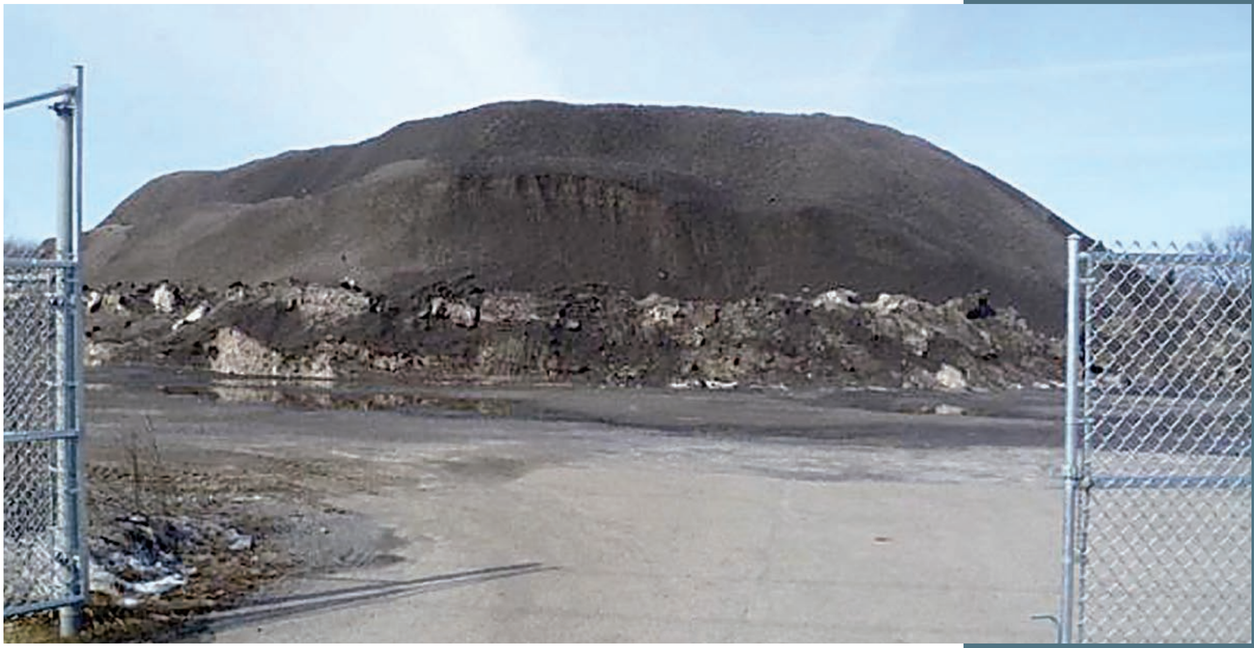
Saskatchewan Snow Dump Management Guidelines



Commissioned by: Communities of Tomorrow
Leveraged Municipal Innovation Fund

Prepared by: Associated Engineers

Sponsoring Municipalities: North Battleford, Yorkton

COMMUNITIES OF TOMORROW
Advancing Municipal Infrastructure Innovation

Municipal Innovation Network

August 2012

Report

Communities of Tomorrow

Saskatchewan Snow Dump Management Guidelines

July 2012

Executive Summary

The development of 'Snow Dump Management Guidelines' was commissioned by Communities of Tomorrow (CT) with input provided by a number of Saskatchewan municipalities. Snow dump management practices vary significantly among Saskatchewan municipalities. Currently, no guidelines exist that explicitly regulate snow dump siting, design or management practices. However, various federal, provincial and municipal regulations can be extrinsically linked and incorporated into design or management considerations. Development of snow dump regulations or guidelines are not currently planned by the Saskatchewan Ministry of Environment but may be reviewed in the future to standardize practices to better serve the environment.

As many Saskatchewan municipalities continue to grow and develop, their snow dump management practices will require improvements. In fact, some municipalities within the province are planning to develop existing snow dump sites into commercial or residential development and may require environmental remediation prior to development. The siting, design and management considerations presented in this report leverages existing knowledge and experience gained from other jurisdictions and should be considered by municipalities who want to improve or reclaim existing snow dump sites or develop new snow dump sites. Adopting improved snow dump siting, design and management practices can mitigate potentially adverse environmental, social and economic impacts.

Key site selection considerations include review of:

1. Existing land use (e.g. agricultural, recreational, environmentally sensitive areas, etc.).
2. Surrounding land use (e.g. proximity to landfills, housing, water bodies, etc.).

Key site design considerations include review of the proposed site's:

1. Capacity.
2. Soil characteristics.
3. Grading.
4. Access.
5. Potential melt water treatment solutions.
   I. Settling ponds.
   II. Wet ponds.
   III. Constructed wetlands.
   IV. Oil/grit separators.
   V. Mechanical treatment.

Key management considerations include:

1. Operations & maintenance.
2. Environmental monitoring.
3. Environmental remediation (if required).

If an existing snow dump site requires remediation, site specific conditions will dictate the remediation process. Typically, this process would involve a Phase I/II Environmental Site Assessment (ESA) and may require Phase III ESA works if contamination is noted. Selection of remediation technologies is dependent on the matrix to be remediated (i.e. soil or groundwater), the nature and extent of the contamination as well as cost and logistic considerations.

Depending on a municipality's motivation towards improving an existing or developing a new snow dump site, the following options are available to adopt the most applicable best management practices including:

1. Identify your municipality's existing snow dump management practices relative to the best practice siting, design and management considerations stated within this report.
2. Identify and implement mitigative measures to reduce your snow dump's social, environmental and economic impacts relative to the siting, design, treatment and management considerations.
3. Consult experienced and qualified professionals (i.e. Professional Engineers) if assistance is required to identify and implement potential improvements relative to existing and future regulation changes.

Table of Contents

1 Introduction

Communities of Tomorrow (CT) is a public-private partnership whose role is to build partnerships that create new and innovative infrastructure solutions to common everyday municipal problems faced by Saskatchewan communities. Working with industry, municipalities and researchers, CT helps foster an environment, which will maximize outcomes and benefit Saskatchewan now and in the future.

The development of 'Snow Dump Management Guidelines' has been commissioned by CT with input provided by a number of Saskatchewan municipalities. As Saskatchewan municipalities continue to grow and develop, the current practices and procedures for snow dump management practices will change. In fact, some snow dump sites throughout the province are currently being considered for commercial or residential development thereby requiring remediation of the existing sites and development of new sites. The management guidelines presented in this report should be considered when improving, reclaiming or developing snow dump sites in order to leverage existing knowledge and experience gained from other jurisdictions and to provide guidance to municipalities regarding snow dump siting, design and management considerations

2 Background

Snow dump sites are designated areas used by municipalities to deposit accumulated snowfall from roadways and parking lots. Snowpack can accumulate significant quantities of contaminants including oil/grease, de-icing salts (e.g. sodium; chloride; magnesium; calcium; iron; sodium ferrocyanide), nitrogen, phosphorus, lead, organics (e.g. polycyclic aromatic hydrocarbons, or PAHs), total solids and accumulated urban litter. When snow is collected and transported to a dump site, the associated contaminants can impact the receiving environment. As the snow begins to melt, the surface water runoff can adversely impact surface water bodies, groundwater aquifers, soils, vegetation, wildlife and concrete and metal structures. These adverse impacts and associated risks will be dependent on the source of snowpack, climate variables, and long and short term operations at the site. However, potential impacts can be mitigated through proper planning and the incorporation of improved management guidelines into the municipality's business processes.

Previously, snow dump management guidelines did not exist in Saskatchewan and as a result municipalities have developed their own practices that vary in economic efficiency and environmental effectiveness. Opportunities exist among the majority of Saskatchewan municipalities to improve their snow dump management practices.

2.1 EXISTING SASKATCHEWAN MUNICIPAL PRACTICES

For comparative purposes, numerous Saskatchewan municipalities were surveyed on their current snow dump management practices related to snow dump siting, existing policies, operation and maintenance procedures, environmental mitigation measures and general challenges. Based on responses provided by communities, the following observations were noted:

1. **Siting:**
   a) All respondent municipalities had at least one designated snow dump location while some municipalities identified multiple locations based on proximity to snow removal routes. Sites were selected to reduce haul costs.
   b) The majority of snow dump locations were located on parcels of land owned by the municipality and allowed water to freely drain away from the snow dump site.

2. **Policies:**
   a) Almost all of the respondent municipalities had formalized snow removal guidelines and policies which related to prioritized roadways and snow removal methodology.
   b) Almost all of the respondent municipalities had no formalized snow disposal guidelines or policies related to snow dumps and subsequent management.

