Appendix I: Guidance on Determining Feasibility and Sizing of Rainwater Harvesting Systems

Introduction

The MRP allows development projects to use infiltration, evapotranspiration, harvesting and use, or biotreatment to treat the full water quality design flow or volume of stormwater runoff, as specified in MRP Provision C.3.d. Project applicants are no longer required to evaluate the feasibility of infiltration of rainwater harvesting and use before proceeding to biotreatment.

If a project applicant desires to use rainwater harvesting systems to meet LID treatment requirements, there must be sufficient demand on the project site to use the water quality design volume, i.e., 80 percent of the average annual rainfall runoff, from the collection area. Appendix I provides guidance on how to the estimate the required landscaping or toilet flushing demand to meet C.3.d requirements. If the project appears to have sufficient demand for captured rainwater, Appendix I provides guidance on sizing the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume.

The information presented in this guidance is based on the “Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report” (referred to as the “LID Feasibility Report”) prepared by the Bay Area Stormwater Management Agencies Association (BASMAA) and submitted to the Regional Water Board in 2011[56].

I.1 Rainwater Harvesting/Use Feasibility Guidance

Rooftop runoff is the source of stormwater most often collected in a harvesting/use system, because it often contains lower pollutant loads than at-grade surface runoff, and it provides accessible locations for collection in storage facilities via gravity flow.

The 2019 California Plumbing Code effective January 1, 2020 includes rainwater harvesting and graywater requirements, codes, and treatment standards. Chapter 16 of the Plumbing Code, which contains the rainwater harvesting requirements, allows rainwater to be harvested from rooftops for use in outdoor irrigation and some non-potable indoor uses. Rainwater collected from parking lots or other impervious surfaces at or below grade is considered graywater and subject to the water quality requirements for graywater in Chapter 15 of the Code. Some small catchment systems (5,000 gallons or less) being used for non-spray irrigation do not require permits – see Chapter 16 for more details[57].

The Plumbing Code defines rainwater as “precipitation on any public or private parcel that has not entered an offsite storm drain system or channel, a flood control channel, or any other stream channel, and has not previously been put to beneficial use.”[58] The Rainwater Capture Act of 2012, which took effect January 1, 2013, specifically states that the use of rainwater collected from rooftops does not require a water right permit from the State Water Resources Control Board.

[56] This report is available on the Countywide Program’s website (www.flowstobay.org/newdevelopment).

[57] 2019 California Plumbing Code, https://iapmo.org/publications/read-uniform-codes-online/ Select CPC 2019 and click on Chapter 16.

[58] 2019 California Plumbing Code, Chapter 2.

I.2 Determining Feasibility of Rainwater Harvesting and Sizing of Cisterns

A key parameter needed to evaluate the feasibility of using harvested rainwater for irrigation or indoor toilet flushing use is the ***Potential Rainwater Capture Area***. This is the impervious area from which rainwater may potentially be captured, if rainwater harvesting and use were implemented for a project. This is typically the roof area of the building(s) draining to the capture facilities.

The text below describes how to determine whether rainwater harvesting may be used to treat the C.3.d amount of runoff on the project site.

Feasibility of Using Harvested Rainwater for Irrigation. Harvested rainwater can be used for irrigation in projects that include a considerable amount of landscaping. Follow the steps below to determine if adequate landscaping is available on the project site:

- Calculate the landscaping available on the project site. Note that the landscape area(s) would have to be contiguous and within the same Drainage Management Area to use harvested rainwater for irrigation via gravity flow.
- Refer to Table 11 in Attachment 2 of this guidance, which present ratios of "Effective Irrigated Area to Impervious Area" (EIATIA) for rain gauge areas.
- Determine if the project has sufficient demand for rainwater for use in landscaping, and size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. Any combination of drawdown time and cistern size may be selected that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for ***1 acre of tributary impervious area***, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Feasibility of Using Harvested Rainwater for Residential Toilet Flushing. If the project consists entirely of residential use, or if rainwater harvesting is being considered for the residential portion of mixed use projects that include some residential use, then the following steps should be taken:

- Calculate the dwelling units per impervious acre by dividing the number of dwelling units by the acres of the Potential Rainwater Capture Area.
- Refer to Table 3 in Attachment 1 for San Mateo County.
- Identify the number of dwelling units per impervious acre needed in the Rain Gauge Area to provide the toilet flushing demand required for rainwater harvesting.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. The applicant can select any combination of drawdown time and cistern size that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note

that the sizing curves are for 1 acre of tributary impervious area, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.

- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Commercial/Institutional/Industrial Toilet Flushing. For projects that consist entirely of commercial, institutional, and/or industrial use, and for the commercial portion of mixed-use projects, follow the following steps:

- Calculate the proposed interior floor area (sq.ft.) per acre of impervious surface by dividing the interior floor area (sq.ft.) by the acres of the Potential Rainwater Capture Area.
- Refer to Table 3 in Attachment 1. This table identifies the required toilet flushing demand based on employees per impervious acre. Identify the square feet of non-residential interior floor area per impervious acre needed in the Rain Gauge Area to provide the toilet flushing demand required for rainwater harvest feasibility.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. Any combination of drawdown time and cistern size may be selected that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for ***1 acre of tributary impervious area***, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

School Toilet Flushing. For school projects, follow the following steps:

- Calculate the proposed interior floor area (sq.ft.) per acre of impervious surface by diving the interior floor area (sq.ft.) by the acres of the Potential Rainwater Capture Area.
- Refer to Table 3 in Attachment 1, which identifies the required toilet flushing demand based on employees per impervious acre.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. Any combination of drawdown time and cistern size may be selected that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for ***1 acre of tributary impervious area***, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Mixed Commercial and Residential Use Projects. The following steps should be followed for mixed use projects:

- Evaluate the residential toilet flushing demand based on the dwelling units per impervious acre for the residential portion of the project, following the instructions above, except using a prorated acreage of impervious surface, based on the percentage of the project dedicated to residential use.
- Evaluate the commercial toilet flushing demand per impervious acre for the commercial portion of the project, following the instructions above, except using a prorated acreage of impervious surface, based on the percentage of the project dedicated to commercial use.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. Any combination of drawdown time and cistern size may be selected that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

Industrial Projects. Follow the steps below for industrial projects:

- If the project will include an industrial processing use for non-potable water, identify the demand for this use.
- Refer to Table 9 in Attachment 2. This Table identifies demand based on the required cistern volume and demand, for the maximum allowable drawdown time, to capture the C.3.d amount of runoff.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Attachment 2. Find the page that shows curves corresponding to the closest rain gauge to the project. Any combination of drawdown time and cistern size may be selected that achieves at least 80 percent capture of runoff on the Y-axis of the graphs. Note that the sizing curves are for **1 acre of tributary impervious area**, (i.e., potential rainwater capture area). The resulting cistern volume must be scaled down to the exact size of the project's rainwater capture area.
- Determine the required demand in gallons per day by dividing the cistern volume by the drawdown time (converted to days).

I.3 Attachments

The following pages include the attachments listed below.

- Attachment 1: Toilet-Flushing Demand for Harvested Rainwater
- Attachment 2: Excerpts from the Feasibility Report (Map of Soil Hydraulic Conductivity and Rain Gauge Areas, Tables 8 through 11, and Figures F-8, F-9, and F-10 from the report's Appendix F)

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Attachment 1: Toilet-Flushing Demand Required for Rainwater Harvesting Feasibility per Impervious Acre (IA) [1,2]

Table 1 - Alameda County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Berkeley	5,900	690	255	860	172,000	170	51,000
Dublin	4,100	480	177	590	118,000	120	36,000
Hayward	4,800	560	207	700	140,000	140	42,000
Palo Alto	2,900	340	125	420	84,000	90	27,000
San Jose	2,400	280	103	350	70,000	70	21,000

Table 2 - Santa Clara County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Morgan Hill	6,500	760	260	940	188,000	190	57,000
Palo Alto	2,900	340	116	420	84,000	90	27,000
San Jose	2,400	280	96	350	70,000	70	21,000

Table 3 – San Mateo County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Palo Alto	2,900	340	124	420	84,000	90	27,000
San Francisco	4,600	530	193	670	134,000	140	42,000
SF Oceanside	4,300	500	182	620	124,000	130	39,000

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Table 4 – Contra Costa County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Berkeley	5,900	690	254	860	172,000	170	51,000
Brentwood	4,200	490	180	610	122,000	120	36,000
Dublin	4,100	480	176	590	118,000	120	36,000
Martinez	5,900	690	254	860	172,000	170	51,000

