# Elements to Successful Rainfall Monitoring

***Rain Gauge Siting Principles for the Urban Sewer Environment***

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**ABSTRACT** Important engineering decisions are made every day regarding sanitary sewer, combined sewer, and storm sewer systems and often involve the use of rainfall data. Although these decisions involve significant capital investment and expenditures that are required to protect life, health, and property, the integrity of rainfall measurements supporting these decisions is often overlooked. The authors have examined guidance from a variety of professional organizations in engineering, water resources, and meteorological fields and have consolidated their findings into a concise, flexible approach to obtain appropriate rainfall data to support sound engineering evaluations and decisions.

The reliability of rainfall data depends on four concurrent factors: selecting suitable rain gauge equipment, determining an appropriate density, properly siting them, and properly maintaining them once installed. Guidelines and best management practices for rain gauge siting are the focus of this discussion, along with procedures to classify siting conditions for both new and existing rain gauge installations.

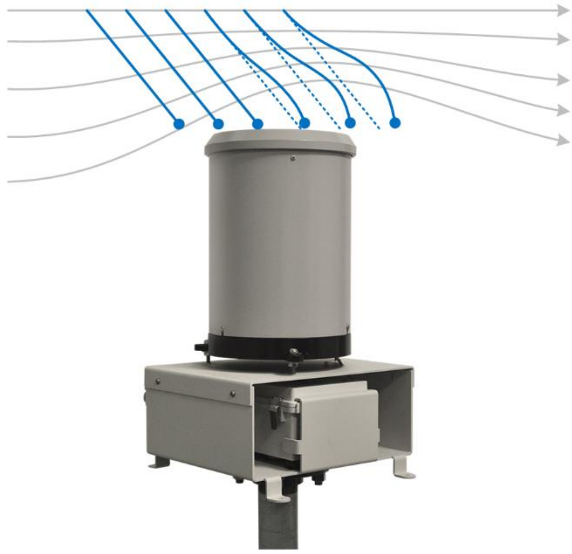
**KEY WORDS** Rainfall Monitoring, Rain Gauge, Siting Conditions

## Introduction

Rain gauge siting conditions affect the accuracy and reliability of rainfall data. Since rain gauges are traditionally installed above grade, wind creates localized disturbances around them, as illustrated in Figure 1, which diverts some rainfall away from the rain gauge. The result is measured rainfall amounts that are less than actual amounts – a condition known as *undercatch*.

The World Meteorological Organization (WMO) indicates that wind-induced undercatch contributes the largest source of error associated with rainfall measurement, on the order of 2% to 10%, with some research reporting a 1% increase in rain gauge undercatch for every 1 mile per hour increase in wind speed.[1,2] Therefore, siting guidelines are designed to minimize adverse wind effects and their corresponding effect on rain gauge accuracy.

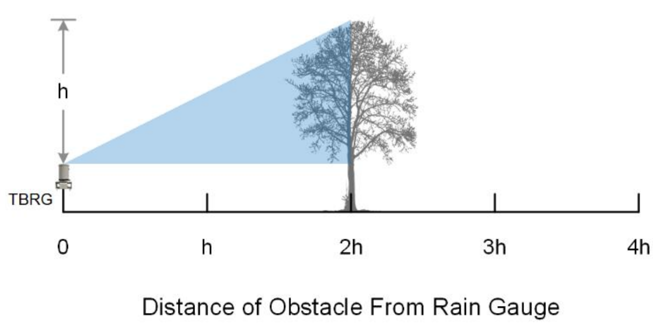
FIGURE 1: Localized Wind Deformation Over a Rain Gauge



