Landfill Operator Certification
Study Guide

Alberta Government

Landfill Operator Certification Study Guide

For copies of this study guide, contact:

Information Centre
Alberta Environment and Parks
Phone: 780-310-ESRD
Email: ESRD.Info-Centre@gov.ab.ca
Website: http://aep.alberta.ca

ISBN: 978-1-4601-3033-9 (PDF online)
Published: September 2016

TABLE OF CONTENTS

Acknowledgements

Alberta Environment and Parks prepared this Study Guide for Landfill Operators in Alberta to help them prepare for the Landfill Operator Certification Exam, help them work safely and protect the environment.

A special thanks to SWANA Northern Lights Chapter (NLC) for developing this Study Guide.

Although many SWANA NLC Directors and volunteers are involved in SWANA's many education programs, this Study Guide was made possible by:

Lead Author: Jim Lapp, A.Sc.T., S.C.
Lead Reviewer: Bud Latta, P.Eng.
Project Manager: Sheri Praski, P.Eng.
Designed By: Territorial.ca

Content Contributers:
John Deagle, S.C.
Steve Johnson, S.C., M.Eng., P.Eng.
Michel Lefebvre, M.Sc., P.Eng.
Tom Moore, S.C.
Tammi Nygaard, S.C.
Sheila Reithmayer
Roland Rusnell, A.Sc.T., S.C.

Glossary of Terms

The definitions of terms provided in this section are not necessarily the 'dictionary' definitions but are in the context of the subject matter.

Aerobic refers to any situation or process where oxygen is present. In the context of waste management, the term is frequently used to describe the process of composting, which REQUIRES that oxygen be present.

Anaerobic refers to any situation or process where oxygen is not present. Anaerobic digestion of organic waste is a process that REQUIRES that oxygen not be present.

Aquifer means an underground water-bearing formation that is capable of yielding water, as through a water well.

Atmospheric pressure is the pressure exerted by the weight of air. The atmospheric pressure at mean sea level is called one 'standard atmosphere' and is defined as 14.7 pounds per square inch, or the pressure exerted by a column of mercury 760mm high.

Biological conversion, for the purposes of this guide, means the process of converting waste into a different material through biological processes such as composting and anaerobic digestion.

Biomedical waste is waste that may be infectious and often comes from hospitals or laboratories. Some examples include blood, human tissue, needles and bandages.

Biosolids are the organic sludges produced when sewage or other organic wastes are biologically 'digested' in an anaerobic process as part of the sewage treatment process. Biosolids are sometimes thickened and then composted as a means of recycling them into a useful soil amendment.

Borehole means a hole drilled into the earth to explore by observing and sampling the materials brought up by the drill and establish the hydrogeological setting and engineering characteristics of the formations below. Water sampling pipes are often installed as well, both to sample the water in the future and to measure the depth to the water level.

Chlorides are salt compounds containing chlorine. Chlorides are in most waste waters, including landfill leachate, and are highly mobile in water, making them a common indicator tested for to determine is leachate contamination has occurred.

Combusted means burned by fire so as to reduce the material to inert ash.

Contravention is an act that involves breaking (contravening) a law, regulation or requirement.

Emanating means to 'come out of'. Landfill gases emanate from a landfill.

Emissions generally refers to air pollutants such as gases from burning, from car tailpipes, and from landfills as landfill gas.

Flashpoint is the lowest temperature at which the vapour at the surface of a solid or liquid will ignite when exposed to spark or flame. It is used as a measure of flammability and risk associated with wastes; particularly wastes contaminated with hydrocarbons or other volatile chemicals.

Friable materials are capable of being easily crumbled when processed or handled. Asbestos that is friable must be handled in particular ways to prevent fibres from escaping.

Gasification is a thermo-chemical process in which organic material, including waste, is partially combusted in a high pressure chamber with limited oxygen. The material which does not combust is converted to synthetic

gas, tars, and ash-like char. In the waste management industry, the syngas is typically used as fuel for power generation or heat, so gasification of waste is considered a form of waste-to-energy.

Geological formations for the purposes of landfill discussions, refers to the types and thicknesses of soils and rock that are in an area.

Geology is the study of the earth, the materials of which it is made (soils, rock), the structure of those materials, and the historical processes (volcanic activity, sedimentation, etc.) that influenced their formation.

Geotechnical as in geotechnical investigation, is the exploration of soils and geological formations beneath the surface, generally undertaken by drilling boreholes and analyzing material samples.

Greenhouse gases are gases that trap heat in the atmosphere and are generally believed to contribute to climate change. There are many different gases that behave as greenhouse gases. The most common one is carbon dioxide, but methane is a stronger greenhouse gas that is produced by materials breaking down in landfills.

Groundwater is water that is below the earth's surface, generally in the pore spaces of soils and bedrock.

Hydrocarbons are organic compounds that contains hydrogen and carbon; generally a petroleum product such as gas or oil.

Hydrogeology is the study of the relationship between water and geology with particular emphasis on the movement and chemistry of water.

Infiltration is the process by which liquid passes through soils or porous materials. In landfills, infiltration generally refers to the passage of precipitation, surface water or groundwater into a landfill cell.

Leachate is a liquid that has percolated through or drained from solid waste, often containing suspended or dissolved waste materials.

Leachate manhole means a manhole, similar to those used in sewer systems, constructed as part of a landfill leachate collection system that provides access to the leachate pipe systems. They are used for inspection, sampling and sometimes as a sump for leachate removal.

Mercaptan is a pungent-smelling gas which has the odour of rotting cabbages or smelly socks. Even low concentrations contribute to the smell of decaying garbage and landfill gas. It is flammable and toxic at high concentrations, but is found only at low levels in landfill gas. It is the odour that is the greatest issue in landfill operations.

Micro turbines are small low-power versions of traditional gas turbines used in large power plants. They have been installed at landfills to produce electricity using landfill gas.

Placarding in waste management, refers to the affixing of a special sign to a truck, box, drum or other container that identifies a hazardous waste within it. There exists a uniform set of symbols and sign standards used globally.

Putrescible waste is waste that has organics and liquid in it that can readily decompose, creating nuisances like odours and insect infestations as well as produce liquid and gas emissions.

Pyrolysis is a process where organic material, which may be waste, is heated in a chamber in the absence of oxygen which results in its conversion into synthetic gas, oils, and a charcoal-like solid residual. The gas and oils can be used as an energy source, so in the waste management industry pyrolysis is generally considered a form of waste-to-energy. The solid is sometimes refined into a soil amending product called "bio-char".

Reciprocating engine is a conventional piston engine, as powers most cars. Reciprocating engines are often powered to landfill gas to produce electricity.

Remediation means to correct an undesirable situation. In waste management, land or water that has been contaminated by waste or chemicals from the waste, as from leachate, is sometimes remediated through processes that can range from removal and disposal of the contaminated soil or water to chemical or biological treatment processes that transform the contaminants into benign forms.

