SIZING CRITERIA
FOR STORMWATER TREATMENT

Prepared for

Santa Clara Valley Urban Runoff Pollution Prevention Program, and
The Santa Clara Valley Water District

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Table of Contents

List of Tables

List of Figures

List of Attachments

1 INTRODUCTION

The purpose of this report is to apply the numeric sizing criteria for pollutant removal treatment systems as required in the Program's NPDES Provision C.3.d to conditions in the Santa Clara Basin; and to compare the results using the different criteria to a few examples.

The following are the sizing criteria that are described Provision C.3.d. The names assigned to each criterion are consistent with the nomenclature used in the 2003 California BMP Manual for New Development and Redevelopment (CASQA, 2003) and are given in bold in the parentheses following each criterion.

i. Volume Hydraulic Design Basis: Treatment BMPs whose primary mode of action depends on volume capacity, such as detention/retention units or infiltration structures shall be designed to treat storm water runoff equal to:

- The maximum storm water quality capture storm water volume for the area, based on historical rainfall records, determined using the formula and volume capture coefficients set forth in *Urban Runoff Quality Management, WEF Manual of Practice No. 23 and ASCE Manual of Practice No. 87, (199*8), pages 175-178 **(URQM Approach);** or
- The volume of annual runoff required to achieve 80 percent or more capture, determined in accordance with the methodology set forth in Appendix D of the *California Stormwater Best Management Practices Handbook*, (1993) using local rainfall data. **(CA Stormwater BMP Handbook Volume Approach).**

*ii. Flow Hydraulic Design Basis***:** Treatment BMPs whose primary mode of action depends on flow capacity, such as swales, sand filters, or wetlands, shall be sized to treat:

- 10% of the 50 year peak flow rate **(Factored Flood Flow Approach)**; or
- The flow of runoff produced by a rain event equal to or at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths **(CA Stormwater BMP Handbook Flow Approach);** or
- The flow of runoff from a rain event equal to at least 0.2 inches per hour intensity **(Uniform Intensity Approach)**.

2 LOCAL RAINFALL DATA: AVAILABILITY AND SELECTION

There are two categories of rainfall data available in the Basin, data collected and compiled by the National Climatic Data Center (NCDC) and data collected as part of the ALERT rainfall network. The available NCDC raingages are shown in Figure 1 on an isohyetal map of the Santa Clara Basin. Information about the gages is contained in Table 1. The NCDC data are generally fixed-interval hourly data. The period of record of the data varies from 3 years at Mount Hamilton to 53 years at the San Jose Airport.

There are numerous ALERT gages in the Basin. The format of the data varies, portions of the records are cumulative tipping-bucket data, while other portions are fixed interval data where the interval is usually 1 hour, but may be as high as 24 hours. The different formats generally provide different precision; for instance, tipping-bucket rainfall data are recorded as multiples of 0.04 in (1 mm), whereas fixed-interval data are typically multiples of 0.1 in. Because the NCDC data provided more consistent data in terms of precision and time interval, the rainfall analysis was conducted using the NCDC data.

Table 1 Santa Clara NCDC Hourly Rain Gauge Location Summaries

Rain Gauge	Elevation (ft)	Lat. (N)	Long. (W)	Available Period of Record	Station Number	Mean Event Rainfall Depth (in)
Gilroy 8 NE	1050	37:01	121:25	’48 - ’01	043419	0.684
Morgan Hill 6 WSW	640	37:06	121:45	’60 - ’75	045846	Not Analyzed
Morgan Hill	375	37:08	121:36	’48 - ’83, ’85 - ‘01	045853	0.760
Mount Hamilton	4206	37:20	121:38	’48 - ’51	045933	Not Analyzed
Palo Alto	25	37:26	122:08	’53 - ’75	046646	0.522
San Felipe Bell STN	371	37:01	121:20	’48 - ’75	047755	Not Analyzed
San Jose	67	37:21	121:54	’48 - ’01	047821	0.512

3 VOLUME-BASED AND FLOW-BASED CONTROLS

The type of rainfall analysis required varies depending on whether the BMP is based on treatment of a volume of water or treatment of a flow of water. This distinction between volume-based and flow-based controls is not always clear, especially in a sequence of BMPs or a treatment train. The following are general guidelines for each type of control.

Volume-based BMPs are designed to treat a volume of runoff, which is detained for a certain period of time to effect settling of solids and associated pollutants. Examples of volume-based controls include wet ponds, detention basins, constructed wetlands, and bioretention systems.

Flow-based BMPs treat water on a continuous flow basis. Examples include vegetated swales, media filters, hydrodynamic separators and screened systems.

Three alternative sizing methods for volume-based BMPs were investigated. The first two methods are defined in Provision C.3.d, whereas the third method has been applied in

Southern California where new development provisions first came into effect in California.

4 SIZING CRITERIA FOR VOLUME BASED CONTROLS

4.1 Method 1: Urban Runoff Quality Management (URQM) Approach

The URQM method estimates the “maximized stormwater quality capture volume” using the equation in *Urban Runoff Quality Management* (Water Environment Federation, 1998). The method is based on a combination of modeling and regression analysis conducted using long term rainfall records from six cities including San Francisco. For details regarding this method, the reader is referred to the Water Environment Federation Manual of Practice, pages 170-178.

The equations used in this method are:

$$P_o = (a \cdot C) \cdot P_6$$

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

Where

P_o = maximized detention storage volume based on the volume capture ratio as its basis (watershed inches);
a = regression constant from least-squares analysis (unit less);
C = watershed runoff coefficient (unit less);
P_6 = mean storm precipitation volume (watershed inches); and
i = watershed impervious ratio (range: 0-1)

Parameter *a* reflects the effect of drain time on storage, and equals 1.963 for drain time of 48 hours, 1.582 for a drain time of 24 hours, and 1.312 for a drain time of 12 hours.

Application of the URQM Method to the Santa Clara Basin

P_6 can be determined by two ways: Figure 5.3 in *Urban Runoff Quality Management*, or preferably by performing analysis on local historical rainfall data. To determine the mean precipitation, EPA’s Synoptic Rainfall Analysis Program – SYNOP – was applied. In this method the rainfall record is subdivided into discrete events separated by a dry inter-event period which in this case was set to a minimum of 6 hours. Small rainfall events defined as events whose depth was less than or equal to 0.10 inches were deleted from the record as such events tend to produce little if any runoff. This approach to defining minimum storm events which produce runoff is consistent with the URQM Method. Values of the mean storm event size for selected raingages in the Santa Clara Basin are provided in Table 1 and plotted in Figure 5 against the mean annual rainfall. Figure 5 along with the isohyetal map shown in Figure 1 can be used to estimate the mean storm size at most locations within the basin where development is likely to occur.

4.2 Method 2 California Stormwater BMP Handbook Volume Approach (adapted)

Most water quality basins are designed to treat only a portion of the runoff from a given site, as it is not economically feasible to capture 100% of the runoff. The percent of runoff treated by a basin is referred to as the “percent capture”. The CA BMP Handbook Method estimates the basin volume to achieve various levels of volume capture.

In the California Stormwater Best Management Practices Handbook (2003), a proprietary version of the Storage, Treatment, Overflow, Runoff Model – STORM – was used as the basis for the volume-based BMP sizing criteria. The model results were presented as the relationship of “unit basin storage volume” and % volume capture of the BMP. The “unit basin storage volume” would then be used to size the BMP, using the following equation:

$$\textit{BMP Volume} = \textit{Unit Basin Storage Volume} \times \textit{Watershed Area}$$

Herein, SWMM was used in place of STORM, as SWMM is a commercially available model and has some features that proved advantageous. For example, SWMM allows one to simulate the effects of soil type and slope. Comparison of the results from STORM and SWMM showed that the two models produced similar and consistent results, justifying the substitution of SWMM for STORM. So the approach used herein is an adapted version of the California BMP Handbook Approach.

Application of the California BMP Handbook Volume Approach to the Santa Clara Basin

This Method takes into account several variables and therefore requires more explanation than the other methods. The following describes what those variables are, and the rationale for their estimation.

Numeric sizing criteria for volume based controls are presented in the form of curves that plot the basin size, expressed as unit basin storage, corresponding to 80% capture as a function of site percent imperviousness, soil type, location (rain gage), and assumed slope. The 80% capture criterion stems from language in the Permit, where the goal is to achieve “80 percent or more capture”. Unit basin storage is expressed in watershed inches which allows design curves to be developed that apply to a range of catchment sizes.

Factors that can affect the percent capture include:

- the rainfall characteristics at the site,
- the percent imperviousness of the site,
- the soil condition and associated infiltration rates (less important for highly impervious projects, or where grading compacts the soils),
- the design drain time for the volume based BMP, and
- the slope of the site.

The following describes how each of these factors was taken into account in developing the design curves.

Drain Time

Drain time is the time required to drain a basin that has reached its design capacity; usually expressed in hours. Drain time is important as it is a surrogate for residence time, which affects the size of particle that could potentially be settled out in the basin. Estimates for design drain time vary, and ideally would be determined based on site-specific information on the size, shape, and density of suspended particulates in the runoff. This information is generally not available and estimates of appropriate ranges for drain time have relied on settling column information reported in the literature. In the WEF Method, equations are provided for 24, 48, and 72 hour drain times.