Table 5 – Solano County:

Rain Gauge[3]	Required Demand (gal/day/IA)[4]	Residential		Office/Retail[5]		Schools[6]	
		No. of residents per IA[7]	Dwelling Units per IA[8]	Employees per IA[9]	Interior Floor Area (sq.ft./IA)[10]	Employees[11] per IA	Interior Floor Area (sq.ft./IA)[12]
Lake Solano	9,000	1,050	362	1,300	260,000	270	81,000
Martinez	5,900	690	238	860	172,000	170	51,000

Notes:

1. Demand thresholds obtained from the "Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report" (LID Feasibility Report) submitted to the Regional Water Board on May 1, 2011.
2. Toilet flushing demands assume use of low flow toilets per the California Green Building Code.
3. See Attachment 3 to identify the rain gauge that corresponds to the project site.
4. Required demand per acre of impervious area to achieve 80% capture of the C.3.d runoff volume with the maximum allowable drawdown time for cistern of 50,000 gallons or less, from Table 9 of the LID Feasibility Report.
5. "Office/Retail" includes the following land uses: office or public buildings, hospitals, health care facilities, retail or wholesale stores, and congregate residences.
6. "Schools" includes day care, elementary and secondary schools, colleges, universities, and adult centers.
7. Residential toilet flushing demand identified in Table 10 of the LID Feasibility Report.
8. Residential toilet flushing demand divided by the countywide average number of persons per household (US Census data reported on www.abag.org), as follows: Alameda County: 2.71 persons per household; Santa Clara County: 2.92; San Mateo County: 2.74; Contra Costa County: 2.72; Solano County: 2.90.
9. Office/retail employee toilet flushing demand identified in Table 10 of the LID Feasibility Report.
10. Interior floor area required for rainwater harvest and use feasibility per acre of impervious area is based on the number of employees in Column 5 multiplied by an occupant load factor of 200 square feet per employee (reference: 2010 California Plumbing Code, Chapter 4, Plumbing Fixtures and Fitting Fixtures, Table A, page 62.)
11. School employee toilet flushing demand identified in Table 10 of the LID Feasibility Report. Each school employee represents 1 employee and 5 "visitors" (students and others).
12. Interior floor area required for rainwater harvest and use feasibility per acre of impervious area is based on the number of employees in Column 7 multiplied by 6 to account for visitors, then multiplied by an occupant load factor of 50 square feet per employee (reference: 2010 California Plumbing Code).