3. **Operational Maintenance:**
   a) Operation and maintenance procedures varied widely and included practices such as:
      i) Dumping snow in a designated field with minimal consideration of piling, runoff, security, etc.

   ii) Pushing snow into piles to create additional room for future snow piles.
   iii) Maintaining site access for municipal and private contractors.
   iv) Re-grading the site after the snow melt to facilitate drainage due to erratic sediment deposits.
   v) Mowing the grass during the summer months for aesthetic appeal.

4. **Environmental Mitigation:**
   a) None of the respondent municipalities incorporated mitigation measures to reduce environmental impacts.
   b) Most municipalities expressed interest in understanding improved practices in order to incorporate within their organizations.

5. **Challenges/Concerns:**
   a) Most municipalities did not express challenges with their current snow dump practices, but expressed interest in understanding better management practices, if available, and especially if regulations are developed and/or enforced in the future.
   b) Municipalities that did identify challenges related them to the following:
      i) Noise.
      ii) Site security.
      iii) Chlorides in melt water and soil.
      iv) Solid waste remnants.
      v) Haul road quality.

2.2 EXISTING REGULATIONS AND GUIDELINES

Saskatchewan municipalities have identified federal and provincial regulations as the probable impetus to modify their existing snow dump practices. Potential regulation changes could impact existing practices on a number of levels including siting, operation and maintenance practices, design features to mitigate environmental impacts and reporting. Municipalities with an understanding of improved snow dump management guidelines may be better able to plan for future expenditures and adjust to potential regulation changes in a timely and efficient manner.

According to governing authorities, no regulations currently exist that explicitly regulate snow dump sites in Saskatchewan. However, the following federal, provincial and municipal guidelines can be extrinsically linked and incorporated into design or management considerations:

2.2.1 Federal Regulations and Criteria

2.2.1.1 Canadian Environmental Protection Act[1]:

The *Canadian Environmental Protection Act (CEPA)* is designed to protect human health and the environment from risks associated with exposure to substances "suspected of being toxic". There are a number of regulations under CEPA which may affect the management of contaminated sites. If present at high enough concentrations, this Act would apply to the potential contaminants (e.g. PAHs, metals, etc.) accumulated in melt water and the soils associated with the snow dump and sets out the processes used to assess the risks.

2.2.1.2 Fisheries Act[2]:

The federal *Fisheries Act* is the main federal legislation affecting all fish, fish habitat and water quality. Section 36 (3) of the act prohibits deposition of deleterious substances in water frequented by fish, while Section 35 (1) prohibits harmful alteration, disruption or destruction (HADD) of fish habitat. This would apply during operations when melt water with high concentrations of contaminants, potentially enters nearby fish-bearing watercourses. Moreover, any activities associated with construction or land clearing that may alter riparian and in-stream fish habitat in important spawning areas will require a *Fisheries Act Authorization* (under Section 35 (2)).

2.2.1.3 Committee of the Status of Endangered Wildlife in Canada and Species at Risk Act[3]:

The *Committee on the Status of Endangered Wildlife in Canada (COSEWIC)* is an independent agency that determines the status of species in Canada. The *Species at Risk Act (SARA)* is federal legislation that provides legal protection of wildlife and their habitats designated under Schedule 1 of the Act. This protection applies to aquatic species, migratory birds covered by the *Migratory Birds Convention Act,* and species that occur on federal lands in Canada. The purpose of the Act is to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, to provide recovery of endangered or threatened species, and encourage the management of other species to prevent them from becoming at risk.

[1] Canadian Environmental Protection Act: http://laws-lois.justice.gc.ca/PDF/C-15.31.pdf
[2] Fisheries Act: http://laws-lois.justice.gc.ca/PDF/F-14.pdf
[3] Species at Risk Act: http://laws-lois.justice.gc.ca/PDF/S-15.3.pdf

During the siting and construction stages, care must be taken to protect existing wildlife species. It is an offence under Sections 32 and 33 of the SARA to:

1. Kill, harm, harass, capture, or take an individual of a listed species that is extirpated, endangered, or threatened.
2. Possess, collect, buy, sell, or trade an individual of a listed species that is extirpated, endangered, or threatened, or its part or derivative.
3. Damage or destroy the residence of one or more individuals of a listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its re-introduction.

2.2.1.4 Migratory Bird Convention Act (Migratory Birds Regulation)[4]:

The federal *Migratory Bird Convention Act* protects migratory birds and nests from indiscriminate harvesting and destruction. Specifically, the regulation stipulates that no person shall disturb, destroy or take a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird" (Section 6 [a]), and "no person shall deposit or permit to be deposited oil, oil wastes or any other substances harmful to migratory birds in any waters or any area frequented by migratory birds" (Section 35 [1]). To avoid sensitive timing for migratory birds, any proposed land clearing activities should be completed outside of the active breeding season (April 1st to July 31st) unless no active nests are present. If land clearing activities are proposed within this time period, a nesting survey should be completed by a qualified biologist.

2.2.1.5 Canadian Council of Ministers Environmental Quality Guidelines[5]:

The *Canadian Council of Ministers of the Environment (CCME)* have published the *Canadian Environmental Quality Guidelines (CEQG) Summary Tables* that establish the criteria, guidelines, objectives, and standards for substances present in the environment. Specifically, the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life, Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses, Recreational Water Quality Guidelines and Aesthetics, Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, and Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* would potentially apply to snow dump sites depending on the surrounding land use and environment, and the nature of the contamination. These guidelines establish the limits to which potential contaminants are permissible in the different matrices, and as targets for remediation activities.

[4] Migratory Bird Convention Act: http://laws-lois.justice.gc.ca/PDF/M-7.01.pdf

[5] Canadian Council of Ministers Environmental Quality Guidelines homepage: http://www.ccme.ca/

2.2.2 Provincial Regulations and Criteria

2.2.2.1 Saskatchewan Ministry of Environment:

The Saskatchewan Ministry of Environment has a number of guidelines to determine whether a certain level of contamination present in environmental media is within acceptable limits based on water/land use. The *EPB #356 Water Quality Objectives* report contains modified objectives for heavy and trace metals, turbidity, oil and grease, and nutrients which are all applicable to snow dump sites. *EPB #344 Risk-Based Corrective Actions for Petroleum Hydrocarbon Impacted Sites* provides site management processes and guidance specifically for soil and groundwater contamination originating from petroleum impacted sites. The *EPB #322 Stormwater Guidelines* report provides site management processes for pollution resulting from stormwater runoff potentially affecting the quality of water and environment in natural receiving systems. Drainage systems for stormwater in urban, commercial and industrial areas such as those associated with snow dump sites will affect the quality and quantity of runoff in the area especially during spring.

2.2.2.2 Environmental Management and Protection Act:

The *Environmental Management and Protection Act (EMPA)* is the primary piece of environmental legislation in Saskatchewan that ensures the protection of land, air, and water resources. Specifically, Part III, Division and 1 and 2 of EMPA deal with Unauthorized Discharges and Contaminated Sites, respectively. In addition, during construction or land clearing, any alteration of a shoreline, bed, bank or boundary, or removal of riparian vegetation of any watercourse requires an Aquatic Habitat Protection Permit under Section 3 of the Act.

2.2.2.3 Wildlife Act:

Under Section 50 (1) (a) of the *Wildlife Act* it is an offense to “kill, injure, disturb, take, capture, harvest, genetically manipulate, or interfere with or attempt to do any of those things to designated species.” Fifteen “wild species at risk” are identified in the *Saskatchewan Wildlife Act*. If rare or endangered species are identified on site during the design and construction stage of the snow dump site development, appropriate restrictions must be followed (setbacks, timing of construction, type of activity) as described in the Saskatchewan Conservation Data Centre’s *Saskatchewan Activity Restriction Guidelines for sensitive species in natural habitats*. Although adherence is needed, formal authorizations and approvals are not required.

2.2.3 Municipal Regulations and Criteria

Applicable municipal regulations and criteria are dependent on the municipality in which the snow dump is to be located. Generally, these requirements will be included in the Official Community

Plans or Bylaws of the municipalities. The appropriate agencies should be contacted as needed.

2.3 OTHER PROVINCIAL PRACTICES

2.3.1 Manitoba

According to governing authorities in Manitoba, no regulations currently exist that explicitly regulate snow dump sites. Similar to Saskatchewan, federal, provincial and municipal guidelines can be extrinsically linked and incorporated into design or management considerations.

