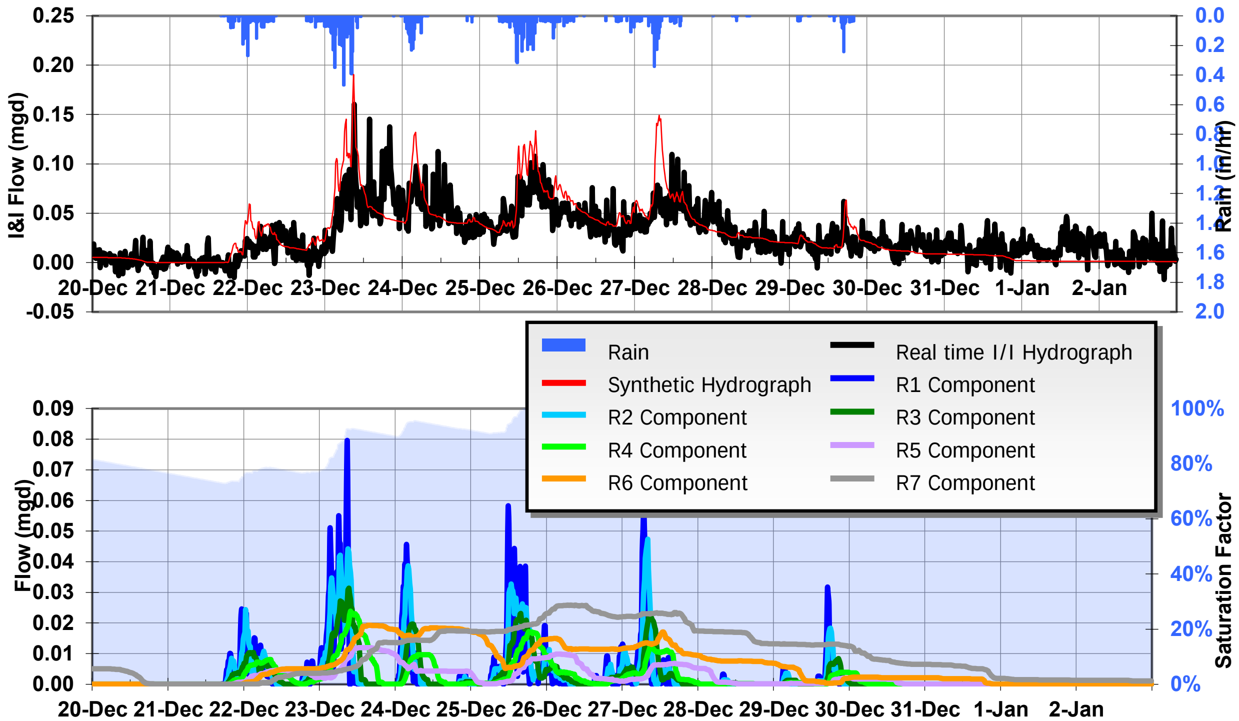


Figure 3-27. Synthetic Hydrograph Development (Site 22)

3.4.2 Design Storm Development

With the I/I response modeled by a synthetic hydrograph, design storms can be applied. This serves two functions: (a) predicted flows are based on the same storm event and are therefore normalized to each other, making for easier and better comparisons, and (b) the resulting I/I flows can be predicted for a design storm event. This helps to calibrate modeling efforts that will determine if the collection system has adequate capacity to handle very large storm events.

V&A used a 10-year, 24-hour design storm for this analysis. Storm events were taken from the NOAA Precipitation-Frequency Atlas of the Western United States. For example, Figure 3-28 summarizes the design storm magnitude and profile at Site 22. The 10-year, 24-hour design storm was developed for each flow monitoring site by taking the design storm for each rain gauge location and using the inverse distance weighting (IDW) method. This particular profile distribution also fits the NOAA criterion for 2-hour and 6-hour durations, in addition to the 24-hour duration.

10-Year, 24-hour Design Storm	
Hour	Inches of Rain
1	0.010
2	0.025
3	0.252
4	0.151
5	0.050
6	0.015
7	0.217
8	0.124
9	0.174
10	0.062
11	0.031
12	0.012
13	0.128
14	0.358
15	0.043
16	0.223
17	0.223
18	0.534
19	0.991
20	0.446
21	0.223
22	0.102
23	0.170
24	0.051
Total:	**4.62**