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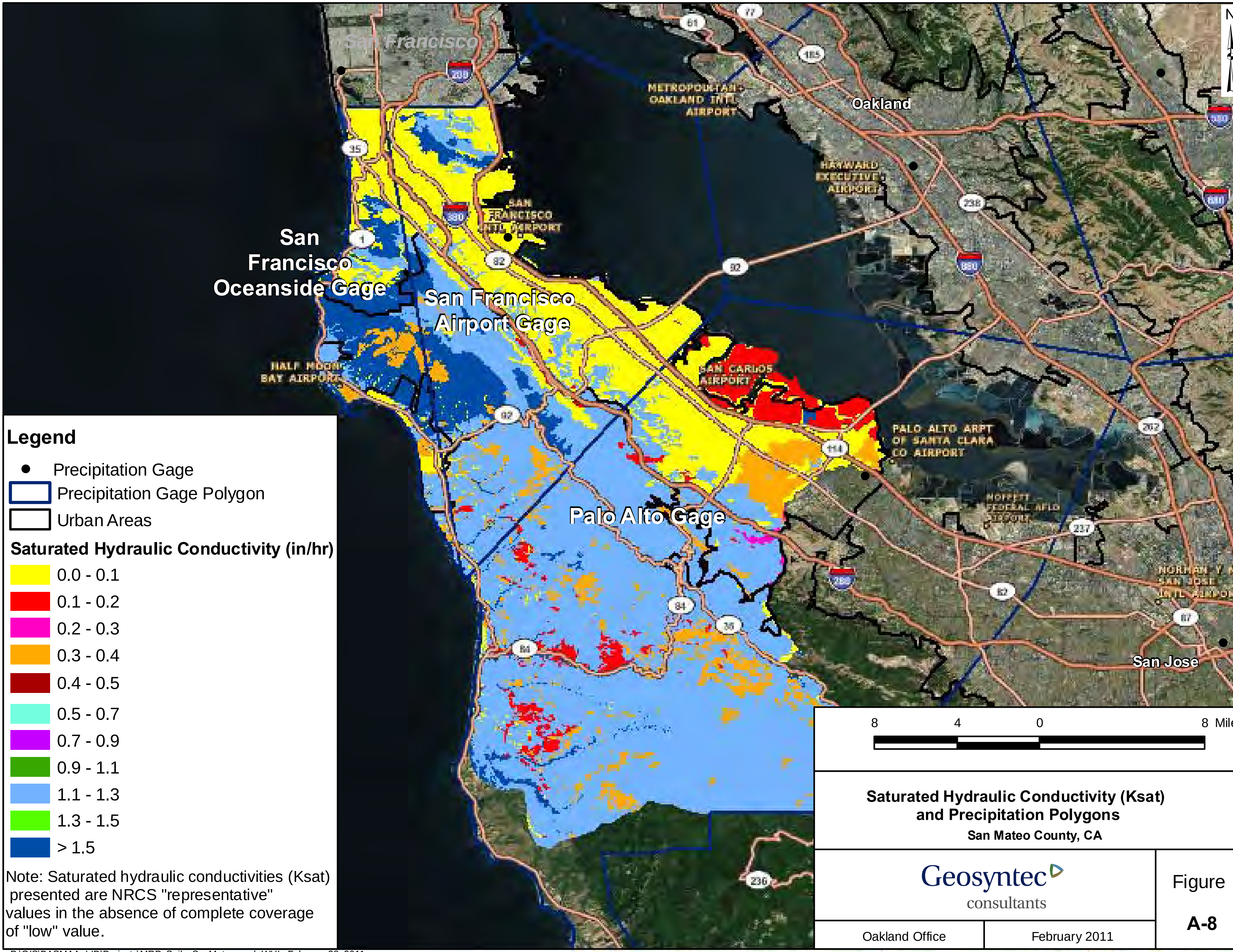
Attachment 2:
Excerpts from BASMAA's
Feasibility/Infeasibility Report

- Figure A-8: Saturated Hydraulic Conductivity (Ksat) and Precipitation Polygons, San Mateo County, CA
- Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-hour Drawdown Time
- Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less
- Table 10: TUTIA Ratios for Typical Land Uses for Rain Gauges Analyzed
- Table 11: EIATIA Ratios for Rain Gauges Analyzed
- Figure F-8: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: Palo Alto
- Figure F-9: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: San Francisco Airport
- Figure F-10: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area: San Francisco Oceanside



Saturated Hydraulic Conductivity (Ksat) and Precipitation Polygons

San Mateo County, CA

Geosyntec consultants

Oakland Office | February 2011

Figure A-8

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Table 8: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with a 48-hour Drawdown Time

Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	48	23,000	11,500
Brentwood	48	19,000	9,500
Dublin	48	21,000	10,500
Hayward	48	23,500	11,750
Lake Solano	48	29,000	14,500
Martinez	48	23,000	11,500
Morgan Hill	48	25,500	12,750
Palo Alto	48	16,500	8,250
San Francisco	48	20,000	10,000
San Francisco Oceanside	48	19,000	9,500
San Jose	48	15,000	7,500

If a longer drawdown time (and lower minimum demand) is desired, Table 9 includes the maximum drawdown time allowable to achieve 80 percent capture for a cistern sized at 50,000 gallons or less per acre of impervious area, along with the required cistern sizes and daily demands.

Table 9: Required Cistern Volume and Demand per Acre of Impervious Area to Achieve 80% Capture with the Longer Drawdown Time Allowable (Minimum Demand) for Cistern of 50,000 Gallons or Less

Rain Gauge	Drawdown Time (hr.)	Required Cistern Size (gallons)	Required Demand (gal/day)
Berkeley	180	44,000	5,900
Brentwood	240	42,000	4,200
Dublin	240	41,000	4,100
Hayward	240	47,500	4,800
Lake Solano	120	45,000	9,000
Martinez	180	44,000	5,900
Morgan Hill	180	49,000	6,500
Palo Alto	360	44,000	2,900
San Francisco	240	45,500	4,600
San Francisco Oceanside	240	43,000	4,300
San Jose	480	48,000	2,400