An important source of drain time information is settling column tests conducted by Grizzard et. al. (1986) as part of the Nationwide Urban Runoff Program (NURP). He found that settling times of 48 hours resulted in removals of 80-90 % of total suspended solids (TSS). Rapid initial removal was also observed in stormwater samples with medium (100 to 215 mg/L) and high (721 mg/L) initial TSS concentrations. For example, at settling times of 24 hours, the 80-90% removals were already achieved in samples with medium and high initial TSS, whereas only 50-60% removal was achieved in those with low initial TSS.

Limited local settling column tests were also conducted by Woodward Clyde Consultants and Kinetic Laboratories Incorporated (KLI) using samples obtained at four stream monitoring stations (Calabazas Creek, Sunnyvale East Channel, Guadalupe River, Coyote Creek) in the Santa Clara Basin. The data were analyzed and reported in an internal Woodward-Clyde memorandum by E.D. Driscoll (1990). Driscoll's analysis indicated that settling times of 48 hours resulted in removals of approximately 73-84% of TSS in four tested stormwater samples (initial TSS concentrations of 22, 28, 69, and 85 mg/L). At 24-hour settling times, 83% TSS was already removed in the sample with initial TSS of 85 mg/l, but only 64-69% TSS removals were achieved in the rest of the samples.

Given the data provided above, a drain time of 48 hours has been used in developing the curves herein. This is also consistent with recommendations of vector control agencies that structures be designed to drain in less than 72 hours, to minimize mosquito production.

It should be pointed out that basin outlet structures are designed to achieve the design drain time. It is recommended that, in order to achieve reasonable treatment for smaller storms that may only fill the basin partially, the outlet be designed to achieve a 24 hour drain time if the basin is only filled to half its design volume. This requirement can easily be achieved with a compound weir or riser with varying numbers and sizes of orifices.

Percent Imperviousness

The major factor affecting basin size is the percent imperviousness of the catchment. Impervious surfaces include paved highways, streets, rooftops, and parking lots. The percent of the catchment area covered by such surfaces is termed the "percent imperviousness" and will vary depending on each project. If the runoff from an impervious surface drains directly into the storm drain system, this area is termed the "directly connected imperviousness area" (DCIA). Values of percent imperviousness generally vary with the type of development. The numerical sizing curves shown are for a range of percent imperviousness (30% to 100%) corresponding roughly with low density single family residential (30%) to commercial and/or industrial development (up to 100%). If the runoff from pervious areas can be treated by infiltration and/or filtering and routed around the BMP, the design can be based on treating the runoff from the impervious area only.

Soil Infiltration and Compaction

The pervious portions of a site can infiltrate some of the rainfall depending on the infiltration characteristic of the soils and the levels of groundwater. For the purposes of characterizing infiltration, soil types have been classified into four Hydrologic Soil Groups (HSGs) by the Natural Resources Conservation Service (NRCS). A further subdivision of soils can be made in terms of soil texture as shown in Figure 2. Figure 2 shows that most soils in the Santa Clara Basin can be classified as clay, clay loam, loam, sandy clay, or silt loam.

The following table shows values of infiltration parameters used in the SWMM Model for various soil textures.

Table 2 Green-Ampt Infiltration Parameters used in SWMM

Soil Texture	Hydrologic Soil Group	SUCT (in)	HYDCON (in/hr)	SMDMAX
Sandy Loam	A	4.33	0.860	0.453
Loam	B	3.50	0.520	0.463
Silt Loam	B	6.57	0.270	0.501
Sandy Clay Loam	C	8.60	0.120	0.398
Clay Loam	D	8.22	0.079	0.464
Sandy Clay	D	9.41	0.047	0.430
Clay	D	12.45	0.024	0.475

SUCT = average capillary suction at the wetting front
HYDCON = saturated hydraulic conductivity of soil
SMDMAX = initial moisture deficit
Source: Maidment, David R. (1993), *Handbook of Hydrology*

An important consideration in the application of these design curves is the effect of soil compaction that can occur during site preparation and grading. Data provided by Pitt (2002) indicates that most urban soils are highly compacted, and it is recommended that design curves for sites where traditional site preparation practices are conducted, use the design curves for a poorly infiltrating soil, such as clay or sandy clay. Where site planning allows for protecting natural areas and associated vegetation and soils, the design curves associated with the site specific soil can be used.

Site-Specific Precipitation

Rainfall amounts and characteristics vary across the Basin in response to orographic effects associated with the Santa Cruz Mountains and the Mount Diablo Range, the directional patterns of storm fronts approaching the Basin, and other factors. These effects are illustrated in Figure 1, which shows the distribution of mean annual rainfall. Obviously the location of the project site will dictate the local rainfall patterns and must be taken into account in developing the design sizing curves. For this purpose, rainfall records from several raingages that represented a range of mean annual precipitation were analyzed.

Slope

The slope of the land can affect runoff volumes and flow rates. For the purpose of this guidance, it was assumed that most development would occur either on the relatively flat valley floor or in upland areas where the slopes are generally mild. The SWMM model was run for two slopes, 1% and 15%, with the idea that this would bracket most development sites. For intermediate slopes, results could be interpolated.

Figures 3-A through 3-D show the sizing curves for the San Jose Airport, Palo Alto, Gilroy, and Morgan Hill rain gages assuming 1% slope, respectively. Figures 4-A through 4-D show the corresponding curves for 15% slope. For each gage, design curves are indicated for a range of soil textures.

A sample checklist for applying this method is provided in Attachment A.

4.3 Method 3: 85th Percentile Storm Event

The 85th percentile storm method is based on the volume of runoff produced by the 85th percentile storm event. This method is derived from the guidance developed in Southern California as required by Standard Urban Storm Water Mitigation Plans (SUSMPs). This method is not one of the candidate methods in the Permit, but the Permit allows the Program to recommend alternative methods.

The Southern California guidance requires that the size of volume-based BMPs be at least the volume of runoff produced from an 85th percentile “24-hour” storm event. Here, storm events were defined based on continuous rainfall irrespective of duration, as storm events may carry over into more than one day. The 85th percentile storm event can be obtained from analyzing the results of SYNOP performed on local historical rainfall record with the same settings used in the URQM method (i.e., inter-event time of 6 hours, and minimum depth of runoff-generating storms of 0.1 in.). Then a modified version of the rational formula, in that runoff volume rather than runoff flowrate is predicted, was used to convert the rainfall volume to the runoff volume. This modified form of the rational method is expressed as:

$$Q = CiA$$

Where

Q = runoff volume, acre-feet
C = volumetric runoff coefficient, calculated by the URQM method’s equation (see above)
i = storm depth, ft
A = watershed area, acres

Application of the 85th Percentile Storm Event Method to Santa Clara Basin

Figure 5 shows the visually best-fit line for 85th percentile storms estimated for the Palo Alto, San Jose, Gilroy, and Morgan Hill rain gages. The sizing line indicates that the design storm would vary from about 0.9 inches on the Valley Floor where the mean annual precipitation is about 14 inches; to about 1.2 inches where the mean annual rainfall reaches 20 inches. For comparison, the estimated average 85th percentile storm event in southern California is 0.75 inches in Los Angeles County (Los Angeles County, 2000), and 0.80 inches in Orange County (San Diego RWQCB, 2002).

5 SIZING CRITERIA FOR FLOW-BASED CONTROLS

The rainfall analysis for flow-based controls focuses on estimating the design rainfall intensity, which is then converted to a flowrate using the rational method.

$$Q = CiA$$

Where

Q = flow, cfs
C = runoff coefficient, calculated by the URQM method's equation (see above) or other acceptable method
i = rainfall intensity, in/hr
A = watershed area, acres

The three alternative sizing methods examined corresponded to those in the C.3.d provision, and are as follows.

5.1 Method 1: Factored Flood Flow Approach

In this method a design intensity equal to 10% of the intensity obtained from local intensity-duration-frequency (IDF) curve is used in the rational method equation to estimate the design flow. To estimate the design intensity one enters the IDF curve for the 50 year return period frequency, and selects the intensity that corresponds to a duration equal to the time of concentration for the site. The design intensity is one-tenth of the intensity obtained from the IDF curve.

The time of concentration is the travel time from the most remote portion of area that drains into the water quality basin. For urban drainage the time of concentration includes an overland flow portion and a portion in which the flow is assumed to be in drainage pipes leading to the basin. Estimates for the time of travel in drainage pipes usually assume uniform open channel flow and are based on Mannings Equation that takes into account pipe size, slope, and roughness.

Figure 6 shows the IDF Curve for the 50 year return period event based on a rainfall analysis conducted by Santa Clara Valley Water District staff for the San Jose Airport. This and similar curves for other rain gages apply to this method.

5.2 Method 2: California Stormwater BMP Handbook Flow Approach

In this method, a design intensity of 2 times the 85th percentile hourly rainfall intensity is used in the rational method equation to estimate the design flow. The factor of 2 is intended to account for the fact that rainfall intensities increase for shorter duration events, and intensities estimated from hourly data tend to under-predict flowrates in small catchments where the time of concentration is less than 1 hour.

Figure 7 shows the smoothed Cumulative Distribution Function (CDF) of rainfall intensity for the Palo Alto, San Jose, Gilroy, and Morgan Hill rain gages. The dashed line on the figure corresponds to the 85th percentile values, which are listed in the following table.

Table 3 Design Rainfall Intensity for Four Rain Gages

Rain Gage	Rainfall Intensity (in/hr) (85th Percentile)	Design Rainfall Intensity (in/hr) (2 x 85th percentile)
Palo Alto	0.096	0.19
San Jose	0.087	0.17
Gilroy	0.11	0.21
Morgan Hill	0.12	0.24

This table indicates that the design rainfall intensity would vary depending on location and therefore the most representative rain gage.

