# APPENDIX L

# WATER QUALITY DESIGN STORM DEVLOPMENT

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## CITY OF EUGENE DEVELOPMENT STANDARDS MEMORANDUM #4
## WATER QUALITY DESIGN STORM SELECTION

### INTRODUCTION

In Development Standards Memorandum #2, the following four approaches for implementing stormwater quality requirements were considered:

1. Stormwater quality facilities are required to reduce pollutants in the stormwater runoff resulting from a specified amount of rainfall, or "water quality design storm"
2. Stormwater quality facilities are required to meet a specified performance threshold (e.g., 80% removal of TSS)
3. Specific stormwater quality facilities are required for specific land uses
4. In-lieu-of fees are allowed

Based on the advantages and disadvantages described for each of the four approaches, we decided to further evaluate Approach #1 – Stormwater quality facilities are required to reduce pollutants in the stormwater runoff resulting from a specified water quality design storm.

Structural stormwater quality facilities (i.e., not site planning) can generally be divided into two groups based on different design requirements: detention facilities and flow-through facilities. Detention type facilities include dry ponds, wet ponds, and stormwater marshes. These facilities are designed to allow for the settling of particulates and other pollutants in stormwater by storing the stormwater runoff for a certain period. Therefore, the total rainfall (depth in inches) of the water quality design storm needs to be specified to determine the appropriate size of a detention type facility.

Flow-through facilities include vegetated swales and/or structural facilities with filter media such as sand or compost. These facilities remove particulates and other pollutants by mechanical means (e.g., baffles) or by passing the stormwater through a filtration media (e.g., vegetation, sand or compost). Since flow-through type facilities operate with little or no detention, these types of facilities are designed to treat a maximum flow rate rather than a total runoff volume. Therefore, the rainfall intensity (inches/hour) of the water quality design storm needs to be specified to determine the appropriate size of a flow-through based facility.

The purpose of this memorandum is to describe the methods used to select the water quality design storm parameters for detention type and flow-through type stormwater quality facilities. This memo contains the following information:

- Description of measured rainfall data sources

- Description of the rainfall analysis procedures
- A discussion of the conceptual design procedure for the preliminary capital projects
- Summary of the results of the water quality design storm analysis
- Comparison to other jurisdictions
- Recommendation for further evaluation

## LONG-TERM RAINFALL DATA SOURCES

The parameters of the water quality design storm (i.e., total rainfall and rainfall intensity) are based on a statistical analysis of local long-term rainfall data. Hourly rainfall measurements are needed to determine the total rainfall volume for designing detention type facilities. For Eugene, long-term hourly precipitation data are available from a rain gage operated by the National Weather Service (NWS) at the Eugene Airport. Hourly precipitation data is available for this gauge location from 1948 to the present.

Shorter increment rainfall measurements (i.e., 5 to 15 minutes) are more appropriate for determining the rainfall intensity for designing flow-through type facilities. The City has operated several rain gauges within Eugene for the past six years that measure rainfall at 15-minute increments. The rainfall data collected at City gauge 11 (located in west Eugene on the Bertlesen Slough) and City gauge M2 (located in Amazon Park) were used in this analysis.

## RAINFALL ANALYSIS PROCEDURES

The statistical analyses of the long-term hourly rainfall measurements collected by the NWS at the Eugene Airport were completed using the Synoptic Rainfall Data Analysis Program (SYNOP). SYNOP provides a summary and statistical analysis of storm event parameters (e.g., rainfall depths, storm intensity, storm duration) and of annual and monthly rainfall totals. The two key input variables in SYNOP are the inter-event time and minimum storm depth. The inter-event time represents the minimum length of dry period, in hours, beyond which additional rainfall measurements are considered to be separate storm events. It is used to separate a long-term continuous rainfall record into discrete, independent storm events. The minimum storm depth is applied to eliminate small storm events from the long-term record that are unlikely to produce measurable stormwater runoff. Storm events with a depth of 0.01 inches or less were eliminated from the long-term record as they are unlikely to produce measurable stormwater runoff. Additional analyses of the results from SYNOP were completed using Microsoft Excel.

## CONCEPTUAL DESIGN OF PRELIMINARY CAPITAL PROJECTS

In order to develop conceptual designs for the preliminary capital projects identified during the basin planning process, a preliminary water quality design storm was needed. A SYNOP analysis was completed on the long-term hourly precipitation data from the NWS gage at the Eugene airport using an inter-event time of 6 hours and a minimum storm depth of 0.01 inches. The results of the SYNOP and spreadsheet

analyses are presented in Figure 1.