Table 10: TUTIA Ratios for Typical Land Uses for Rain Gauges Analyzed

Rain Gauge	Required Demand[1] (gal/day)	Toilet Users per Impervious Acre (TUTIA)[2]							
		Residential		Office/Retail		Schools		Industrial	
		Current	CGBC[3]	Current	CGBC	Current	CGBC	Current	CGBC
Assumed Per Capita Use per Day (gal/day)[4]		18	8.6	14	6.9	66	34	11	5.4
Berkeley	5,900	320	690	420	860	90	170	540	1,090
Brentwood	4,200	230	490	300	610	60	120	380	780
Dublin	4,100	220	480	290	590	60	120	370	760
Hayward	4,800	260	560	340	700	70	140	440	890
Lake Solano	9,000	490	1050	640	1,300	140	270	820	1,670
Martinez	5,900	320	690	420	860	90	170	540	1090
Morgan Hill	6,500	350	760	460	940	100	190	590	1,200
Palo Alto	2,900	160	340	210	420	40	90	260	540
San Francisco	4,600	250	530	330	670	70	140	420	850
San Francisco Oceanside	4,300	230	500	310	620	70	130	390	800
San Jose	2,400	130	280	170	350	40	70	220	440

Footnotes:

1 For a 50,000 or less gallon tank to achieve 80 percent capture within maximum allowable drawdown time (Table 9).

2 The TUTIA ratios are based on employee toilet users per impervious acre. These ratios were calculated using the daily toilet and urinal water usage from Table 5, which are per employee and encompass usage by visitors and students within the daily demand (assumes about 5 students per school employee).

3 CGBC = California Green Building Code Requirements water usage accounting for water conservation.

4 From Table 5, Toilet and Urinal Water Usage per Resident or Employee.

EIATA Ratios

Comparing the required daily demands for rainwater harvesting systems for both 48-hour drawdown times and maximum drawdown times to daily demands per irrigated acre, it becomes evident that the required demands are many times larger than irrigation demands. This can be translated into an 'Effective Irrigated Area to Impervious Area' (EIATIA) ratio by dividing the required rainwater harvesting system demand by the daily irrigation demand (shown in Table 7). Since both demands are calculated on a per acre basis, the EIATIA ratio represents the number of acres of irrigated area needed per acre of impervious surface to meet the demand needed for 80 percent capture. EIATIA ratios were analyzed for the rain gauges used for analysis and the evapotranspiration data listed in Table F-1. These ratios, as well as the required total imperviousness (assuming a project includes the impervious tributary area and the irrigated area only) are included in Table 11.

Table 11: EIATIA Ratios for Rain Gauges Analyzed

Rain Gauge	Required Daily Demand[1] (gal/day)	ET Data Location[2]	Conservation Landscaping			Turf Areas		
			Demand per Irrigated Acre[3]	EIATIA	Resultant Imper-viousness (%)	Demand per Irrigated Acre[3]	EIATIA	Resultant Imper-viousness (%)
Berkeley	5,900	Oakland	420	14.0	7%	850	6.9	13%
Brentwood	4,200	Brentwood	420	10.0	9%	850	4.9	17%
Dublin	4,100	Pleasanton	430	9.5	9%	850	4.8	17%
Hayward	4,800	Fremont	520	9.2	10%	1,040	4.6	18%
Lake Solano	9,000	Fairfield	420	21.4	4%	840	10.7	9%
Martinez	5,900	Martinez	380	15.5	6%	760	7.8	11%
Morgan Hill	6,500	Morgan Hill	500	13.0	7%	1,000	6.5	13%
Palo Alto	2,900	Redwood City	450	6.4	13%	900	3.2	24%
San Francisco	4,600	San Francisco	360	12.8	7%	720	6.4	14%
San Francisco Oceanside	4,300	San Francisco	360	11.9	8%	720	6.0	14%
San Jose	2,400	San Jose	470	5.1	16%	940	2.6	28%

Footnotes:
1 To achieve 80 percent capture within maximum allowable drawdown time (Table 9).
2 Closest location selected, from Table F-1.
3 From Table 7.