Scrapie is a fatal disease that affects sheep and goats and is believed to be related to 'mad cow' disease.

Surface water is water that is on the surface of the earth, as opposed to groundwater, which is below; generally refers to rivers, lakes, streams, ponds and wetlands.

Syngas or synthetic gas, is a fuel gas produced by conversion of organic materials through processes like pyrolysis and gasification. Syngas is composed of hydrogen and carbon monoxide.

Topography is the form of a land surface. A topographic map is a detailed map of the surface features of land. It includes the mountains, hills, creeks, and other bumps and lumps on a particular part of the earth.

Vectors in the context of the landfill business, refers to 'disease vectors' such as birds, mice, rats, and insects, that can spread diseases.

Introduction

In Alberta, the key landfill operating personnel at a site are required to have a Landfill Operator Certificate. To be eligible, the operators must pass a certification exam and have at least one year of experience. This document is a study guide for individuals planning to obtain an Alberta Landfill Operator Certificate.

The Alberta Landfill and Composting Facility Operator Certification Program was established to verify that landfill facility operators have the knowledge needed to:

- Protect the environment
- Protect public health and provide for public safety
- Achieve regulatory compliance
- Efficiently operate their facilities
- Protect employee safety and well-being
- Meet waste reduction and resource conservation objectives
- Follow the waste management hierarchy of reduce, reuse, recycle, and recover

Figure I-1 provides an overview of the structure of the program and the steps involved in obtaining and maintaining an Operator Certificate. This study guide addresses only certification of landfill operators; composting facility operator certification, while part of the same program, is not covered. The landfill operator certification program is currently administered by the Northern Lights Chapter of the Solid Waste Association of North America. Compost operator certification is administered by the Compost Council of Canada.

To meet program goals, it is important that the operator understands applicable provincial and federal regulations, principles of landfill operations, Alberta Environment and Parks (AEP) approvals process, landfill design concepts, and principles of safe operations.

An operator preparing to challenge the Landfill Operator Certification exam will find value in this manual, classroom courses, and on-the-job training.

As indicated in the program overview diagram in Figure I-1, in order to maintain certification, operators must continue to learn about landfills, compost facilities and the environment. This ongoing education is called ‘Continuing Education Units’ or ‘CEUs.’ The Continuing Education Unit Policy is available on AEP’s website. It includes a list of currently recognized training courses.

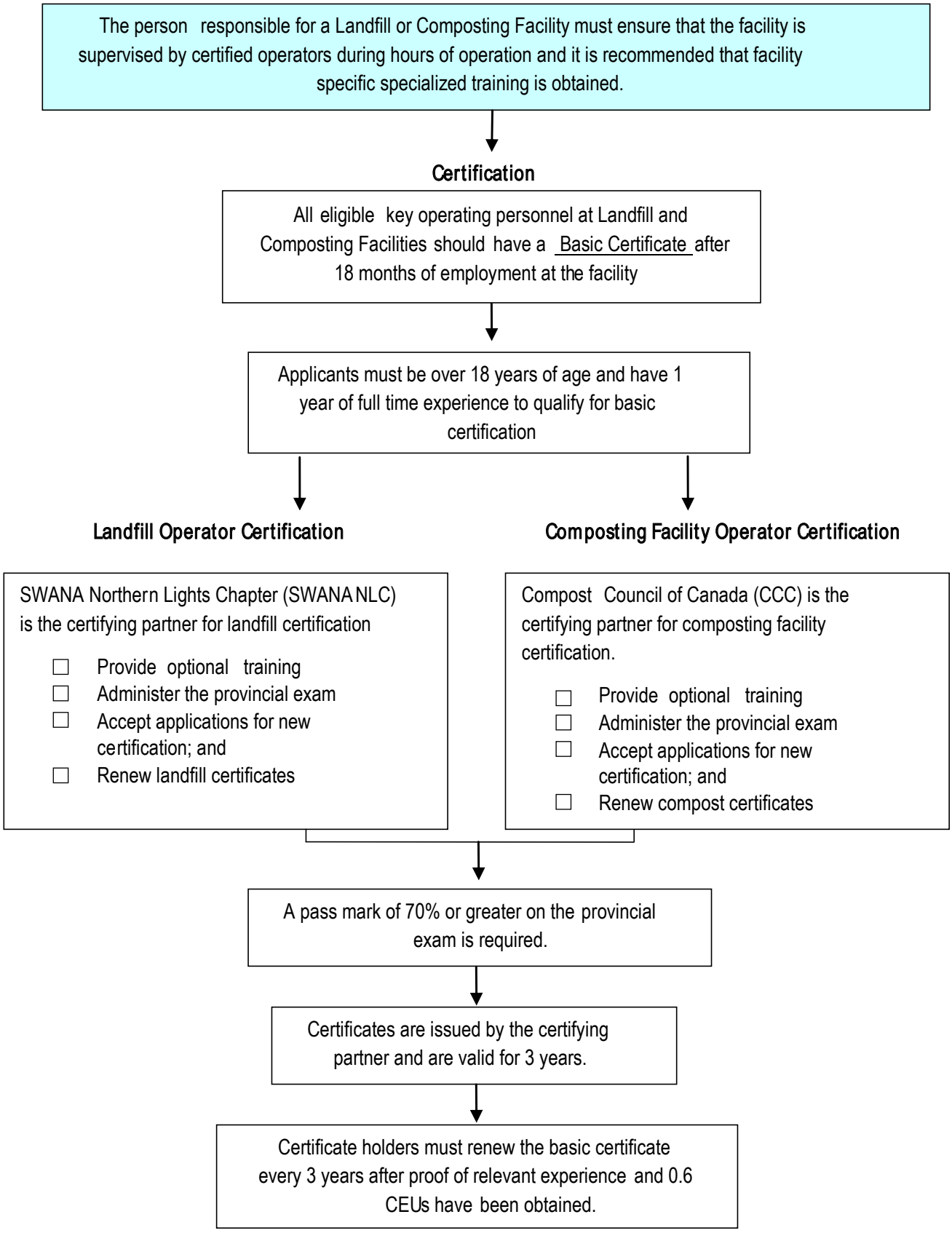


Figure I.1 Overview of the Alberta Landfill and Composting Facility Certification Program

01 Chapter

Landfill and Integrated Solid Waste Management

Landfills and Integrated Solid Waste Management

It is important for landfill operators to understand the broad social and technological setting of the waste management industry. Landfill facility operators can influence the extent to which their operations align with societal objectives in waste reduction and management.

Learning Objectives

This chapter provides an overview of:

- Waste generation in Alberta
- The waste management hierarchy
- Integrated waste management
- Sorting and processing technologies
- Landfill's role in an integrated system

1.1 AN OVERVIEW OF INTEGRATED SOLID WASTE MANAGEMENT

The term *integrated solid waste management* refers to a strategic approach to sustainable management of solid wastes covering all sources and all aspects. It considers generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. This section provides background and history that is useful in understanding the evolution of today's integrated approach to waste management. It goes on to describe the tools and approaches typically seen in systems in Alberta.

