Chapter 2
Storm Water Considerations for Alaska

2.0 Introduction

Alaska is a diverse environment with respect to the sensitivity of its streams to land development, its range of climate, soils, terrain and development patterns, and how these constrain and challenge designers to adapt storm water management tools developed at lower latitudes. This chapter begins by reviewing why controlling storm water runoff is important to protect water quality and stream health. Next, it describes the great diversity in rainfall, snowfall, temperature and soils throughout the state, and describes five broad climatic zones to guide storm water implementation. The next section describes how these climatic and terrain factors influence local decisions to focus on managing rain water or snowmelt, and briefly describes the key elements of each management approach.

The fourth section outlines the extreme factors in Alaska that constrain the use of storm water practices developed in other regions of the world and indicates how these factors influence the sizing, design and selection of storm water practices. The fifth section is a reminder that Alaska is experiencing climate change and presents some suggestions on adaptive engineering to ensure that storm water infrastructure can accommodate it. The sixth section briefly discusses the topic of winter construction, which is a common condition in parts of the state. The chapter concludes by outlining the special pollution prevention, source control, and storm water treatment requirements for operations and activities classified as *storm water hotspots* that are known to produce higher levels of runoff pollution and merit greater controls.

2.1 Why Urban Storm Water Matters to Alaska Streams

Extensive research conducted at lower latitudes has shown that land development and, more specifically impervious cover, have a strong influence on stream hydrology, water quality, habitat and biodiversity [Center for Watershed Protection (CWP) 2003; Schuster et al. 2007; Pitt et al. 2004; Roy 2005; Schueler et al. 2009]. Impervious cover consists of hard surfaces created after development, such as rooftops, streets, sidewalks and parking lots. In general, stream quality indicators degrade as more impervious cover is added to a watershed. Impervious cover and compacted soils generate greater volumes of storm water runoff, which degrades stream habitat. In addition, significant loads of sediment, nutrients, pathogens, metals and other pollutants wash off impervious surfaces and are quickly delivered to streams. The effect of declining water quality and degraded habitat generally lead to much lower biodiversity in streams. A similar phenomenon has been observed for streams and wetlands, lakes and near-shore coastal habitats (CWP 2003). In addition, pollutant washoff can contaminate water supplies and reduce drinking water quality.

The limited but growing body of Alaskan research on impervious cover, storm water and stream health generally reinforces this paradigm. Indeed, the research suggests that Alaskan streams might be even more vulnerable to the effects of land development because of the extreme climatic stressors found in the state. To date, most of the research has focused on Anchorage and southeastern Alaska. Some key findings are outlined below.

Changes in Hydrology: Topographic relief is often extreme in Alaskan communities, and the growth of impervious surfaces has produced major changes in stream hydrology. For example, recent models have indicated that runoff volumes have increased three- to fivefold in Anchorage watersheds from 1950 to 2000, and peak discharge rates have increased by a factor of 5 to 10. Dry-weather stream baseflow has declined by an order of magnitude over the same time frame because of lower groundwater recharge (MOA 2004).

Increased Pollutant Washoff: Recent monitoring studies have indicated that several storm water pollutants are a significant water quality concern in urban watersheds in Alaska (MOA 2003; MOA 2004; Shannon and Wilson 2006; Ourso and Frenzel 2003). Such pollutants include suspended sediment, chloride, pathogens such as fecal coliform bacteria, oil and grease, trace metals—such as cadmium, zinc and lead—and trash and floatable debris.

Urban Stream Channel Erosion: Increased urban storm water flows appear to be greatly increasing channel erosion and sediment delivery in Anchorage streams (MOA 2004), with a consequent decline in channel condition, substrate habitat and sediment quality (Ourso and Frenzel 2003). Other effects noted in urban streams include decreased slope, increases in sediment size, width, depth and meander wavelength. These changes in stream habitat quality are particularly noteworthy given their importance to sustaining anadromous fish runs, such as salmon. Research on salmon streams in the Pacific Northwest has shown a strong link between increasing urbanization and the decline of local salmon runs (Morley and Karr 2002).

Declining Stream Biodiversity: In perhaps the most comprehensive study of urban stream health in Alaska, Ourso and Frenzel (2003) found that aquatic insects, considered both a critical element of the aquatic food chain and a leading indicator of stream quality, declined with as little as 5 percent watershed impervious cover compared to 10 percent impervious cover in the lower 48 states as reported by Schueler et al. 2009; NRC 2008; Moore and Palmer 2005; Morgan and Cushman 2005. Several studies indicate that if predevelopment watershed and/or riparian land cover is primarily forested or otherwise undisturbed, as is the case in many places in Alaska, stream biodiversity may be more sensitive to initial changes caused by stressors than areas with land uses such as crops that may have already been disturbed (Schueler et al, 2009).