5.3 Method 3: Uniform Intensity Approach

In this method a design intensity of 0.2 in/hr is used in the rational method equation, without regard to location or time of concentration.

6 COMPARISONS OF METHODS

6.1 Comparison of Volume Based Methods

For comparison, the three sizing criteria methods were applied to two examples, a residential example and a commercial example.

Residential Example: Area = 100 acres; % Impervious = 50; Drain time of the BMP = 48 hours; Rainfall data: San Jose International Airport; soils=clay; slope=1%.

Commercial Example: Area = 10 acres; % Impervious = 80; Drain time of the BMP = 48 hours; Rainfall data: San Jose International Airport; soils=clay; slope=1%.

The required volume of the BMP using the three methods is shown in the following table.

Table 4 Comparisons of Volume Based Methods

Method	BMP Volume Required (acre-ft)	
	Residential: 100 AC; 50% IMP	**Commercial: 10 AC; 80% IMP**
1) URQM method	2.84 acre-ft (C=0.34)	0.50 acre-ft (C = 0.6)
2) CA BMP Handbook (adapted)	3.33 acre-ft (Clay, 1% slope)	0.42 acre-ft (Clay, 1% slope)
3) 85th percentile storm method	2.55 acre-ft (C= 0.34)	0.45 acre-ft (C = 0.6)

The table shows that no one method tends to be higher in both examples. For the residential example, the basin size using the CA BMP Handbook Approach is the highest, followed by the URQM Method and then the 85th Percentile Storm Method. For the commercial example, the basin size using the URQM Method is highest followed by the 85th Percentile Storm Method, and then the CA BMP Method. The maximum difference between the methods is about 30%.

There are a variety of factors that could account for this ordering. One interesting point is that the adapted CA BMP Handbook Method predicts the largest basin for the residential example and the smallest basin for the commercial example. The adapted CA BMP Handbook Method is the least empirical of the methods, and takes into account more factors such as slope, soil type, and effects of “back to back” rainfall events. For the residential example, where the impervious percentage is only 50%, the runoff from the soils becomes important, and in this case we have assumed the soils to be clay which is less infiltrative than other soils. The result is higher runoff predicted than the other methods, and a larger basin. In the commercial case where the site is largely impervious, the effect of soils is less important, and the adapted CA BMP Handbook Method prediction is the lowest.

6.2 Comparison of Flow-Based Sizing Methods

For comparison, the three alternative sizing criteria also were applied to a residential and a commercial example. In these examples, however, the size of the drainage was limited to 1 acre because many flow-based controls are intended to be integrated into the development project. For Method 1, it was assumed that the time of concentration for the 1 acre commercial example was 5 minutes, and for the 1 acre residential example, 10 minutes.

For Methods 1 and 2, data from the San Jose Airport rain gage were used. In each of these methods the runoff coefficient as described in the URQM Method was applied. The results are summarized below:

Table 5 Comparison of Flow Based Sizing Methods

Method	**Residential: 1 AC; 50% IMP; C = 0.34**		**Commercial: 1 AC; 80% IMP; C = 0.60**	
	Design Rainfall Intensity	**Design Flowrate**	**Design Rainfall Intensity**	**Design Flowrate**
1) Factored Flood Flow	0.170 in/hr	0.058 cfs	0.241 in/hr	0.144 cfs
2) CA BMP Handbook	0.174 in/hr	0.059 cfs	0.174 in/hr	0.104 cfs
3) Uniform Intensity	0.200 in/hr	0.068 cfs	0.200 in/hr	0.120 cfs

As with the volume based methods, no one method is consistently higher or lower. For the residential example, Methods 1 and 2 are in agreement, and Method 3 predicts a flowrate about 20% higher. In the commercial example the range of estimates is larger. Method 1 predicts the highest flowrate, a value that is about 40% higher than the lowest estimate given by Method 2.

7 RECOMMENDATIONS

For volume based controls, the adapted CA BMP Handbook Method is recommended because it takes into account rainfall characteristics, percent imperviousness, drainage time, soil infiltration conditions, and slope. All of these factors can be relatively easily determined for a site, and graphs provided in this report should be sufficient for sizing basins. There should be no need to conduct additional model runs, except perhaps under unusual circumstances. Also the method simulates the operation of a basin under realistic conditions, and it is reasonable to assume that basins designed using this method will achieve the desired percent capture specified in the Permit. Lastly, the method explicitly incorporates a drain time that begins to address the level of treatment.

For flow based controls, we recommend using the CA BMP Handbook Method as estimated for each of four rain gages: Palo Alto, San Jose Airport, Gilroy, and Morgan Hill. This method is based on local rainfall data and achieving a percent capture of small storms consistent with the Permit requirements.

The following table summarizes the advantages and disadvantages of the various sizing criteria

Table 6 Advantages and Disadvantages of Candidate Sizing Criteria

Volume Based Methods	Advantages	Disadvantages
1) Urban Runoff Quality Management Method	Takes into account drain time. Based on modeling and regression analysis using long term rainfall records in six cities including San Francisco. Easy to apply.	Does not simulate performance under local rainfall patterns, but rather estimates volume based on average storm event size. Does not consider soil type or slope.
2) CA BMP Handbook Method (adapted using SWMM Model)	Most comprehensive method. Takes into account drain time, slope, and soil types. Based on continuous simulation of detention storage, outflow, and bypass using local long term rainfall records.	Most complex method of the three candidate methods, but graphs are provided that should cover most applications.
3) 85th Percentile Design Storm	Design storm concept is familiar to most engineers and easy to use and understand.	Only addresses percent capture, not drain time. Does not consider soil type, or slope. Leaves more discretion to engineer. Determining if standard is met by permitting agency could be more difficult than either of other 2 methods.
Flow Based Methods		
1) Factored Flood Flow Approach (10% of 50-year rainfall intensity)	Intensity-duration-frequency curves very familiar to most engineers. Takes into account local rainfall conditions.	Not based on achieving any given percent capture. Sensitive to time of concentration estimate which could make it more difficult for permitting agency.
2) CA BMP Handbook Approach (2 times 85th percentile rainfall intensity)	Takes into account local rainfall conditions.	Some question regarding appropriateness of factor of 2.
3) Uniform Intensity Approach (0.2 inches/hr)	Simplest of methods.	Does not take into account local rainfall patterns and statistics. “One size fits all”.

8 REFERENCES:

California Stormwater Quality Association, 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment, January.

Driscoll, E.D. 1990. Memorandum from ED Driscoll to G. Palhegyi which included Santa Clara (internal) Settling Test Report Based on Settling Column Tests Conducted by Kinetic Laboratories Inc. (KLI). April 25.

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Pitt Robert, Shen-En Chen, and Shirley Clark (2002). *Compacted Urban Soils Effects on Infiltration and Bioretention Stormwater Control Designs*, in Global Solutions for Urban Drainage; 91UCD.CD-ROM Proceeding of the 9th International Urban Drainage Conference (September 8-13, 2002)

San Diego Regional Water Quality Control Board, 2000. NPDES Permit and Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewers Systems (MS4s) Draining the Watersheds of the County of Orange, The Incorporated Cities of Orange County, and the Orange County Flood Control District within the San Diego Region.

WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87, 1998: *Urban Runoff Quality Management*

ATTACHMENT A

CHECKLIST FOR SIZING VOLUME-BASED BMPS BY SWMM METHOD

1. Determine the drainage area for the BMP: __________acres ☐
2. Determine % imperviousness of the drainage area: __________% ☐
3. Determine from Figure 1 the mean annual rainfall at the location of the project: __________ inches ☐
4. Identify from Figure 2 the soil type that is representative of the pervious portion of the project:

   ☐ Loam ☐ Silt Loam ☐ Clay Loam

   ☐ Sandy Loam ☐ Clay

5. Identify the gage with a mean annual rainfall closest to that determined in Step 3 – from the following list:

   ☐ San Jose Airport – 13.9 in ☐ Palo Alto – 13.7 in

   ☐ Gilroy – 18.2 in ☐ Morgan Hill – 19.5 in

6. With the information gathered in the previous steps, select an appropriate figure from Table 1. With the % impervious (Step 2) and soil type (Step 4), obtain the unit basin storage.