In the early 1900's, municipal solid waste was largely made up of ashes and street debris. Little packaging was used, purchased goods were not discarded, and there was less food wasted. 100 years later, the waste stream is made up of more packaging, such as plastics, cardboard and metals. More products purchased today are considered as disposable and more organics are wasted.

1.1.1 The Challenge of Managing Solid Waste

Managing solid waste is challenging as waste volumes grow along with the population as does society's dependence on packaging, manufactured goods, and products of convenience. Our waste stream is continually changing as new products enter the market and are eventually discarded. Continuing growth and change requires ongoing adaptation of approaches to maintain effective waste management and minimization.

Figure 1.1 is a visual representation of the change in waste types over the past 100 years. Data was collected from the City of New York in 1905 (W.F. Morse) and from the United States Environmental Protection Agency (USEPA) municipal waste data since 1960.

As new consumer goods enter the market, the waste stream can be expected to continue to change in the decades ahead.

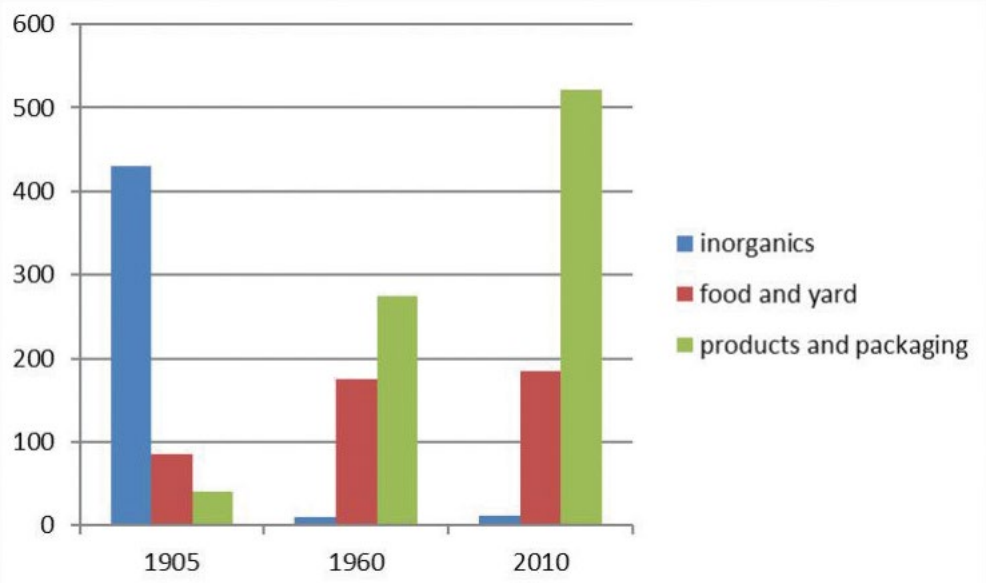


Figure 1.1 – Changing Waste Stream – Units kg/person/year
Adapted from: Helen Spiegelman and Bill Sheehan, Unintended Consequences: Municipal Solid Waste and the Throwaway Society, 2005

Poor or uncontrolled disposal of solid wastes can lead to a variety of problems including:

- Land pollution created by litter and by contamination carried from a landfill or from stored loose trash in run-off water
- Landfill gas emissions to air – both an air quality and greenhouse gas issue
- Property damage, air pollution and downwind soil contamination from trash fires
- Pollution of surface water bodies caused by contaminated run-off water
- Groundwater contamination from seepage of leachate or contaminated surface water
- Public health concerns and effects due to ineffective containment of chemical and biological contaminants and irritants, including odours
- Conflicts with, and impacts on, wildlife

Governments, private companies and individuals apply the upper tiers of the waste management hierarchy - reduce, reuse, recycle, and recover - to manage waste in better ways that avoid these problems. Governments develop regulations to prevent pollution and protect public health. Despite reduction efforts, landfills remain an essential part of the waste management industry and so must be built and operated so as to mitigate these risks.

Comprehensive planning and development of solid waste systems is needed to store, collect, transport, process and dispose of our discards. An effective solid waste system requires training and education programs to develop the skill sets that are needed to understand waste management systems and operations.

1.1.2 Waste Generation

Statistics Canada maintains a database of waste management generation, diversion and disposal for the country. Statistics Canada's web page Waste Management Industry Survey provides this information.

Since 2006 waste disposal in Canada as a whole has been quite steady at between 25 million and 26 million tonnes per year (Figure 1.2). Disposal volumes are influenced by a number of factors such as the state of the economy and population growth and shifts.

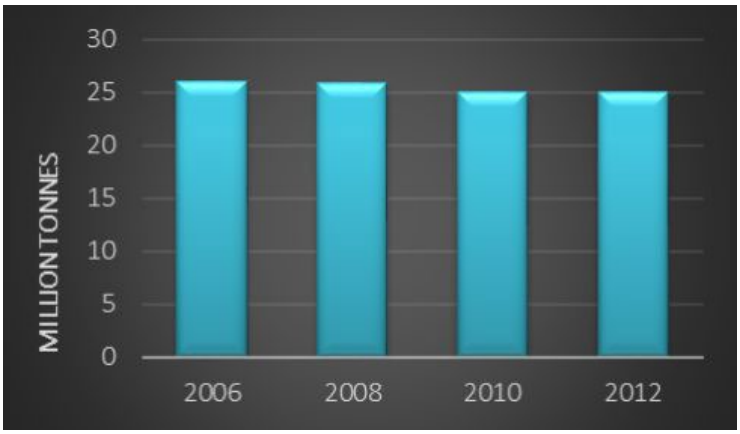


Figure 1.2 – Annual MSW Disposal – all of Canada – 2006 to 2012
Based on published data from Statistics Canada

The population served and the amount of resources recovered and diverted from the waste stream affects the amount of waste finally disposed of in the landfill. Alberta disposes of nearly 4 million tonnes per year, while Ontario with a larger population disposes of over 9 million tonnes. By calculating a per capita (per person) rate of disposal, a better comparison can be made between provinces (Figure 1.3). By this measure, it can be seen that Alberta is the highest waste generator on a per-person basis. It must be understood that these figures include not just waste from homes, but also waste from industrial, commercial and institutional (ICI) sources as well as the debris from construction, renovation and demolition (CRD) work. Provinces and communities with different diversion policies and programs will have lower disposal rates. As shown in Figure 1.3 below, Nova Scotia has achieved a rate of less than 400 kilograms per person annually.

