# Storm Depth Estimation for Frequent Return Intervals for Contra Costa County, California

by

Contra Costa County Flood Control and Water Conservation District

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We are frequently asked by engineers, architects, landscape architects, and planners to provide the 24-hour storm depth for storms less than the 5-year storms. Our standard Precipitation Duration-Frequency-Depth (DFD) Curves are published in drawing numbers B-158 through B-162. However, these only cover the 5-year through 100-year storm recurrence intervals.

*(As of the last editing of this document, the PDFs of these documents can be downloaded from http://www.co.contra-costa.ca.us/index.aspx?nid=2455)*

To estimate the storm depth for a storm smaller than the 5-year storm, probability-log paper can be used along with information from the DFD curves. The following is a step by step explanation of how to do this using an example. The example will be a site in San Ramon near the Bollinger Canyon Road intersection with Interstate 680. The desired rainfall amount is the 2-year 24-hour storm depth.

## Step 1 - Determine the MSP

The first step is to determine the Mean Seasonal Precipitation (MSP) for your site. Determine this from the Isohyet[1] map found at the link above. The map with the GIS features provides smaller MSP intervals which is handy in some area of the county. Find your site location on this map and interpolate as needed between the isohyets to determine the MSP at your site. The site location for our example is within the circle in Figure 1 and has an estimated MSP of 21.0 inches.

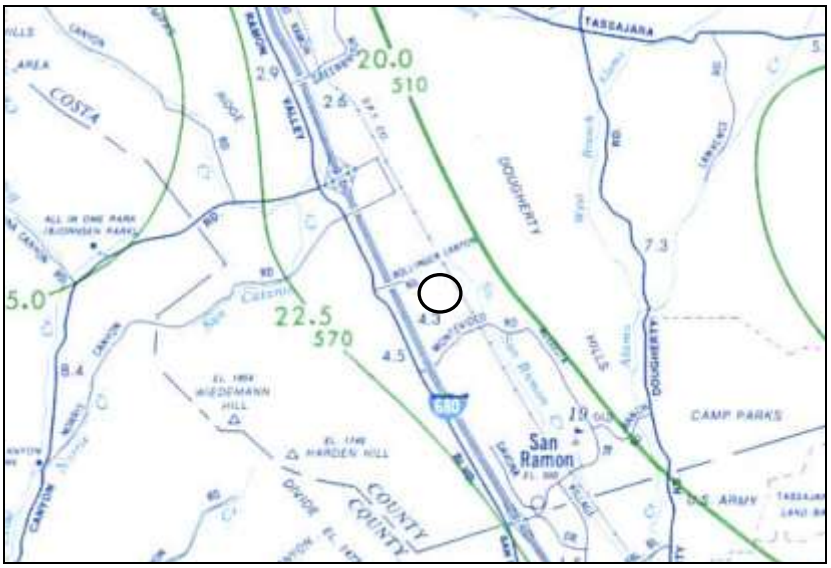


**Figure 1 - A portion of the Contra Costa County Mean Seasonal Isohyet Map**

[1] In hydrology, **Isohyet** refers to a line on a map that represents the rainfall depth. All points along an isohyet line have the same depth of rainfall. The rainfall amount can be per year, per month, or from a single storm. The FC District's isohyet map is for average (mean) seasonal (annual June-July) rainfall totals.

## Step 2 - Determine the Rainfall for Other Recurrence intervals.

The next step is to determine the storm depth for the duration you want the depth for. In our example we want the 24-hour storm depth. We first find the 24-hour storm depth from the DFD curve for the 5-year, 10-year and 25-year storms. These three points should be enough to estimate the 2-year storm depth. You can also find the 50-year and 100-year storm depths if you'd like. The DFD curves can be found via the link above.

In our example, start with the 5-year recurrence interval DFD curves and find 24-hours (1 day) on the horizontal axis. We trace the 24-your grid line up to a point between the 20 inch and 25 inch MSP. Next we interpolate between the MSP lines to find the 21" MSP, and read the depth from the vertical axis. In the example in Figure 2, the precipitation depth for the 5-year, 24-hour storm is 3.4 inches.