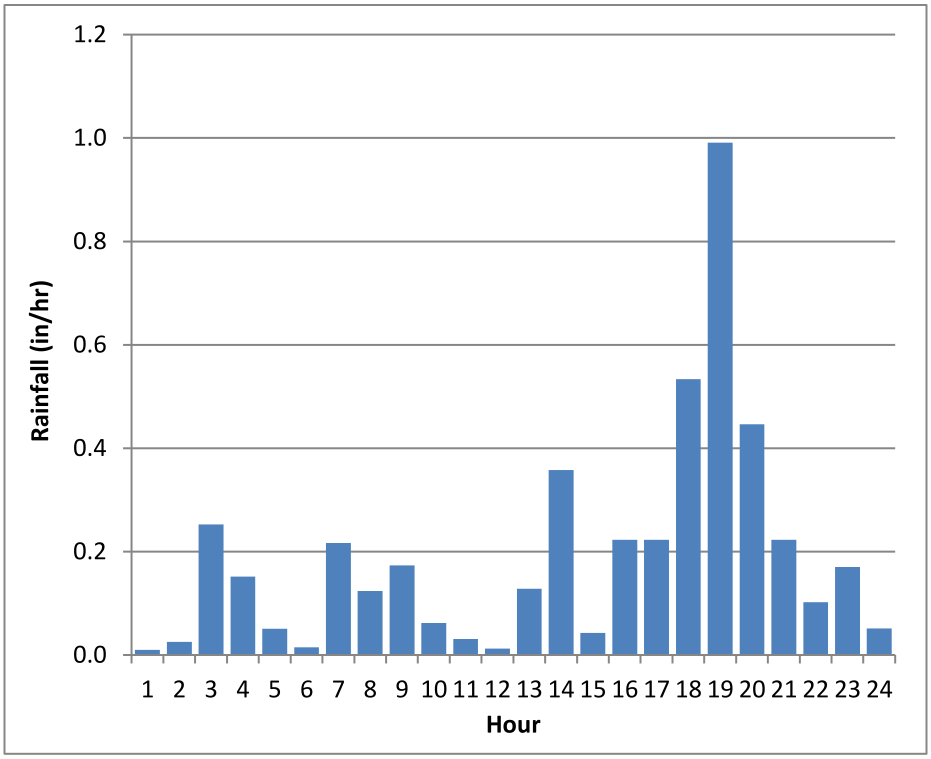


Figure 3-28. 10-Year, 24-Hour Design Storm Values, and Profile (Site 22)

3.4.3 Design Storm Response Summary

The 10-year, 24-hour storm event was applied to the synthetic I/I hydrograph components developed for each flow monitoring site. This method produces the best estimated response to the design storm events. These results assume full ground saturation, and the peak I/I flows from the design storm coincides with peak sanitary flows to get a “worst-case” scenario of peak wet weather flows.

Table 3-12 summarizes the final results for the design storm on a site-by-site basis.

Table 3-12. Design Storm I/I Analysis Summary – by Site

Monitoring Site	Peak Dry Weather Flow (mgd)	Peak I/I Rate (mgd)	Peak Flow (mgd)	Combined I/I (gallons)
Site 1	0.463	0.672	1.135	199,000
Site 2	0.203	0.560	0.763	205,000
Site 3A	0.915	2.729	3.644	1,584,000
Site 4A	0.229	0.509	0.738	214,000
Site 5	0.450	0.967	1.417	627,000
Site 6	0.194	0.379	0.573	215,000
Site 7	0.148	0.146	0.294	69,000
Site 9A	0.006	0.043	0.049	24,000
Site 9B	0.004	0.011	0.015	4,000
Site 9C	0.058	0.113	0.171	31,000
Site 10	0.458	1.275	1.733	788,000
Site 11	0.568	1.157	1.725	857,000
Site 12	0.239	1.378	1.617	968,000
Site 14	0.148	0.266	0.414	72,000
Site 15	0.132	0.308	0.440	147,000
Site 16	0.801	2.065	2.866	1,587,000
Site 18	0.075	0.413	0.488	207,000
Site 19	0.112	0.819	0.932	637,000
Site 20	0.186	0.813	0.999	445,000
Site 21	0.089	Not Available	Not Available	Not Available
Site 22	0.047	0.532	0.578	378,000
Site 24	0.148	0.358	0.506	177,000
Site 25	0.070	0.552	0.622	280,000
Site 26	0.036	0.058	0.093	17,000
Site 27	0.137	0.393	0.530	106,000
Site 28	1.206	1.966	3.172	1,203,000
Site 29	0.408	0.470	0.878	191,000
Site 30	1.300	1.736	3.036	1,129,000
FLUME	5.084	6.594	11.678	4,545,000

Note: It is possible that the peak flow rates predicted for a design storm event cannot be conveyed due to conveyance capacity limitations of the local collection system. A comprehensive dynamic model is required to determine the locations of the capacity issues and methods for relieving capacity.

Figure 3-29 shows the synthetic hydrograph response for the design storm event at Site 22.