2.2 Rainfall, Snowfall, Climate and Soils

Storm water and snowmelt begin with precipitation, and the variation in precipitation across Alaska ranges from less than 4 inches per year in the Arctic to more than 200 inches per year in the southeastern panhandle. Similarly, annual snowfall ranges from about 30 inches in the Arctic to more than 200 inches in Valdez (Table 2-1). To address this climatic diversity, Figure 2-1 shows Alaska divided into five broad climatic regions, loosely following the precipitation zone classification found in the *Precipitation Frequency Atlas of the Western United States*, referred to as NOAA Technical Publication (TP)-47 (Miller 1963) and Shulski and Wendler (2007).

Table 2-1. Summary of annual precipitation, snowfall and snow/rain split by climatic region[a]

Region[b]	Location	Annual precip. (inches)	Snowfall (inches)	Snow/rain[c] (%)
Coastal	Cordova North	162.1	101.3	6%
	Dutch Harbor	62.2	90.2	14%
	Ketchikan	153.1	36.9	2%
	Juneau	69.3	90.1	13%
	Kodiak	76.9	71.5	9%
	Sitka	85.9	39.3	4%
	Skagway	26.5	49.1	18%
	Valdez	61.9	218.3	35%
	Wrangell	79.9	56.7	7%

Table 2-1. (continued)

Region[b]	Location	Annual precip. (inches)	Snowfall (inches)	Snow/rain[c] (%)
Southcentral	Anchorage	15.9	70.2	44%
	Homer	24.5	54.9	22%
	Matanuska Valley	16.0	60.7	37%
	Kenai	18.9	61.2	32%
Western	Bethel	17.0	54.3	32%
	Dillingham	25.5	82.9	32%
	Nome	16.1	60.8	38%
Interior	Big Delta	11.4	43.8	38%
	Fairbanks	10.5	66.4	63%
	Fort Yukon	6.6	41.9	63%
	Galena	13.2	63.4	48%
Arctic	Kotezbue	9.6	52.4	53%
	Prudhoe Bay	4.3	33.1	77%
	Umiat	5.6	55.2	61%
	Barrow	4.0	29.0	74%

Note: There are significant precipitation variations within each region, so the site-specific information could result in differing feasibility determinations; practitioners should use the best available data.

a. Source of data are long-term climate records in WRRC (2007) and Shulski and Wendler (2007)

b. The Coastal Region includes TP-47 zones 1, 2 and 6; the Southcentral Region is TP-47 zone 4 ; The Western Region includes TP-47 zones 5 and 8; the Interior Region includes TP-47 zones 3 and 7; and the Arctic region is TP-47 zone 9

c. The ratio was derived assuming a 10:1 water equivalency for snowfall depth

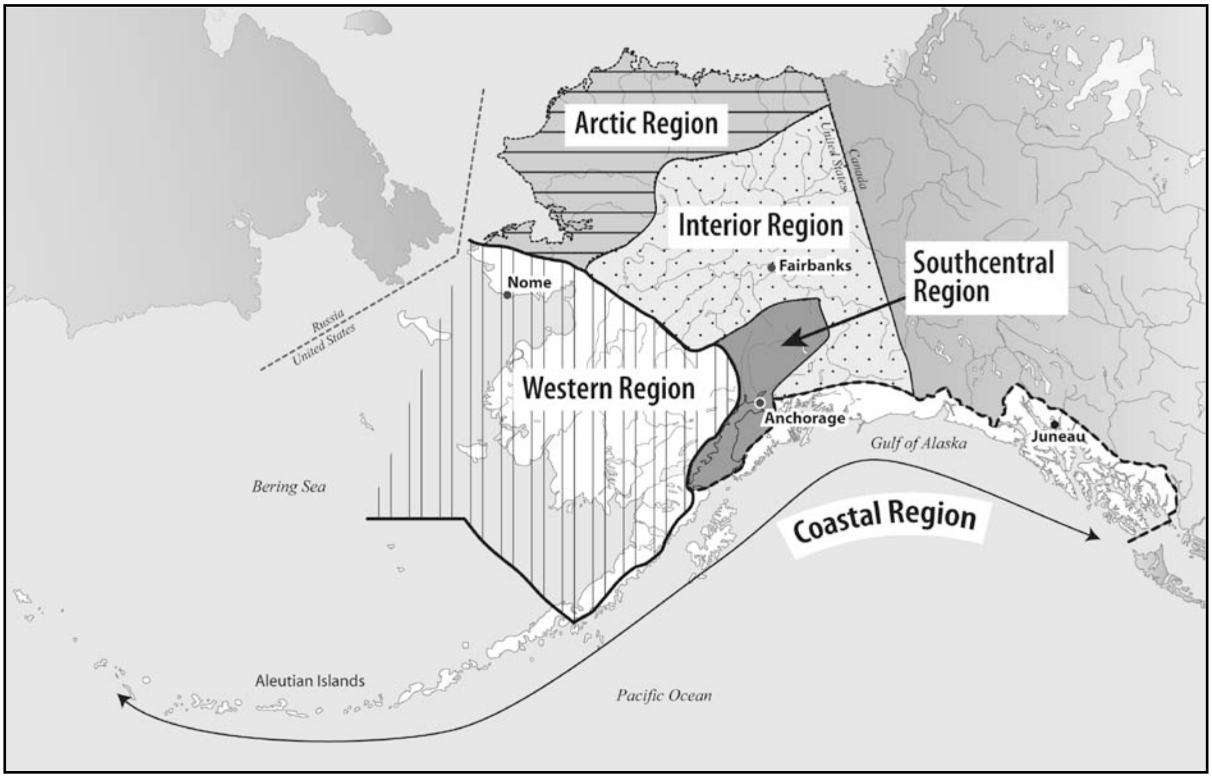

Figure 2-1. The five climatic regions.