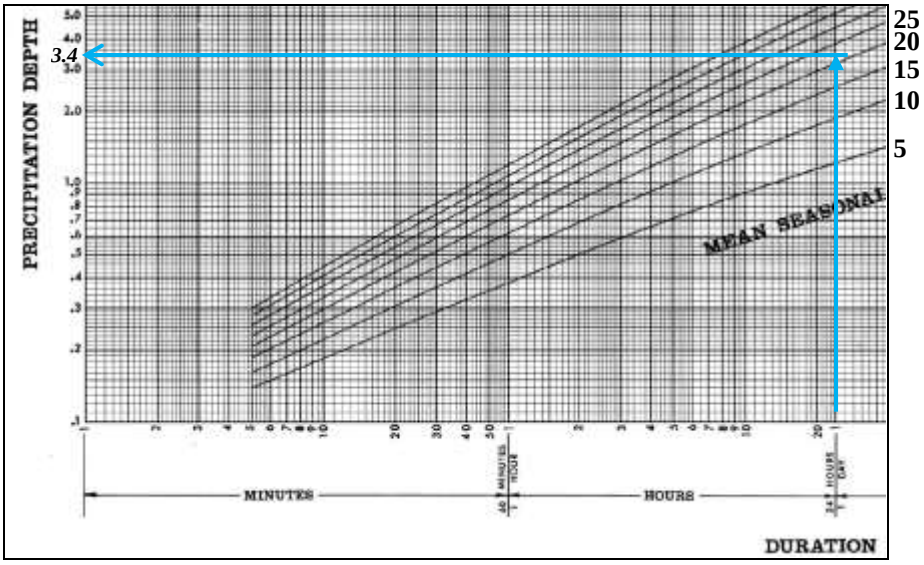


**Figure 2 – Determining the 5-year 24-hour Storm depth from the 5-year DFD curves.**

In our example, we repeat the process used for the 5-year recurrence interval to find the 10-year and 25-year 24-hour storm depths. For this example:

- 10-year 24-hour storm depth is 4.2 inches
- 25-year 24-hour storm depth is 4.8 inches

## Step 3 - Plotting the Data on Probability-Log Paper

The recurrence interval for the depths you determined need to be converted to percent chance. You do this simply by taking their inverts. The 5-year recurrence interval is the 1/5 or 20-percent annual chance storm. The 10-year and 25-year storms are the 1/10 or 10-percent annual chance and 1/25 or 4-percent chance storms. "Percent annual chance" is also known as the "percent annual exceedance probability".

Our example is summarized below in Table 1 below.

**Table 1 - Summary of 24-hour Storm Depths**

| Recurrence interval | Percent Chance Storm | Depth (inches) |
|---|---|---|
| 5-year | 1/5 = 0.20 = 20% | 3.4 |
| 10-year | 1/10 = 0.10 = 10% | 4.2 |
| 25-year | 1/25 = 0.04 = 4% | 4.8 |

A scan of a sheet of probability-log paper is also available on-line. Print a copy of the probability-log sheet. Plot the values in Table 1 on the probability-log paper as shown in the example in Figure 3. Project the best fit straight line through the three points to the 50% vertical grid which represents the 2-year recurrence interval. From this we read the 2-year 24-hour storm depth of approximately 2.3 inches. This is the storm depth we are looking for.

## Other Considerations

- It is a good idea to neatly document your calculations on the plot sheet for future reference (see Figure 3 example).

- This method can be used to estimate other durations. You must always use the same duration for each of the points you plot on the graph. For example, you could use this method to estimate the 1.5 year 12-hour storm depth, but you would have to determine the 12-hour storm depth for the 5-, 10-, and 25-year storm recurrence intervals.

- Technically, you cannot estimate the 1-year storm depth. Plotting the 1-year percent chance, which equals 1/1 or 100%, is not technically feasible because chart that only goes to 99.99%. Sometimes we are asked for the 1.5 year (66.67% chance) storm depth or flow as a surrogate for the 1-year event.

- This graph paper can also be use to project storm peak flows, but should be use with caution in doing that. Flow peaks can be influenced by off stream storage (natural flooding or man-made detention basins), backup of flows behind road embankments, and other factors.

Questions regarding this procedure or other hydrology questions can be directed to the Flood Control District Hydrologist via the Contra Costa County Public Works receptionist at 925-313-2000.

