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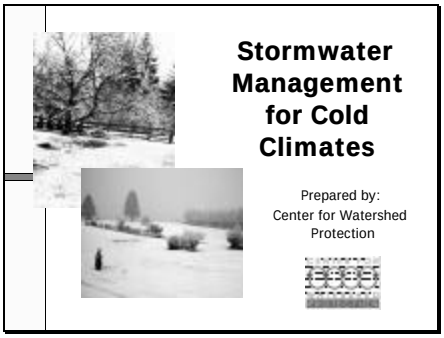

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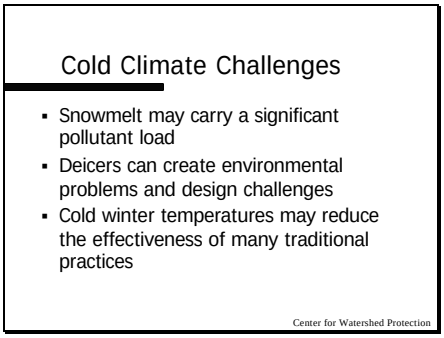

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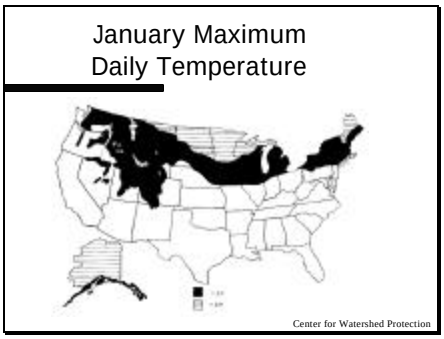

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Sources of Pollutants in the Snowpack

- Atmospheric pollutants adsorbed by snowflakes
- Dry deposition
- Automotive sources
- Pet waste
- Litter
- Pavement deterioration
- Deicers

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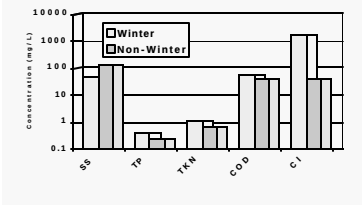
Winter and Non-Winter Pollutant Concentrations



Source: Novotny, et al. (1999)

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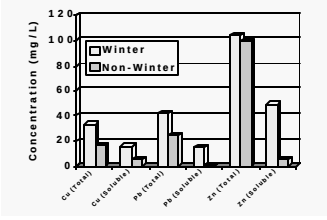
Winter and Non-Winter Metals Concentrations



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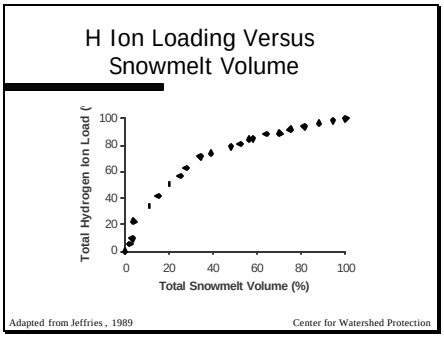

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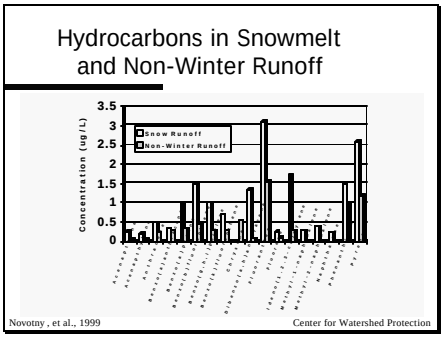

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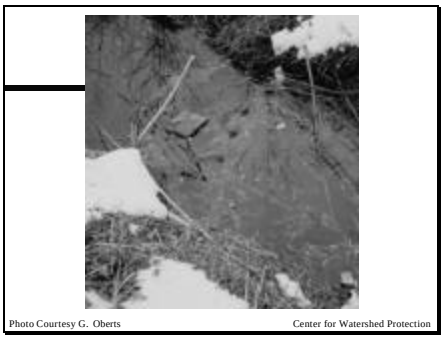

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Deicing/Abrasive Options: Salts

Option	Notes
Rock Salt (Sodium Chloride)	• Chlorides • Sodium impacts on roadside vegetation • Contains ferrous cyanide as an anticaking agent
Magnesium or Calcium Chloride	• Chlorides • Calcium Chloride is corrosive to highway infrastructure • Magnesium, calcium may buffer chemical impacts and may enhance the soil • Much more expensive than rock salt (about 6 times), but less required per application • Melts ice at lower temperatures

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Deicing/Abrasive Options: Other Roadway Applications

Option	Notes
Sand/ Other Abrasives	• Sediment and phosphorus loading • Only option at extremely low temperatures
CMA	• High BOD • No chloride issues • High Cost (20 times rock salt) • Slower acting than salt
Ice Ban	• Organic residue from alcohol production • Usually mixed with a brine or with the salt/sand mix • High BOD

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Strategies to Reduce the Amount of Deicer Applied