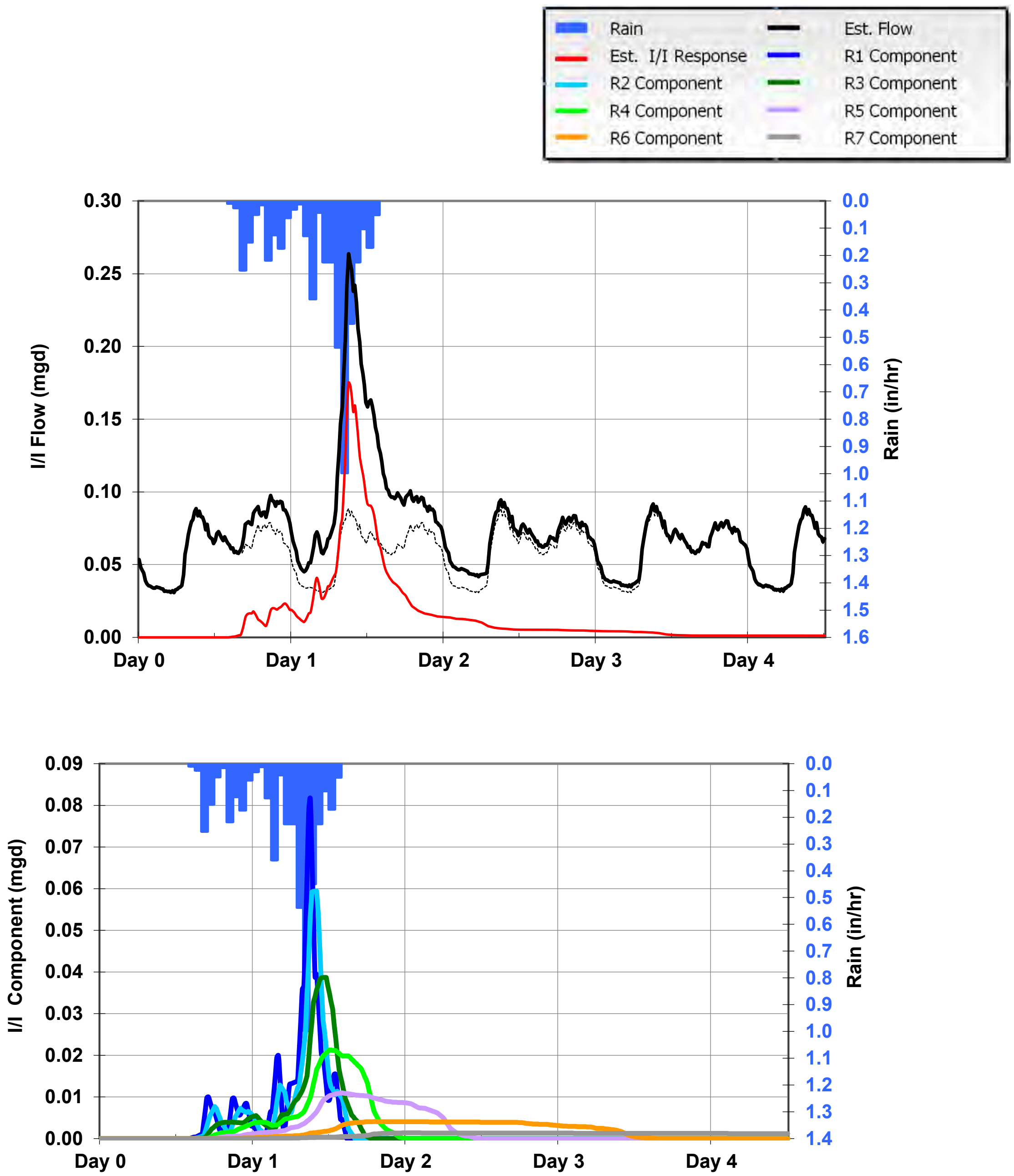


Figure 3-29. 10-Year, 24-Hour Design Storm: Estimated I/I Response at Site 22

3.5 Comparison to Previous Studies

3.5.1 Smoke Testing

Smoke testing is a means of identifying potential inflow and infiltration (I/I) sources and sanitary sewer system defects by introducing smoke into the system via manholes and documenting where smoke exits the system. A typical test setup consists of a few pipe segments with the blower at a manhole in the middle (Figure 3-30).

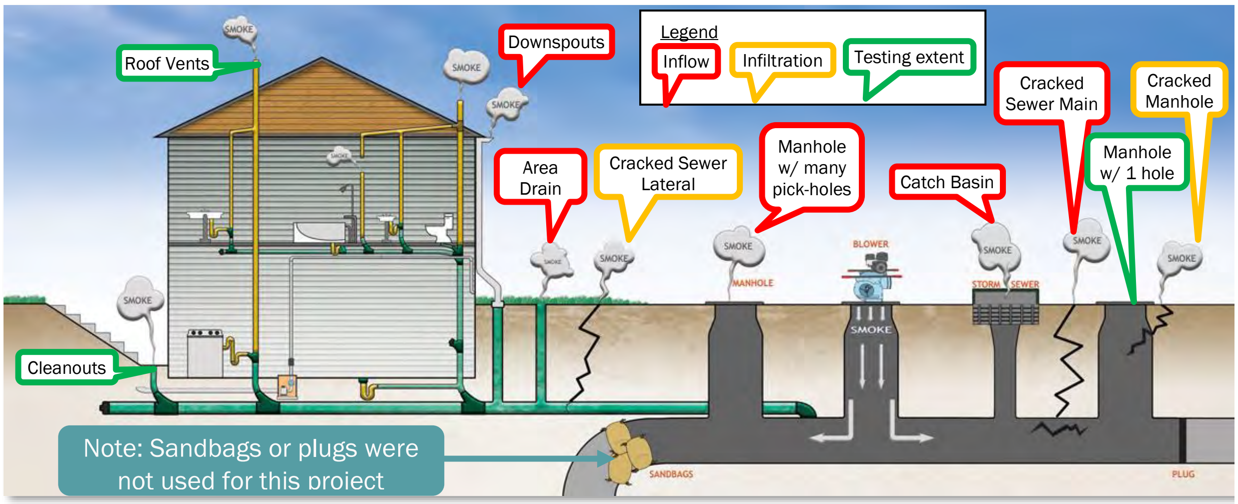


Figure 3-30. Typical Smoke Testing Setup and Returns

In 2018, V&A performed smoke testing in the District service area. The scope was 129,100 linear feet (24.5 miles) of sanitary sewer lines in Basins 22, 9, and 4a. Testing was performed from October 11 through November 7, 2018. A total of 252 findings were documented; findings included 136 "smoke returns" and 116 "other findings". Generally, the number of moderate to severe inflow severity smoke returns per pipe length matched the flow monitoring I/I rankings, with the most being Basin 22, then Basin 9, then Basin 4a. The details and results can be found in the "Cupertino Sanitary District 2018 Smoke Testing Report" submitted November 2018, V&A Project No. 18-0188.