2.3.2 Alberta

The Province of Alberta developed *Snow Disposal Guidelines* in February 1994 (see Appendix A) which have not been updated since. These guidelines identify considerations for siting and designing snow disposal sites. In addition to these guidelines, Alberta communities would be subject to other federal, provincial and municipal guidelines which can be extrinsically linked and incorporated into design or management considerations. It is important to note that large municipalities such as the City of Edmonton have developed design standards for snow dump facilities. Lessons learned and pertinent design standards from the City of Edmonton have been incorporated into this report.

3 Site Selection Considerations

Snow dump sites should be carefully selected to reduce social, economic and environmental impacts. Site selection considerations will be similar for all municipalities. However, the site design and site management considerations will vary depending on each site's unique attributes. Many of the site selection considerations are integrated and require a 'systems approach' in their consideration and analysis. The key factors to be considered when selecting a snow dump site include:

3.1 SURROUNDING LAND USE

The location of a snow dump site needs to correspond with surrounding land use in order to minimize social, economic and environmental impacts. Surrounding land use considerations, in no particular order, include:

1. **Noise:** Municipal bylaws may be applicable regarding allowable decibels for properties. Noise impact assessments should be conducted to identify if haul routes and 24 hour site operations will adversely impact surrounding land users. In the *Alberta Environment Snow Disposal Guidelines (1994),* proposed snow dump sites should be located at a minimum of 350 metres from existing or planned residential development.
2. **Haul Routes**: Proposed snow dump sites should be situated in proximity to snow removal areas to minimize the distance for truck route hauling and subsequent operation costs.
3. **Zoning:** Proposed snow dump sites should be situated within municipally owned land that is zoned for industrial usage. The site should be situated so that it allows for long-term use and will not have to be relocated which could result in costly remediation efforts.
4. **Landfills:** Proposed snow dump sites should not be situated within or adjacent to landfills since the melt water from the snow dump site may increase landfill leachate generation and transport.
5. **Surface Water:** Proposed snow dump sites should not be situated on or adjacent to water bodies since this could introduce contaminants directly into the water body. According to the *Alberta Environment Snow Disposal Guidelines (1994),* sites should be setback at a minimum distance of 200 metres from existing water bodies with gradients less than 15 degrees.
6. **Drainage Courses:** The capacity of receiving storm sewers, culverts and open channels should be sufficient in size to accommodate storm and melt water and prevent flooding of the site or adjacent lands. If melt water is drained into storm or sewer systems, surcharging may results.

3.2 SITE LAND USE

The land used for a snow dump site should not interfere with existing usage, minimize environmental impacts, enable development at reduced cost and allow for all necessary operation and maintenance requirements. Site land use considerations, in no particular order, include:

1. **Agricultural Use**: Proposed snow dump sites should not be situated on prime agricultural land since the contaminants (i.e. metals, salts, hydrocarbons) can adversely impact the soil and property value.
2. **Recreational Use:** Proposed snow dump sites should not be situated on or used as recreational sites due to the risk of exposure of contaminants to people that can exist within the debris once the snow has

melted.

3. **Environmentally Sensitive:** Proposed snow dump sites should not be situated on environmentally sensitive land that includes permanent or intermittent wetlands or protected flora and fauna. Environmental assessments are recommended for site development.
4. **Soil:** Proposed snow dump sites should contain low permeable materials that promote surface drainage rather than infiltration. Geotechnical and soil assessments are recommended for site development.
5. **Ground Water:** Proposed snow dump sites should not extend below existing ground water levels or be in proximity to groundwater aquifers that are used as a potable water supply. Contaminants may infiltrate into the aquifers and impact the quality of the water. Hydrogeological assessments are recommended for site developments which are typically completed in coordination with geotechnical assessments.
6. **Heritage Land:** Proposed snow dump sites should not be situated on land that is culturally significant or possess heritage artifacts. Heritage assessments are recommended for site development.
7. **Existing Infrastructure:** Proposed snow dump sites should be free of existing infrastructure such as buildings, power lines, railways, etc… and should not contain any utility right-of-ways in case access is required or the modified site conditions interfere with the infrastructure's original design.
8. **Size:** Proposed snow dump sites should be sized to accommodate long-term projected snow storage, treatment and site traffic. Access to allow multiple trucks to use the site at the same time as well as storage of operation or maintenance equipment is recommended.
9. **Shape:** Proposed snow dump sites should preferably be rectangular or square in shape to allow for efficient and effective operation and maintenance.
10. **Topography:** Proposed snow dump sites should be situated on land that is flat or gently sloping to minimize earthwork cost and promote adequate drainage.

4 Site Design Considerations

Improved snow dump sites should be designed by qualified Professional Engineers with input from an Environmental Scientist. As indicated in the previous section, a significant number of siting criteria should be considered when developing or modifying a snow dump site. Careful consideration of the snow dump siting criteria can significantly improve the design, construction and operation and maintenance of a site as well as reduce potentially adverse social, economic and environmental impacts. Snow dump site design should be conducted in close consultation with municipal representatives, operation and maintenance personnel, applicable authorities and other relevant stakeholders. The key factors to be considered when designing a snow dump site include:

4.1 CAPACITY

Snow dump sites often require space for the following components: access road, dumping zone, snow storage, equipment storage, berms and a settling pond. Each component of the snow dump site must be sized to meet the capacity demands they serve. The size of the overall dumping area will be dependent on anticipated snow volumes which would typically reflect historical measurements and demands on existing snow dump sites. In addition, snow dump operation practices such as snow piling can significantly influence capacity requirements. For example, some municipalities may simply dump-and-drive while other municipalities may dump-and-pile snow as high as 20 metres such as the City of Edmonton. Operation practices should align with site capacity to ensure all snow dumped on-site and subsequent melt water can be controlled. To facilitate site containment, berms along the perimeter and within the snow dump site may be required.

4.2 SURFACE

Snow dump site surfaces can vary depending on their anticipated operation. Ideally, the site surface should provide a surface to control drainage and provide a working platform for equipment. A typical site surface would include a compacted clay liner. The thickness of the liner can vary depending on soil conditions, but can be up to 600 mm in thickness and constructed of plastic clay material with a permeability coefficient no greater than 1x10-7 cm/s. Compacted clay liners can be installed along the base and interior slopes of the dumping area and perimeter berm as well as the side slopes and base of the settling pond. Advanced snow dump sites can be armoured with roller compacted concrete or asphalt cement to minimize damage to the liner during the removal of sediment.

4.3 GRADING

Snow dump site grading is required to control overland flow and direct the melt water to a settling pond or designated drainage run. Grades of 0.5% to 1.0% are considered adequate to allow for ease-of-operation and reduced velocity of melt water runoff to minimize erosion. Grading can vary depending on the operating philosophy of the snow dump site. Sites should be designed to prevent runoff entering from off-site. Perimeter berms can be constructed to contain melt water, prevent outlying melt water from entering the site as well as provide noise attenuation. If berms are considered relevant to the proposed site, side slopes of 3:1 are common.

4.4 ACCESS

Snow dump sites experience a significant volume of truck traffic during snow clearing events. To facilitate safe site operations, proposed sites should have an entrance and exit wide enough to accommodate two lanes of truck traffic or separate entry and exit points. In addition, the site should be designed to allow multiple trucks to use the site at any given time due to the nature of snow removal operations. Lighting can be installed at the entrance and key locations throughout the snow dump area to allow for safe operation. A chain link fence can be erected around the perimeter to prevent unauthorized access.

4.5 SETTLING POND

Settling ponds are used to improve water quality leaving the snow dump site. Improved snow dump sites will include a settling pond that provide a water retention time of approximately 24 hours. Settling ponds should be designed to accommodate the peak rate of site snowmelt runoff plus enough freeboard to contain a 25 year design rain storm event. Preferred design guidelines can vary among municipalities. Designers may reference guidelines such as the Saskatchewan Ministry of Environment EPB 322 Stormwater Guidelines and adapt as necessary.

Advanced snow dump sites will include a secondary settling pond to enhance the quality of discharge water or to be used while the primary settling pond is being cleared of debris. In addition to the settling pond's compacted clay liner along the base and side slopes, synthetic liners can be placed along the inner side slopes to reduce infiltration. Settling pond outflows can range from a controlled weir discharging into an open-channel to a lift station that pumps the melt water to a point of discharge. The design of the outflow should prevent sediment buildup and plugging of the discharge structure or pipe.

4.6 WATER QUALITY

Based on current regulations, no enforceable water quality is required leaving snow dump sites. However, municipalities should strive to meet the Saskatchewan Ministry of Environment's EPB 356 Surface Water Quality Objectives. The two most prevalent contaminants in melt water include suspended solids and chlorides. Unfortunately, chlorides are not readily treated by simple technologies, but may be passively controlled through detention and/or dilution. Technologies available for treating contaminants in the melt water could include:

1. **Settling pond:** The incorporation of a settling pond into a snow dump site that provides a 24 hour retention time will allow some of the suspended solids and other contaminants to settle prior to discharge. However, not all contaminants will settle and will therefore discharge into the environment. Inclusion of a sampling manhole that will allow water samples to be collected for testing is a recommended design inclusion for advanced systems.