## Distance of Obstacles

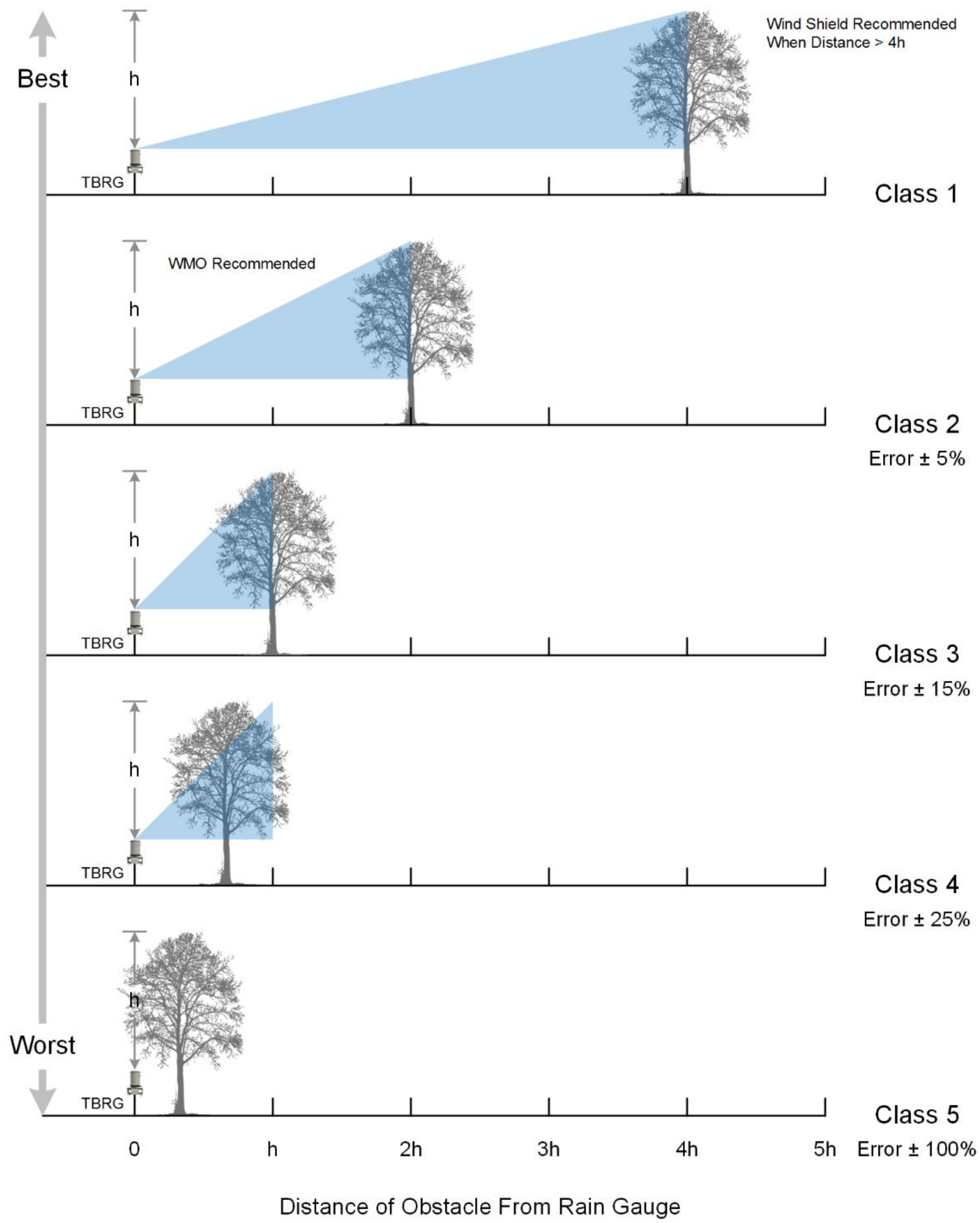
The most suitable rain gauge siting conditions are in clearings where surrounding trees and vegetation provide a natural wind break. Although surrounding trees provide shelter from the wind, a rain gauge must not be too sheltered and should also be situated in an area free from rain interference, such as overhanging trees, nearby buildings, or other obstructions. General siting guidance recommended by the WMO is shown in Figure 2, where nearby obstacles or obstructions should be no closer than twice their height (h) above the rain gauge rim.[1]

FIGURE 2: Most Common Rain Gauge Siting Criteria




It is important to note that ideal siting conditions cannot always be found, especially in urban and suburban environments. Therefore, actual siting conditions should be documented and their potential impact on accuracy should be understood when relying on such data for sewer design or evaluation. Michel Leroy at Météo France originated a simple yet practical classification system to categorize the relative effect of siting conditions on accuracy.[1,3] This classification system is illustrated in Figure 3.