The scope of the 2021 smoke testing project was approximately 126,000 linear feet (23.9 miles) of sanitary sewer lines in Basin 18, 19, 20, 25, and 27. Testing was performed from July 20 through Aug 19, 2021. A total of 178 findings were documented; findings included 59 "smoke returns" and 119 "other findings". The number of moderate to severe inflow severity smoke returns were mostly evenly spread between the basins smoke tested. The details and results can be found in the "Cupertino Sanitary District 2021 Smoke Testing Report" submitted September 2021, V&A Project No. 20-0045.

The prioritization of these basins for smoke testing was partly based on the flow monitoring I/I results and partly based on requests by the District. Prior to smoke testing, V&A reviewed the 2012, 2015, and 2016 flow monitoring results[34]. The 2018 and 2021 smoke testing would have completed the top 9 inflow basins measured in the 2015 I/I study. Table 3-13 summarizes the flow monitoring results for the smoke testing basins. Note that the rain events and basins were different between the years.

[34] 2012, 2015, and 2016 flow monitoring projects were V&A project no. 12-0139, 15-0305, and 16-0327 respectively.

3.5.2 Pre & Post Smoke Testing

Between 2015/16 and 2021/22 flow monitoring, it is assumed that most of the 2018 smoke return findings in public jurisdictions have been repaired; approximately half of the smoke return findings in private areas have been repaired. The percentage of 2021 smoke return findings that were repaired within the half year prior to flow monitoring needs to be confirmed with the District.

Table 3-13 summarizes the inflow and RDI normalized per ADWF rankings for the smoke tested basins before and after smoke testing. Table 3-14 summarizes the design storm response of all the flow monitoring basins throughout the years. The basins highlighted in **bold** were smoke tested. A lower ranking relative to the other basins in Table 3-13 and a lower peak I/I rate and combined I/I design storm response in Table 3-14 would indicate an I/I reduction. Generally, the smoke tested basins had some I/I reduction, as more evidently shown in Figure 3-31; Site 9A 2016 versus 2021 design storm response. However, it often takes comprehensive lower and upper lateral, mainline, and manhole rehabilitation to quantitatively measure a reduction via flow monitoring due to the measurement error and uncertainty (Section 2.4), and different wet weather seasons.

Table 3-13. Multi-Year Summary of I/I Normalized per ADWF Ranking[A] for Smoke Testing Basins

Basin	2012/13: 23 basins				2015/16: 28 basins		2021/22: 28 basins	
	Inflow	RDI	Combined I/I	GWI	Inflow	RDI	Inflow	RDI
2018 Smoke Testing								
Basin 22	8	10	7	**Yes**	**1**	**1**	**2**	**1**
Basin 9 [B]	6	10	4					
Subbasin 9A					**5**	16	**1**	5
Subbasin 9B					**4**	15	4	21
Subbasin 9C					8	**4**	17	17
Basin 10 (include remaining Basin 9)					16	12	12	10
Basin 4 (subtracted out subbasin 8)	5	8	5					
Subbasin 8	14	10	15	**Yes**				
4A (including subbasin 8) [C]					12	7	10	18
2021 Smoke Testing								
Basin 18	10	10	12		**2**	24	5	21
Basin 19	13	6	**2**	**Yes**	**7**	21	6	**2**
Basin 20	10	10	6		9	9	18	9
Basin 25 (part of Basin 20 in 2012)	10	10	6		**6**	**5**	**3**	**3**
Basin 27 (part of Basin 16 in 2012) (analyzed with Basin 21 in 2021)	12	**4**	13		**3**	22	7	13

[A] *Normalized per ADWF was used in 2012/13 and 2015/16, so normalized per ADWF rankings for 2021/22 is also used here for comparison. Normalized per IDM and Acre were introduced this year and presented in the above sections as more data was available.*

[B] *"Basin 9" in the 2012 I/I study included subbasins 9a, 9b, and 9c and some remaining areas which became part of Basin 10 in 2015 I/I study. The remaining areas was not smoke tested as it ranked low in the 2015 I/I study.*

[C] *"Basin 4a" includes the 2012 "Basin 8" area and was smoke tested, as requested by the District.*