2. **Wet pond:** Similar to a settling pond, the wet pond is significantly larger in size and designed with permanent, year-round vegetation to promote uptake of nutrients and to trap contaminants, particularly sediment. Wet ponds provide improved treatment compared to most cost-effective stormwater treatment processes but still provide minimal treatment of fine sediments and soluble pollutants such as chlorides. Wet ponds can be designed in multiple configurations but typically contain a forebay, dispersion and permanent pond area. Operation and maintenance of wet ponds would include periodic removal of sediments.
3. **Constructed wetland:** Similar to wet ponds, constructed wetlands designed for saline conditions are even larger in size due to their shallow depth and support an aquatic ecosystem that promotes contaminant degradation using chemical, physical and biological methods. Similar to wet ponds, constructed wetlands are among the most cost-effective treatment solution for stormwater runoff but also provide minimal treatment of fine sediments and chlorides. Constructed wetlands typically have less biodiversity compared to natural wetlands. Operation and maintenance of constructed wetlands often require sediment removal as well as plant removal to prevent the impact of biodegradation and release of nutrients into subsequent water sources.
4. **Oil/grit separators:** A series of chambers that melt water passes through to trap oil and coarse sediment prior to discharge. Manholes exist to provide entry for maintenance. Pollutant removal is enhanced by maximizing storage capacity of the chambers and regularly removing sediment and oil. Various designs of oil/grit separators exist with variable degrees of effectiveness and have been recommended for use as pre-treatment, spill control or in combination with multiple treatment processes.
5. **Secondary settling pond:** A secondary settling pond could be constructed adjacent to a primary settling pond and allow for additional settling time of contaminants, particularly suspended solids. A secondary settling pond would be of equivalent size to the primary settling pond and therefore require more land area and capital expense to construct and maintain. However, a secondary settling pond would improve operating capability by creating a bypass option for cleaning the primary settling pond if required during the melt season.
6. **Mechanical treatment:** Mechanical treatment processes such as reverse osmosis, electro-dialysis, distillation or freeze desalination could remove various constituents such as chlorides. Reverse osmosis and electro-dialysis are often used for potable water treatment and required significant capital, operation and maintenance costs. Therefore, mechanical treatment systems for treating snow dump melt water are likely unfeasible for the benefits derived.

5 Site Management Considerations

Management considerations encompass all social, economic and environmental concerns due to the ongoing operation of a snow dump site. Improved snow dump sites will have reduced adverse impacts due to improved siting, design and management. Key management considerations include operation and maintenance of the site, environmental monitoring to assess impacts and implementation of remediation efforts, if required.

5.1 OPERATION AND MAINTENANCE

Incorporation of operation and maintenance personnel input throughout the design phases of a snow dump site can significantly reduce future operation and maintenance challenges. Operation and maintenance considerations should be carefully compared against the above stated siting and design criteria as well as capital expenditure.

Key operation and maintenance issues should be incorporated into snow dump site management considerations. Depending on the design and siting considerations of the snow dump, the operation and maintenance philosophy will vary but could include the following:

5.1.1 Operation

1. Snow dumping should begin at the lowest elevated section of the pad.
2. Snow piles should be dumped in a southward alignment to capitalize on sunlight exposure and enhance melt time.
3. Compacted clay liners along the snow storage pad can become damaged during site operations with heavy machinery.
4. A secondary settling pond of equal size to the primary settling pond can be used in major storm events.
5. Secondary and primary settling ponds can be alternated from year to year.
6. Use of portable pumps to empty the settling ponds can increase time demand from operation personnel.
7. As the snow piles melt, the majority of debris and sediment should remain on the storage pad or within the primary settling pond.
8. Surface water runoff from the melt pile should flow unrestricted to the perimeter ditch and designated swales.
9. Scheduled monitoring should occur of the soil, groundwater and surface water for contaminants.

5.1.2 Maintenance

1. Damaged liners may require regular re-grading/compaction.
2. Hard surfaced storage pads (i.e. Roller Compacted Concrete, Asphalt Cement) can reduce erosion.
3. Vehicle access to the settling pond(s) is required to facilitate operation and maintenance.
4. A secondary settling pond of equal size to the primary settling pond can be used when the primary pond requires cleaning.
5. Increased slopes along the bottom of the settling pond(s) can enhance de-watering and removal of material.
6. A sump and pump in the lowest end of the settling pond(s) can facilitate general maintenance by pumping out standing water to enable the pond bottom to dry out.
7. A raised inlet on the discharge pipe within the settling pond will reduce plugging.

5.2 ENVIRONMENTAL MONITORING

Once the snow dump site has been designed, constructed and commissioned there is potential for contaminants such as salts, heavy metals and organics to accumulate in nearby surface water, groundwater and soil. Ideally, the design, operation and maintenance of the site will reduce the risk for any adverse impacts. Regular monitoring of environmental contaminant concentrations at sentry or boundary locations can also reduce the risk of adverse impacts to offsite property and local receptors and is an important component in managing a snow dump site. By conducting regular site assessments and implementing a monitoring program, problems can be detected early and through adaptive management, allow for operations to continue in an environmentally responsible manner.

5.2.1 Surface Water

Melt water from snow dump sites may contain increased contaminant loads that discharge into neighbouring water bodies such as drainage channels, wetlands, rivers and lakes. These water bodies may be vulnerable to potential contamination. Contamination of neighbouring water bodies is most likely to occur during the periods of “first melt’ and “end-melt”. During ‘first-melt”, soluble or dissolved contaminants (i.e. chlorides) in the melt water can concentrate and shock the receiving aquatic environments. The final “end-melt” period is generally associated with the movement of particulates and hydrophobic substances (e.g. metals, PAHs, and phosphorus) from the depleted snowpack (Oberts et al. 2000). Sampling and analyzing melt water at scheduled intervals and strategic locations throughout the melt season can identify patterns for contaminant loads. Treatment or mitigation measures can be developed based on analysis results, if required.

The additional volume of water and flow rates discharging from snow dump sites can also enhance erosion and cause sedimentation issues. Depending on the method of melt water discharge (e.g. weir, culvert, pump), flow rates can be monitored and adjusted to reduce the risk of downstream erosion or flooding.

5.2.2 Soil and Groundwater

Contaminants such as metals and salts may be transported with the melt water, accumulating in shallow soil and migrating outward over time, potentially impacting local aquifers. Soil characteristics such as pH, ion exchange capacity, conductivity, permeability and organic matter content as well as pH level of the melt water and environmental conditions such as bio-attenuation rates and the freeze-thaw cycle can influence the environmental fate and transport of the contaminants.

Sampling and analyzing groundwater and soil samples at scheduled intervals and strategic locations on an annual basis can identify patterns for contaminant loads and allow for the development of treatment or mitigation measures, if required.

5.3 ENVIRONMENTAL REMEDIATION

Environmental remediation is a management practice that ideally does not have to be implemented due to appropriate preventative measures being executed in the siting, design, construction and operation and maintenance of a snow dump site. However, for many Saskatchewan municipalities, remediation of their existing snow dump sites may be required due to contaminant accumulation and migration and/or potential changes in future regulations or land use plans.

Environmental remediation is site specific and requires detailed analysis by qualified professionals to determine the most appropriate course of action. The general process to proceed with environmental remediation includes conducting a screening for potential environmental contamination and then comparing the recorded contaminants against regulatory guidelines as well as current and future land use criteria. In Saskatchewan, environmental criteria are compared to the Canadian Environmental Quality Guidelines. Detailed analysis of contaminant delineation is critical and may require Phase I, II and III Environmental Site Assessments (ESA).

A Phase I ESA identifies areas of potential environmental concern (APECs) from operations of previous or current land use. A Phase II ESA is an intrusive investigation, involving the collection of soil and or water samples to quantitatively determine the concentrations of relevant potential contaminants of concern (PCOCs) at the identified APECs and evaluate them against established guidelines and criteria. If contamination is identified, a Phase III ESA, is completed to design a remediation program and confirm the success of the remediation works. Phase III ESAs may involve additional sampling, testing, and modelling; remedial feasibility studies; assessment of alternative cleanup methods, costs, and logistics; and, follow-up monitoring for residual contaminants.