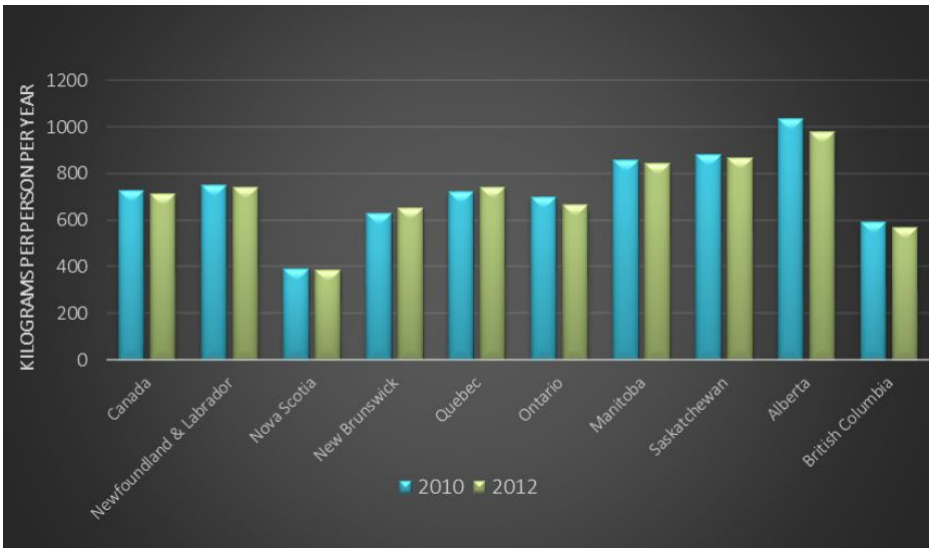


Figure 1.3 – Provincial Per-Capita Disposal 2010 and 2012
Based on published data from Statistics Canada

In 2010 residential waste made up about 37% of the total municipal solid waste stream in Canada. The remaining 63% was non-residential waste generated from institutional, commercial, industrial and construction, renovation, and demolition activities. (Figure 1.4)

Some of the top producers of ICI waste include:
- hotels and food service providers
- health care institutions (hospitals, social services)
- manufacturing
- retail stores

Sources of CRD waste include:
- Building construction
- Home and building renovation
- Building demolition and street rehabilitation

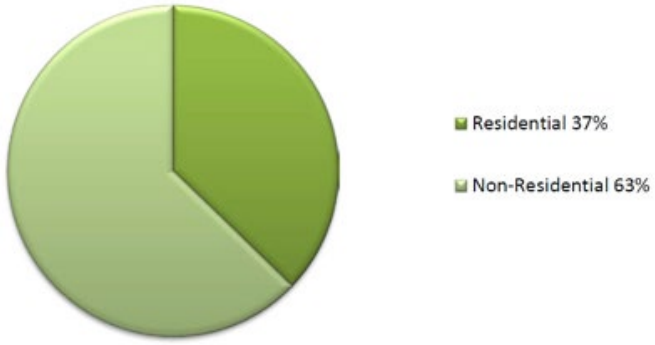


Figure 1.4 – Residential Portion of Non-hazardous Waste in Canada
Adapted from: State of Waste Management in Canada, CCME, Giroux Environmental Consulting, 2014

As a rule of thumb, in Alberta about one tonne of discards (waste, compostables and recyclables) is generated for every person in a community (example: 10,000 people = approximately 10,000 tonnes of materials). We can quickly estimate waste portions using the 30-30-30 rule: 30% residential, 30% ICI, and 30% CRD materials. The remaining 10% may be either ICI or CRD waste depending on individual community activities. This approach is useful only for early discussions when contemplating a waste management project or facility. Every community is different and a comprehensive waste generation study should be completed for further planning purposes.

1.1.3 Integrated Solid Waste Management

Integrated Solid Waste Management (ISWM) is a comprehensive system that includes elements of waste reduction and re-use, recycling, composting, energy production, and final disposal of post-consumer goods. An ISWM considers the environmental benefits, public health benefits, social commitments, and economic sustainability of the system. A system that is best for one community may not be best for another. A well planned ISWM takes into consideration the community's particular needs, economic capacity, community and political support to select the most appropriate components. The components work together to achieve the goals of minimizing the amount of waste materials remaining and to safely process or dispose of it.

The amount of discards generated includes materials that are recyclable, compostable, recoverable, and disposable. With effective programs to make use of discarded materials, there is less waste to be disposed.

The solid waste management hierarchy illustrated in Figure 1.5 has been accepted to define preferred order of actions in waste reduction and management.

"Reduce" is waste prevention or source reduction. It focuses on actions that minimize the amount of waste produced such as reducing packaging, extending product life (repair vs. replace), and reducing manufacturing wastes through process improvements. For a household, backyard composting and grass-cycling are considered reduction strategies. Waste prevention can be extended to retail businesses, institutions and homeowners to reduce consumption and waste of products. Waste prevention can reduce the requirements for collection, transport, processing, and disposal.

Encouraging home composting and grass-cycling reduces the amount of material that needs to be collected at the curb and disposed of.

"Re-use" refers to using a product for a second life, either for its original purpose (examples: used clothing, used furniture and appliances) or re-purposing the product (example: re-use of re-fillable containers).

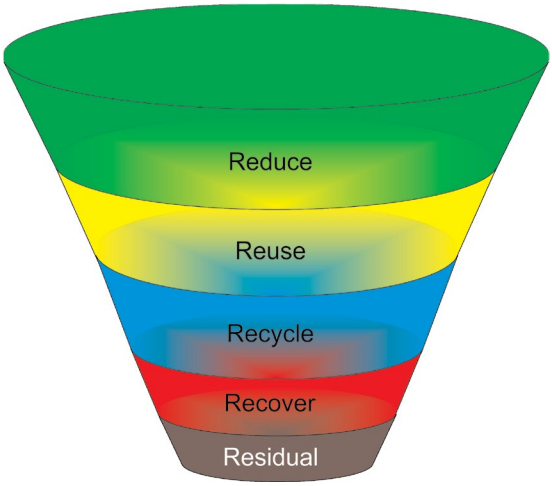


Figure 1.5 – Waste Management Hierarchy
Source: JLTechnical Services

"Recycling" involves collecting materials and processing those materials to manufacture new materials or products. Commonly recycled materials include metals, glass, plastics, and paper products. Recycling programs can be an economic stimulus as they create employment, markets and supply raw materials for industry. Photo 1.1 shows a recycling depot where residents can drop off recyclable materials.

Photo 1.1 – Recycling Containers
Photo Source: JLTechnical Services

Photo 1.2 – Windrow Composting Operation
Photo Source: JLTechnical Services

Composting is generally considered a form of recycling. It is the conversion of organic materials by biological decay into a rich soil amendment. Composting has the added benefit of reducing greenhouse gas by eliminating the landfill gas that would be generated if the materials were landfilled. Photo 1.2 shows one method of composting. It is discussed more fully in Section 1.1.9.