Table 3-14. Multi-Year Comparison of Design Storm Response

Monitoring Basin	2012/13			2015/16			2021/22		
	Basin ADWF (mgd)	Peak I/I Rate (mgd)	Combined I/I (gallons)	Basin ADWF (mgd)	Peak I/I Rate (mgd)	Combined I/I (gallons)	Basin ADWF (mgd)	Peak I/I Rate (mgd)	Combined I/I (gallons)
Basin 1	0.231	0.268	165,000	0.131	0.366	Negl.	0.173	0.112	Negl.
Basin 2[35]	0.129	Negl.	Negl.	0.268	1.219	288,000	0.137	0.560	205,000
Basin 3A				0.098	0.224	Negl.	0.000	0.356	Negl.
Basin 4A [36]	0.017	0.023	Negl.	**0.127**	**0.913**	**378,000**	**0.152**	**0.509**	**214,000**
Basin 5	0.124	Negl.	Negl.	0.068	0.254	331,000	0.088	0.442	343,000
Basin 6	0.143	0.577	298,000	0.120	0.320	97,000	0.026	0.020	38,000
Basin 7	0.145	0.144	69,000	0.129	0.564	125,000	0.093	0.146	69,000
Basin 8	0.107	0.333	210,000						
Basin 9	**0.219**	**0.750**	**296,000**						
Basin 9A				**0.008**	**0.110**	**42,000**	**0.003**	**0.043**	**24,000**
Basin 9B				**0.001**	**0.013**	**5,000**	**0.002**	**0.011**	**4,000**
Basin 9C				**0.038**	**0.402**	**208,000**	**0.042**	**0.113**	**31,000**
Basin 10	0.093	0.302	193,000	0.319	1.501	690,000	0.216	1.108	729,000
Basin 11	0.087	0.071	20,000	0.081	0.414	230,000	0.073	Negl.	69,000
Basin 12	0.080	0.336	148,000	0.064	2.517	1,232,000	0.138	1.378	968,000
Basin 14	0.104	0.291	87,000	0.035	0.491	150,000	0.090	0.266	72,000
Basin 15	0.029	0.016	8,000	0.100	0.462	161,000	0.057	0.308	147,000
Basin 16	0.098	0.070	33,000	0.137	Negl.	511,000	0.233	Negl.	192,000
Basin 17	0.378	0.964	403,000						
Basin 18	**0.126**	**0.379**	**176,000**	**0.033**	**0.608**	**188,000**	**0.051**	**0.413**	**207,000**
Basin 19	**0.050**	**0.230**	**108,000**	**0.041**	**0.392**	**124,000**	**0.049**	**0.288**	**259,000**
Basin 20	**0.045**	**Negl.**	**Negl.**	**0.042**	**0.395**	**214,000**	**0.085**	**0.261**	**165,000**
Basin 21	0.097	0.436	263,000	0.018	0.173	59,000	0.039	Not Avail.	Not Avail.
Basin 22	**0.037**	**0.256**	**120,000**	**0.040**	**0.883**	**533,000**	**0.029**	**0.532**	**378,000**
Basin 23	0.020	0.340	159,000						
Basin 24				0.085	0.721	254,000	0.097	0.358	177,000
Basin 25				**0.059**	**0.616**	**287,000**	**0.042**	**0.552**	**280,000**
Basin 26				0.023	0.110	21,000	0.021	0.058	17,000
Basin 27[37]				**0.038**	**0.511**	**91,000**	**0.062**	**0.336**	**89,000**
Basin 28				0.472	0.760	16,000	0.043	0.300	132,000
Basin 29				0.322	1.117	266,000	0.213	0.470	191,000
Basin 30				0.322	0.297	Negl.	0.309	Negl.	Negl.
Basin Flume	1.506	3.349	1,270,000	0.298	Negl.	394,000	1.059	0.106	783,000