5.3.1 Remediation Objectives

All of the data collection and analysis conducted during the environmental site assessments (Phase I/II/III ESA) are incorporated into the Remediation Management Strategy (RMS), which is ultimately based on the initial contaminant screening level and the detailed contaminated site assessment. The development of an RMS can incorporate two main approaches in defining the remediation objectives including:

1. Guideline/Criteria Approach.
2. Risk Assessment Approach.

5.3.1.1 Guideline/Criteria Approach

The guideline/criteria approach is designed to require fewer resources while providing a basis for protection according to established environmental quality guidelines or modified site-specific guidelines. The remediation objectives and plan should consider, at a minimum, the following factors:

1. Likelihood of achieving remediation objectives.
2. Practicality.
3. Safety.
4. Cost.
5. Simplicity.
6. Other technical and practical considerations.

The potential for residual contamination and long-term management and monitoring requirements is generally lower using this approach because remedial activities involve the reduction of contaminants in-situ via biodegradation, treatment or removal/excavation (followed by treatment at a licensed disposal facility).

5.3.1.2 Risk Assessment Approach

The risk assessment approach is used in instances where the guideline/criteria approach is not suitable for a site due to cost, logistical, environmental or safety considerations.

The risk assessment approach procedures are required to develop site-specific remediation objectives that correspond to an acceptable level of risk to human or ecological receptors. This usually involves a qualified environmental professional capable of conducting human and ecological risk assessments. This approach may be more time consuming, costly, complex and require a long-term monitoring plan to address residual contamination.

Risk management activities include in-situ isolation of ground water using underground concrete barriers or slurry walls, addition of amendments, site flushing, mobilization or immobilization of metals, thermal treatments, etc. The remediation technology used will depend on the contaminant(s) of concern, the complexity of the site and contamination and the final objectives.

Once the risk management measures have been implemented, confirmatory sampling of the remediated site should include the following in order to conclude that remediation or risk management objectives have been achieved:

1. Sampling of contaminated media (e.g. soils, sediment, water resources).
2. Comparison of sample results to objectives/criteria.
3. Final reporting to regulatory bodies.

5.3.2 Remediation Technologies and Site Management Strategies

Remediation technologies and site management strategies are selected on a case by case basis and depend on the extent and concentrations of the contaminant(s) of concern, the complexity of the site, and the long-term plans and objectives for the site. Remediation technologies and site management strategies can be considered based on soil or groundwater, and conventional or innovative technologies/strategies. While the technologies are described in terms of soil and groundwater, it is important to note that the remediation of soils is closely related to groundwater and *vice versa*, as most contaminants in the dissolved phase would be within the pore spaces of the soil matrix both above and below the groundwater table. Remediation technologies for soil may involve the movement or transfer of contaminants through soil pore water. Conventional technologies include those that have been adapted from general commercial uses in other industrial sectors, whereas, the term innovative refers to technologies that have been developed specifically for the site remediation industry and may not yet be recognized as a full-scale treatment technology. Although each technology is discussed separately, innovative remediation programs will often employ more than one technology to achieve the cleanup of a given site.

5.3.2.1 Conventional Technologies/Strategies (Soil)

1. **Excavation and Disposal**: For snow dump sites potentially impacted by inorganics and metals, the traditional strategy has been to excavate and remove the contaminated matrix (e.g. soil) followed by its subsequent treatment or disposal at an approved facility. For soil excavation, un-contaminated material would also have to be brought to the site to replace the original material. To prevent the build-up of contaminants in the soil, site management strategies may include periodic removal of the upper 5 cm to 10 cm of soil for disposal or treatment. These soils are removed before contaminant levels become too concentrated so that they do not exceed the regulatory criteria for material that can be readily disposed of in landfills. The cost of excavating and replacing the soil more frequently increases the operations cost but the potential for cost savings is significant if greater volumes of soil and groundwater contamination can be avoided.

   Advantages: Usually a rapid method of dealing with contaminated material and public acceptance is generally high.

Disadvantages: High costs associated with transporting or landfilling large volumes of material and regulatory acceptance can be low because treatment is preferred.

Cost: Approximately $70/tonne (municipal disposal) to $550/tonne (hazardous waste disposal).

2. **Incineration**: Incineration is a process where excavated materials are heated from 870°C to 1,200°C to volatilize and combust organic contaminants such as fuel hydrocarbons. The most widely used incinerators are the rotary kiln and the fluidized bed reactor. Effective for mostly fuel hydrocarbons and semi-volatiles.

   Advantages: Can be a permanent solution and applicable to a wide variety of contaminants media types.

   Disadvantages: Off-site incineration facilities must be available, soils with volatile metals and salts are difficult to treat, and public acceptance is low.

   Cost: Approximately $120/tonne to $1,175/tonne.

3. **Solid Phase Biological Treatment**: Involves a broad range of *ex-situ* biodegradation technologies such as soil piles, composting, and prepared treatment beds. The careful control of moisture, heat, nutrients, oxygen, pH, and tilling can enhance biodegradation in above-ground enclosures or treatment beds. Effective for mostly fuel hydrocarbons and not salts or metals.

   Advantages: Simple to implement, low capital, operations and maintenance costs, can be a permanent solution, and regulatory and public acceptance is generally high.

   Disadvantages: a large amount of space is required, remediation may take several months to years and atmospheric emissions may require treatment.

   Cost: Approximately $150/tonne including design, installation, and excavation.

4. **Solidification/Stabilization**: Contaminants are physically or chemically bound to the medium to produce a non-leachate material. Binding agents can include cement, lime, organic polymers, and silicates. Can be done

either *in-situ* or *ex-situ* at commercially available off-site facilities. Works well for inorganics and some metals.

Advantages: Most soils can be treated, relatively short time to complete cleanup, and low O&M costs.
Disadvantages: Immobilization of organics not assured, potential for interference with binding by organic compounds, results in increases in volumes of contaminated material by 50 to 100%, and high capital costs.

Cost: Approximately $70/tonne to $200/tonne.

5. **Surface Capping**: Surface capping utilizes an impermeable ground cover to isolate the contaminants from the surface and redirect surface water and percolation away from the contaminated soil. Surface caps can be made of synthetic membranes, soil-bentonite mixtures, asphalt, steel or concrete. This may be an option during the closure of a snow dump site as it is effective for all types of contaminants.

   Advantages: Easily installed, reduces exposure of public, and low O/M costs.

   Disadvantages: Long term liability, periodic maintenance and monitoring may be required, and groundwater controls may be needed.

   Cost: Depends on the material and size of the capping.

5.3.2.2 Conventional Technologies/Strategies (Groundwater)

1. **Free product recovery:** Pumping or passive collection methods (e.g. surface skimming) are used to remove un-dissolved liquid phase organics from the subsurface. This method is primarily used to remove pooled hydrocarbons and other light non-aqueous phase liquid hydrocarbons (LNAPLHs) from contaminated aquifers. Snow dump sites are unlikely to encounter such a scenario.

   Advantages: Low capital and O&M costs, can be a permanent solution, regulatory and public acceptance is high, and effective for contaminants that float on water.

   Disadvantages: Reuse or disposal of recovered free product is required, dissolved component still requires treatment, and pumping can cause problems of spreading the contaminant into areas not previously contaminated.

Cost: Approximately $1 to $2/1,000 L including design, installation, and O&M costs.

2. **Carbon Adsorption:** An *ex-situ* process that involves pumping contaminated groundwater through a series of activated carbon cells (may also use other effective sorbents). The carbon will absorb dissolved organics and inorganics from the groundwater. After treatment, the groundwater can be disposed or pumped back into the ground.

   Advantages: Can be a permanent solution, has low capital cost, and regulatory and public acceptance is high.

   Disadvantages: Carbon may require periodic regeneration or disposal, metals can clog the carbon, high O&M cost, and becomes expensive for groundwater with high contaminant concentrations.

   Cost: Approximately $3 to $4/1,000 L including design, installation, and O&M costs.

3. **Slurry Walls:** A vertically excavated trench is filled with bentonite-water slurry to form an impermeable subsurface barrier. Walls can be used to contain migrating contaminant plumes, and also to direct plumes to targeted extraction zones. Effective for all contaminants including hydrocarbons, metals, and salts.

   Advantages: A rapid method of dealing with migrating contaminants, simple to implement, and low O&M costs.

   Disadvantages: Complete containment is difficult in high groundwater, bentonite can be degraded if the plume contains acids, bases, or salts; regulatory and public acceptance is low and high capital costs.

   Cost: Approximately $1 to $2/1,000 L including design, installation, O&M costs.

