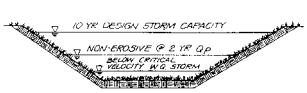
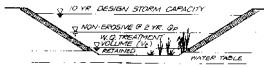
7. Open Channels

Open channel systems treat stormwater runoff through a combination of filtration through a vegetative cover and infiltration. These treatment systems, along with ponds and wetlands, are the most recommended BMPs of stormwater experts in cold climates (CWP, 1997).

7.1 Types of Open Channels

Four basic types of open channel systems are grass channels, dry swales, wet swales and vegetative filter strips. All of these systems treat runoff through similar mechanisms, but differ slightly in their application and design. Table 7.1 outlines some of the characteristics of these four open channel BMPs.

TABLE 7.1 TYPES OF OPEN CHANNELS

	Grass channel	Dry Swale	Wet Swale	Filter Strip
Schematic				
Ideal Application(s)	• Pervious Surfaces	• Roads and Highways • Residential • Pervious Surfaces	• Limited use due to standing water	• Roads and Highways • Residential Areas • Pervious Surfaces • Rooftop Runoff
Land Consumed (% Impervious Area)	6.5%	10-20%	10-20%	100%

- Grass Channel

  Grass channels are modifications of traditional conveyance channels that provide some water quality treatment. Grass channels have a broad, mildly sloped channel, and a thick vegetative cover. The grass channel is the only BMP with a **rate-based** design (i.e., the flow rate is the principle design criteria variable). Specifically, the design objective is to maintain a minimum residence time of ten minutes for the water quality volume.

- Dry Swale

  Dry swales are vegetated channels with moderate slopes. In dry swales, a prepared soil bed is designed to filter the runoff for water quality. The runoff is then collected in an underdrain system and discharged to the conveyance system or stream. Dry swales are designed to drain the water quality volume in twenty-four hours.

- Wet Swale

  Wet swales are similar to stormwater wetlands in their use of wetland vegetation to treat stormwater runoff. Wetland vegetation can be planted or allowed to naturally colonize these systems. Wet swales are designed to retain the water quality volume for twenty four hours. Their use may be restricted due to concerns regarding odor and mosquitos.

- Filter Strip

  Filter strips provide a buffer, usually grass, between development and streams or stormwater conveyance systems. They provide some pollutant removal and infiltration and reduce the velocity of overland flow before it reaches the streams. These systems are often part of a riparian buffer system, including a forested buffer at the stream edge (Schueler, 1995). The use of filter strips is limited by the amount of space they consume. They can also be overwhelmed by too much, or concentrated, runoff, which can cause gullies, and thus bypass the filtering media.

7.2 Base Criteria

Base design criteria for open channel systems are presented in Table 7.2 (Claytor and Schueler, 1996). These criteria are not discussed in detail because they do not address cold climate conditions specifically.

TABLE 7.2 BASE CRITERIA FOR OPEN CHANNEL SYSTEMS

Grass Channels

- Side slopes flatter than 3:1
- Longitudinal slope between 1% and 4%
- Non-erosive for the two-year storm
- Water quality volume retained or infiltrated in 24 hours
- Small forebay at the inlet as pretreatment

Swales (Wet and Dry)

- Side Slopes 3:1 to 4:1
- Longitudinal slope between 1% and 2%
- Check dams can be used to maintain the longitudinal slope in a swale.
- Maintain a dense vegetative cover
- Non-erosive for the two-year storm
- Water quality volume retained or infiltrated in 24 hours
- Underdrain and prepared soil bed used in a dry swale to promote filtration.
- Small forebay at the inlet as pretreatment

Vegetated Filter Strip

- Greater than 25 feet long
- Slope between 2% and 6%
- Maintain a dense vegetative cover
- Maximum contributing length 75 feet for impervious drainage; 150 feet for pervious drainage
- Sized to temporarily pond the design water quality volume

7.3 Modifications for Cold Climates

Because open channel systems are "minimum structural" BMPs (i.e., their designs include few pipes or other structures), they require few modifications for cold climates. The primary modifications are with respect to meltwater treatment and a shortened growing season.

7.3.1 Feasibility

In general, open channel BMPs are feasible in most cold climates. Two restrictions are:

- A small setback may be required between grass swales and roads when frost heave is a concern (depth of frost >5' and clay or silty soils)
- No open channel BMPs should be used in regions that have permafrost. Infiltration will be extremely limited, decreasing the effectiveness of these BMPs. There is also a risk associated with infiltrating stormwater into permafrost. The possible thawing of the permafrost may cause ground collapse.