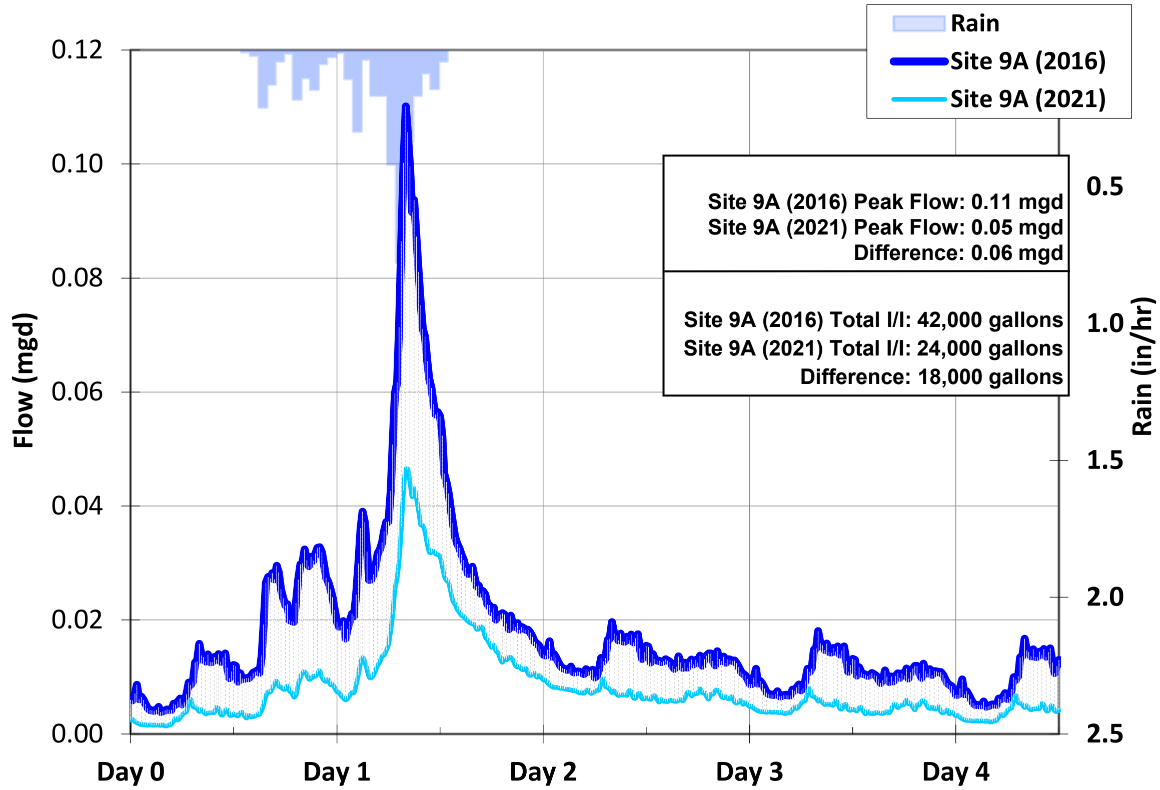


Figure 3-31. Site 9A (standalone basin) comparison of 2016 and 2021 design storm response.

- Basins 4A, 9A, 9B, 9C, 20, and 22 saw a reduction in peak I/I rate and combined I/I design storm response between 2016 and 2021.
- Basins 18, 19 saw a reduction in peak I/I rate but an increase in combined I/I design storm response between 2016 and 2021.

It is interesting to note that many basin's ADWF has reduced since 2016, possibly due to water conservation efforts. The engineer should be careful in using peak flow or peak I/I rate comparisons between the years. It is our understanding that the District is concerned with (1) the peak *flow* through the Flume to Santa Clara and also (2) the peak I/I rate for I/I reduction efforts.

4 Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Master Plan and Model Implementation**: The District is currently having a hydraulic model designed and/or updated to determine the overall needs of the District relative to I/I. Flow monitoring results should be incorporated and the changes over the years understood.
2. **Verify Interconnections and Overflows**: understanding the interconnections and overflows can help with the hydraulic model, basin isolation and I/I analysis.
3. **Capacity Analysis**: Sites 16 and 21 surcharged during the study; flow levels for these sites were less than one foot above the pipe crown when surcharged. The District may want to analyze the capacity constraints in the updated hydraulic model.
4. **Determine I/I Reduction Program**: The District should examine its I/I reduction needs to determine their needs and goals for a future I/I reduction program.

   Since peak flows are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest normalized inflow occurs in Basins 4A, 19, and 5. Basins 4A and 19 have already been smoke tested. Night-time I/I reconnaissance may be attempted. Night-time reconnaissance work occurs between 12am to 4am after a rain event to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution. CCTV systematic review and analysis can also be attempted.

Cupertino Sanitary District

Memo

Item 10A

To: **Board of Directors**

From: **Benjamin Porter, District Manager-Engineer**

Date: **August 3, 2022**

Re: **ANNUAL RENEWAL FOR GRANITE SOFTWARE**

Background:

Granite Software from CUES is an asset inspection and decision support software that provides the upgrade path for obtaining all new features, interfaces and enhancements including the flexibility to create many types of inspections in addition to CCTV condition assessments such as cleaning inspections, smoke test inspections, GPS surveys, inclination surveys, and more. Additionally, this software platform offers a User Interface that helps users become proficient.

Renewal Support Plans include:

- 1 Premium Inspection Software Package
- 1 Office Software License
- Remote Online Technical Support
- Software maintenance and enhancement Release Updates

Mark Thomas owns one user license for GraniteNet and it is licensed to be used in the Cupertino Office to facilitate downloading and cataloguing of CCTV videos and PACP reports. Mark Thomas uses the software predominantly for Cupertino Sanitary District to analyze the condition of the Cupertino Sanitary District's sanitary sewer system and asset data is synchronizing between Field, Office, and ArcGIS.

The total cost of the annual renewal cost for this software is $2,150. Mark Thomas is requesting that the District consider full reimbursement to Mark Thomas.

Board Consideration/Action:

Cupertino Sanitary District Board of Directors authorize a reimbursement amount of $2,150 to Mark Thomas.

Attachment:

- GraniteNet Software Quote

Item 10.A.
Attachment

INVOICE

Remit To: CUES, Inc.
P.O. Box 639633
Cincinnati, OH 45263-9633

CUES

3600 Rio Vista Avenue
Orlando, Florida 32805
(407) 849-0190 E-Fax (407) 641-9222

Bill To: MARK THOMAS AND COMPANY, INC.
2833 JUNCTION AVE
SUITE 110
SAN JOSE, CA 95134

Ship To: MARK THOMAS AND COMPANY, INC.
20863 STEVENS CREEK BLVD
SUITE 100
CUPERTINO, CA 95014

TODAYS DATE: July 13, 2022
INVOICE DATE: July 13, 2022
INVOICE #: 615496
SALES ORDER #: 000801586
CUSTOMER PO: 22.1001

SALES PERSON: CK
TERMS: NET 30 DAYS
F.O.B.: DESTINATION
WAYBILL NUMBER:
CONTACT: LINH GIANG
PHONE NUMBER: 408-453-5373

Order Date	Bill To #	Terr	Tax	Tax %	Ship To #	Stores	Ship Via
7/7/2022	95112010	183	N	9.13	95112011	CENTRAL	SEE REMARKS