Note: This guide collapses the nine precipitation-based zones presented in TP-47 into five climatic regions, as follows: Coastal Region = TP-47 zones 1, 2 and 6; Southcentral Region = TP-47 zone 4; Western Region = TP-47 Zones 5 and 8; Interior Region = TP-47 zones 3 and 7; and Arctic Region = TP-47 zone 9

The **Coastal Region** contains the southeast panhandle, Gulf of Alaska, and west coast, including the Aleutian Islands and has a strong maritime influence. Consequently, it experiences high annual rainfall (60 to 150 inches), moderate to very high annual snowfall (40 to 200 inches), but a low ratio of snow:rain (2 to 20 percent).

The **Southcentral Region** includes communities around Cook Inlet, such as Anchorage, that experience moderate rainfall (15 to 25 inches), moderate to high snowfall (55 to 70 inches) and moderate split between snow:rain (25 to 45 percent). The primary difference between this region and the Western Region is that winter temperatures are higher, and consequently, permafrost is largely absent from much of the region.

The **Western Region** includes the western coastal, lower Yukon and lower Kuskokwim areas that experience moderate rainfall (15 to 25 inches), moderate to high snowfall (50 to 80 inches) and a moderate split between snow:rain (30 to 50 percent).

The **Interior Region** includes the a major portion of the Yukon River basin, Fairbanks and south to the Copper River Basin, and is typified by low annual rainfall (10 to 15 inches), moderate annual snowfall (40 to 70 inches) and a high ratio of snow:rain (40 to 60 percent).

The **Arctic Region** is typified by extremely low annual rainfall (4 to 8 inches), low snowfall (20 to 30 inches) and a high snow:rain ratio (60 to 70 percent).

Other key climatic factors that affect snowmelt and storm water include the length of the growing season, the presence of permafrost, average minimum air temperatures for the coldest month, and soil drainage. Depending on the ratio of snowfall to annual rainfall, runoff will be generated at different times of year (Table 2.1). For example, regions dominated by snowfall will have their peak runoff events in the spring, whereas regions dominated by rainfall will experience peak runoff at other times of the year corresponding to maximum rainfall events. Each of these factors has a strong influence on the design of storm water practices, and they sort out well by the five climatic regions described earlier (Table 2-2).

The prevailing geology, glaciation, climate and terrain in a particular region all play a strong role in soil formation, and their properties. As might be expected, the soils of Alaska are diverse and varied and may change over short distances. Soil surveys conducted by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) are available for many areas of Alaska (see Link 24 in Appendix A for a link to these surveys).

Table 2-2. Comparison of characteristics in the rive climatic regions

Climatic region	Representative city[a]	Growing season[b] (days)	Permafrost[c]	Mean low winter temp[d] (° F)	Soil drainage
Coastal	Juneau	140 to 180	Absent	15 to 25	Variable
Southcentral	Anchorage	80 to 120	Absent	5 to 10	Variable
Western	Nome	80 to 100	Intermittent	–15 to +15	Poor
Interior	Fairbanks	80 to 120	Intermittent	–10 to -25	Poor
Arctic	Prudhoe Bay	15 to 75	Continuous	–20 to -30	Very Poor

a. Shown for illustrative purposes, the statistics shown in table are based on range for at least five weather stations in each region

b. Drawn from various sources

c. From map by Seifert (2007)

d. Average minimum monthly temperature for coldest month of the year

The ADNR Division of Geological and Geophysical Surveys has mapped the engineering geology for many areas of Alaska (for more information, see Link 25 in Appendix A). Table 2-3 presents a general overview of soils with the five climatic regions of the state, following Gallant et al. (1995).

Table 2-3. General soil conditions in the five climate regions

Coastal Region (Southeast, Gulf of Alaska, Aleutians). Soils near the mountains tend to be gravelly or sandy moraine deposits. Soils in poorly drained depressions are filled with organic material and tend to be saturated. Debris flows can occur in shallow soils on slopes of 35 to 60 degrees where the underlying bedrock surfaces are often glacially smoothed. Permafrost is absent in coastal areas.

Southcentral Region (Cook Inlet) The region tends to be covered by glacial deposits covered with low moraines and interspersed with many lakes, bogs and broad outwash plains. There are areas where the surface soil layers are formed by wind blown loess from the floodplains of glacial rivers and from volcanic ash blown from nearby volcanoes. Subsurface soil layers tend to be formed predominantly of glacial deposits ranging from gravelly clay loam to very gravelly sandy loam. Alluvial terraces and outwash plains tend to be water-worked, very gravelly sand. Soils in depressions tend to be bogs consisting of peat. Permafrost is substantially absent.