3.3.3 Summary

In summary, TUTIA ratios indicate that dense land uses would be required to provide the needed demand to make rainwater harvesting feasible in the MRP area. A project must have sufficiently high toilet flushing uses to achieve 80 percent capture within the maximum allowable drawdown time (see Table 9 for maximum allowable drawdown time for a 50,000 gallon tank or less). For instance, approximately 280 to 1,050 residential toilet users (roughly 90 – 130 dwelling units per acre[5]) are required, depending on location, per impervious acre to meet the demand needed for 80 percent capture with the maximum allowable drawdown time and CA Green Building Code flush requirements. Meeting the demand requirements would entail a very dense housing

5 Assuming three residents per dwelling unit.

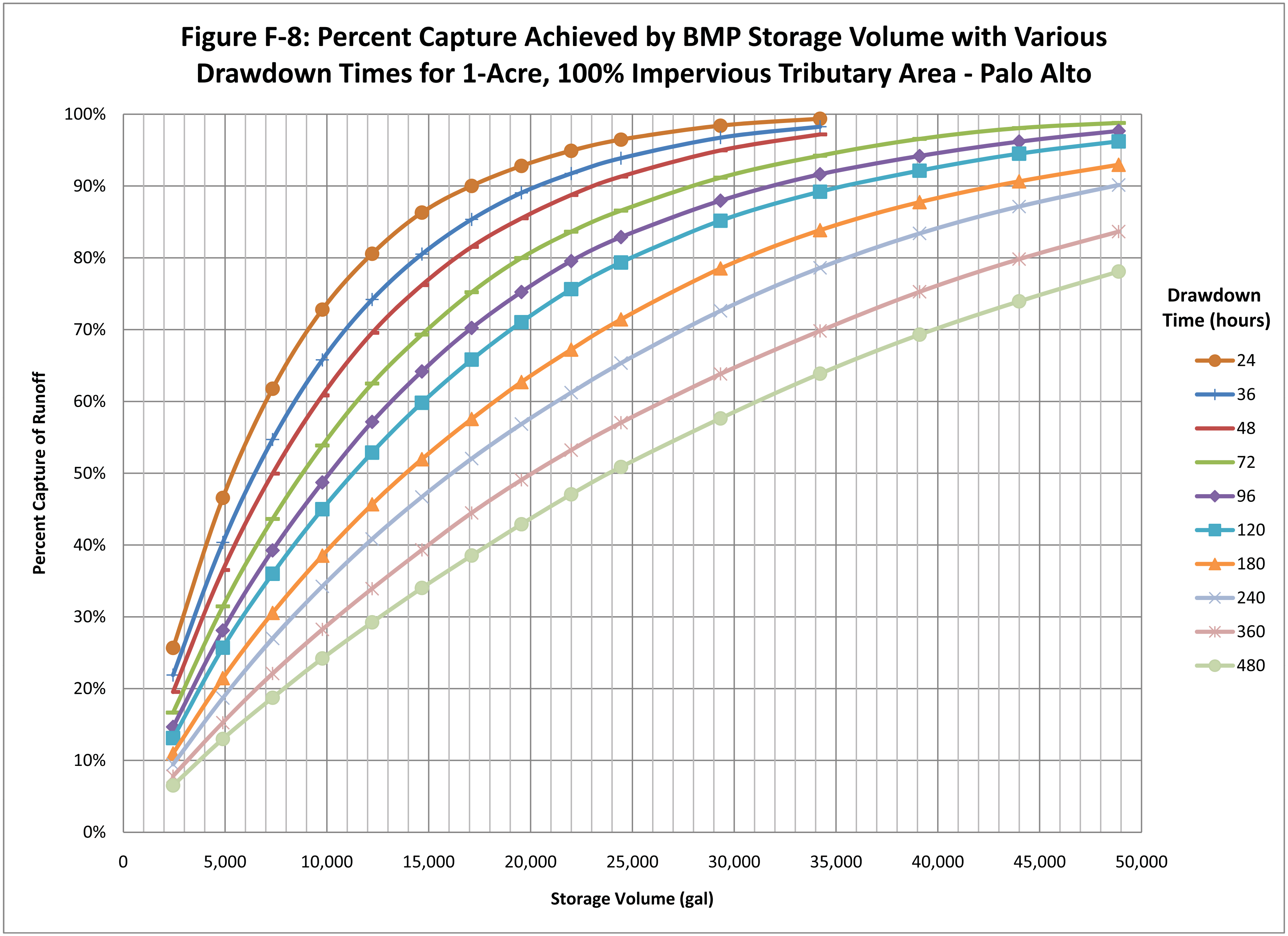
Figure F-8: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - Palo Alto
Percent Capture of Runoff
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Storage Volume (gal)
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