Ln #	SO Ln #	Part # Description	Prod Code	Order Qty	Ship Qty	Bal Due	Tax Rate	Disct %	Price	Amount
001	001	GN538 SOFTWARE,OFFICE SUPPORT PLAN GNET	PT183	1	1	0	0.00	0.00	350.00	350.00
002	002	GN536 SOFTWARE,PREMIUM SUPPORT PLAN GNET	PT183	1	1	0	0.00	0.00	1,800.00	1,800.00
003	003	HANDLING HANDLING CHARGES	IN183	1	1	0	9.13	0.00	0.00	0.00
999	999	FREIGHT CHARGES					0.00			0.00

As agreed to by Buyer, this Invoice and the goods and/or services purchased hereunder are subject to Cues, Inc. Terms and Conditions of Sale found at: https://cuesinc.com/pages/cues-terms-and-conditions-of-sale.

Sub Total :	2,150.00
Tax Total :	0.00
TOTAL DUE >	$2,150.00

Payment Options:
Fifth Third Bank, Wire ABA #042000314, ACH ABA #042000314
Account Name: Cues, Inc. Account #7028939929, SWIFT: FTBCUS3C
Bank Address: Fifth Third Bank 38 Fountain Square Plaza Cincinnati, OH 45263
Please email remittance advice to AccountsReceivable@cuesinc.com

Remarks:

INVOICE

Remit To: CUES, Inc.
P.O. Box 639633
Cincinnati, OH 45263-9633

GRANITENET SOFTWARE SUPPORT PLAN RENEWAL
CONFIRMING ONLY
INSP
502169
OFFICE
504683
SUPPORT PLAN STARTS
FEBRUARY 24, 2022
AND ENDS
FEBRUARY 23, 2023
****DO NOT LET COVERAGE LAPSE - A $2500 REINSTATEMENT FEE PER ENHANCED LICENSE WILL BE ASSESSED IN ADDITION TO THE COST OF LAPSED SUPPORT PLAN CHARGES.****
****DO NOT LET COVERAGE LAPSE - A $500 REINSTATEMENT FEE PER OFFICE INSPECTION LICENSE WILL BE ASSESSED IN ADDITION TO THE COST OF LAPSED SUPPORT PLAN CHARGES.****

California Mandatory Retirement Plan Explained

FINANCE AND TAXES

Lorraine Roberte
Contributor

5 min read July 20, 2022

California implemented a new mandatory law requiring all companies with more than five employees to offer a retirement plan to their workers by June 30, 2022. Companies that don't will be required to enroll in CalSavers, the state-sponsored individual retirement account (IRA), or face fines.

Although California was the first state to pass legislation related to mandatory retirement plans, it's not the only state to do so. Similar laws exist or are being put into effect in several places, including in CO, CT, IL, MD, MA, ME, NJ, NY, and OR. Many other states are actively exploring a state-sponsored retirement option.

To help make sense of it all, we break down why the California law came about, who it applies to, and some retirement programs businesses can consider offering.

Why Is California Mandating Retirement Plans? A Quick History of the Program

In 2011, a series of UC Berkeley Labor Center studies revealed that nearly half of California workers weren't prepared for retirement. To help improve this retirement-readiness gap, the state legislature prepared a bill to create a simple way for nearly every employee in California to save for retirement.

When the bill passed in 2012, the state of California became the first state to establish a state-run retirement savings plan for workers in the private sector. Then in 2016, Governor Jerry Brown signed another bill into law, officially approving the California mandatory retirement plan.

While there have been many challenges in court, the 9th Circuit Court of Appeals upheld the CalSavers retirement savings program in 2021. This means the state law remains, and affected businesses must implement a retirement program by the June 30th deadline to avoid non-compliance penalties.

What Is the Law on California's Mandatory Retirement Plan?

Retirement Plan?

California Government Code **§§100000-100050** establishes the CalSavers Retirement Savings Trust Act. It requires California businesses with **five or more California-based employees** (one of whom is at least 18 years old), to offer either an employer-sponsored retirement plan or the state-sponsored retirement plan to their workers. Participating employees would elect an amount to save as part of their **payroll deductions** in both instances.

Whether your business classifies as having the minimum number of employees is based on the average number of employees you reported to the Employment Development Department on your DE9C filings for the previous year.

Eligible companies providing employer-sponsored retirement plans must file an exemption on the **CalSavers website**. Those that don't have an approved retirement option available, must register for CalSavers to avoid penalties. Under the law, **eligible employees** are defined as people employed by an eligible employer, except for employees:

- Covered under the federal Railway Labor Act
- Who aren't California-based
- Have their employer contribute to their employee pension trust funds through the Taft-Hartley Act

The state created a three-year rollout period of implementation, with staggered deadlines based on company size. All of the deadlines have passed. The final one was **June 30, 2022**. All employers required to participate must have either signed up for CalSavers or exempted themselves if they offer a different retirement plan.

Businesses that don't comply will get a notice from the state giving them 90 days to adhere to the new law. If the business still doesn't comply, **they'll be fined $250 per employee**. That penalty goes up by $500 per employee after 180 days, meaning you'd owe $750 per employee at that point.

What Are the Pros and Cons of CalSavers?