The plot in Figure 1 presents the average annual percentage of storm events (y axis) that are equal to or less than a specific design storm rainfall depth (x axis). For example, approximately 80% of the storm events have a rainfall depth of 1.4 inches or less. Therefore, if a detention type stormwater quality facility were designed to capture and treat the stormwater runoff from a site resulting from a 1.4 inch storm event, approximately 80% of the annual stormwater runoff from the site would be treated. This storm depth, 1.4 inches, was selected as the preliminary water quality design storm for completing the conceptual designs for the detention type stormwater quality capital projects.

## WATER QUALITY DESIGN STORM ANALYSIS

Based on recent Department Advisory Committee meetings, it seems apparent that development standards for stormwater quality are recommended for portions of Eugene. Therefore, we completed a more detailed analysis of the NWS and City rainfall records to develop the specific parameters of the water quality design storm for implementing development standards. The total rainfall and rainfall distribution is required to design detention type stormwater quality facilities. The rainfall intensity is required to design flow-through type facilities (both off-line and on-line). The procedures used to obtain these water quality design storm parameters are described below.

### Detention Type Water Quality Facilities

Long-term hourly precipitation data at the Eugene airport were analyzed to select the water quality design storm parameters for designing detention type stormwater quality facilities. The SYNOP analysis was conducted using an inter-event time of 6 hours and a minimum storm depth of 0.01 inches. Based on the results presented in Figure 1, a design storm rainfall depth of 1.4 inches is required to capture approximately 80% of the average annual runoff from a site. A design storm rainfall depth of 0.95 inches is required to capture approx mately 70% of the average annual runoff from a site. A design storm rainfall depth of 2.4 inches is required to capture 90% ofthe average annual runoff from a site.

The rainfall distribution describes the temporal distribution for the total rainfall. The U.S. Soil Conservation Service (SCS) developed a rainfall distribution for western Oregon and Washington referred to as SCS Type 1A. The duration of the SCS Type 1A storm event is typically specified as 24 hours. Based on our SYNOP analysis, the average storm durations for a 6-hr, 12-hr, and 24-hr inter-event time were 16 hours, 26 hours, and 46 hours, respectively. Therefore, a 24-hour rainfall distribution appears to be appropriate.

### Flow-through Type Water Quality Facilities

Flow-through type facilities can be installed as off-line or on-line structures. With off-line facilities, an inlet control structure (e.g., flow control manhole) is installed to limit

the maximum allowable flow rate that can be treated by the stormwater quality facility. Stormwater flows that exceed the maximum allowable flow rate are bypassed around the facility. The off-line configuration minimizes the possibility that particulates and other pollutants previously trapped by the facility will be resuspended and transported downstream during higher flows.

For on-line facilities, the high flows are not bypassed around the stormwater quality facility. A typical example of this type of facility is a vegetated swale. Most vegetated swales are designed to treat the peak flow rate resulting from the water quality design storm but also convey the peak flow rate resulting from the flood control design storm. During high flows, the treatment effectiveness of an on-line facility is eliminated or greatly reduced. Furthermore, there is a risk that a portion of the particulates and other pollutants that were previously trapped by the on-line facility could be resuspended and transported downstream. Due to these concerns, for an equivalent drainage area, an on- line facility typically must be significantly larger than an off-line facility to provide an equivalent degree of water quality treatment. Therefore, two rainfall intensities need to be specified for designing these facilities: one for the design of on-line facilities and one for the design of off-line facilities.

*QA/QC* for the 15-Minute Rainfall Data Collected at City Gauges 11 and M2

The 15-minute rainfall data collected at City gauges 11 and M2 were used to determine the rainfall intensity for designing flow-through type facilities. The rainfall data were available from 11 and M2 from January 1995 to December 1999. A comparison of the rainfall data from the two gauges indicated that significant differences exist in the two data sets for some periods of record. Therefore, the 15-minute rainfall data collected at 11 and M2 were studied and analyzed for quality assurance and control purposes. The daily precipitation data collected from the NWS Rain Gauge at the Eugene Airport were also used in the data QA/QC process. The steps involved in data QA/QC are summarized below.

First we calculated daily precipitation at 11 and M2 from 1995 to 1999 by summing all the 15-minute rainfall data collected on each individual day. The daily precipitation at 11 and M2 were then compared with the daily precipitation data collected from the National Weather Service Rain Gauge at the Eugene Airport. One rainfall data file was developed from the two city data sets (i.e., the 11 and M2 rain gages) based on the following criteria:

- If the daily precipitation data for specific dates at one city gauge were significantly different from the daily rainfall data from the NWS gauge and the other city gauge, the data collected at this city gauge were excluded for those dates;
- If the daily precipitation data collected at the two city gauges were similar for a storm event but were quite different from the data collected from NWS, the city gauge that had the closer daily rainfall values to the NWS data were included in the combined data set;

- For certain days in a month that the daily rainfall data were different at all three rain gauges, data from the city gauge that was excluded the least frequently in that month was included in the combined data set.