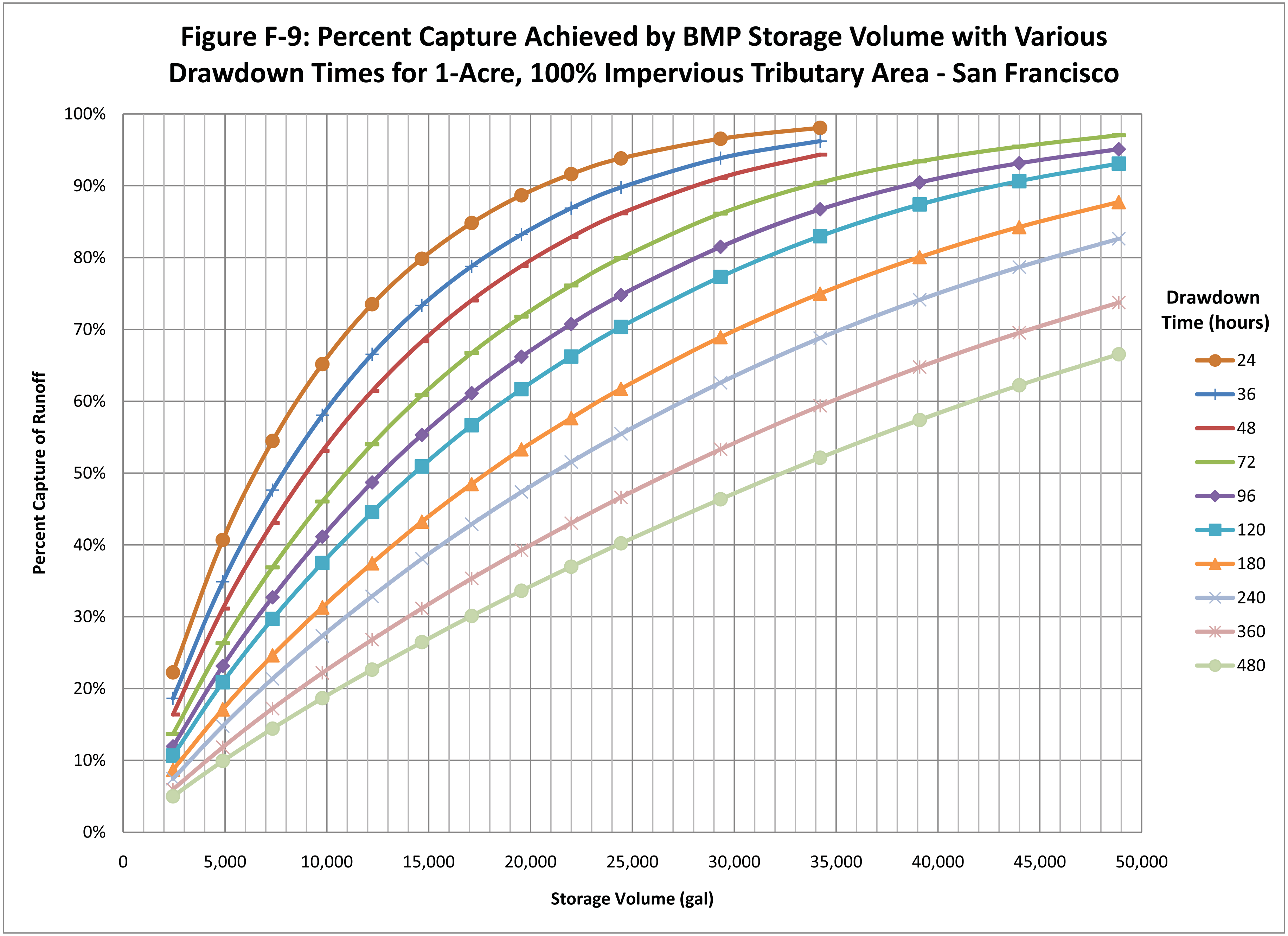
Figure F-9: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area - San Francisco
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480