Western Region (Bristol Bay coastal areas and western interior) Most soils are formed by volcanic ash deposits of various thicknesses and are underlain by gravelly glacial till, outwash deposits or silty alluvium. Coastal plain soils other than the Yukon River delta can be formed in gravelly alluvium. Low-lying areas can be filled with organic material. Permafrost is discontinuous throughout the region.

Interior Region (Upper Yukon and Copper River basins) Many of the upland soils were formed by silty, loess, or colluvial material. Some other upland area soils were formed by stone and gravel weathered from local rock. Lowland soils were formed in silty alluvium and loess derived from floodplains of large rivers. Soils are generally shallow, often overlying ice-rich permafrost and tend to be poorly drained. Those soils with permafrost are very susceptible to alteration upon disturbance of the organic vegetation. Permafrost can be prevalent on north-facing slopes and nearly absent on south-facing slopes. Soils in the Copper River basin tend to be poorly drained and underlain with permafrost. Organic soils typically fill depressions, while well-drained soils typically cover upland areas.

Arctic Region (Northwest and Northslope) The principal soils of the Arctic Coastal plain and broad valley bottoms tend to be poorly drained, developed under a thick layer of vegetation and are underlain with thick permafrost. They are interspersed with many lakes. The dominant soils in the valleys and long slopes of the Arctic foothills are silty or loamy colluvial sediments. The hills and ridges are mostly composed of very gravelly material eroded from sedimentary rock.

2.3 Treatment of Runoff and Snowmelt

This section describes how climatic factors influence local decisions to focus on managing runoff or snowmelt and briefly describes the key elements of each management approach. The basic decision for a community is whether water quality is most influenced by washoff of pollutants during the growing season or the pulse of pollutants from the snowpack that is released during the spring melt. Once again, this decision can be made by analyzing the distribution of rainfall and the end-of-season snow depth across the five broad precipitation zones, as shown in Table 2-4.

In the course of a year, many precipitation events occur within a community. Most events are quite small, but a few can be several inches deep. A rainfall frequency spectrum describes the average frequency of the depth of rainfall events that occur during a normal year (adjusted for snowfall and rainfall events that do not produce runoff). Figure 2-2 provides an example of a typical rainfall frequency spectrum from Anchorage, Alaska, that shows the percent of rainfall events that are equal to or less than the indicated rainfall depth. As can be seen, the majority of storms are relatively small, but a sharp upward inflection point occurs at about one inch of rainfall.

Table 2-4. Water quality sizing based on rainfall runoff, snowmelt runoff

Climatic region	Runoff treatment?	Max summer[a] rain depth (in)	Meltwater treatment?	EOS snow depth[b] (in)	90 percent rainfall depth[c] (in)
Coastal	**Yes**	1.0 to 1.5	No	1 to 5	1.25 in
Southcentral	No	0.5 to 0.75	**Yes**	5 to 15	1.0 in
Western	No	0.5 to 0.75	**Yes**	1 to 10	1.0 in
Interior	No	0.5	**Yes**	10 to 25	1.0 in
Arctic	No	0.25	**Yes**	5 to 10	0.5 in

EOS = End-of-season

a. On the basis of a visual inspection of individual period of record climate summaries for five stations per region [Western Region Climate Center (WRCC) 2007]; specifically, it is the minimum number of summer days that were greater than or equal to the maximum precipitation class. Note that snow at the end of the winter season melts over several days or weeks, which is a different time scale than rainfall events.

b. End-of-season snow depth reported in WRCC (2007) for months with more than one inch of snow on the ground, with a minimum of five stations per region.

c. Communities should conduct a rainfall frequency analysis to determine actual depths for the 90 percent storm, which is 0.63 inches in Anchorage (Figure 2-2). This precipitation depth can be used to determine the water quality volume by multiplying the precipitation depth by the site runoff coefficient (see examples in Box 1). These recommendations are based on a regional review of hydrology. A site-specific analysis can determine whether runoff treatment or meltwater treatment should be used as the basis of water quality volume.

