CLIMATE 4

4.1 INTRODUCTION

Temperature affects physical (Chapter 7), chemical (Chapters 3, 11, and 12), and biological (Chapter 13) processes. Within the temperature range common to stormwater, the viscosity of water differs significantly. The viscosity of cold water is greater than warm water, leading to slower rates of flow through filter media and soil, with complete termination should total freezing occur. The settling rate of particles decreases by about 40 percent with a decrease in temperature from 25^o to 5^{o}C. Biological rates decrease by a factor of two with each 10^{o}C decline in temperature. Below 15^{o}C, rates of nitrification and denitrification decrease significantly with bacteria essentially inactive below 5^{o}C. Chlorides from deicing salt and traction sand may affect treatment performance in cold climates.

Rainfall intensity and in turn washoff rates affect the carrying capacity of stormwater. Regions with high average rainfall intensities may have higher pollutant concentrations than regions with milder climates.[955] Higher runoff rates may affect the hydraulic efficiency of wet basins. Wet basins in regions with high rainfall intensities and correspondingly high inflow rates are more susceptible to short-circuiting. The inter-event time between storms is a consideration in the sizing of treatment systems. Arbitrarily specifying an emptying time without considering the length of time between storms may lead to under or oversized facilities depending on the region and treatment system. Wind speed and direction may affect the hydraulic efficiency and therefore the performance of wet ponds and constructed wetlands. Wet basins sheltered from the wind during the summer are more susceptible to thermal stratification. Climate affects the availability of dry-season flow and therefore the feasibility of systems dependent on water such as grass swales, wet ponds, and constructed wetlands. Relationships between climate, and the design and performance of stormwater treatment systems are introduced in Chapter 4, and presented in detail in other chapters.

4.2 CLIMATIC REGIONS

Simplistically, climates may be divided into five broad types: cold, temperate, semi-arid, semi-tropical, and tropical. Temperate refers to regions which experiences sufficient rainfall in volume and timing that irrigation of vegetation or retention or freezing of a wet pool. Regions identified as having cold climates experience winter freezing; where the washoff of deicing salt and freezing conditions affect performance and choice of treatment systems. Semi-arid refers to areas where the lack of water affects decisions. The semi-tropical southeast changes little seasonally and therefore perhaps performance as well. Water availability is not an issue. The focus of the book is temperate regions. Special consideration is given here and in several chapters to three of the additional climatic types, indicating how processes might differ and how design criteria might be modified accordingly. Tropical regions are not considered.

Annual rainfall and rainfall patterns for the United States are shown in Figures 4.1 and 4.2 respectively. Figure 4.3 presents the mean number of annual runoff events. The figure overstates the number of events in cold climates since precipitation events in the winter occur as snow. Figures 4.4 and 4.5 identify the mean monthly temperatures for January and July. The graphics provide insight as to how performance may differ between climate regions and the transferability of data and experiences between climate regions.

Cold regions

Cold regions can be defined by Figures 4.6 through 4.8. Figure 4.6 presents air freezing index values, which are the cumulative degree-days below 32^{o}F (0^{o}C). It has been suggested that ice cover may occur on lakes in regions with values greater than 100.[1335] Figures 4.7 and 4.8 present annual snowfall depths and length of freeze free period. Figures 4.9 through 4.11 are relevant to the question of how deep treatment systems must be placed subsurface to avoid freezing, for examples, fine-media filters and wet vaults. The information provides perspective. More definitive data available by state or province should be consulted.

Issues: Table 4.1 lists issues facing treatment in climate regions where substantial freezing occurs. The table expands on summaries provided by others.[1333,1400,1540,1634,1677,1716,1738,1742,1881] Caution is warranted with many of the suggestions given lack of field experience. Most of the adjustments in Table 4.1 are discussed more fully elsewhere in the book. These discussions should be consulted inasmuch as some adjustments may conflict, be inappropriate, or of inconsequential value in certain situations. Some issues may be overstated.

Stormwater quality: Of particular concern is the use of deicing salts, in particular sodium chloride. Heavy metals in the presence of chloride tend towards the dissolved state but low temperatures are a major factor as well (Chapter 2). Sediment concentrations may be much greater in the spring melt due to the use of traction sand and/or the extended period of atmospheric deposition on snow piles. The spring melt may represent a disproportional fraction of the total annual loading of many pollutants. Chloride deicing salts may include an anticaking amendment that contains cyanide (Chapter 2).

Basins: Ponds may be preferred by default given inadequacies and risks of freezing attendant to other systems such as swales and fine-media filters. Although the performance of ponds may degrade in comparison to ponds in temperature regions, their performance may be better than the alternatives.

High concentrations of chloride in the melt water may cause saline stratification in the winter and spring melts (Chapter 5) and toxicity (Chapter 13). It is commonly believed that lower performance occurs during melts. While a legitimate concern, field studies suggest that lower performance may be due more to bottom scour than degraded removal processes. Chapter 7 explores this aspect fully. Solubilization of particulate metals and phosphorus may occur, which is examined in Chapter 12.

Depending on several factors, in particular wet pool depth, stratification may remain through the summer, creating essentially a permanent dead zone at the bottom of wet ponds and vaults. This decreases hydraulic efficiency (Chapter 5) and may adversely affect the removal of dissolved pollutants (Chapters 12). High chloride concentrations may be toxic to wetland plants (Chapter 13).

Swales and filter strips: The winter adversely affects the condition of the grass, reducing its effectiveness during spring melt unless significant infiltration occurs.

Filters and infiltration: These two types of treatment systems respond similarly. Fine-media in filters will likely freeze unless placed below the frost line. Organic media is most susceptable to freezing as it retains more moisture. If as pellets or a similar form the organic media may lose its structural integrity.

Like fine-media filters, soils may freeze. However, as explained in Chapter 12 soils do not freeze completely. Generally, the coarser the soil the less the effect of freezing. Similarly, freezing of filter media may be avoided with coarse media but performance may decrease accordingly. There may be other reasons to avoid either system as explained in the respective chapters.