The following periods of precipitation data were excluded altogether from the records due to the malfunctioning ofboth the I1 and M2 rain gages:

1. March 6, 1995 through March 31, 1995
2. September 1, 1999 through December 31, 1999.

The *QA/QC* results can be found in the spreadsheet files titled 1995.xls, 1996.xls, 1997.xls, 1998.xls and 1999.xls. The shaded areas in the spreadsheet represent the periods of record that were excluded. A new set of 15-minute rainfall data was developed by combining the 15-minute rainfall data collected at I1 and M2 from 1995 to 1999 as described above. A spreadsheet analysis was then performed on the combined data set to develop a frequency distribution of rainfall intensities for on-line and off-line flow-through water quality facilities. Descriptions of the spreadsheet analysis for both off-line and on-line flow-through facilities are provided in the following sections.

Off-line Flow-through Type Facilities

A spreadsheet analysis of the combined 15-minute rainfall data collected at City gauges I1 and M2 was completed to summarize the occurrence of rainfall intensities for off-line facilities. The results are presented in Figure 2. The results are based on the assumption that all stormwater runoff would be treated if the measured rainfall intensity was equal to or less than the design storm intensity. If the measured rainfall intensity exceeded the design storm intensity, then the percentage ofthe storm that could be treated was set equal to the ratio of the design storm intensity to the actual storm intensity. For example, if the facility is designed to treat storm events with a maximum intensity of 0.2 in/hr, then all the runoff from storm events with intensities less than or equal to 0.2 in/hr can be treated. However, if the rainfall intensity is 0.3 in/hr, then only 2/3 (or 66%) of the runoff generated this storm event would get treated.

Based on these assumptions, 80% of the average annual runoff volume would be treated ifthe off-line facility is designed using a rainfall intensity of 0.13 in/hr. Approximately 70% of the average annual runoff volume would be treated using a rainfall intensity of 0.08 in/hr, and 90% would be treated using a rainfall intensity of 0.19 in/hr.

On-line Flow-through Type Facilities

A spreadsheet analysis of the combined 15-minute rainfall data collected at City gauges I1 and M2 was also completed to summarize the occurrence of rainfall intensities for on- line facilities. The results are presented in Figure 2. The results for on-line facilities are based on a different set of assumptions than for off-line facilities. Similar to off-line facilities, if the measured rainfall intensity was less than or equal to the design storm

intensity, then all ofthe stormwater runoff would be treated. However, if the measured rainfall intensity exceeded the design storm intensity, the results are based on the assumption that all of the stormwater runoff from that event would not receive treatment.

Based on these assumptions, 80% of the average annual runoff volume would be treated if the off-line facility is designed using a rainfall intensity of 0.22 in/hr. Approximately 70% of the average annual runoff volume would be treated using a rainfall intensity of 0.17 inlhr, and 90% would be treated using a rainfall intensity of 0.34 in/hr.

## COMPARISON WITH OTHER JURISDICTIONS

Several other regional jurisdictions have recently adopted development standards for water quality. The following table presents the water quality requirements for Portland, Gresham, and the Unified Sewerage Agency with proposed requirements in Eugene.

| Jurisdiction | Average Annual Rainfall (in) | Water Quality Design Storm | | | |
|---|---|---|---|---|---|
| | | Detention Type Facilities | | Flow-through Facilities | |
| | | Total Rainfall (in) | Storm Duration | Off-line Facilities | On-Line Facilities |
| Portland | 34 | 0.83 | 24-hr duration | Not Specified | Not Specified |
| Gresham | 34 | 1.2 | 12-hr duration | 0.11 in/hr | 0.20 in/hr |
| USA | 40 | 0.36 | 4-hr duration | Not Specified | Not Specified |
| Eugene | 45 | 1.4 | 24-hr duration | 0.13 in/hr | 0.22 in/hr |