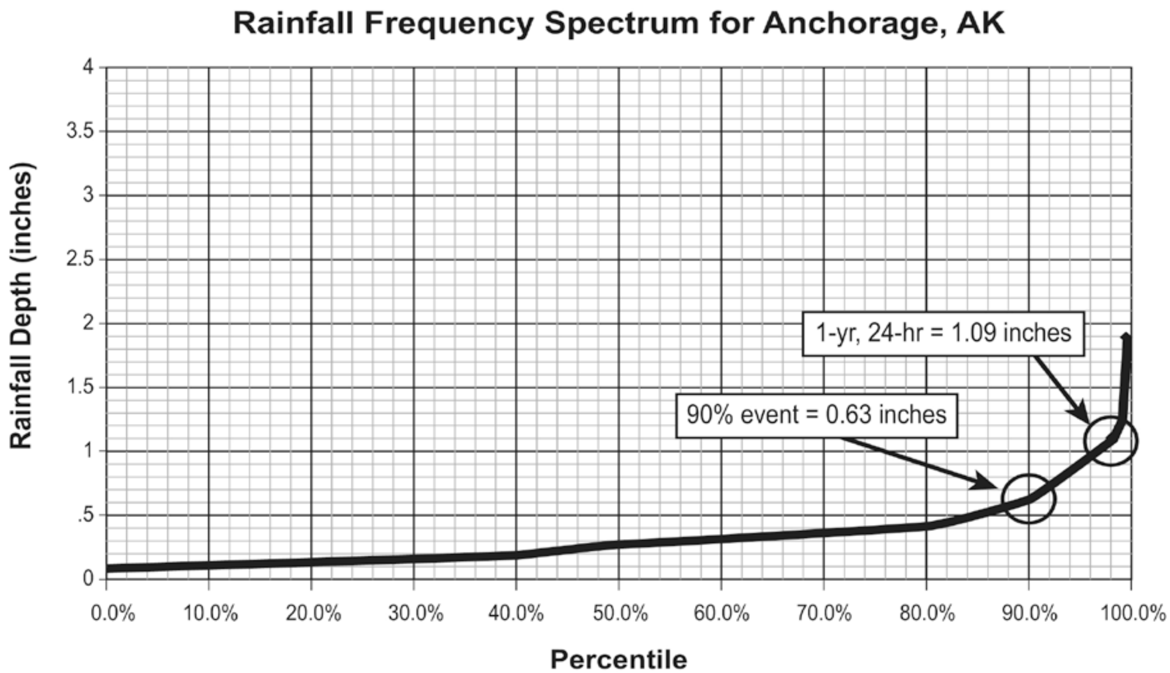

Figure 2-2. Rainfall frequency spectrum for Anchorage, 1952–2008.

The rainfall frequency spectrum helps identify the size of rainfall events that deliver the majority of the storm water pollutants during the course of a year. Many states have adopted a water quality-based approach of capturing and treating the 90 percent storm, as defined by an analysis of a local rainfall frequency spectrum. This criterion, referred to as the water quality volume, optimizes runoff capture resulting in high load reduction for many storm water pollutants. The rainfall depth associated with the 90 percent storm varies geographically across Alaska, but it typically ranges between 0.5 and 1.25 inches. This rainfall depth is then multiplied times the site's area and runoff coefficient to determine the actual water quality volume. This water quality volume is used to size BMPs to treat runoff at the site. More information on water quality volume is presented in Section 3.3.

Deriving a water quality volume is done slightly differently in parts of Alaska where the average expected spring snowmelt runoff volume exceeds the volume computed using the 90 percent rainfall depth. In such cases, the higher snowmelt volume is used to define the water quality volume (see Table 2-4).

Basically, if the snowmelt volume in the spring exceeds the maximum annual runoff volume in the growing season, the storm water practices should be sized on the basis of expected snowmelt volume for each climatic region (Coastal, Southcentral, Western, Interior and

Arctic). Conversely, if runoff from the maximum annual rain storms exceeds the spring snowmelt volume, the storm water practices should be sized on the basis of the expected runoff volume (e.g., Coastal Region). Although the specific techniques to derive the local water quality storm event are described in Chapter 3, Table 2-4 presents a range of expected depths for the water quality volume for each climatic region.

Additional guidance on how Alaskan communities can determine whether their water quality volume should be based on summer rainfall depths or end–of-season snowpack depth can be found in Box 1. The box also provides the basic equation for determining water quality volume at individual development sites.

The basic elements of the runoff and snowmelt approach to managing storm water are described in Tables 2-5 and 2-6, respectively. The two approaches are not meant to be mutually exclusive; indeed, the basic steps outlined for site development for runoff management also apply to communities that need to manage snowmelt. The main difference is the water quality volume needed for storm water practices used and how they are operated and maintained during each season the year.

Box 1:
Analyzing your rainfall and snowmelt to determine local water quality volume (continued)

Box 1:
Analyzing your rainfall and snowmelt to determine local water quality volume

Example 1: A hypothetical community in Southeast Alaska is in the Coastal Climatic Region and has analyzed long-term rainfall statistics at the airport and determined that the rainfall depth associated with 90 percent of the runoff producing storms is 1.25 inches.

By comparison, the long-term local average for the depth of end-of-season snowpack is only 6 inches. Assuming a 10:1 ratio for water equivalency of the snow (Caraco and Claytor 1997), this would indicate a meltwater depth of 0.60 inches.