A perfect retirement plan doesn't exist. To find the one that's right for your business, you'll need to weigh the pros and cons of your options. Below are a few things to consider about CalSavers.

Pros

- **Low costs**: There are no start-up or administrative costs to enroll in CalSavers.
- **Easy to use**: CalSavers is designed to be easy for both employers and employees. It offers automatic enrollment and investment options, allowing employees to change their standard contribution rate to a percentage that works for them.
- **No fiduciary responsibility**: The law removes fiduciary **responsibility from employers**, making it more simple to manage.

Cons

- **Income limits:** As a Roth IRA plan, the IRS sets **income limits** based on the **employee's tax filing status**. If your employee is above the limit, they aren't eligible.
- **Contribution limits:** Roth IRAs have relatively low **contribution limits** ($6,000 a year or $7,000 for people over 50).
- **Fees for employees:** The cost employees pay is currently between **$0.83 and $0.95 for every $100** in the savings account.

Can California Employers Opt Out of CalSavers?

If you don't want to enroll your California employees in the state-sponsored IRA, you can set up a

If you don't want to enroll your California employees in the state sponsored IRA, you can set up a different type of retirement plan that works better for you and your employees.

Here are some common qualified retirement plans to consider:

401(k): This is an employer-sponsored savings account, tax-advantaged and funded by employer and employee contributions. Businesses can either set up their own 401(k) or use a third-party provider to administer it for them.

408(p): Also known as a **SIMPLE IRA**, this plan lets both employers and employees contribute a certain percentage of gross pay to a traditional IRA.

408(k): Also known as a Simplified Employee Pension (SEP) plan, this retirement savings account allows employers to make payroll contributions on behalf of their employees.

Here's how these retirement options stack up against CalSavers.

Retirement Plan Options

CRITERIA	CALSAVERS	401(K)	SIMPLE IRA	SEP PLAN
Annual Contribution Limit	$6,000	$20,500	$14,000	The lesser of 25% of employee salary OR $61,000
Annual Contribution Limit Age 50+	$7,000	$27,000	$17,000	No catch-up contributions allowed
Employer Match Allowed?	No	Yes	Yes	No, only the employer contributes
Pre-Tax Contributions?	No	Yes	Yes	Yes
After-Tax Contributions?	Yes, with income limits	Yes, with no income limits	No	No
Allows Loans?	No	Yes	No	No

Simple IRAs are the most common for small businesses because they're economical and easy to manage. While 401(k)s are also a popular option, they require a yearly nondiscrimination test to ensure large discrepancies don't exist between the savings of non-highly compensated employees and highly compensated ones.

Something called a Safe Harbor 401k plan exists, which does away with the IRS test and instead implements **maximum annual contribution limits**. The catch is employers must make fixed contributions to employee 401(k) accounts, with the money being vested immediately.

The U.S. Department of Labor's Employee Benefits Security Administration (EBSA) and the IRS worked together to create a **guide to help small business owners** pick the right retirement plan to offer. If you decide not to go with CalSavers, this is a good resource to help you sort through your alternative options. No matter which type of retirement plan you go with, you'll be helping your employees save for their future.

If You Missed the Deadline, It's Not Too Late

Whether you go with CalSavers or pick a different retirement plan, it's essential to implement something quickly if you missed the June 30 deadline. California will grant you 90 days to comply from when they serve you a failure-to-comply notice. After that, you'll start racking up fines for each eligible employee.

Make sure to review the pros and cons of the CalSavers program. Then you can decide if you're going to use it or a different type of retirement plan for your employees. If you choose to create an employer-sponsored retirement plan, don't forget to **report an exemption** on the CalSavers website.

FINANCE AND TAXES

June 24, 2022

Your Easy Guide to Accounting for Small Business

By Ryan Isaac 5 min read

FINANCE AND TAXES

June 14, 2022

What Is SUI Tax and How Do I Pay It?

By Kat Boogaard 6 min read

FINANCE AND TAXES

July 22, 2022

What is a W-3 and Who Should File One?

By Maddy Osman 7 min read

Item 12.A.

CUPERTINO SANITARY DISTRICT
MEETING/EVENT SCHEDULE

AUGUST 2022

08/03: 1st Regular Meeting

08/08: TAC

08/11: TPAC

08/17: 2nd Regular Meeting

08/10-12: CASA Conference

AUGUST 2022

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3 1st Regular Meeting	4	5	6
7	8 TAC	9	10 CASSA CONFERENCE	11 TPAC	12	13
14	15	16	17 2nd Regular Meeting	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

SEPTEMBER 2022

09/05: TAC

09/07: 1st Regular Meeting

09/08: TPAC

09/21: 2nd Regular Meeting

SEPTEMBER 2022

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5 TAC	6	7 1st Regular Meeting	8 TPAC	9	10
11	12	13	14	15	16	17
18	19	20	21 2nd Regular Meeting	22	23	24
25	26	27	28	29	30	

OCTOBER 2022

10/05: 1st Regular Meeting

10/10: TAC

10/13: TPAC

10/19: 2nd Regular Meeting

OCTOBER 2022

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3	4	5 1st Regular Meeting	6	7	8
9	10 TAC	11	12	13 TPAC	14	15
16	17	18	19 2nd Regular Meeting	20	21	22
23	24	25	26	27	28	29
30	31					