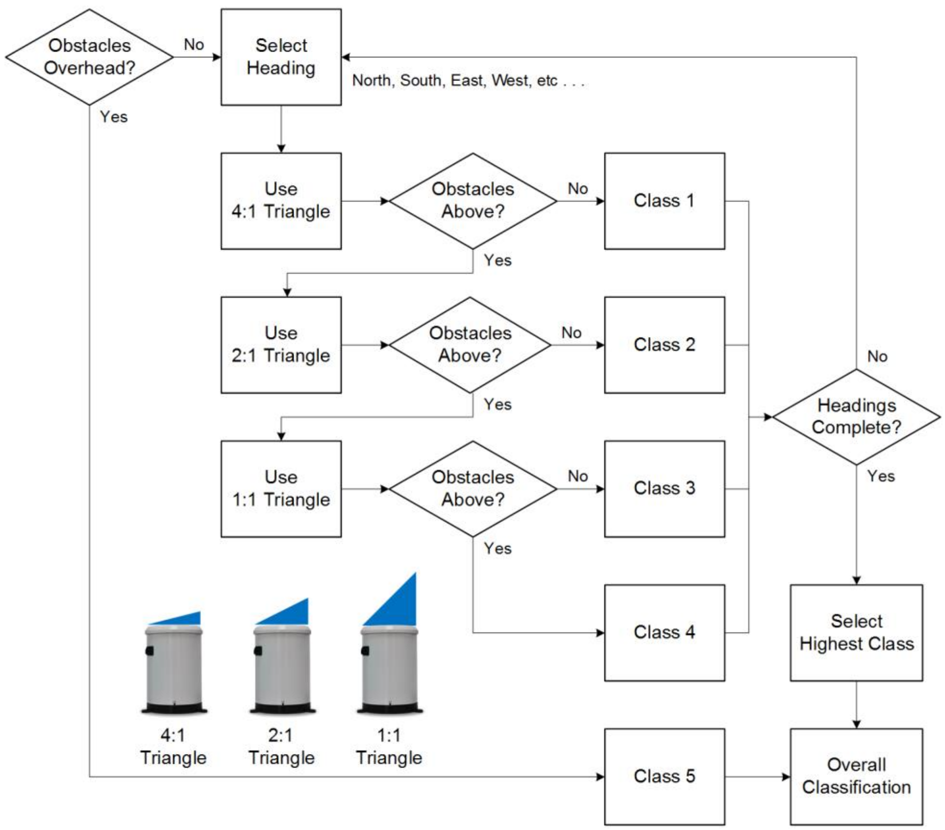
**FIGURE 3: Rain Gauge Siting Criteria and Classification System**




Based on this system, Class 1 locations are too exposed to wind and should be avoided unless equipped with a wind shield, a feature almost never found on rain gauges installed in urban or suburban areas. Class 2 locations are preferred and provide siting conditions suitable for gathering high quality rainfall data. Class 3 locations are acceptable, but only when more suitable siting conditions are unavailable. Class 4 and Class 5 locations should generally be avoided.