"Recovery" refers to technologies that aim to recover at least some of the value of the resources that went into the original material that could not be recycled and has now become waste. It is often associated with waste-to-energy facilities. Large scale waste-to-energy plants are typically incineration systems (Photo 1.3) with heat recovery and electrical power generation. Other forms of recovery are gaining momentum. Examples are gasification and anaerobic digestion, both of which produce energy and in the case of the former, the possibility of producing industrial chemicals.

Photo 1.3 - High-Temperature Incineration of Solid Waste
Photo Source: JLTechnical Services

Photo 1.4 – Solid Waste Compactor at a Landfill
Photo Source: JLTechnical Services

"Residual" is the material that remains that have not been diverted through the higher processes in the hierarchy and so must be landfilled (Photo 1.4). Current standards for landfills are based on good practices for siting, design, construction and operation to minimize impacts to land, air, and water. The operation of a landfill must be carried out in a controlled and professional way to protect the environment. Landfills require long-term care and monitoring to provide this assurance for generations.

1.1.4 Components of an Integrated Waste Management System

There are several core components to a municipal waste management system that must be fully integrated to be economical and efficient.

Components used for a given community may include:

- Curbside collection
- Transfer and haul
- Community drop off points for hazardous waste, recyclables, and/or trash
- A composting operation
- A recycling plant
- Waste-to-energy or other advanced recovery technologies
- Community re-use or 'take-it-or-leave-it' depots
- Other programs and facilities that meet community needs

Some municipalities only provide the essential elements of waste collection and disposal. Others have more complex systems that include waste transfer to distant landfills and processing of recyclable materials or organics for composting. Still others may include recovery technologies as well. Figure 1.6 illustrates the potential pathways of material flow from generator through to final disposal or to recycling or recovery solutions.

A municipal waste management system can be influenced by many factors such as:

- Size of community
- Distance to recycling markets
- Available landfill space
- Economics
- The community's prevailing degree of concern for the environment

Zero Waste is a goal that aims to have no waste going to landfills. It calls for the use of all of approaches described above along with others that call for broad social and regulatory change. There are communities in Canada that have set long term goals of zero waste and communities in Europe that are getting close to achieving zero waste.

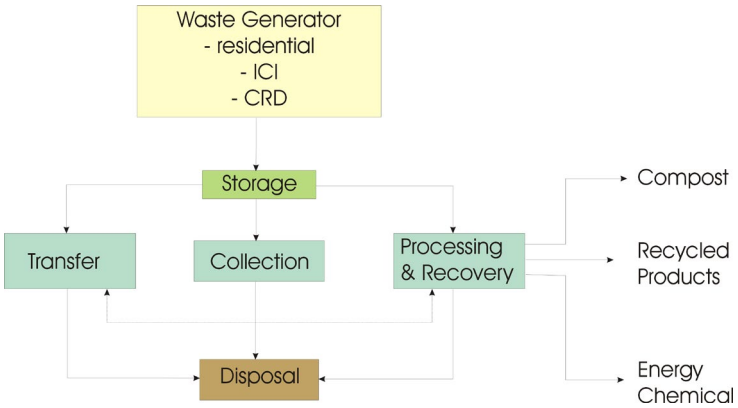


Figure 1.6 – Interrelationships of Components in a Municipal System
Source: JLTechnical Services

Municipal governments influence the degree of waste diversion in a community through policies such as:

- green procurement policies
- banning of specific materials from landfill disposal (some have banned cardboard and yard waste)
- adoption of a 'Pay-As-You-Throw' cost of service strategy (See highlight box, Section 1.1.5)

It is important in program and facility design to be aware that, within each component of the municipal waste system, there is opportunity to include programs to reduce waste disposal. These can include:

- Source separation by residents and businesses
- Multi-material collection (examples: blue box collection, green bin, waste bin)
- Curb-side collection or central drop-off locations for re-usable and recyclable materials
- Separation at transfer stations or community depots for recycling or composting
- Separation at disposal sites for recycling or composting
- Education about consumer choices and about options provided by the community's waste management system
- Policies – see highlight box

A mature waste management system should aim to use as many of these opportunities as possible.

Programs for the management of products designated by regulation can further enhance waste diversion. In Alberta, examples of these include beverage containers, used oil and oil containers, used paints, electronics, and tires. Municipalities in Alberta can participate in these programs.

The Alberta Recycling and Management Authority (Alberta Recycling) is a non-profit agency that administers the tire, electronics, and paint recycling programs in Alberta. Alberta Recycling also coordinates household hazardous waste round-ups along with Alberta Environment and Parks.

The Alberta Used Oil Management Association (AUOMA) is the non-profit Delegated Administrative Organization (DAO) charged with managing programs to sustain and facilitate the responsible collection and recycling of used oil materials in Alberta.

The Beverage Container Management Board is the DAO mandated under the Beverage Container Recycling Regulation to regulate and enhance the extensive beverage container recycling system in Alberta.

Besides these government-mandated programs, there are other opportunities available through industry supported programs:

- Heath Products Stewardship Association – Dubbed ENVIRx in Alberta, this program is managed by the Alberta Pharmacists Association. Residents can return prescription drugs, over-the-counter medications, and natural health products to pharmacies for proper disposal.
- Recycle My Cell – In Alberta, a partnership between the Government of Alberta and the Canadian Wireless Telecommunications Association has established over 500 locations where cell phones can be returned for recycling.

- Call2Recycle – A rechargeable battery recycling program is managed by the Rechargeable Battery Recycling Corporation Canada. Batteries are returned to over 30,000 locations in North America including recycling depots or retailers that are registered with Call2Recycle.

Impact of Diversion on Landfills

It is clear that there is much emphasis in ISWM systems on efforts to divert waste from landfill. Besides the clear benefits of putting materials to better uses rather than landfilling, there are benefits to the landfills that are also part of the system. Diverting waste will reduce the amount of waste going to landfill. This extends the landfill life and increases the duration between the expense of building new cells or new landfills. Diverting organic waste to composting facilities can reduce the generation of landfill gas and may lessen the harmful characteristics of leachate produced.

1.1.5 Waste Collection

Waste bags, cans, carts or bins are filled by residents and businesses and set out for collection. In small communities, contracted or municipally operated trucks may serve both residential and commercial customers. In most communities separate residential and commercial collection systems exist, and the systems involve a mix of municipal fleet, municipally contracted services, and independent for-profit waste haulers servicing private business customers.

There are many variations of residential and commercial waste collection systems. Of most interest to landfill operators is the way the collected waste is delivered to their facility and the nature of the waste in the load.

Different types of residential materials are often collected and delivered to the waste management facilities separately. Three variations are described in the Table 1.1 below.

Table 1.1 – Examples of common multi-stream collection systems

SINGLE STREAM	TWO STREAM	THREE STREAM
All materials are set out in the same container(s). They are collected in one vehicle and disposed at a landfill, or delivered to a mixed waste processing facility for recovery of available recyclables.	Recyclable materials and waste are set out in different containers. Recyclables are collected in one vehicle, and waste collected in a second vehicle. Some two-stream collection systems may use compartmentalized collection vehicles for both.	Waste materials, recyclable materials, and organics for composting are set out in separate containers and collected separately.