- Adjust Application Based on Use
- Use a Clean Sand Source
- "Anti-Icing"
- Calibrated Spreaders
- Combination of Deicers

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Cold Climate Design Challenges

- Freezing of the Permanent Pool
- Pipe Freezing/Frost Heave
- Decreased Biological Activity and Settling Velocities
- Lower Oxygen Levels in Bottom Sediment
- Reduced Soil Infiltration
- Shorter Growing Season

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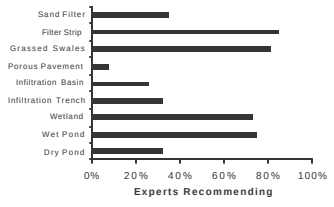
Practices Recommended in Cold Climates

(Caraco and Claytor, 1997)



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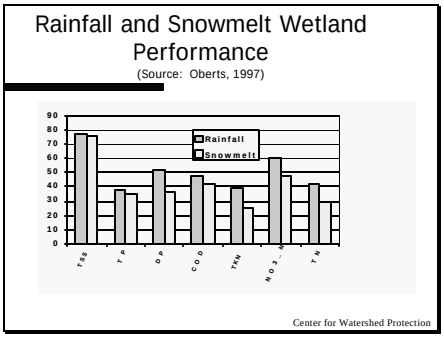

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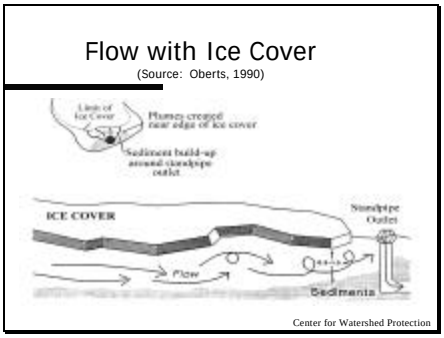

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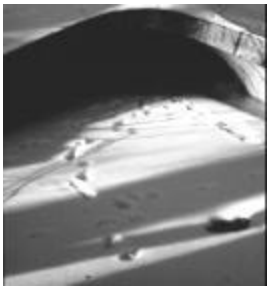

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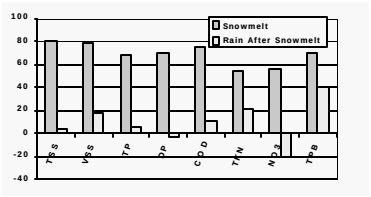
Wetland Performance in Snowmelt and Rain on Snow



Source: Oberts 1994

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Design Modifications: Ponds and Wetlands/ Treatment and Pretreatment

- Provide some portion of the water quality storage as extended detention.
- Provide additional treatment and pre-treatment (forebay) volume.
- Consider "seasonal operation" to capture snowmelt.
- Emphasize Pond/Wetland Systems where possible.

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Dry ED Storage as Pretreatment

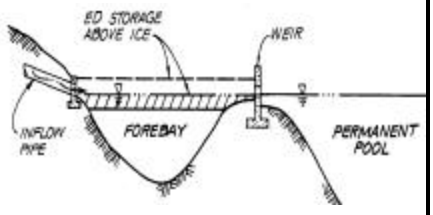

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Photo Courtesy G. Oberts

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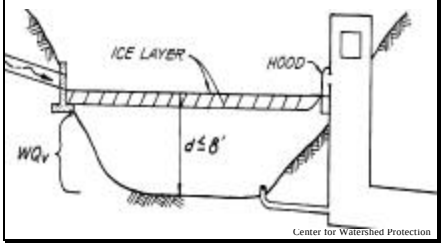
Increase Total Volume



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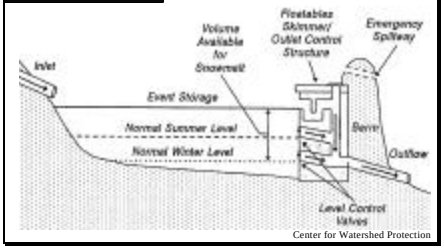
Seasonal Operation Pond



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Design Modifications:
Ponds and Wetlands/Landscaping

- Use salt tolerant species, when pond or wetland receives road or parking area runoff.
- Adjust the “planting window” to ensure establishment.
- Consider winter planting with dormant rhizomes.

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Stormwater Wetland with Level Spreader Pretreatment

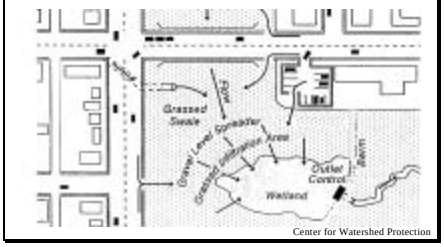

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Photo Courtesy G. Oberts

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Design Modifications- Ponds and Wetlands/ Conveyance and Maintenance

- Avoid submerged inlets
- Consider using frost-free outlets such as weirs
- Avoid small diameter outlets
- Consider alternative trash rack or riser hood configurations
- Consider in-line ponds where practical