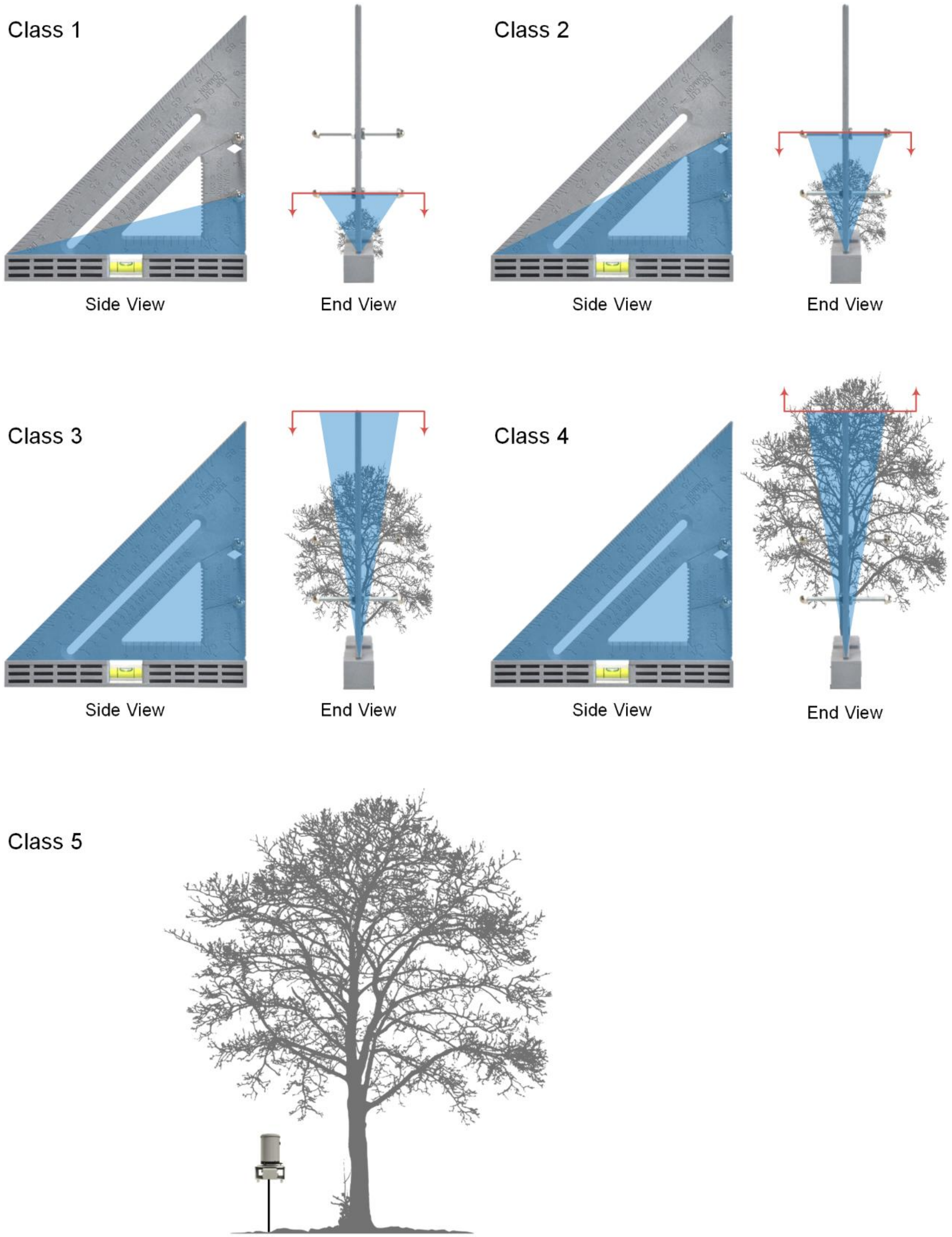
Siting conditions are difficult to assess with the unaided eye but can be easily classified using three right triangles with the proportions shown in Figure 3 and the procedure outlined in Figure 4. Simply place each triangle on top of the rain gauge, position the eyes level with the rim, look up the hypotenuse of the triangle, and document the results. Practical application of this procedure suggests the use of up to eight directional headings, and the overall classification of siting conditions is defined as the *highest* classification observed from the various directional headings.

**FIGURE 4: Field Classification of Rain Gauge Siting Conditions**




The authors have developed a Field Siting Device (FSD) that combines all three triangles into one simple design and provides a convenient way to evaluate siting conditions in the field. While the FSD is not commercially available, one can be easily assembled using materials and supplies readily available at most local hardware stores. Use of the FSD for site classification is illustrated in Figure 5.

**FIGURE 5: Classification of Siting Conditions Using the Field Siting Device**




The application of the rain gauge siting classification system is demonstrated in the following example.