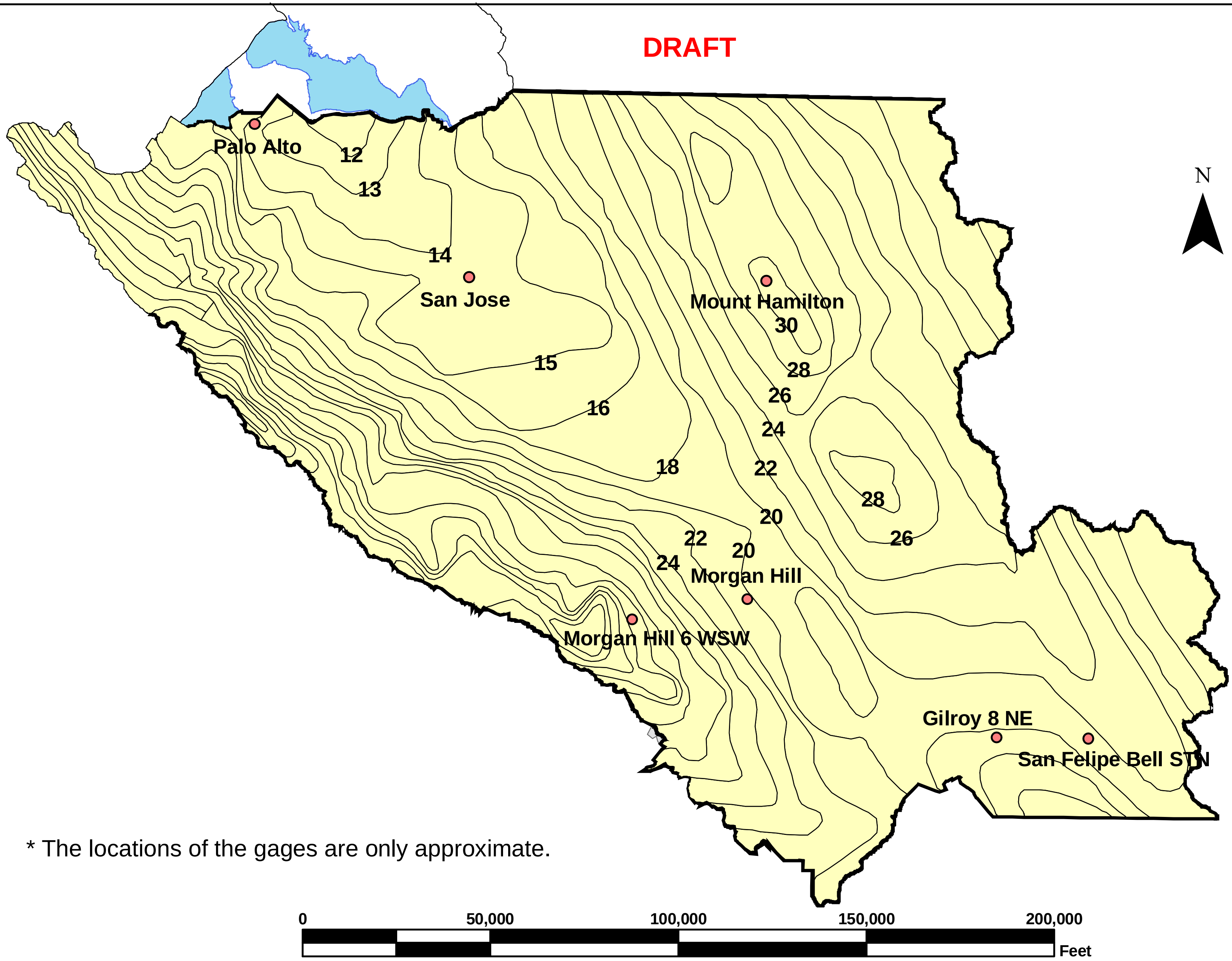
Table 1 Summary of appropriate figures to use based on terrain types and mean annual rainfall

Gages (Step 6)	Figures
San Jose Airport – 13.9 in	3-A ☐
Palo Alto – 13.7 in	3-B ☐
Gilroy – 18.2 in	3-C ☐
Morgan Hill – 19.5 in	3-D ☐

7. Apply a correction factor -- the ratio between the mean annual rainfall at the site (Step 3) and that at the gage from which the unit basin storage was obtained (Step 5 and 6).
8. Size the BMP, using the following equation:

$$BMPVolume = CorrectionFactor \times UnitStorage \times DrainageArea$$ ☐

DRAFT



* The locations of the gages are only approximate.

Figure 1 Some NCDC Rain Gages in Santa Clara County and Mean Annual Rainfall Isopleths

(GIS DATA OBTAINED FROM SANTA CLARA VALLEY WATER DISTRICT)

Hydromodification Management Plan

GeoSyntec Consultants

Santa Clara Valley Water District

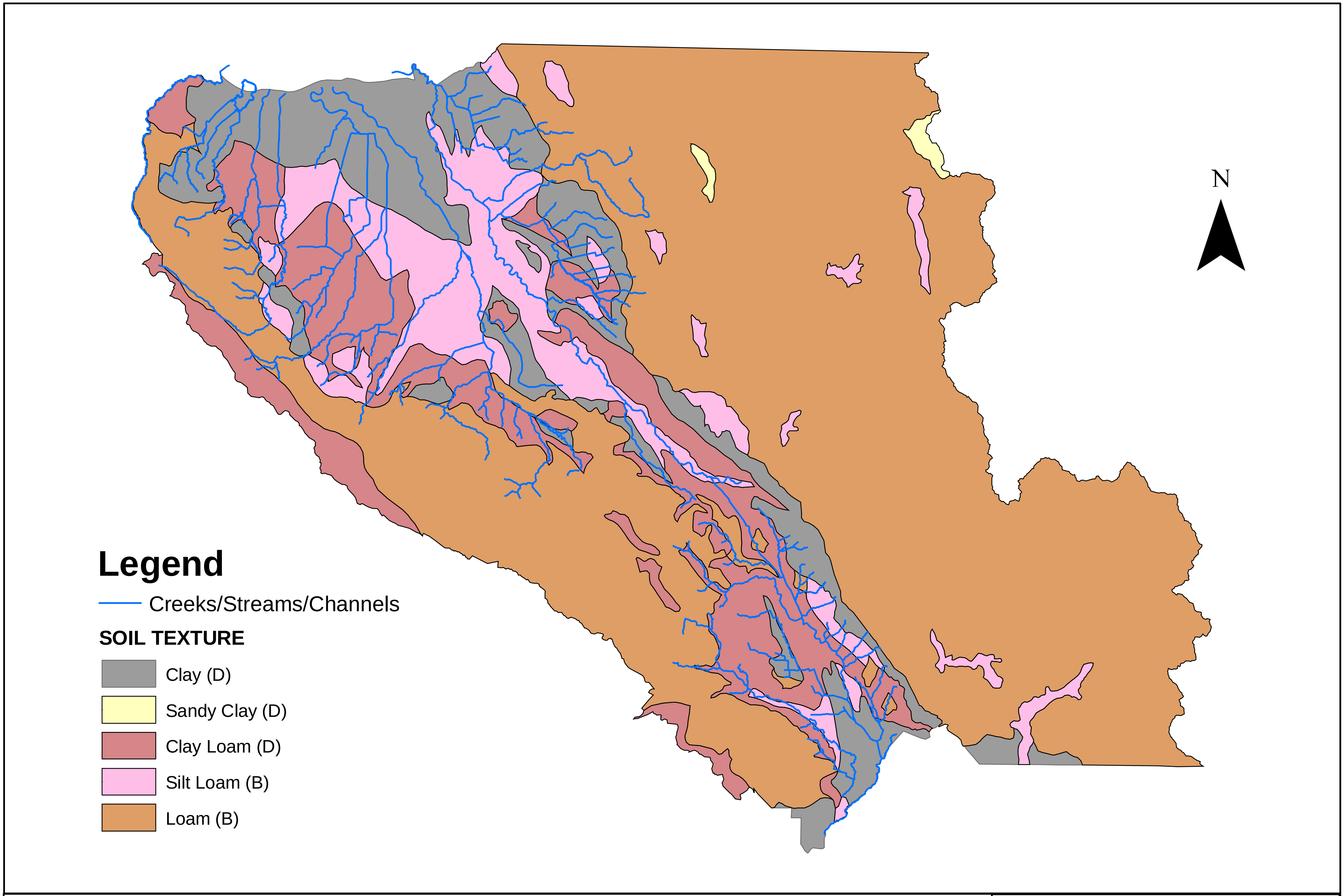


Figure 2 Map of Soil Textures in Santa Clara County

(GIS DATA OBTAINED FROM SANTA CLARA VALLEY WATER DISTRICT)