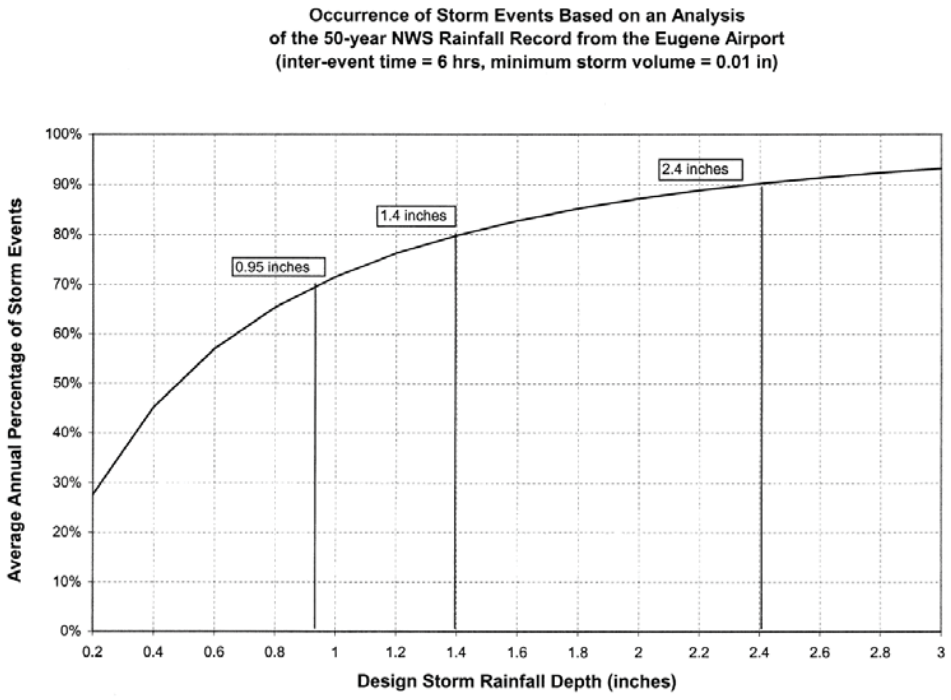
## RECOMMENDATION

Based on the above analysis, we recommend that preliminary capital project designs and example site designs (for the DAC) incorporate the use of the following design storm specifications:

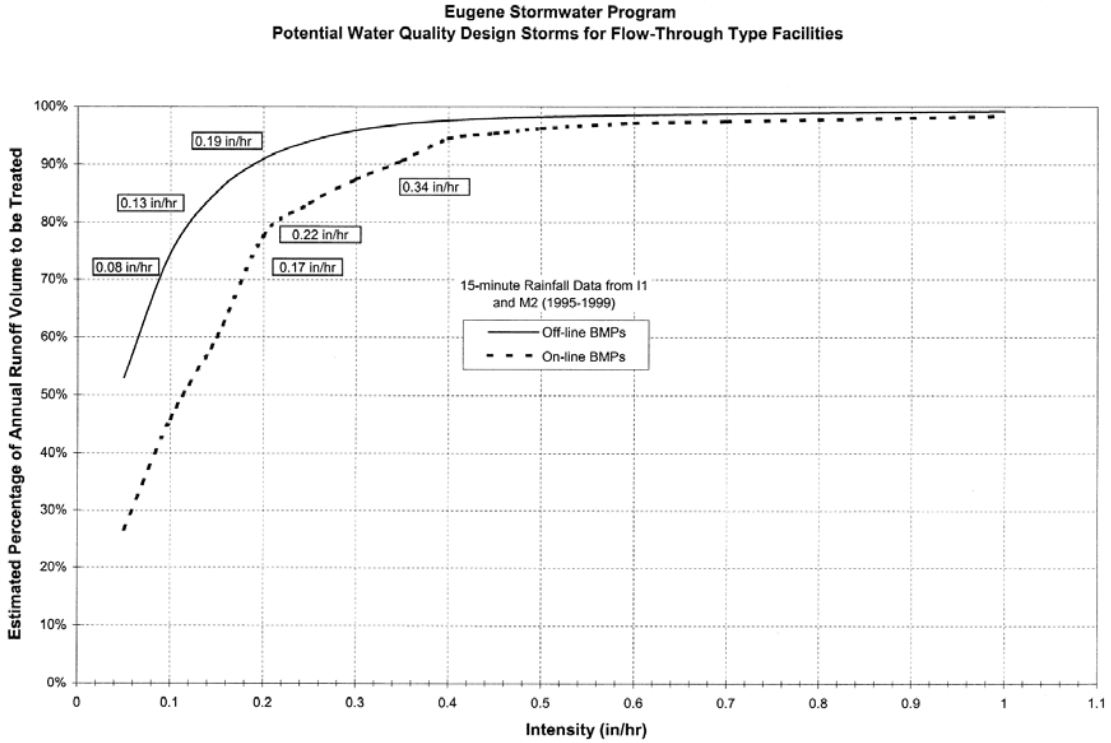
- For detention type facilities: required storage volume is equal to the stormwater runoff resulting from a 1.4 inch, 24-hour duration design storm
- For off-line flow-through type facilities: treat the peak flow rate resulting from a design storm with a rainfall intensity of 0.13 inlhr
- For on-line flow-through type facilities: treat the peak flow rate resulting from a design storm with a rainfall intensity of 0.22 inlhr

For the development of design tools (Task 400B1) and development of the BMP manual (Task 400B3), we recommend further analysis of the proposed design storms. Specifically, we recommend designing some example facilities to meet these requirements and running the **lon**g-term rainfall record through the facilities to ensure 80% capture of runoff.

## Figure 1




## Figure 2



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