**EXAMPLE**

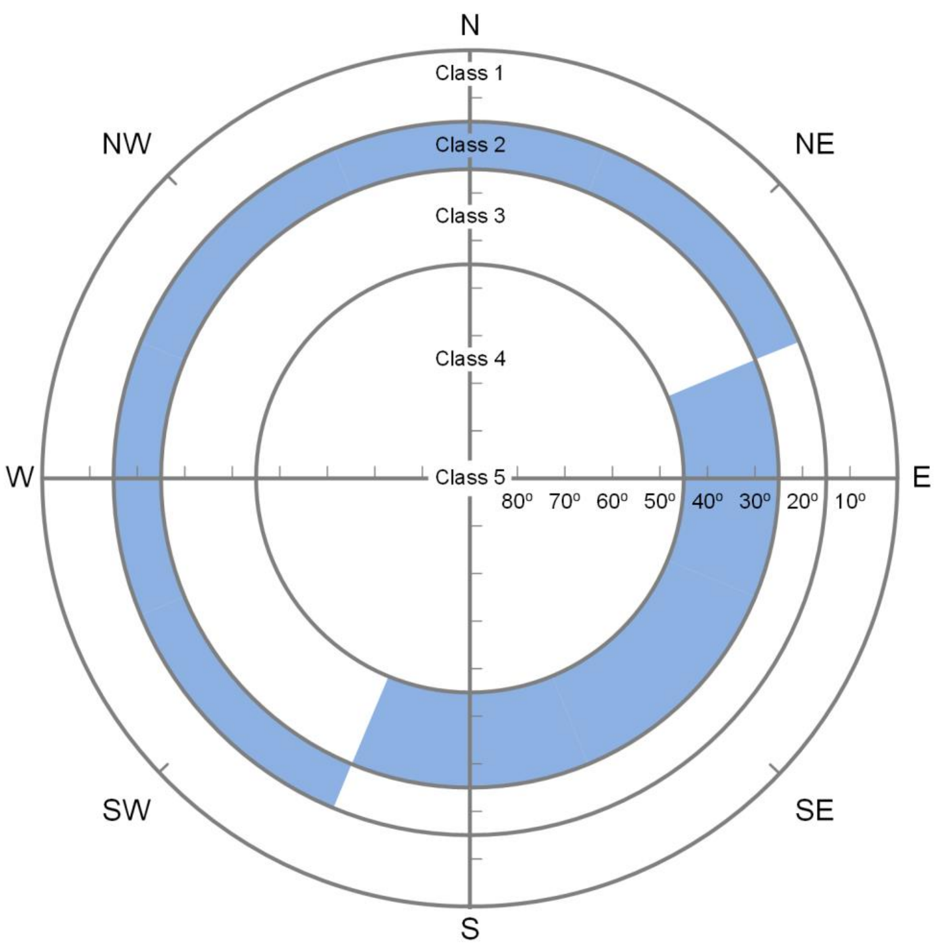
Siting conditions at a rain gauge location were classified with a field siting device for eight directional headings. What is the overall siting classification and is this acceptable?

| Direction: | N | S | E | W | NE | SE | NW | SW |
|---|---|---|---|---|---|---|---|---|
| Class: | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |

*Solution*

The siting classification is equal to the highest classification from all of the individual directional headings. Therefore, the siting classification for this rain gauge location is Class 3.

Siting conditions are visualized on a circular graph called a siting rose, analogous to a wind rose used by meteorologists.



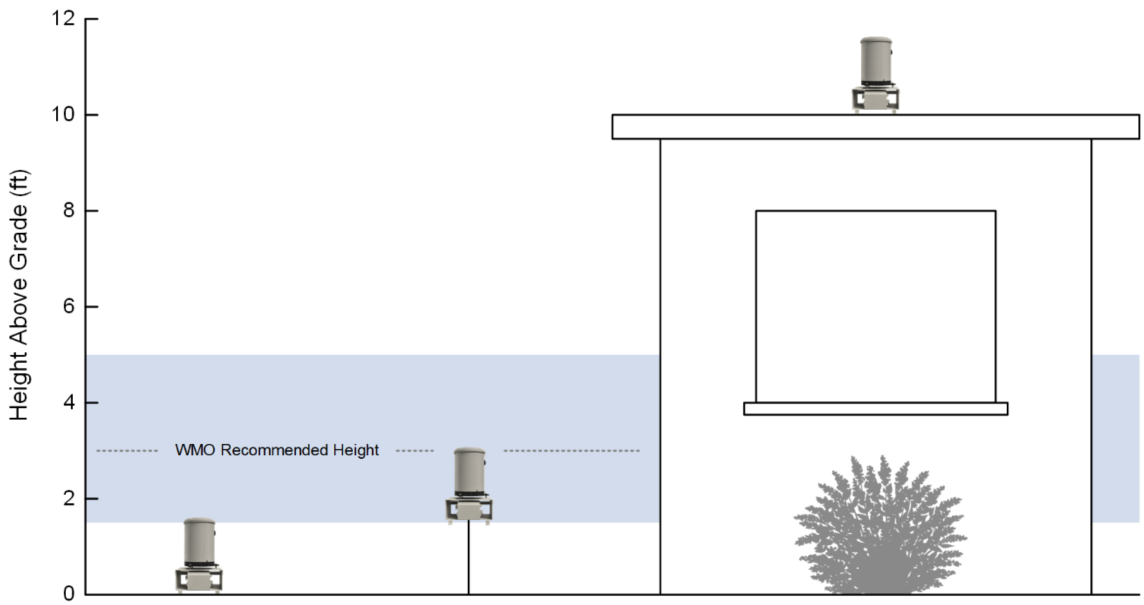

While Class 2 siting conditions are preferred, Class 3 siting conditions are acceptable.