5.3.2.3 Innovative Technologies/Strategies (Soil)

1. **Slurry Phase Biological Treatment**: This system usually consists of a series of large tanks or bioreactor vessels that contain a mixture of water, nutrients, and other additives, along with the excavated soils. The biodegradation process is carefully controlled within the vessel. Used to treat fuel hydrocarbons and semi-volatiles and not salts or metals.

Advantages: Treats a wide variety of soils including fine-grained material, treatment rates are better than other bioremediation methods, can be a permanent solution, and regulatory and public acceptance is generally high.

Disadvantages: High capital and O&M costs, limited by reactor size, and treatment and disposal of wastewater are necessary.

Cost: Approximately $80/tonne to $230/tonne including O&M costs.

2. **Soil Washing**: Remediates excavated soils by separating contaminants sorbed onto soil particles with an aqueous solution that may contain leaching agents, surfactants, chelating agents, or pH adjustment. Treated soils are returned to the excavation site or removed to an off-site landfill. This method is used to treat fuel hydrocarbons and inorganics.

   Advantages: Process is transportable to the site, can be a permanent solution, time to cleanup is short, and regulatory and public acceptance is high.

   Disadvantages: Silts and clays are difficult to remove from the washing fluid, optimization is difficult with complex contaminant mixtures, treatment and disposal of wastewater and sludge is necessary and high capital and O&M costs.

   Cost: Approximately $55/tonne to $165/tonne including O&M costs.

3. **Chemical Reduction/Oxidation**: Reducing/oxidizing agents are used to chemically convert toxic contaminants in excavated waste materials to less toxic compounds that more stable, less mobile (e.g. precipitation), and inert. Commonly used reducing/oxidizing agents are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. Treatment is mostly effective for inorganics and metals and less effective for hydrocarbons.

   Advantages: Time to complete cleanup is short, and low capital and O&M costs.

   Disadvantages: Incomplete oxidation may occur, and not effective for high contaminant concentrations.

   Cost: Approximately $150/tonne to $450/tonne including design, installation, excavation, and O&M costs.

4. **Thermal Desorption**: Excavated materials are heated to 95°C to 540°C to volatilize water and organic contaminants, but prevent oxidation. Volatiles in atmospheric gas are then commonly removed using carbon adsorption filters. Effective for treating fuel hydrocarbons and other volatiles.

   Advantages: Separates a wide range of organics, process is transportable to the site, and can be a permanent solution.

   Disadvantages: Excessive particulate and volatile air emissions can occur, high moisture soils are difficult to treat, and high capital and operating costs.

   Cost: Approximately $150/tonne to $450/tonne including design, installation, excavation, and O&M costs.

5. **Vitrification**: Vitrification is a process where excavated contaminated soils and sludges are melted at high temperatures to form a vitreous slag with very low leaching characteristics. Non-volatile inorganics are encapsulated in the slag, rendering them immobile.

   Advantages: Vitrified material is highly resistant to leaching and is stronger than concrete and the immobilization of inorganics is permanent.

   Disadvantages: Off-gases need to be controlled, disposal of slag is required, accessibility to sufficient power supply is required, high capital and O&M costs, and regulatory and public acceptance is low.

   Cost: Approximately $770/tonne including design, installation, excavation, and O&M costs.

6. ***In-Situ* Biodegradation**: Biodegradation involves stimulating naturally occurring microbes to convert contaminants into less toxic compounds such as carbon dioxide and water. Nutrients and oxygen can be added to enhance biodegradation. This treatment method is effective for semi-volatiles and fuel hydrocarbons.

   Advantages: Minimal site disturbance, low capital cost, can be a permanent solution, and public acceptance is high.

   Disadvantages: Contaminant mobility may increase due to microbe enhancement, not effective in sites with clay, bedrock sub-surfaces, high concentrations of salts, metals, and chlorinated organics, regulatory acceptance is low, remediation may take several months to years, and not cost effective for small volumes.

Cost: Approximately $150/tonne to $450/tonne including design, installation, and O&M costs.

7. **Bioventing**: Bioventing is a form of biodegradation in which oxygen in the form of air is supplied to the contaminated un-saturated soils using a series of injection and extraction wells. Low air flow rates are used to provide just enough oxygen to enhance biodegradation of semi-volatiles and fuel hydrocarbons.

   Advantages: Better oxygen delivery to less permeable formations, minimal site disturbance, low capital and O&M costs, can be a permanent solution, regulatory and public acceptance is moderate, and no off-gas treatment is required if it is a closed system.

   Disadvantages: Not recommended where water table is close to the surface, monitoring of off-gases may be required, and remediation may take several months to years.

   Cost: Approximately $30/cu. meter including O&M costs.

8. **Soil Vapour Extraction**: Induces air flow through un-saturated soils to remove volatilized contaminants. Air flow is supplied by applying a vacuum to the soil via a network of extraction wells. This technology is applicable to volatile compounds with a high vapour pressure such as fuel hydrocarbons and requires a system for handling off-gases. Volatilization may be enhanced by heating the subsurface with injected steam or applied electrical currents.

   Advantages: Minimal site disturbance, low capital costs, can be a permanent solution, and regulatory and public acceptance is high when off-gas is treated.

   Disadvantages: Volatilization is inhibited by humic content of soil, suited for relatively permeable and homogeneous soils, residual liquid from treated air requires disposal, thermal enhancement may be detrimental to subsurface microbes required for biodegradation, high O&M costs, and remediation may take years.

   Cost: Approximately $25,000 to $50,000 for design and installation, and approximately $75/tonne including O&M costs.

9. **Phyto-Extraction**: Phyto-extraction or phyto-remediation is an emerging technique that exploits the property of some plants to absorb large amounts of heavy metals for storage in their roots and shoots. This involves selecting and/or cultivating plants that are suited to the local soil and climate conditions. Plants can accumulate metals up to 1000 times greater than would normal species. Their shoots may be harvested and subsequently treated as waste, although the majority of the remediation occurs within the root zone. Works well for inorganics (i.e. salts and metals).

   Advantages: Low capital and O&M costs, and can treat large areas of contaminated soil.

   Disadvantages: Long time periods are required, not yet recognized as a full-scale treatment technology, treatment only extends to the depth of the roots, not effective for highly contaminated soils, and plants must be removed and properly disposed of after treatment.

   Cost: Depends on the area, plant species, and planting density.

10. **Electrokinesis**: Electrokinetic *in-situ* remediation is an emerging technology that has been successfully used to treat salt and metals contamination in soils. It is a process in which a low voltage, direct current electric field is applied across a section of contaminated soil in order to move and extract contaminants. The resulting electrokinetic phenomena displace ions and water soluble pollutants, disturbing the equilibrium between the solid and liquid phase components of the formation. Contaminants become localized close to the electrodes and the amount of soil volume that needs to be excavated is reduced.

    Advantages: Increases mobilization of inorganics, reduces the volume required for excavation or treatment, no site disturbance, can be a permanent solution.

    Disadvantages: Contaminant mobility may increase, contaminant concentrations increase in localized areas, high capital and O&M costs, not yet recognized as a full-scale treatment, and requires subsequent excavation or treatment of localized contaminated media.

    Cost: Not available.

5.3.2.4 Innovative Technologies/Strategies (Groundwater)

1. **Oxygen Enhanced Biodegradation**: Oxygen enhanced biodegradation of groundwater involves pumping air, ozone, hydrogen peroxide, or other oxygen sources through injection wells to enhance aerobic degradation of organic contaminants such as fuel hydocarbons.

   Advantages: Can be a permanent solution, low capital costs, regulatory and public acceptance is moderate.

   Disadvantages: Not effective in low permeability heterogeneous soils, high iron content can reduce hydrogen peroxide concentrations, and high O&M costs.

   Cost: Approximately $1 to $2/1,000 L including design, installation, and O&M costs.

2. **Passive Treatment Walls**: A permeable treatment wall is installed in front of a migrating contaminant plume, allowing the plume to passively move through the wall. The contaminants degrade by interaction with a catalyst contained in the porous media of the wall. Effective for inorganics.

   Advantages: Effective for treating chlorinated hydrocarbons and low O&M costs.

   Disadvantages: Applicable only to shallow aquifers with established flow direction, reactive media of the wall must be replaced on a regular basis, and high capital costs.

   Cost: Not available.

3. **Air Sparging**: Air is injected into the groundwater through a network of injection wells creating a subsurface air stripping system that separates contaminants from the groundwater trough volatilization. Air sparging must operate in unison with a soil vapour extraction system to capture volatiles.

   Advantages: Low capital and O&M costs, can be a permanent solution, and regulatory and public acceptance is high.

   Disadvantages: Channeling of air flow can occur in layered or fractured terrain adversely affecting performance, and not effective in low permeable soils.