Hydromodification
Management Plan

**GeoSyntec
Consultants**

Santa Clara
Valley Water District

P:\GIS\santaclaraWD\projects\SoilMap.mxd

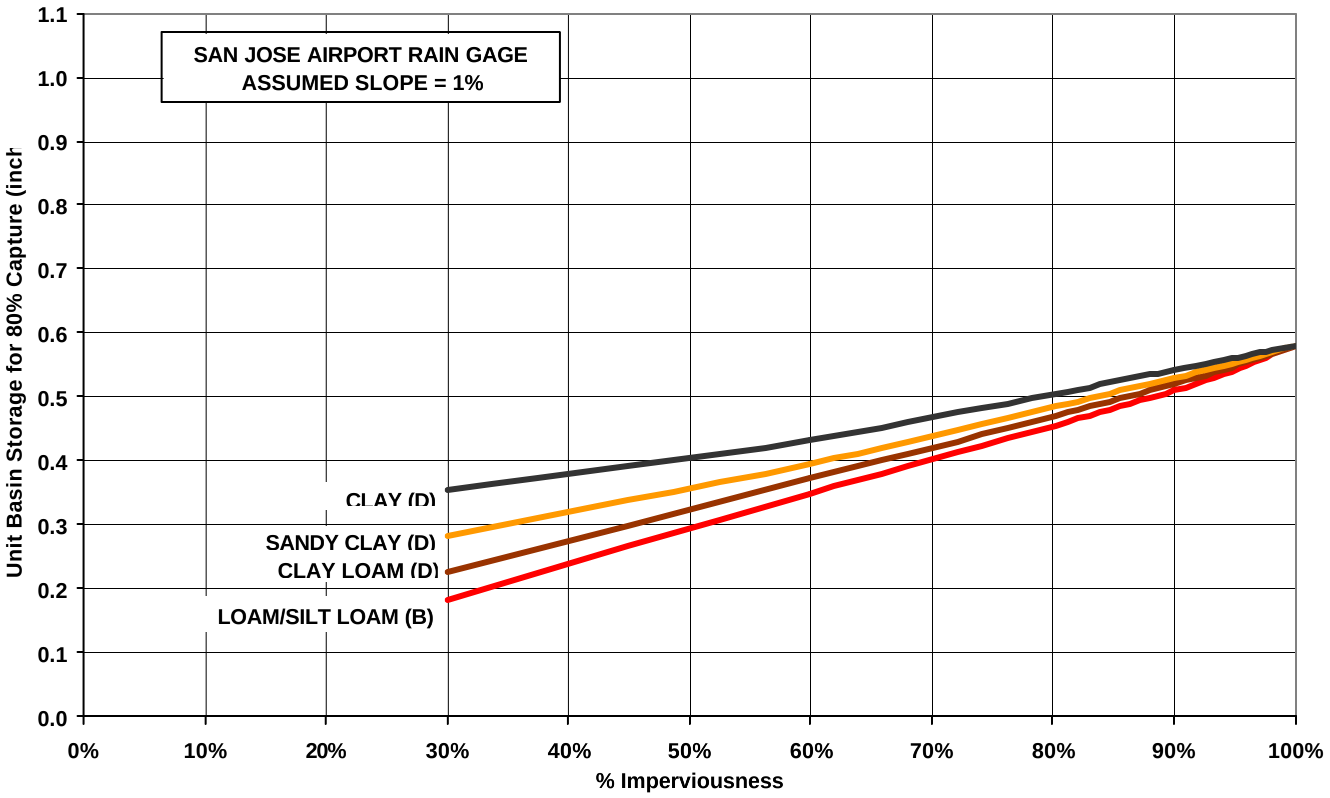


Figure 3-A Unit Basin Volume for 80% Capture - **San Jose Airport** Rain Gage

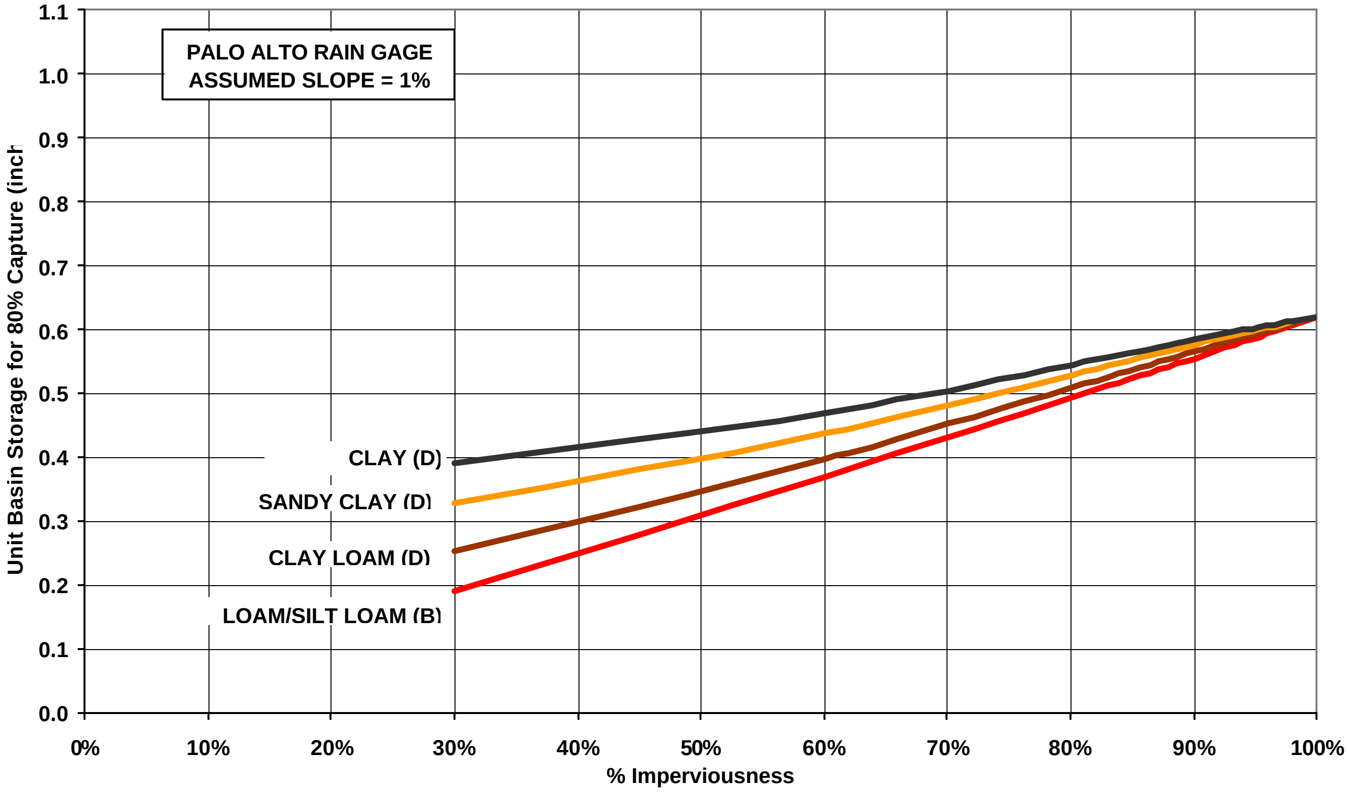


Figure 3-B Unit Basin Volume for 80% Capture - **Palo Alto** Rain Gage