Note that siting conditions may change over time. Nearby trees and vegetation may grow, and new buildings or other structures may be constructed in the surrounding area. Therefore, siting conditions should be evaluated and documented upon installation and on an annual basis thereafter to determine if any changes are observed and if those changes have any significant adverse effects on rain gauge accuracy or performance.

## Rain Gauge Height

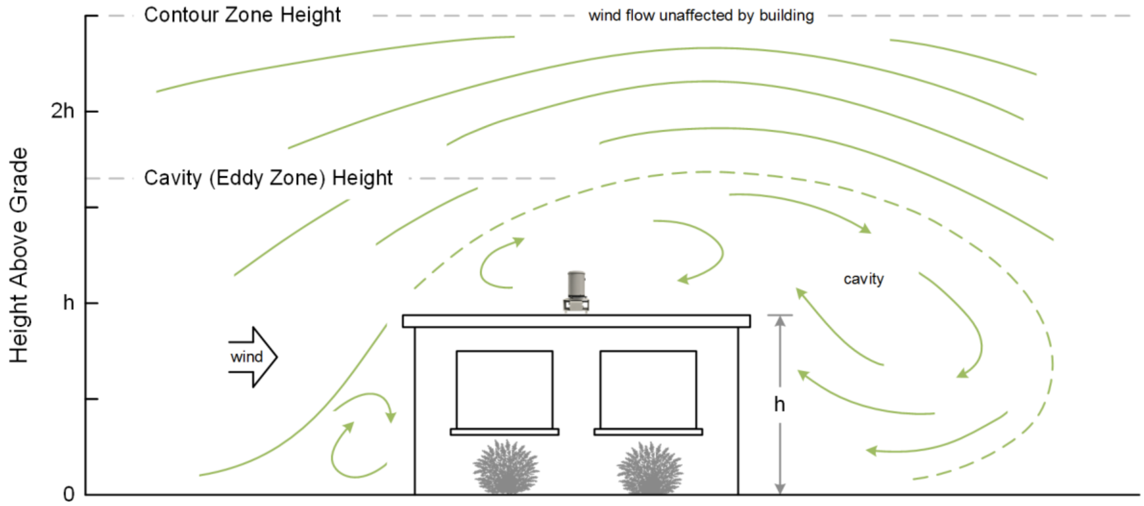
The height above grade at which a rain gauge is installed is another important siting consideration. Wind speed is known to increase as the height above grade increases, and since rain gauge accuracy decreases as wind speed increases, it follows that rain gauge accuracy also decreases as its height above grade increases. Therefore, the most common siting guidance for rain gauge height is about 3.0 feet above grade, although rim elevations ranging from 1.5 feet to 5.0 feet above grade are commonly encountered in meteorological practice.[1] Commonly used configurations are shown in Figure 6 with respect to the recommended height above grade.

**FIGURE 6: Most Common Rain Gauge Siting Criteria for Height Above Grade**




Rim elevations above the recommended range are more susceptible to adverse wind effects, while rim elevations below the recommended range are more susceptible to splashing of rainfall from nearby surfaces, particularly asphalt or concrete.[1] Rooftop installations should be avoided, where possible.[1] Not only is the height above grade a concern due to increased wind speed, but the additional wind motion up and over the rooftop may result in drastic rain gauge undercatch, as shown in Figure 7.

**FIGURE 7: Wind Deformation Over a Building With a Roof-Mounted Rain Gauge**




If a rooftop installation is the best available option, the rain gauge should be located near the center of the roof, as far from the edge of the roof as possible.[4]

## Limitations

Ultimately, rain gauge siting is a balance of competing priorities. While the siting guidelines discussed in this section are designed to maximize accuracy, site access and security cannot be ignored.[4] The benefits accrued from Class 2 siting conditions installed at the recommended height above grade can be easily negated if a rain gauge is vandalized or cannot be easily accessed for routine maintenance.

## Conclusion

Wind creates localized disturbances around rain gauges resulting in a condition known as *undercatch*, a potential source of error associated with rainfall measurement. As a rule-of-thumb, rain gauge accuracy decreases as wind speed and turbulence increase. Therefore, siting guidelines are designed to reduce their adverse effects. Best management practices for rain gauge siting have been presented and discussed, as well as an objective method to determine siting conditions in the field. Providing the best rain gauge siting conditions possible improves the accuracy of rainfall data and increases the confidence in engineering decisions based on such data.

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