Cost: Approximately $1 to $2/1,000 L including design, installation, and O&M costs.

4. **Bioreactors**: Contaminated groundwater is extracted and treated with microbes *ex-situ* in bioreactors. The biological systems in bioreactors can be suspended (i.e. suspended particles in activated sludge promote microbial growth and aerobic degradation) or attached (i.e. degradation occurs on an inert support matrix such as trickling filters). Used to treat fuel hydrocarbons.

   Advantages: Can be a permanent solution, low O&M costs, and regulatory and public acceptance is high.

   Disadvantages: Metals may need to be removed prior to treatment, precipitation of inorganics may clog treatment system, and solid residuals that settle out may require treatment and disposal.

   Cost: Approximately $1 to $2/1,000 L including design, installation, extraction, and O&M costs.

5. **UV Oxidation**: UV oxidation is an ex-situ process where contaminated groundwater is exposed to ultraviolet radiation to destroy organic contaminants such as hydrocarbons. Ozone or hydrogen peroxide is commonly used to enhance the oxidation and destruction of the contaminant. Off-gases are treated by an ozone destruction unit.

   Advantages: No residual produced, and low O&M costs.

   Disadvantages: Inorganics and naturally occurring soil organics can adversely affect system performance, and high capital costs.

   Cost: Approximately $1 to $4/1,000 L including design, installation, extraction, and O&M costs.

6 Conclusion

Snow dump management practices vary significantly among Saskatchewan municipalities. Currently, no guidelines exist that explicitly regulate snow dump siting, design or management practices. However, various federal, provincial or municipal regulations can be extrinsically linked and incorporated into design or management considerations. Development and enforcement of regulations is not currently planned but future regulations may be imposed since snow dumping practices can have a significant impact on soil and water quality if left unmanaged.

The development of these 'Snow Dump Management Guidelines' are intended to leverage existing knowledge and experience to provide Saskatchewan municipalities with a reference in developing improved snow dump sites and in reclaiming land previously used as a snow dump site. Adopting improved snow dump siting, design and management practices can mitigate potentially adverse environmental, social and economic impacts.

Key site selection considerations include review of existing land use (e.g. agricultural, recreational, environmentally sensitive areas, etc.) and surrounding land use (e.g. proximity to landfills, housing, water bodies, etc.). Key site design considerations include review of the proposed site's capacity, soil characteristics, grading, access and potential melt water treatment solutions such as settling ponds, wet ponds, constructed wetlands and oil/grit separators. Key management considerations include operations, maintenance, environmental monitoring and environmental remediation, if required. If an existing snow dump site requires remediation, site specific conditions will dictate the remediation process. Typically, this process would involve a Phase I/II Environmental Site Assessment (ESA) and may require Phase III ESA works if contamination is noted. Selection of remediation technologies is dependent on the matrix to be remediated (i.e. soil or groundwater), the nature and extent of the contamination as well as cost and logistic considerations.

7 Recommendations

These 'Snow Dump Management Guidelines' have been developed based on industry best practice with input from various municipalities and government organizations. Depending on a municipality's motivation towards improving an existing or developing a new snow dump site, the following options are available to adopt the most applicable best management practices including:

1. Identify your municipality's existing snow dump management practices relative to the best practice siting, design and management considerations stated within this report.
2. Identify and implement mitigative measures to reduce your snow dump's social, environmental and economic impacts relative to the siting, design, treatment and management considerations.
3. Consult experienced and qualified professionals (i.e. Professional Engineers and Environmental Scientists) if assistance is required to identify and implement potential improvements relative to existing and future regulation changes.

Bibliography

1. Alberta Ministry of Environment, Environmental Protection. 1994. *Snow Disposal Guidelines for the Province of Alberta.*

2. Associated Engineering Ltd. 2012. *Development Scenarios and Capital Planning Recommendations.* Prepared for City of Yorkton.

3. Associated Engineering Ltd. 2004. *Desalination Process Options.* Prepared for City of Edmonton.

4. Associated Engineering Ltd. 2011. *Northeast Snow Storage Facilities Development – Preliminary Design.* Prepared for City of Edmonton.

5. Associated Engineering Ltd. 2006. *SW Snow Storage Facility Site Assessment & Preliminary Design.* Prepared for City of Edmonton.

6. MacViro & Ecoplans Consultants. 2004. *Snow Disposal Sites Conceptual Designs Part A – Snow Meltwater Characteristics and Treatment Technologies.* Prepared for City of Toronto.

7. Saskatchewan Ministry of Environment, Environmental Protection Branch. 2006. *Stormwater Guidelines EPB 322.*

8. Environment Canada, Environmental Protection Branch. Tabs #23 on Contaminated Sites: *Ex-Situ Remediation Technologies For Contaminated Sites*.

9. Environment Canada, Environmental Protection Branch. Tabs #24 on Contaminated Sites: *Remediation Technologies For Groundwater Contamination.*

10. Environment Canada, Environmental Protection Branch. Tabs #22 on Contaminated Sites: *In-Situ Remediation Technologies For Contaminated Sites.*

A Appendix A – Snow Disposal Guidelines for the Province of Alberta

SNOW DISPOSAL GUIDELINES FOR THE PROVINCE OF ALBERTA

Air & Water Approvals Division
Alberta Environmental Protection
February 1994

Pub. No: T/559
ISBN: 0-7785-1380-7 (Printed Edition)
ISBN: 0-7785-1381-5 (On-line Edition)
Web Site: http://www.gov.ab.ca/env/

Any comments, questions, or suggestions regarding the content of this document may be directed to:

Environmental Sciences Division
Alberta Environment
4th Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-5883
Fax: (780) 422-4192

Additional copies of this document may be obtained by contacting:

Information Centre
Alberta Environment
Main Floor, Great West Life Building
9920 – 108th Street
Edmonton, Alberta T5K 2M4
Phone: (780) 944-0313
Fax: (780) 427-4407
Email: env.infocent@gov.ab.ca

A. INTRODUCTION AND BACKGROUND

Snow falling onto municipal roads and highways, may become mixed with contaminants such as suspended solids, organic chemicals, phosphates, dissolved salts, heavy metals, trash, and oil. These substances are not normally characteristic of freshly fallen snow, they are a result of urbanization, industrialization and of the related activities of people. The collection and removal of snow may pose a risk to the environment if it is disposed of improperly.

Alberta Environmental Protection strongly discourages the direct dumping of waste snow into watercourses, or onto ice-covered water bodies as this may introduce contaminants to the water bodies and produces unsightly conditions. The preferred locations are inland sites. Such sites should be selected and designed to maximize treatment, minimize safety hazards and control the rate and location of snow melt discharges.

These guidelines are intended to assist urban centres and municipalities to develop methods of waste snow disposal that minimize the potential for negative environmental impacts.

B. SITING GUIDELINES FOR SNOW DISPOSAL SITES

The location of snow disposal sites, especially permanent sites, must be well planned in order to minimize environmental impacts and other impacts such as noise. Disposal sites must be large enough to accept the projected amount of snow that may be deposited during any one year. They should be close enough to the serviced area to minimize hauling costs, yet not be a nuisance to surrounding land users.

The following points should be considered when selecting a snow disposal site:

1. LANDFILLS

It is not advisable to dispose of snow in or adjacent to landfills. The snowmelt may increase the generation rate of landfill leachate. Leachate is any liquid that has passed through or emerged from waste material and contains soluble, suspended, or miscible materials removed from such wastes. It poses a threat to groundwater and its collection, treatment and disposal can be involved and expensive.

2. AGRICULTURAL LAND

It is not advisable to place sites on prime agricultural land. The metals, hydrocarbon residues, salts, and sand usually found in waste snow can pollute and devalue such property, unless rigorous site selection and management criteria are practised.

3. GROUND WATER

The location, depth and nature of any groundwater aquifers in the area of a proposed snow disposal site should be carefully evaluated. It is not advisable to choose sites above a groundwater aquifer with a high water table or that is used as a potable water supply source. Pollutants, particularly chlorides, may percolate down into the groundwater and adversely affect the quality of water in the underlying aquifer. A hydrogeological study may be necessary to determine the appropriateness of the site for snow disposal.

4. UTILITIES

It is not advisable to locate snow disposal sites on lands with below ground or above ground utilities. Electrical transmission right-of-ways should be avoided unless strict restrictions are placed on the height of the waste snow piles. Snow disposal over underground utilities can create significant repair and/or maintenance problems. The generally high chloride content of waste snow may also accelerate the corrosion and deterioration of above or below ground concrete and steel structures.