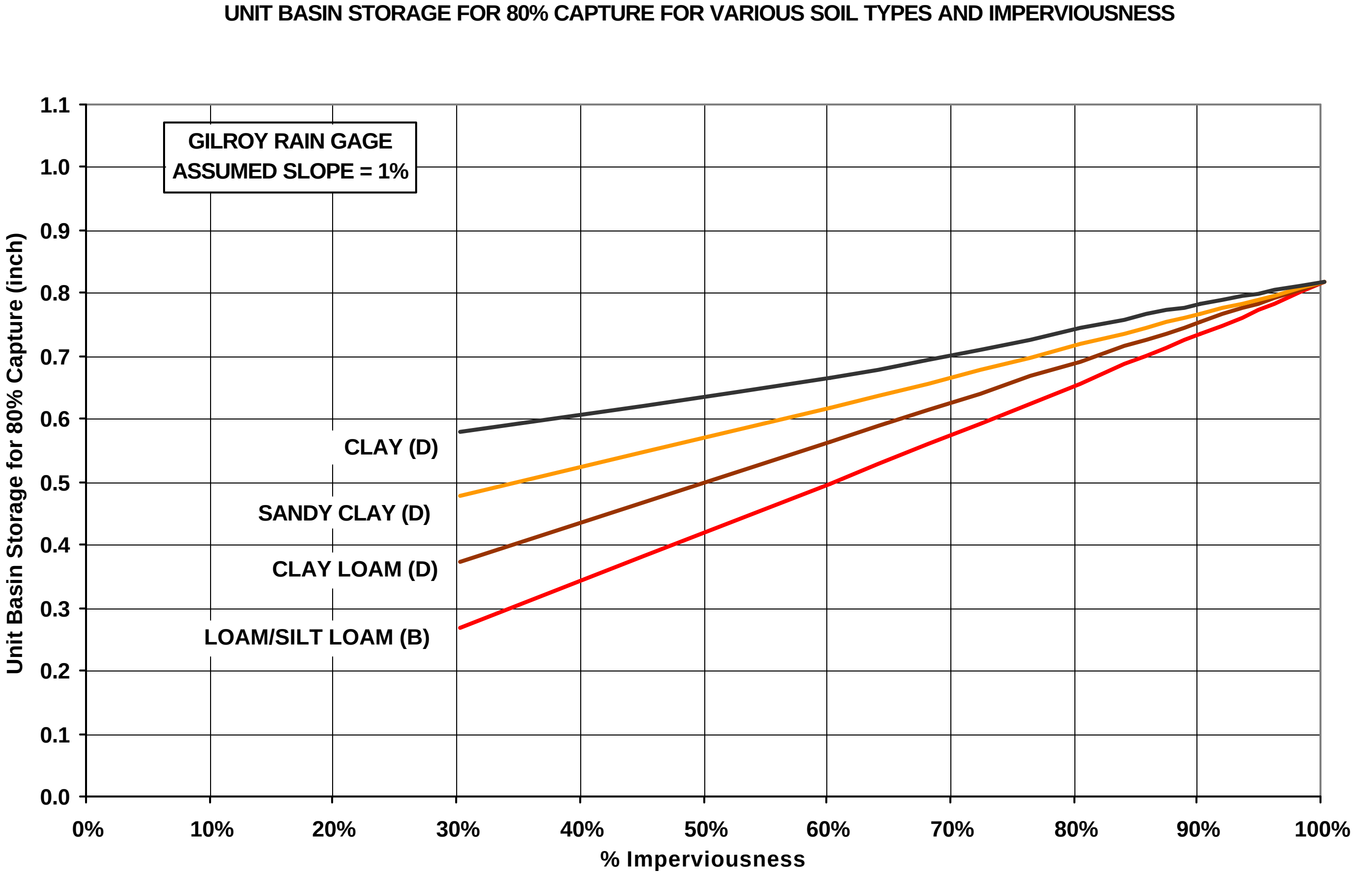


Figure 3-C Unit Basin Volume for 80% Capture - **Gilroy** Rain Gage

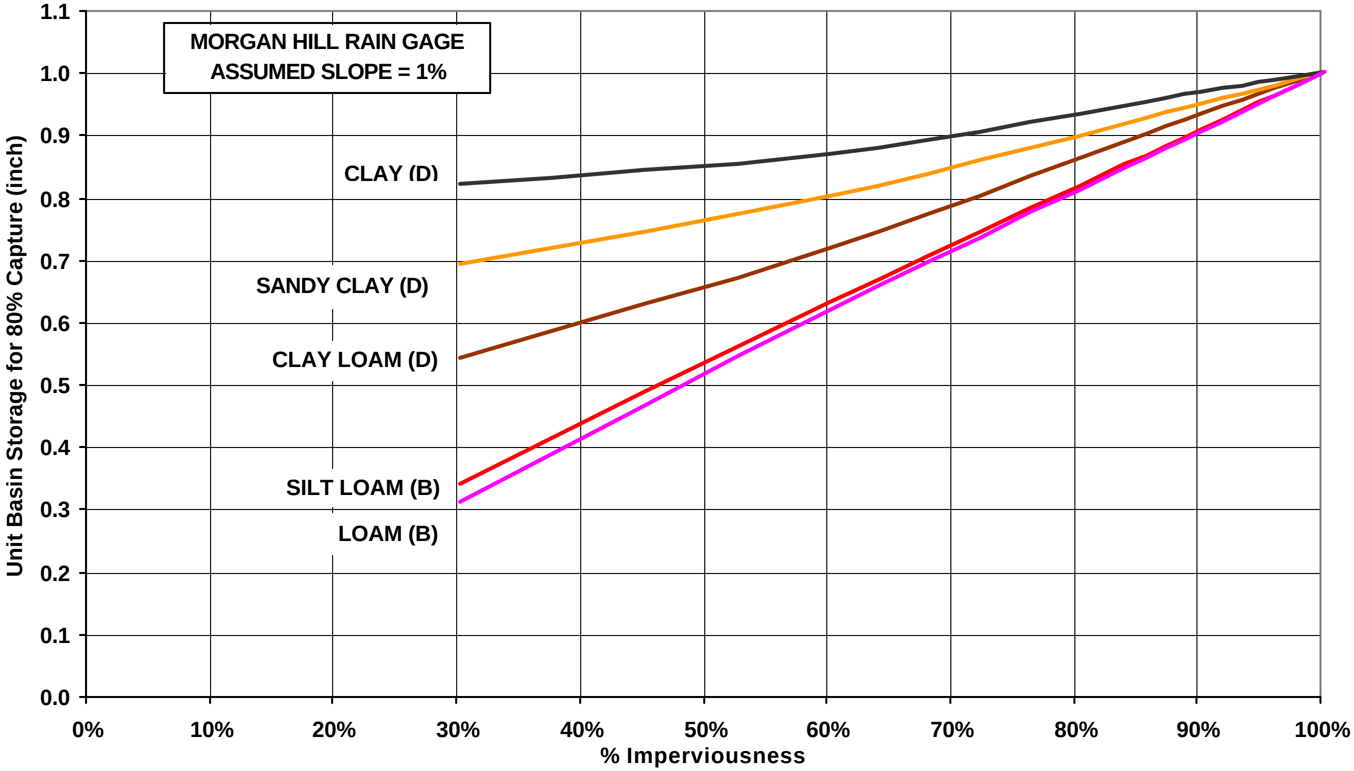


Figure 3-D Unit Basin Volume for 80% Capture - **Morgan Hill** Rain Gage

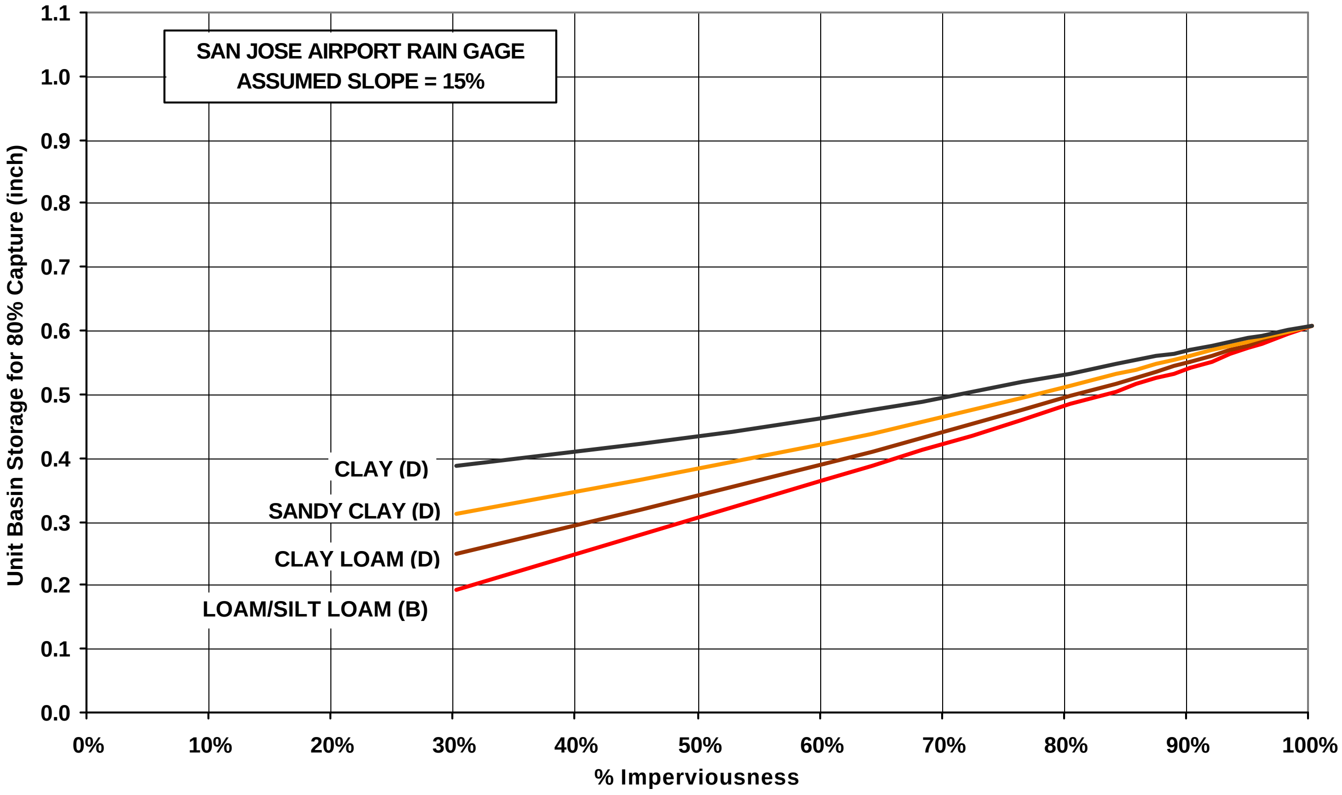


Figure 4-A Unit Basin Volume for 80% Capture - **San Jose Airport** Rain Gage