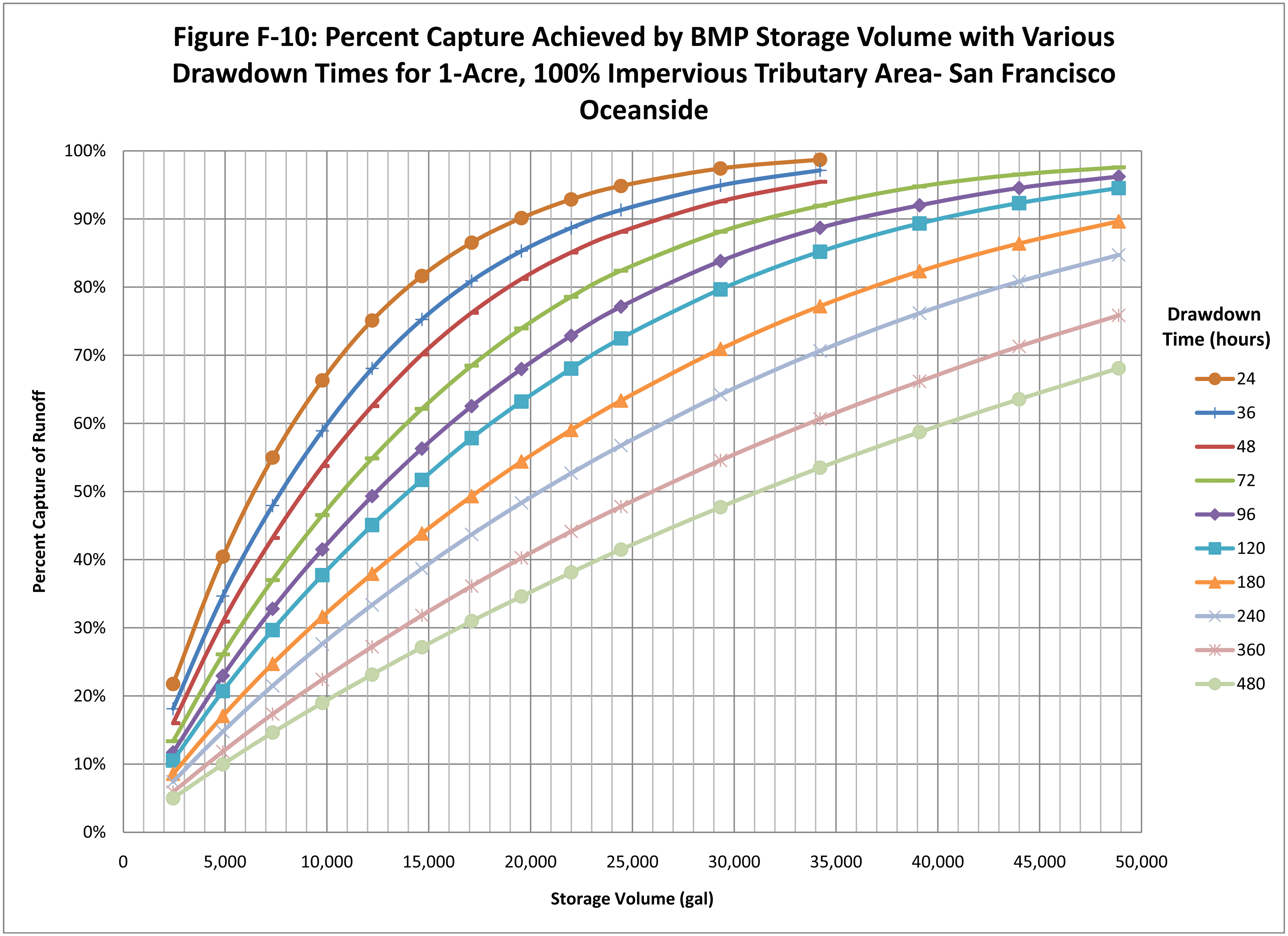
Figure F-10: Percent Capture Achieved by BMP Storage Volume with Various Drawdown Times for 1-Acre, 100% Impervious Tributary Area- San Francisco Oceanside
Percent Capture of Runoff
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Storage Volume (gal)
Drawdown Time (hours)
24
36
48
72
96
120
180
240
360
480