5. NOISE

To mitigate the impact of noise, sites should be located a minimum of 350 metres from existing or planned residential housing. An objectionable noise level can be produced by snow hauling and dumping operations, particularly as they are commonly undertaken at night. A dumpsite and associated road access should, therefore, not be in a location where noise of the operation will be a nuisance to nearby residents. Sites in hollows or other locations where natural or artificial barriers will baffle sound are preferred. In some cases, the snow pile itself can be situated in such a way as to create a sound barrier.

6. DRAINAGE

Snow disposal sites should be located in areas with sufficient storage capacity or with adequate drainage to prevent flooding of adjacent lands. Snow deposited at the site should be placed in such a manner that existing drainage patterns are not obstructed. For disposal sites located within urban drainage areas, it is preferable to prevent meltwater from entering combined storm/sanitary sewer systems where surcharging may result in raw sewage bypasses and overflows.

7. SITE EXPOSURE

Snow disposal sites should be located to maximize exposure to the sun, particularly the afternoon sun. This will ensure a relatively rapid melt. Melting waste snow is somewhat unsightly in appearance and therefore the faster it melts the less of an eyesore it will be. A faster melt period will also permit the ground to dry much quicker.

8. RECREATION

Snow disposal sites should not be used as, or located in, recreational areas for small children, because of their propensity to play in the dirt and then put their fingers in their mouths. From an overall quality standpoint, snowmelt water may also not be suitable for use in a recreational water body.

9. WATERBODY SET BACK

A minimum setback distance of 200 metres from any water body is required, sites with gradients greater than 15 degrees will require greater setback distances.

C. DESIGN GUIDELINES FOR SNOW DISPOSAL SITES

A selected snow disposal site needs to be engineered to minimize environmental impacts. The specific environmental protection measures required will depend on the possible risk and impacts associated with each individual site.

The following are impact mitigation measures that may be required at a snow disposal site:

1. CONTAINMENT

Containment structures such as earthen berms and compacted subgrades may be necessary. These types of structures can be used to direct meltwater and surface runoff to settling ponds and to minimize the possible seepage of contaminants into groundwater. Berms also provide for noise attenuation from snow disposal activities and improve aesthetics particularly for adjacent land users. Berm erosion protection may be necessary. Landscaping vegetation around berms or adjacent to the snowmelt area should be salt tolerant as snowmelt water may be high in salts.

2. SETTLING PONDS

Constructed settling ponds may be necessary to reduce suspended particulate loadings in meltwater thereby minimizing impact to downstream receiving facilities (e.g. sewage treatment plants) or downstream surface waters. Ponds should be sized relative to anticipated snow meltwater volumes. Ponds and trench construction should provide retention times of at least four days (total) for suspended particulate settlement. Settling ponds may have to be lined depending on local soil and groundwater conditions.

3. GRADING

Snow disposal sites should be graded so as to minimize snowmelt runoff percolation to groundwater. The sites should be graded so that runoff from outlying areas does not enter the site.

4. RELEASE OF MELTWATER

Meltwater discharge structures may be required to allow for control of off-site discharge of meltwater to receiving facilities and downstream surface waters. Such control allows for meltwater release during periods of optimum dilution and/or control of releases during storm events. A suitable flow control system (e.g. weir or flume) should be installed at the outlet of all settling ponds.

5. SITE BASE

Soils under snow piles should be relatively impermeable and an appropriate thickness of compacted inorganic clay may be required. Where native clay is not available, site surfaces can be underlain with waterproof membrane materials, asphalt, imported clay or any other similar material.

6. SECURITY

Security fencing and lighting should be provided to limit unrestricted and unauthorized access. Security protects against dumping which is unrelated to snow disposal and reduces the risk of accidental injury to the general public, particularly children.

D. <u>GENERAL</u>

1. SNOW REMOVAL

Snow from heavily travelled roads should be removed as quickly as possible following a storm. The level of contaminants found in snow tends to increase with traffic flow, and with the length of time that the snow remains on the road. Quickly removing snow will minimize the time that the waste snow has to accumulate such contaminants.

2. PERMANENT SITES

It is preferable to have permanent sites zoned solely for snow disposal. Permanent sites can be engineered to minimize environmental impacts and may also be less costly in the long run than having a number of temporary sites not specifically designed for the purpose of snow disposal.

3. SOLID WASTE DISPOSAL

Waste snow tends to accumulate various solid materials. To avoid turning the snow disposal site into a landfill, these solid wastes should be disposed of, as soon as is practicable, to an approved landfill.

B Appendix B - Description of Environmental Site Assessment (Phase I, II, III) Relative to Snow Dumps

Appendix B
Description of Environmental Site Assessments (Phase I, II, III) Relative to Snow Dumps

Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) identifies areas of potential environmental concern from operation of previous or current land use. Phase I ESAs provide the basis for evaluating the need for additional assessments or site remedial measures. A Phase I ESA interprets this risk from information such as: site history (aerial photographs, property-use records, land titles, etc.); operations; potential contaminants of concern; materials and processes used on site; legislation and published guidelines that apply to the site; previous environmental monitoring data; topographic information; geological and geotechnical reports; utility records; other relevant reports and studies; as well as information from interviews with persons knowledgeable of the site and from observations of the site. During this phase, sample collection, laboratory testing, or intrusive investigations are not included.

Phase II Environmental Site Assessment

Phase II ESAs use the information obtained in the Phase I ESA to establish site-specific requirements and an appropriate scope for the Phase II ESA investigation. This systematic process is used to characterize the concentrations of potential contaminants of concern (PCOC), which in the case of snow dump sites would be related to chemical characteristics of contaminants in the collected snow. The concentrations of these PCOCs are measured by an accredited laboratory and then compared to established guidelines and criteria. A Phase II ESA may provide a preliminary basis for evaluating the need for site remedial measures (Phase III ESA) or additional Phase II ESA delineation, as required.

The origin, quantity, and quality of stored snow piles will govern the nature of the substances of concern present at the site. The extent of potential environmental impacts is related to site-specific conditions such as geology, infiltration rates, site grading and topography, and the presence of existing management strategies (e.g. constructed or natural melt water settling ponds). Snow received at the snow dump site is reflective of the substances that are applied to parking lots or municipal streets such as de-icing or anti-slipping agents (e.g. salts, brines, alcohols, glycols, sand/gravel, etc.) as well as discharges from general automobile wear and tear including fluid leaks. In Saskatchewan, typical substances of concern for snow dump sites can be classified into four groups: salts (e.g. sodium magnesium and calcium chloride); heavy metals (e.g. chromium, aluminium, lead, iron, nickel, etc.); petroleum hydrocarbons (e.g. oil and grease, total petroleum hydrocarbons/BTEX); and total suspended solids (TSS). Soluble inorganics may infiltrate the subsurface and reach the groundwater reservoirs or become transferred to nearby surface waters. Metals and organics tend to accumulate in the upper 5 cm to 10 cm of shallow soil depending on its composition (e.g. organic carbon content, clays, and silts). Total suspended solids and some organics can also transfer to nearby surface water bodies through surface flow or groundwater migration. Additionally, melt water with higher levels of TSS can transport heavy metals associated with particulate matter into the surrounding surface water bodies.

Knowledge of potential contaminant fate and transport processes and local site conditions will determine the appropriate level of sampling and monitoring effort required. For existing snow dump sites that are suspected of having contamination, initial sampling effort should be focused on determining contaminant concentrations in localized “hot spots” as a worst-case scenario. An understanding of the physical characteristics, geology, and snow dump management strategies should be considered when designing an initial sampling plan.

If the snow dump site is graded and contains natural pools or ponding of surface water, samples for water analysis should be collected from these locations. Similarly, water samples should be collected from constructed settling ponds. Water sample analysis should be focused on the concentration of dissolved salts, metals, petroleum hydrocarbons, and TSS. If the geological conditions or design of the snow dump site is intended to allow for infiltration of melt water, soil sampling may be conducted in a grid-like pattern to obtain a good representation of the site. Sampling methods may include test-pitting and bore-holes and sample analysis should be focused on measuring concentrations of heavy metals, petroleum hydrocarbons, soil conductivity, and sodium absorption ratio (SAR). The SAR provides a good indication of the soil’s assimilation capacity. Installation of ground water monitoring wells may also be used to determine ground water impacts if shallow aquifers are present beneath the site. Mobile dissolved contaminants have the potential to infiltrate the soil and enter groundwater reservoirs, especially if the assimilation capacity of the soils is exceeded.

Phase III Environmental Site Assessment

A Phase III ESA, usually referred to as confirmation of remediation, is based on the information gathered in Phase I and Phase II ESAs. Phase III ESAs may include additional sampling, testing, and modelling; costing, and logistics; and, follow-up monitoring for residual contaminants.