7.3.2 Conveyance

Few conveyance modifications are needed for open channel systems, because they have minimal infrastructure. Four design modifications suggested for grass swales are presented in Table 7.3. Their purpose is to prevent flooding and encourage infiltration in swales. No conveyance modifications are required for vegetated filter strips.

TABLE 7.3 CONVEYANCE MODIFICATIONS FOR OPEN CHANNEL SYSTEMS

Conveyance Modifications	Purpose (s)
Eight Inch Underdrain Pipe	• Encourage infiltration • Protect underdrain against frost heave
Minimum One Foot Gravel Base	• Encourage infiltration • Protect underdrain against frost heave
Permeable Soil Bed	• Encourage infiltration
"Ice Free" Culverts	• Prevent flooding

- Eight inch underdrain diameter

  Underdrains are often used in dry swales to prevent standing water. In cold climates, the underdrain pipe diameter should be 8" or larger. Increasing the diameter promotes drainage, which prevents saturated soil at the beginning of the cold season. It also protects the underdrain pipe against frost damage.

- Minimum one foot gravel base

  This recommendation is made for the same reason that the underdrain diameter is increased. The one foot gravel bed surrounding the underdrain creates a high capacity for infiltration and protects the underdrain pipe.

- Permeable soil bed

The soil bed permeability should be NRCS class SM or ML (NRCS, 1984). This level of permeability is slightly higher than that in moderate climates to prevent frost heaving and encourage snowmelt infiltration in cold climates.

- "Ice-free" culverts

  Culverts are often used as a part of a dry swale system, under driveways or road crossings. In cold climates, culverts can become covered with ice or clogged with snow, causing flooding concerns. By oversizing culverts and promoting flow through the culvert pipes, these concerns are somewhat minimized.

  - Use culvert pipes with a minimum diameter of 18"
  - Design culverts with a minimum 1% slope where possible

In extremely cold or snowy climates (depth of frost greater than 5' or greater than 8' of snow):

- Use a portable steamer to remove blockages from culverts.

7.3.3 Treatment

Combining open channel systems with other BMPs is highly recommended for cold climates. Open channel systems are particularly valuable due to their capacity for meltwater infiltration. These BMPs can be used as pretreatment device or as conveyance to a downstream treatment device.

7.3.4 Maintenance

In cold climates, open channel BMPs should be inspected after the spring melt. At this time, residual sand should be removed and any damaged vegetation should be replaced.

If roadside or parking lot runoff is directed to the BMP, mulching may be required in the spring to restore soil structure and moisture capacity. This is because deicing salts can damage soil structure, reducing the organic content of the soil (Jones and Jeffrey, 1992).

7.3.5 Landscaping

Use salt-tolerant plant species if the BMP will be used for snow storage or for treatment of roadside drainage. A list of some appropriate plant species is included in Table 5.5, Section 5.3.5. This precaution is particularly important for roadside swales.

In regions with very short growing seasons (i.e., less than four months) two growing seasons may be necessary to establish significant grass cover in channels or swales. In these conditions, erosion control measures such mats or blankets are necessary to stabilize the sides of the channel or swale while the vegetative cover becomes established.

7.3.6 Snow Management

Although the performance of open channel BMPs is reduced in the winter season, these BMPs are valuable from a snow management standpoint. When immediately next to road networks, grass swales provide a place for plowed snow to be stored. Vegetated filter strips can act as a permeable snow storage area. Extra maintenance may be needed if snow from roads or parking lots, which is high in sands and chlorides, is stored in the swale or channel.

In addition to being convenient snow storage zones, these BMPs infiltrate meltwater, reducing the peak flows from snowmelt. In addition, many of the pollutants in the snowpack can be treated through infiltration. In one application in Milwaukee, Wisconsin (Woodward-Clyde, 1996), grassed swales were used to divert parking lot stormwater to a vegetated filter strip and bioretention area. This filter strip,

surrounded by low berms, acted as a snow storage area (Figure 7.1) and provided water quality treatment.

FIGURE 7.1 OPEN CHANNEL BMPS USED IN SNOW STORAGE (SOURCE: WOODWARD-CLYDE, 1996)