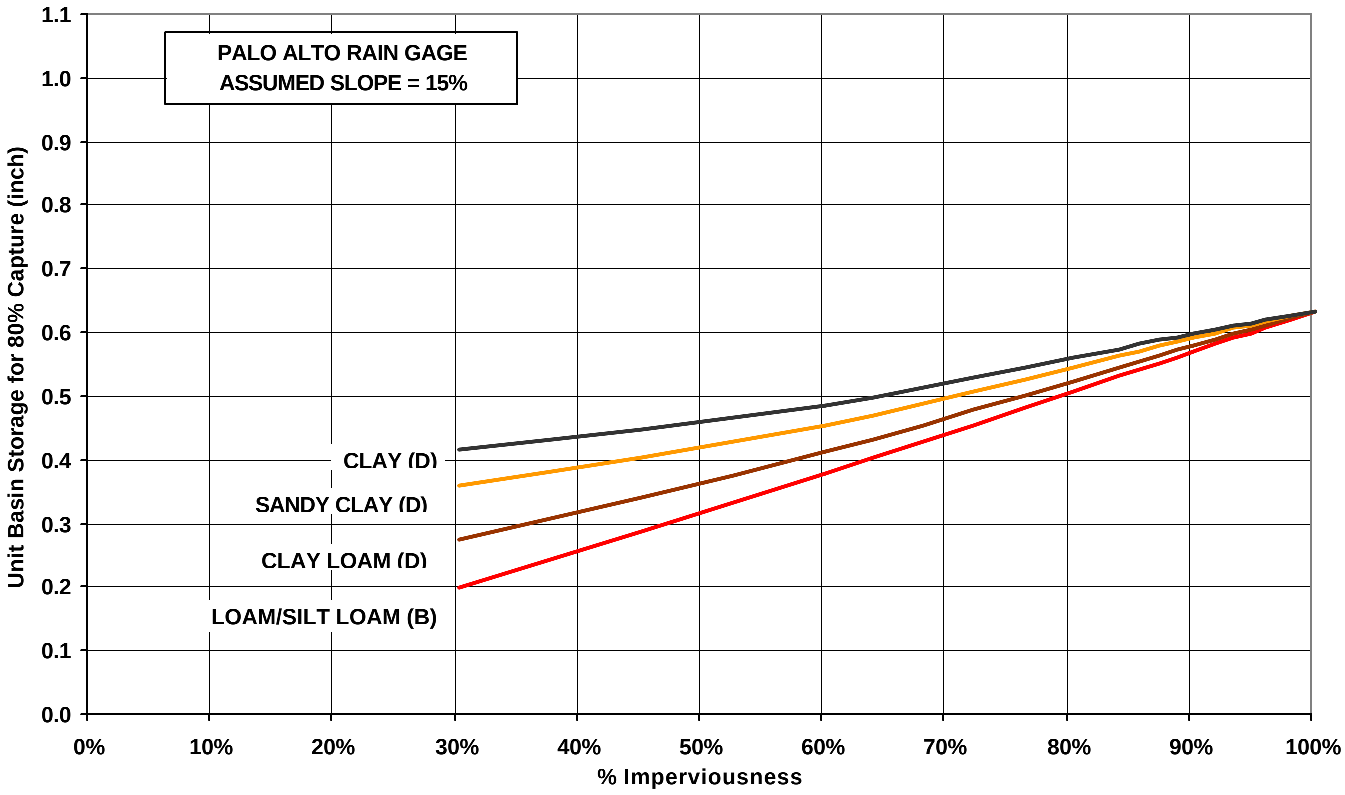


Figure 4-B Unit Basin Volume for 80% Capture - **Palo Alto** Rain Gage

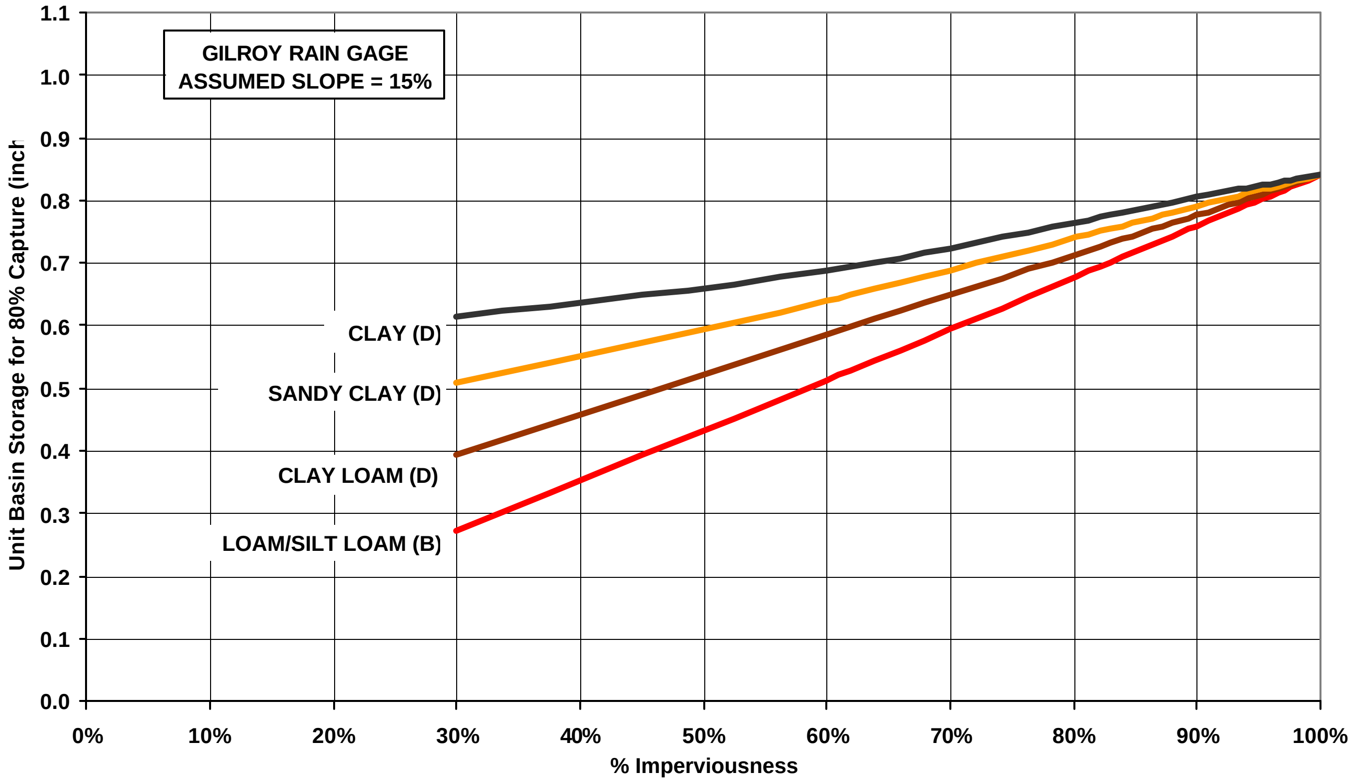


Figure 4-C Unit Basin Volume for 80% Capture - **Gilroy** Rain Gage

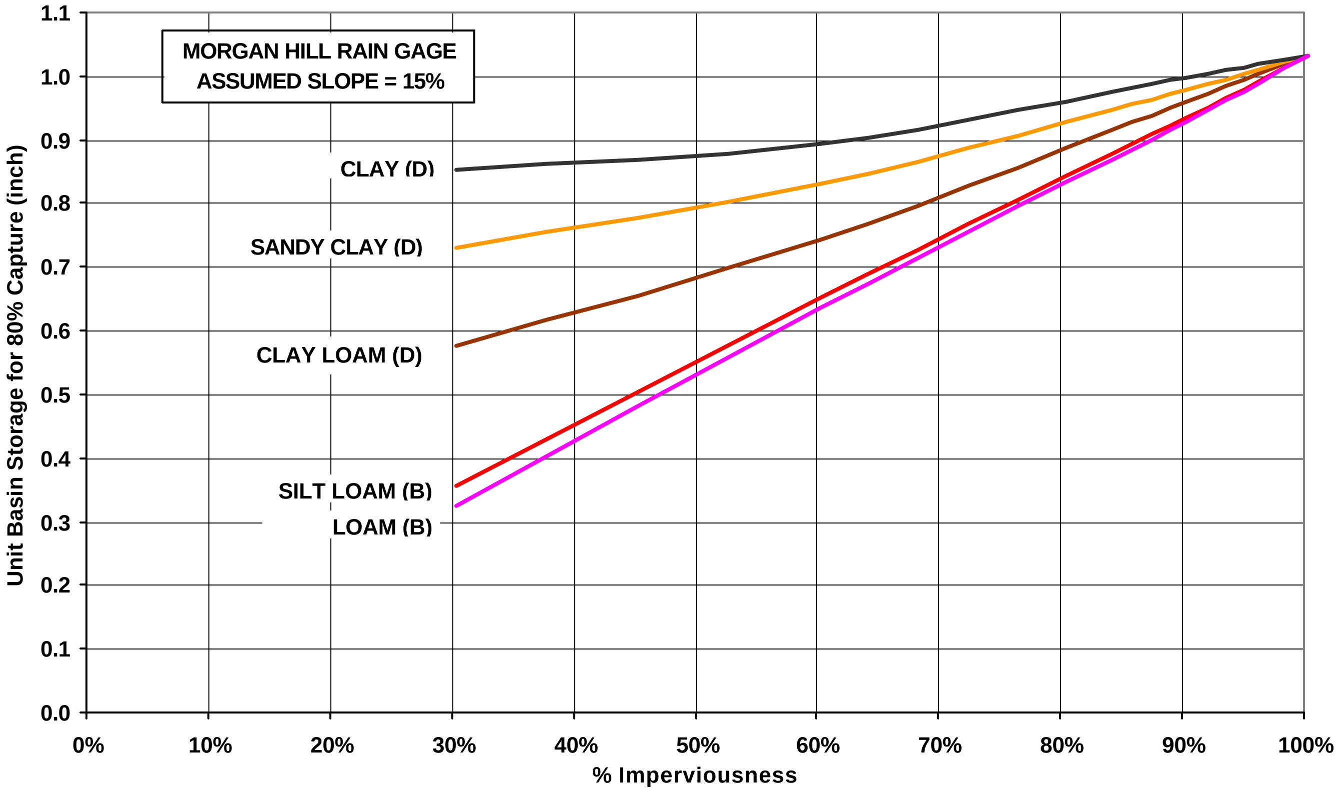


Figure 4-D Unit Basin Volume for 80% Capture - **Morgan Hill** Rain Gage

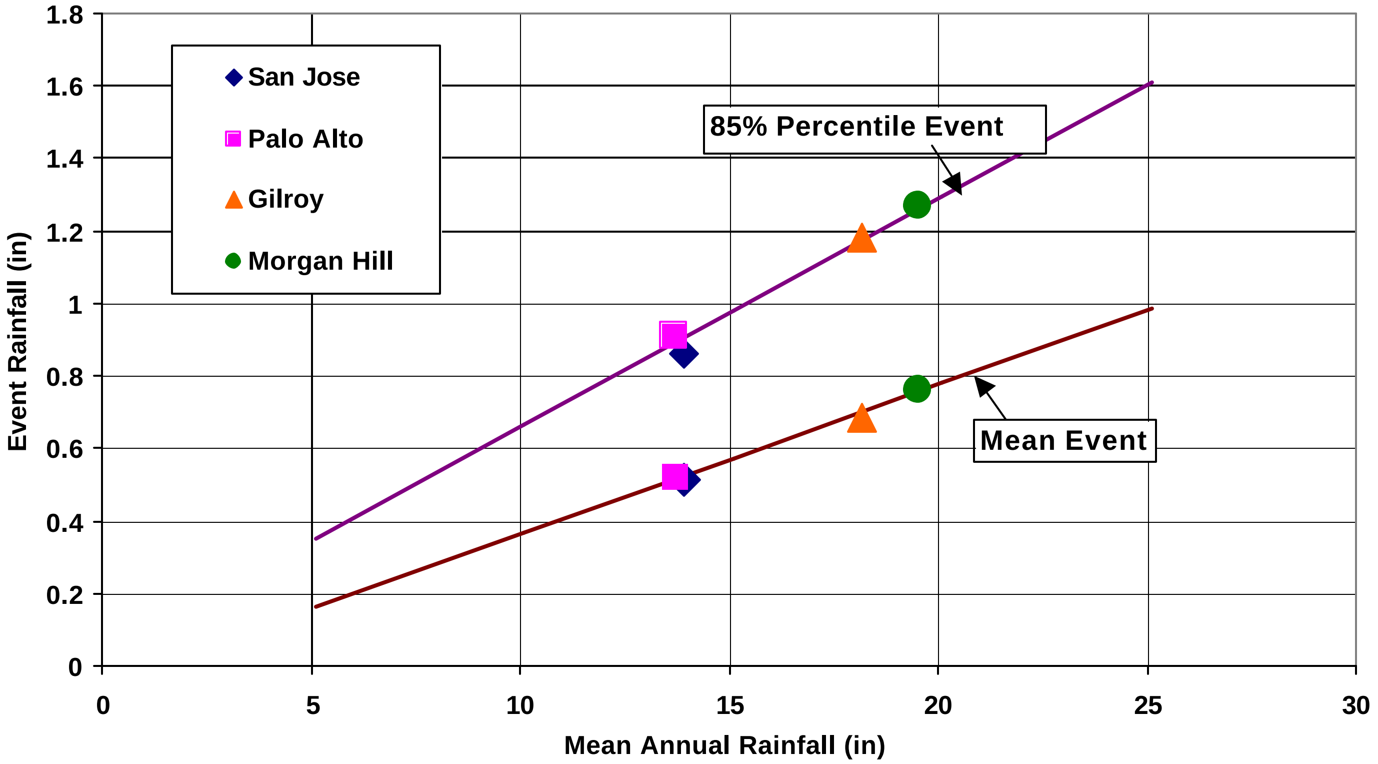