Because the rainfall depth is greater than meltwater depth, the 1.25-inch value would be used to define the water quality volume that must be treated by an acceptable set of storm water practices, using the following equation:

$$WQv = (1.25) \times (Rv) \times (A) / 12 \qquad \text{Equation (1)}$$

where

WQv = *Water quality volume (in acre-feet)*
1.25 = *90% rainfall depth (in inches)*
Rv = *Site runoff coefficient, defined as Rv = 0.05 + 0.009 (I)*
IC = *Site impervious cover (%)*
A = *Total site area (in acres)*

Thus, for a 10-acre residential subdivision, with 28% *IC*, the *WQv* required would be:

$$WQv = (1.25) \times (0.302) \times (10) / 12$$

or 0.314 acre-feet of required treatment storage

Example 2: A hypothetical town in interior Alaska is in the Interior Climatic Region. The local storm water manager has analyzed climate statistics and concluded that the 90 percent rainfall depth during the growing season is only 0.5 inch, whereas the average end of season snowpack is 12 inches.

Again, assuming a 10:1 ratio of water equivalency for the snow, this would translate to meltwater treatment depth of 1.2 inches. Because the meltwater depth is greater than the rainfall depth at an interior location, the 1.2-inch value should be substituted into Equation (1) to calculate the required water quality volume.

So, for an *identical* 10-acre residential subdivision in the Interior Climatic Region (also with 28% IC), the WQv required would be

$$WQv = (1.2) \times (0.302) \times (10) / 12$$

or 0.302 acre-feet of required treatment storage

Table 2-5. Runoff management strategy

Step 1: Early Site Assessment. Analyze site and prepare a map showing environmental, drainage and soil features before site layout.

Step 2: Maximize Vegetative Cover. Fingerprint the site to maximize retention and revegetation of native cover, particularly forest canopy where applicable, to intercept rainfall.

Step 3: Stream Corridor Protection. Reserve a buffer along the corridor of the perennial stream network and maintain in forest or other native cover.

Step 4: Conserve Soils and Contours. Minimize the amount of mass grading and soil compaction that are needed at the site.

Step 5: Minimize Impervious Cover in Site Design. Evaluate the proposed development design to look for opportunities for narrower roads, smaller parking lots, rooftop disconnection, cluster lots and other better site design techniques (CWP 1998).

Step 6: Reduce Runoff Near the Site. Install a series of low impact development practices to capture, disconnect, store or reuse runoff from the roof, driveway or yard (e.g., rain gardens, soil compost amendments, dry wells).

Step 7: Filter Runoff in the Conveyance System. Filter runoff along streets and roadways using dry swales, compost-amended grass channels or wet swales.

Step 8: Final Runoff Treatment. Treat remaining runoff in wetlands, ponds or biofiltration practices that utilize settling and biological processes to maximize pollutant removal.

Table 2-6. Snowmelt management strategy

Step 1: Fall Pollution Prevention. Keep contaminating materials away from paved surfaces and snow piles (e.g., litter and pet waste controls), stabilization and erosion control, better storage and handling road chemicals (e.g., covered storage and mix areas).
Step 2: Winter Snow and Snow Pack Management. Reduced use of deicing and anti-skid chemicals, snow removal and storage in less sensitive pervious areas or treatment areas.
Step 3: Temporary Meltwater Storage and Infiltration. The first stage of meltwater should be diverted to pervious areas where some storage and infiltration can occur. This can be a bioretention area, filter strip, grass swale or similar practice. If source areas produce high chloride levels and are near drinking water sources, infiltration should be avoided.
Step 4: Meltwater Treatment in Seasonally Operated Storm Water Practice. The main stage of meltwater should be treated in a dry, extended detention pond, shallow wetland or similar practice with enough storage capacity to provide extended detention for the full snowmelt water quality volume (to settle out sediments and other particulate pollutants). Design techniques for ponds and wetlands operated in a seasonal mode is in Chapter 9 of the *Minnesota Stormwater Manual* (MSSC 2005).
Step 5: Spring Housekeeping. The last step involves efforts to remove accumulated pollutants from streets, parking lots and catchbasins through intensive sweeping and cleanouts that occur after the spring melt but before the first summer rains. In addition, annual maintenance will need to be performed at meltwater storage and storm water practices, such as revegetation or stabilization.

2.4 Storm Water Design Constraints in Alaska

This section evaluates the extreme factors in Alaska that constrain the use of storm water practices developed in other regions of the world and indicates how such factors influence the sizing, design and selection of storm water practices. Once again, the nature and severity of these constraints vary by climatic region, as shown in Table 2-7.

Table 2-7. Key design constraints for storm water practices, by climatic region

Climatic region	Permafrost	Surface freezing	Frost line (ft)	Growing season	Snow pack	Rainfall
Coastal	○	□	3 to 4	○	□	●
Southcentral	□	●	4 to 6	□	□	○
Western	●	■	4 to 6	●	□	○
Interior	●	■	6 to 8	□	□	○
Arctic	■	■■	■■	■	○	○

Code:
○ Usually not a constraint
● Major constraint at most sites
□ Moderate constraints at some sites
■ Severe constraints at all sites

The challenges that these constraints pose for storm water management practices are outlined in Table 2-8. Perhaps the most unique constraint in Alaska is the presence of permafrost in some climatic regions. Permafrost is defined on the basis of the soil temperature. It is rock or soil material, with or without moisture or organic matter that has remained below 32 degrees Fahrenheit (° F) continuously for two or more years (Ferrians et al. 1969). Ice in permafrost can occur in unconsolidated materials and acts as a cementing agent, making the mass of unconsolidated material as hard as rock.