Clearly, in the examples above, different materials will be tipped at different locations on arrival at the facility. In the case of three stream collection, organics would be tipped at the composting site, recyclables at the Materials Recovery Facility, and trash at the landfill, transfer station, or, in some cases, at a waste-to-energy or other advanced recovery process.

Pay-As-You-Throw (PAYT)
PAYT can take various forms. The common principle is a financial incentive to reduce the amount of waste one produces for disposal. Communities who collect waste set out in garbage bags might require that each bag have a paid tag affixed to it (tag-a-bag). More bags = higher cost. Communities with cart-based collection may offer small, medium and large carts – with the monthly fee for service increasing with the size chosen.

Industrial, commercial and institutional (ICI) wastes are typically collected in larger bins using front-load trucks. Mixed waste in most loads is delivered to the landfill, transfer station or processing plant. In some communities the municipality or the commercial hauler may offer separate collection of recyclable materials, which are delivered to a processing plant or direct to a buyer of that material.

Construction, renovation and demolition CRD wastes are typically collected and stored in roll-off bins which are collected by specially equipped trucks when full. This material is not compacted and can include large and heavy items requiring care when being unloaded. If the community has a CRD recycling operation these loads may tip there, or they may tip at the transfer station or landfill.

Waste 'transfer stations' are used where landfills are far outside of an economical direct haul trucking distance. Waste is unloaded from collection vehicles into larger capacity vehicles for more economical transport to the landfill. Transfer stations can provide a convenient facility for residents and businesses to dispose of wastes and in some cases small transfer stations are established at landfill sites so that the general public can be accommodated without having to go to the tipping face. In these situations, the landfill operator will operate special trucks, usually roll-off, to transfer the waste through a short distance to the tipping face. Photo 1.5 shows a typical simple open-air transfer station.

Photo 1.5 – Rural Transfer Station
Photo Source: JLTechnical Services

A residential transfer station often sets aside designated bins or areas to receive materials suitable for recycling and for household hazardous waste collection.

The Alberta Transfer Station Technical Guidance Manual (2008) includes an in-depth description of the various types of waste storage, collection, and transfer systems used in Alberta.

Photo 1.6 – Take it or Leave it
Photo Source: Tom Moore, Slave Lake

1.1.6 Reuse Initiatives

Municipalities and businesses can encourage reuse of materials. Reuse businesses include Goodwill, thrift stores and stores that sell used sports equipment. Local organizations, such as the Foothills Salvage and Recycling Society, have shown that by accepting donated goods for sale or exchange they can divert materials from landfill disposal. Another example is the City of Edmonton's Reuse Centre. Landfill operators can also develop opportunities for controlled salvaging with facilities where customers can drop off usable items they no longer need and can look over items left by others and take what they can use. Scavenging from an active landfill face is unacceptable. Photo 1.6 is an example, dubbed "Take It or Leave It".

1.1.7 Recycling Facilities

Recycling collection systems in a community can vary from simple systems where residents deliver their recyclables to a drop-off location to a coordinated curb-side collection of recyclables. In both cases, these systems rely on waste generators to separate recyclable materials from waste materials. The collected materials are delivered to a sorting facility, or a Materials Recovery Facility, called a MRF (pronounced like "smurf"). Photo 1.7 shows the inside of a MRF with both hand and mechanical sorting systems.

In the simplest systems, recyclable materials are dropped by residents into dedicated depot bins (e.g. cardboard, metals, plastics) and minimal sorting is required. Materials are sometimes further sorted at a MRF, but often are delivered direct to brokers or end users.

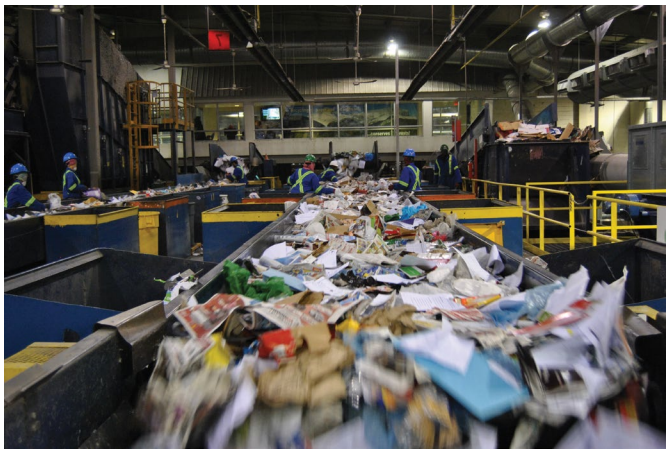


Photo 1.7 – Materials Recovery Facility (MRF)
Photo Source: JLTechnical Services

A Materials Recovery Facility, or MRF, is a facility that processes incoming material streams to sort out recyclables and prepare them for markets.

Most MRF's process separately collected recyclables. Mixed waste MRF's process the entire trash stream to recover recyclables and sometimes organics for composting.

In more complex systems materials are mechanically and hand sorted into various commodity streams. MRFs are typically found in larger municipalities and where large volumes of varying materials are collected for recycling. The sorted materials are usually compacted or baled for shipping to brokers or end users.

1.1.8 Hazardous Waste Depots

Hazardous waste depots are facilities that accept household hazardous waste and other problem materials to keep them out of the landfill. They are often located at central locations in a community, but are also often a part of the operation at a landfill site. Typical materials accepted include:

- Paints and solvents
- Household cleaners
- Used oil
- Antifreeze
- Batteries
- Fluorescent lights
- Household pesticide containers

Some depots accept designated electronic goods for recycling through the Alberta Recycling program. Some also accept refrigeration units for CFC removal and recycling.

Photo 1.8 – Example of a Hazardous Waste Depot
Photo Source: JLTechnical Services

Programs mandated by the province of Alberta (described earlier) provide for the recycling or appropriate disposal of many of these materials. In Alberta, AEP also provides communities with financial assistance for the final disposal of collected hazardous materials not covered by other programs. Photo 1.8 shows a simple hazardous waste depot constructed using shipping containers.

1.1.9 Composting

Composting is the degradation of organic materials by microorganisms into a humus or soil-like material. Organic waste such as grass, leaves, and food waste can be collected separately and composted either in outdoor or indoor operations. Most composting operations are outdoors as these tend to be the most economical. The most common method of composting blends organic materials with different characteristics according to a composting recipe and piles them in long windrows or static piles. These static piles or windrows are turned to add oxygen to the pile, ensure even composting of all the organics, and help minimize odours. Following the composting recipe is important because decomposition occurs most efficiently when the nutrients and moisture are optimal for the decomposing microorganisms. Photo 1.9 shows the kind of specialty equipment typically used for windrow composting.