Figure 5 85th Percentile Storm Depth vs. Mean Annual Rainfall

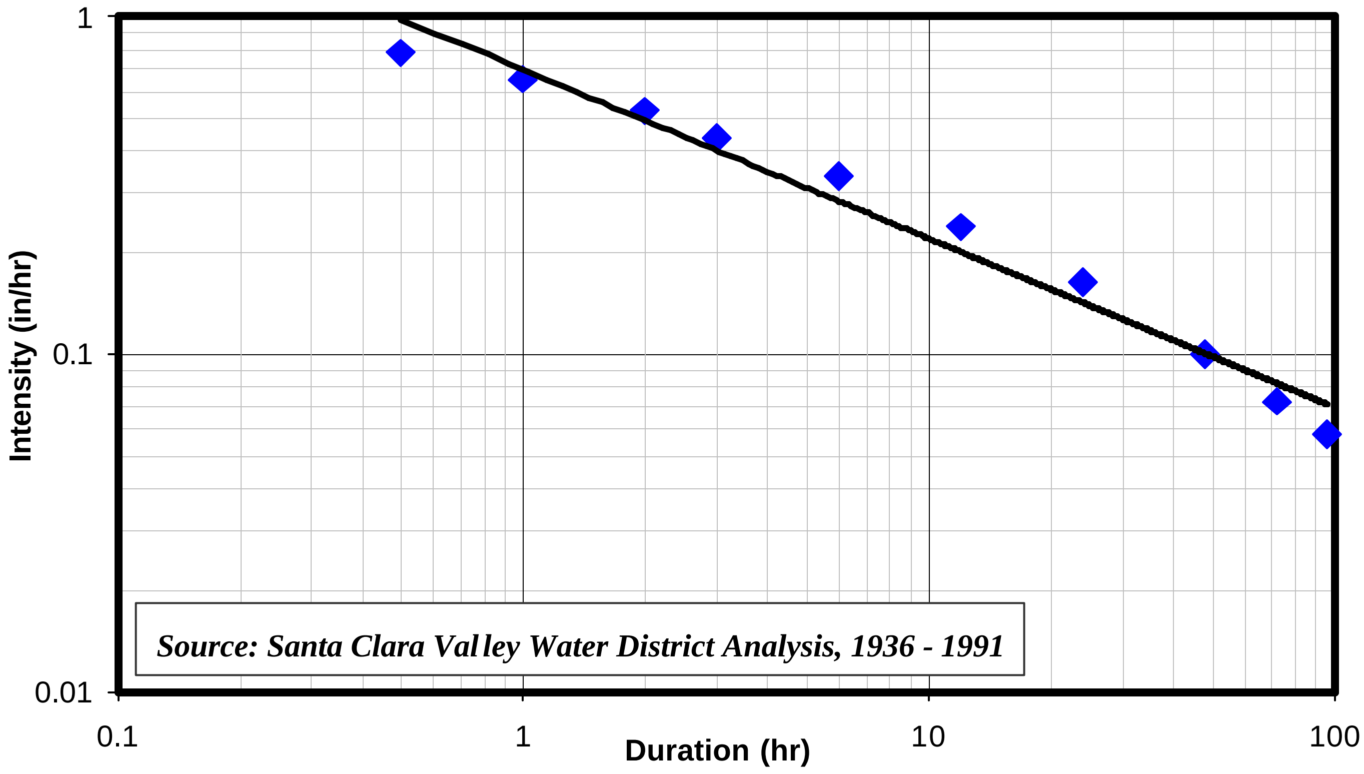


Figure 6 Intensity-Frequency-Duration Curve for 50-Year Return Period for San Jose Airport Rain Gage

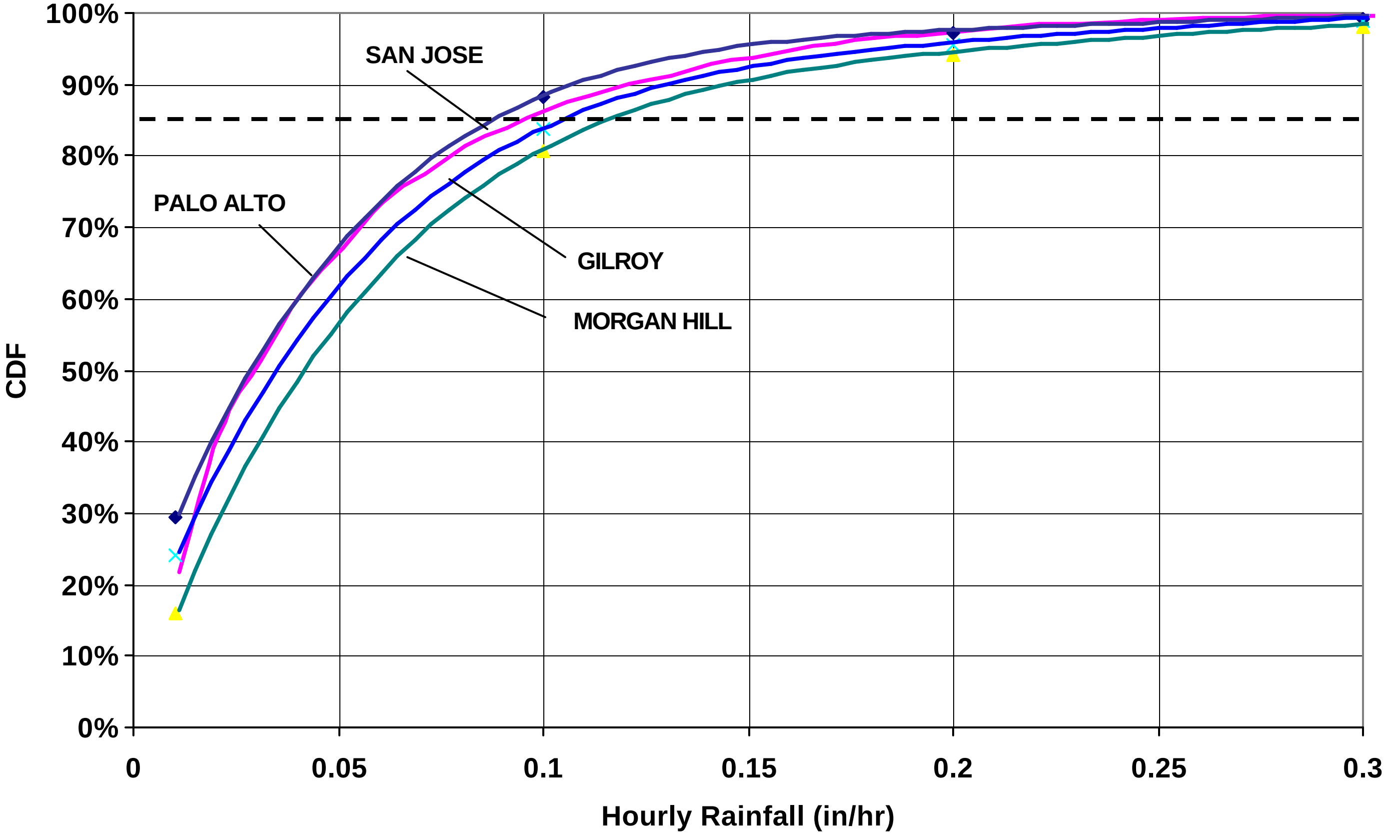


Figure 7 “Smoothed” Cumulative Distribution Function (CDF) Plots of Hourly Rainfall Intensity