Problems arise where permafrost occurs in poorly drained, fine-grained sediments. In fine-grained sediments there are generally large amounts of ice, and when the thermal regime is disrupted, the ice begins to melt. The thawing process produces soft or semi-liquid sediments that are unstable and can flow laterally or downslope. In permafrost areas, improper drainage can cause problems. This can be a particularly significant concern with roads or other linear projects because road fill that is allowed to saturate is more susceptible to frost heaving. Although permafrost thaws when exposed, water flowing alongside the fill can hasten the melting of the permafrost and cause thawing and subsequent collapse. This makes it difficult to work in areas with permafrost in the summer at most sites.

The design constraints within each climatic region have a profound effect on the selection and design of storm water practices (Table 2-9). Many widely used practices in lower latitudes could require major design adaptation to operate in extreme conditions (see Table 2-4). The design of storm water practices requires some adaptation to perform well under Alaskan conditions; more information on recommended adaptations is in Chapter 4.

Table 2-8. Challenges for the design of runoff management practices in Alaska

Permafrost	• Makes infiltration of runoff difficult • Poor surface drainage • Shallow root structures • Excavation of permafrost in summer create a talik layer leading to thawing and instability
Sub-zero temperature	• Pipe freezing unless located below frost line • Surface permanent pools to be frozen in winter • Glaciation in road cuts from groundwater seepage • Reduced biological activity and settling velocities
Frost line	• Frost heaving of structures and earthworks • Reduced soil infiltration • Pipe freezing
Short growing season	• Short period to establish vegetation on-site and on storm water treatment practices • Narrow list of plant species adapted for conditions
Snowpack	• High runoff volumes occur during snowmelt and rain-on-snow events • High sediment pollutant loads in spring melt, depending on source area
Sparse vegetation	• Higher sediment loads requires greater pretreatment • Smaller benefit of reduced runoff rate because of less evapotranspiration
Steep terrain	• Slopes constrain use of many storm water practices • Runoff and snowmelt can contribute to slope instability/failure • Lack of room on the site for storm water and snowmelt treatment practices
Annual rainfall	• Frequent rainfall events create soggy or saturated conditions within practices • Cloud cover reduces plant growth and evapotranspiration • The 90 percent rainfall depth that defines the water quality volume may be as high as 1.25 to 1.75 inches • Practices must be designed with a safe overflow for more intense storms that create flooding

Sources: Adapted from Caraco and Claytor (1997) and MSSC (2006)

Table 2-9. Feasibility of storm water practices by climatic region

Storm water treatment practices (for a description, see Section 5.4)	Alaskan climate regions				
	Coastal	South-central	Western	Interior	Arctic
Bioretention	○	○	□	○	✪
Infiltration	□	□	□	□	■
Filtering Practices	□	□	■	□	■
Dry ED Ponds	□	○	○	○	■
Constructed Wetlands	○	□	✪	✪	✪
Wet Ponds	○	□	■	■	■
Green Roofs	✪	□	■	■	■
Rain Tank/Cistern	✪	■	■	■	■
Permeable Pavers	□	□	■	■	■
Dry Swale	○	□	■	○	■
Filter Strips	✪	○	○	○	✪
Underground	□	□	■	■	■

Feasibility codes:

○ Widely feasible

□ Might be feasible in certain situations

✪ Only feasible with major design adaptation

■ Infeasible and not recommended

Note: This is general guidance; site-specific conditions will dictate proper BMP selection.

Sources: Shannon and Wilson 2006; Caraco and Claytor 1997; MOA 2007

2.5 Storm Water Management in an Era of Climate Change

Alaska is now experiencing an era of climate change that could lead to increased precipitation, higher rainfall intensity, warmer temperatures and thawing of permafrost, depending on the region (ACIAC 2008). Several recent studies indicate that such changes could have a pervasive and negative effect on municipal infrastructure in the coming years (Larsen and Goldsmith 2007; Cole 2007). While the specific effects on existing storm water infrastructure (or new storm water practices proposed in this manual) have not yet been extensively investigated in Alaska, Oberts (2007) has recently summarized some of the potential risks.

The Alaska Climate Impact Assessment Commission (2008) strongly recommends an adaptive engineering approach to minimize the risks to future storm water infrastructure, and specifically noted the critical need to update TP-47 rainfall records (which date to the mid-1960s) and improve engineering standards to respond to an era of changing climate.