Photo 1.9 – Compost Windrow Turner
Photo Source: JLTechnical Services

Further information on composting is available in the following Alberta Environment and Parks publications:
Leaf and Yard Waste Composting Manual (1999)
Mid-Scale Composting Manual (1999)

1.1.10 Waste-to-Energy and Conversion Technologies

Waste-to-energy is a term used to describe a variety of technologies that convert waste to produce energy in the form of heat or power. The most common technology today is incineration. In a modern incineration system, waste is burned at high temperatures and air is controlled to optimize the process. Sophisticated air scrubbing equipment is used to clean the exhaust air before it is released to meet regulated air quality standards. The combustion heat is commonly captured and used for heating or generating electrical power. Photo 1.10 shows the vent stacks of a Waste-to-Energy facility.

Emerging technologies, often referred to as “conversion technologies”, include gasification systems and anaerobic digestion. Gasification technology uses a thermo-chemical process to convert prepared waste to a synthetic gas or ‘syngas’ that is used as a fuel for energy production, or converted to industrial chemicals. Anaerobic digestion is the biological degradation of organic waste in an oxygen starved environment. Anaerobic decomposition results in the production of methane gas which can be recovered and used for energy production. The resulting solid organic material (digestate) can be used directly as a soil amendment or after stabilization for aerobic composting.

Photo 1.10 – Waste-to-Energy Facility
Photo Source: JLTechnical Services

1.2 PAST, PRESENT, AND FUTURE OF LANDFILLS IN ALBERTA

Landfills in the past were commonly located for convenience, with little attention given to protecting the environment. Many of these sites were uncontrolled, did not have engineered designs, and waste was commonly burned to free up space. Photo 1.11 reflects common practice 35 years ago.

Landfill managers are under increasing pressure to meet the demands of growing populations who have a greater understanding of environmental protection. The practices of the past are no longer acceptable.

In 1996 regulation of waste management and landfills in Alberta was transitioned from the Public Health Act to the Environmental Protection and Enhancement Act with more stringent requirements coming into effect. Landfills today must be carefully located and designed with engineering features to minimize impacts on land, water and air. They must be supervised by trained and certified employees, and be monitored to demonstrate environmental protection. Current standards and how they are satisfied are the subject of later sections of this study guide.

Photo 1.11 – Rural Alberta Dump, circa 1980
Photo Source: JLTechnical Services

The Alberta initiative to replace poorly designed and operated 'dumps' with regional engineered landfills was driven by the prevalence of scenes such as the one in Photo 1.11.

With higher standards, landfills cost more money to build and operate. Many of the small municipal landfills in Alberta have been closed and replaced with larger regional landfills that are designed, built, operated and monitored to comply with the new standards. There were over 650 active municipal landfills in Alberta before 1980. Just over 70 municipal landfills were operating in 2015.

Photos 1.12 and 1.13 provide an example of how one of those old landfill sites was re-developed to become a real asset to the community.

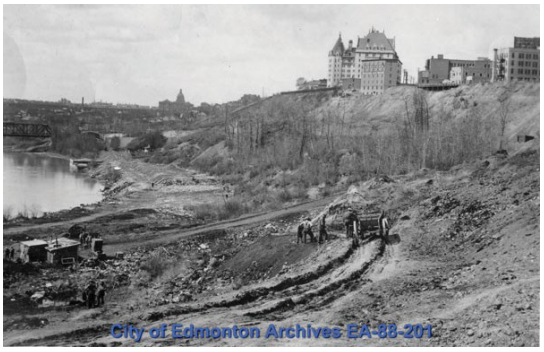


Photo 1.12 – Grierson Hill Dump, circa 1930
Photo Source: City of Edmonton Archives

Fifty years ago the Grierson Hill dump operated in the heart of the City of Edmonton's downtown river valley. The grand old Hotel Macdonald (now Fairmont Hotel Macdonald) and the provincial legislature are in the background.

Photo 1.13 – Grierson Hill today - Louise McKinney Park
Photo Source: Tom Arban Photography Inc.

Today, Grierson Hill is the site of the award-winning Louise McKinney park – an example of how old landfill sites can be re-developed as real assets to a community.

Those in the industry should expect more changes for landfills in the future such as:

- Continuous strengthening of regulations and standards
- Technology advances
- Increased waste diversion through the principles of reduce, reuse, recycle and recover
- Continuation of the trend to larger regional landfills and multi-use waste management “centres”

Innovations in landfill design and operation are advanced regularly. Bioreactor landfills designed and operated to accelerate the decomposition and stabilization of the landfill are an example of such innovation. Approaches are being tested that aim to minimize emissions of methane by using organic cover materials that biologically transform the methane.

Landfills are increasingly becoming but one component of multi-purpose sites which are home to recycling and processing operations.

Landfill owners are looking for new ways to reclaim and re-purpose sites as landfills approach closure. An example of a revenue producing approach is the development of sites as energy parks with solar or wind power installations, landfill gas fired generators and waste-to-energy facilities.

The Turkey Point Renewable Energy Park in Lancaster County, Pennsylvania (Photo 1.14) is a good example of a landfill developed with wind power and landfill gas generated electricity.

Photo 1.14 – Turkey Point Renewable Energy Park, County of Lancaster, PA
Photo Source: Lancaster County Solid Waste Management Authority

An Alberta example of a multi-purpose waste management site is the Edmonton Waste Management Centre (Photo 1.15). The Centre includes a nearly complete landfill with landfill gas power generation, on-site leachate treatment, a major transfer station and waste processing facility, a MRF, construction and demolition waste recycling operations, an electronics recycling facility, a major composting operation, organics anaerobic digestion coupled with a combined heat and power plant (operational 2017), a leading edge waste-to-biofuels technology, and two research facilities.

Photo 1.15 – Edmonton Waste Management Centre
Photo Source: The City of Edmonton

Landfills will continue to be an integral component of waste management systems for the foreseeable future. Even with reduction and recycling initiatives and advanced processing technologies, there are still residuals that require landfill disposal.

02 Chapter

Communication, Health and Safety

Communication Health and Safety

Effective communication is important for the safe and orderly operation of landfill sites. Communication and site safety go hand-in-hand.

Learning Objectives

In this Chapter you will learn about:

- How to communicate effectively with the public, customers, employees, contractors and site visitors
- The importance of open communication with site neighbours
- How to use effective landfill signs to convey information, directions and safety rules
- The value of public support and acceptance
- The need to communicate complex information clearly
- The importance of occupational health and safety regulations
- Common incidents at landfills and how to prevent them
- Your responsibility for safety of employees, customers and visitors
- The importance of hazard assessments and controls
- Reporting and documentation of incidents and near misses
- What personal protective equipment is for and how to use it
- The importance of effective emergency response and emergency response plans

2.1 OVERVIEW

Communication is an important part of managing and operating a landfill. Landfill operators need to be prepared to communicate routinely with:

- Site employees
- Customers
- Site neighbours

Depending on the size and structure of the municipality or company that owns the site, operators may also need to communicate with:

- The public at large
- Senior executives
- Political leaders
- Tour groups, and
- The media

A communications strategy will help staff when communicating with these various groups. If your employer has a communications or public relations department they should be involved in developing and delivering communications appropriate for different situations and audiences. Routine communications with the public and customers might be to introduce new waste management programs, inform of changes in site operations, or changes in disposal fees. Such communication can make use of a variety of tools, including:

- Media news releases and advertising
- Open house meetings and facility tours
- Hand-outs to customers at the scale
- Personal communication
- Posted call lines for inquiries
- Web pages and social media

Media Communication

- Have a designated spokesperson
- Be prepared – know the purpose of the interview
- Answer questions honestly
- Stay on point with your message
- Speak in common (not technical) language
- There is no such thing as “off the record”

Similar tools can be used in dealing with non-routine situations – usually events such as a fire, opening of a significant new facility, or a significant accident at the site.