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Baffle Weir Near Outlet

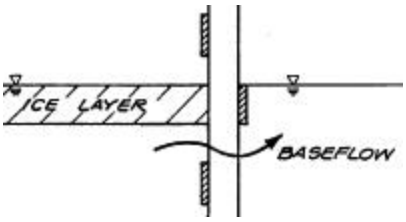

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Photo Courtesy G. Oberts

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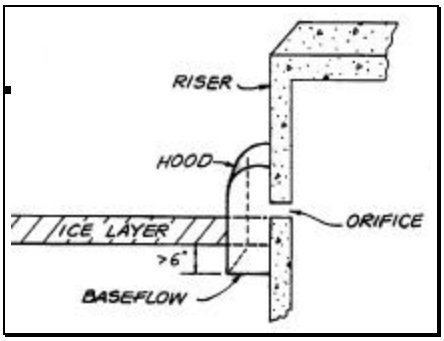

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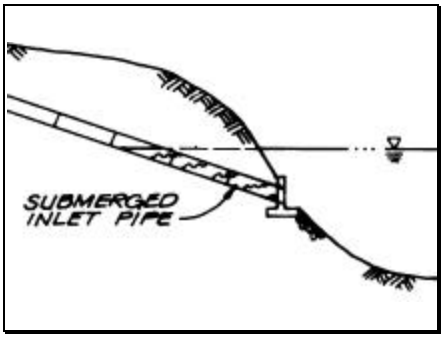

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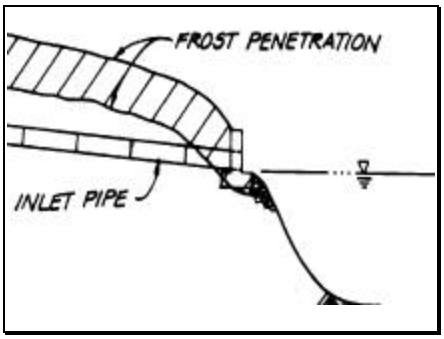

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Design Modifications: Infiltration Systems

- Avoid Porous Pavement for sanded surfaces
- Ensure that infiltration practices do not create a groundwater concern, possibly by diverting winter snowmelt
- Consider seasonal operation
- Use a porous medium on infiltration basin floors, if possible

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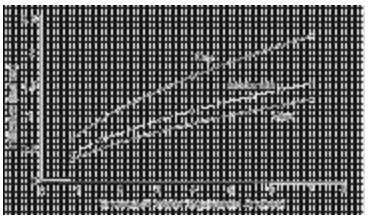
Infiltration Versus Soil Moisture



Source: Granger *et al.* (1984)

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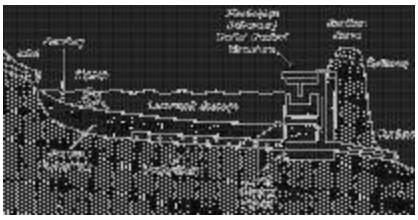
Seasonal Operation Infiltration Basin



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Design Modifications: Sand Filters

- Use a gravel layer at the base of the filter to prevent freezing
- Design underground filters to be below the frost line
- Use frost free inlets and outlets where possible
- Increase the slope of underdrain pipes to at least 1% to ensure flow through the system
- Avoid organic filters

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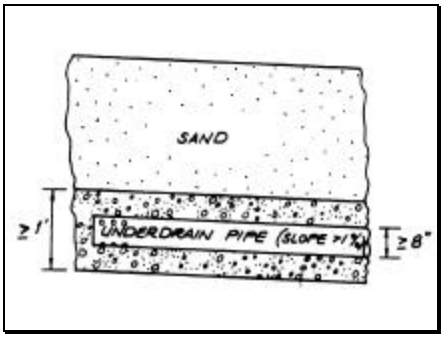

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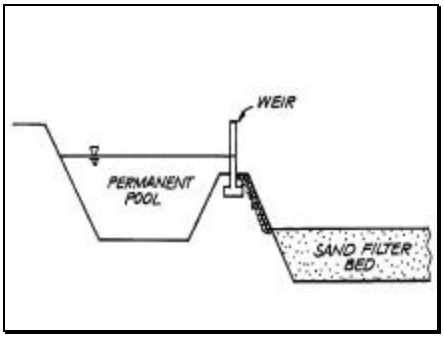

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Design Modifications: Open Channels

- When used as a roadside practice, mulch to restore moisture and soil structure lost due to deicer application
- Use salt tolerant plant species when used as a roadside practice
- Incorporate open channel practices into a snow storage system

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Glossary

Deicer: One of various compounds used to melt ice from pavement.

Frost-Free: Inlet and outlet designs that limit the risk of freezing during winter months.

Preferential Elution: The tendency of certain pollutants to be released at the beginning or end of the snowmelt process, depending on their solubility.

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Glossary

Rain-On Snow Event: Runoff events that occur when rain when rain falls onto existing snow cover.

Snowmelt: Runoff that occurs when snow melts, either during the spring, or throughout the winter in smaller melt events.

Snowpack: The accumulation of snow on the ground at any point in time.

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