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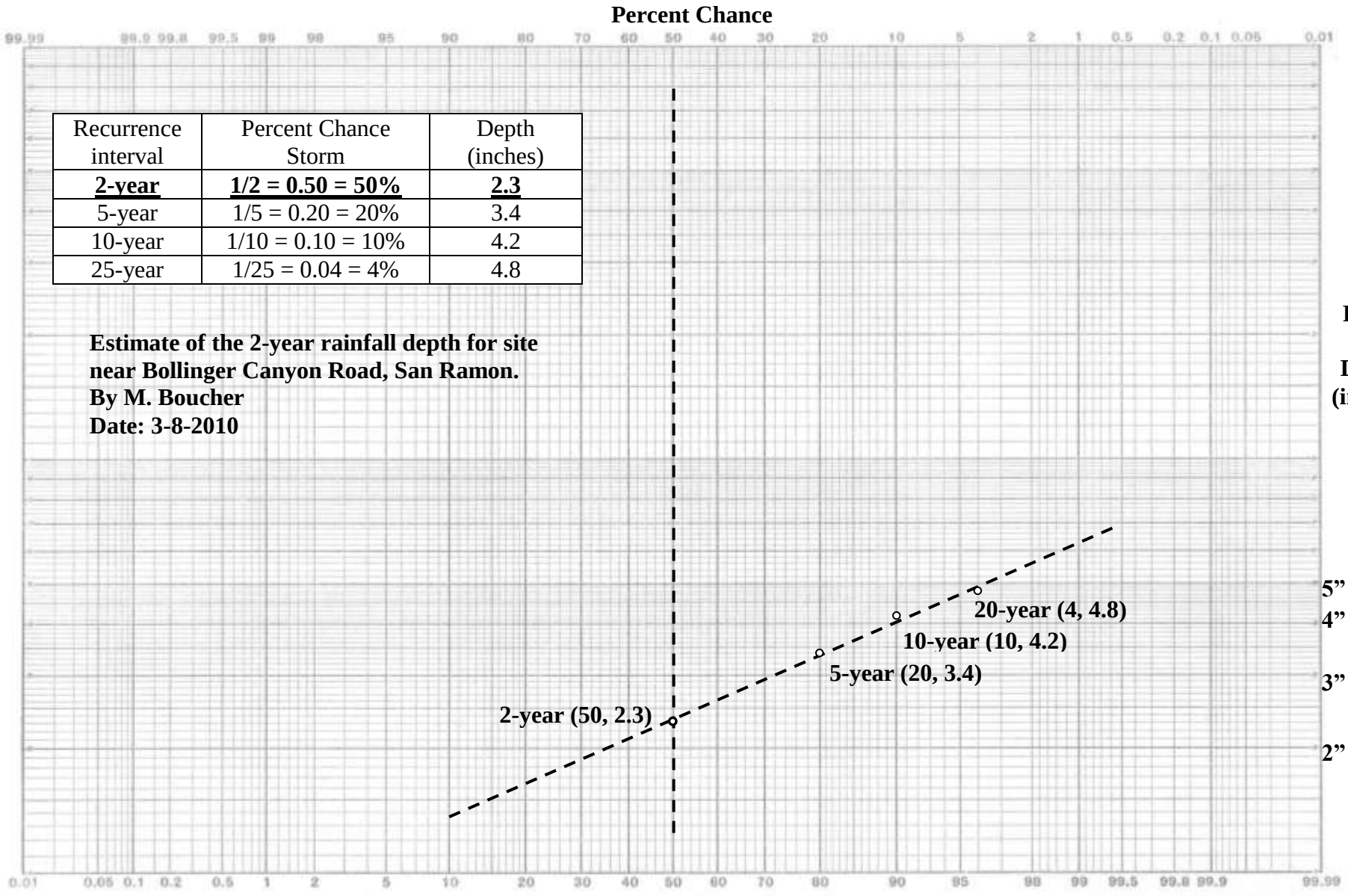
**Figure 3 – Determining the 5-year 24-hour Storm depth from the 5-year DFD curves.**




| Recurrence interval | Percent Chance Storm | Depth (inches) |
|---|---|---|
| **2-year** | **1/2 = 0.50 = 50%** | **2.3** |
| 5-year | 1/5 = 0.20 = 20% | 3.4 |
| 10-year | 1/10 = 0.10 = 10% | 4.2 |
| 25-year | 1/25 = 0.04 = 4% | 4.8 |

**Estimate of the 2-year rainfall depth for site near Bollinger Canyon Road, San Ramon.**
**By M. Boucher**
**Date: 3-8-2010**