Although a full review of the effects of climate change on storm water design is beyond the scope of this initial manual, reviewers should carefully scrutinize the options presented to see how they might withstand the following:

- More intense summer rainfall events
- More frequent winter rain events, including rain on snowpack/frozen ground
- Gradual thawing of the permafrost layer
- Increased intensity of flooding events
- Increased use of salt and deicers
- Longer growing season
- More rapid spring melt and breakup

2.6 Winter Construction

Given the short growing season, milder winters and adoption of new building techniques in Alaska, construction might now extend or even be initiated in the winter season. Even when construction ceases in the winter, soils could be exposed until building conditions improve in the spring. Given frozen soils, it might be difficult or impossible to stabilize soils with sprays, mulch or vegetative cover. In addition, many common erosion and sediment control practices that work well during the growing season, perform much worse during winter conditions, as shown in Table 2-10. This often means that soils and slopes are left bare throughout the winter only to be exposed to the erosive forces of meltwater and spring runoff when little protection is in place. Consequently, sediment delivery from construction sites could become extremely high, unless aggressive measures are made before, during and after winter to keep soil in place. A series of recommended erosion and sediment control practices to apply to winter construction sites is in Section 3.4.5a. These Fall-Winter-Spring practices are particularly important for all climatic regions other than the Coastal Region.

Table 2-10. Challenges of winter erosion and sediment control

Vegetative Ground Cover and Hydroseeding
• Vegetative ground cover cannot be established outside the growing seasons, which means the most effective form of erosion control is unavailable during the winter months. • The stabilizers used for hydroseeding work poorly in cold conditions, and limited seed germination of seed can be expected in winter months.
Silt Fence and Erosion Control Blankets
• Silt fence is difficult to install on frozen ground, is frequently damaged or destroyed by snow storage in the winter months, and is likely to fail during initial spring melt. • Erosion blankets cannot be properly installed on frozen ground. Poor installations that are not effectively anchored before winter may wash away or slump during spring melt.
Diversion Structures and Grass-Lined Channels
• Diversion structures are difficult to impossible to install on frozen soils. Diversion structures installed before the onset of winter will be degraded by ice and spring melt flows. • Grass-lined channels are extremely difficult to install once the ground freezes, and early spring grass cover will usually be insufficient to prevent erosion during meltwater events.
Sediment Traps and Basins
• Must be installed before ground freezing, capacity is overwhelmed by spring meltwater and sediment deposition.
Imperious Stabilization
• Paving and other measures to stabilize soil cannot be performed in winter.
Sources: Adapted from MSSC (2005) and VTDEC (2006)

2.7 Storm Water Pollution Hotspots

Storm water *hotspots* is a term for an operation or activity that produces higher pollutant concentrations in runoff or meltwater, or has a higher risk for spills, leaks or illicit dischargers. Some types of industrial facilities are considered to be hotspots and must obtain an Alaska Pollutant Discharge Elimination System (APDES) industrial storm water permit to control their discharges (see Chapter 1). Consequently, storm water treatment and pollution prevention practices must be customized at storm water hotspots to prevent contamination of surface or groundwater, particularly when the hotspot discharges to a drinking water source. Depending on the severity of the hotspot, one or more of the following management strategies might be required:

1. **Storm Water Pollution Prevention Plan**. This plan is required as part of an industrial storm water permit and includes all structural and nonstructural pollution prevention and treatment practices to prevent polluted runoff from discharging from the site.

2. **Source Control Plan** (SCP). This plan is recommended for new development projects that have potential to become a hotspot and includes an addendum to the storm water plan on pollution prevention practices to reduce contact of pollutants with rainfall or snowmelt.

3. **Snowmelt Management Plan** (SMP). This plan could apply to an existing site or new development project and outlines the process for clearing, storing, removing and treating snow from the site to minimize snowmelt pollution. Guidance on developing these plans are in MOA (2007) and Chapter 9 of MSSC (2005).

4. **Infiltration Prohibition** (IP). This approach involves a local approval for new development projects that effectively prohibits infiltration of snowmelt from severe storm water hotspot to prevent potential groundwater contamination by chloride or other toxics. In such cases, an alternative storm water practice such as a bioretention area, sand filter or constructed wetland must be used to filter runoff before it reaches surface or groundwater. The prohibition of direct infiltration of hotspot runoff is often used to protect the quality a community water supply.

As shown in Table 2-11, there are a broader group of operations and activities in Alaska that have potential to become storm water pollution hotspots. The designation is important in that it can trigger up to four management responses as described above.

Table 2-11. List of Alaskan storm water hotspots

Storm water hotspot operation or activity	Recommended management response			
	SWPPP	SCP	SMP	IP
APDES industrial permits (see Chapter 1)	●		●	●
Industrial machinery and equipment		●		●
Railroad equipment		●		●
Airfields and aircraft maintenance areas	●		●	●
Fleet storage areas		●	●	●
Gas stations		●		●
Retail/wholesale vehicle/equipment dealers		●		●
Road construction	●			
Construction business (paving, heavy equipment storage and maintenance)		●		●
Petroleum storage facilities		●		●
Port facilities	●		●	●
Parking lots (40 or more parking spaces)			●	●
Rural-horse paddocks		●		●
Residential-dog kennels		●		●
Commercial snow dumping and storage area			●	●
Public works yard	●		●	●
Shipyards and repair facilities	●			●
Metal recyclers	●	●		●

Source: Adapted from MDE (2000) and Schueler et al (2004).