Landfill employees may be asked for media interviews. It is best to have a designated spokesperson who has been trained and has experience with media interviews. Employees who are asked to conduct interviews should refer the media to the designated spokesperson. This is important to maintain a consistent message and to provide key information. It is especially important in the case of non-routine events.

2.2 COMMUNICATING SAFETY AND SITE USE

Important communications are those which address health and safety and site operational procedures and rules. All employees at the landfill need to be part of the conversation between:

- Employees
- Customers
- Contractors working at the site
- Site visitors and tour groups
- Regulatory inspectors

2.2.1 Communicating with Customers

A customer may be a resident with a small load of yard waste, or it may be a driver of a residential collection truck or large commercial truck.

Repeat customers, such as the residential collection and commercial truck drivers, will know the procedures. Site staff may need to explain the procedures to new drivers with regular hauling companies. The landfill operator should work with the hauling companies to train their drivers. This can involve communication with the hauling company (which may be a municipal waste collection branch) through:

- Written procedures to follow at the landfill
- Face to face meetings to review procedures
- Communicating observed unsafe practices with drivers
- Reporting unsafe practices to company or branch supervisors

The more challenging customers are those who do not go to the landfill frequently and are unaware of procedures and safety risks. Site staff may need to take additional time to explain where the customer needs to go and some basic safety rules of the site.

Communication with customers at the landfill begins at the site gate, with information signs and through communication with the scale or gate attendant. The attendant will collect information about customer and the load, provide direction to the correct tipping area, and to relay safety information.

Safety Messages

- No smoking
- No scavenging
- Children remain in vehicle
- Watch for vehicles and equipment

Photo 2.1 – First Point of Contact
Photo Source: JLTechnical Services

2.2.2 Communicating with Employees

Communication with site employees is key to the proper and safe operation of the landfill. Communicating with employees should include training on site operating policies and procedures and safety policies and procedures. Daily communications with employees can take the form of:

- Tailgate meetings
- Verbal discussions and explanations
- Memorandums
- Radio or phone conversations
- Emails if staff have access

It is important to have contact with employees who are working alone. The employee working alone must be able to contact someone in the event of an emergency situation. It is also important to have scheduled phone or radio checks with the employee who is working alone. There are technologies available that will send alert notifications if, for example, an employee does not check in within a prescribed time or does not move within a certain time interval – indications of a possible medical emergency or accident situation.

Photo 2.2 – Regular management visits with staff is an effective way to keep communication lines open
Photo Source: Tammi Nygaard, Drumheller and District Landfill

Radio or cell phone communication between employees is important to maintain site control and site safety. In cases where there is anything out of the ordinary, such as a waste load that requires special handling, a bear was seen in the area, or vehicle or equipment breakdowns, there needs to be a reliable communication system.

In the event of an emergency on site, the communication plan needs to include protocols for notifying employees and customers, and contacting emergency services. All employees must be aware of the communications procedures when an emergency situation occurs and their individual roles and responsibilities. This is captured as part of a site Emergency Response Plan.

2.2.3 Communicating with Contractors

Contractors may be working on the landfill for construction of new landfill cells or for other site works. Contractors need to be informed of site hazards and site safety requirements that they must follow. They need to know the location of site utilities, of electric fences if used, and of features such as monitoring wells that must not be damaged. They need to be made aware of the hazards that may be present when working in areas where landfill gas may be present.

Before a contractor begins work at the site, the landfill operator should conduct a site safety orientation that informs the contractor of general safety policies and procedures, and highlights any specific hazards and procedures for the work area.

Contract agreements should be very clear on Prime Contractor responsibility for safety. The Prime Contractor rules are further discussed in Section 2.6.3. If the contractor is the Prime Contractor, site staff will need to be informed about the contractor's safety procedures which must be followed in their work area. There must be an established communications process between the contractor and the landfill management and staff, regardless of which party is the designated Prime Contractor.

2.2.4 Communicating with Visitors and Managing Tours

A landfill operator may have site visitors such as neighbours, community leaders, or operators from other facilities who are interested in the site operations. At times, the landfill operator may be requested to lead tours for school groups, community social groups, or even conference tours and training course students. Accommodating such visits can be an important way to be seen as a positive asset to the community and the industry.

There should be advance notice for site visits, but sometimes single visitors or small groups arrive at the site expecting to be accommodated. The site owner should establish policy on whether this will be allowed or not. If policy allows, the operator should always be prepared, but if the operator's judgment is that a visit or tour cannot be accommodated safely or adequately, they should be empowered to say "no."

Photo 2.3 – Site Orientation
Photo Source: JLTechnical Services

Visitors should sign in at the site office or scale house and be escorted by a site employee. The operator should begin a site visit by asking questions about what they would like to see. The operator should be courteous when answering questions. If the operator doesn't know the answer to a question, they should say so and offer the contact information for someone who can provide an answer.

Landfill tours by groups are typically pre-arranged. It is preferable to schedule tours in low traffic periods of the day when site employees are more available. All site employees should be informed of a tour schedule so they are aware and can take proper safety precautions. Before starting on the tour, a site orientation should be given, including an overview of the site, what they will see on the tour, and safety procedures during the tour. If required, PPE must be worn. Tour groups should remain in vehicles when in high traffic areas and where equipment is

working. If a tour group views a part of the operation on foot for a demonstration or to see a specific piece of equipment, the group should remain with the tour guide. Landfill employees should always remain friendly and helpful to tour groups.

2.3 LANDFILL SIGNS

Signs are important communication tools at landfill sites. Signs are posted to:

- Give general information such as fees
- Give directions to various facilities and tipping areas
- Communicate safety rules

Too much signing can be confusing and many people will then not bother to read them. Signs should be short, clear, and to the point. Signs and the text on them needs to be larger than one might expect. Signs that are too wordy or too small will not likely be read.

Alberta legislation requires that information signs at landfill gates provide at least the following information:

- Name of approval holder
- Class of landfill
- Waste restrictions, and
- Phone numbers of
  - ✔ Person responsible
  - ✔ Local fire department
  - ✔ Alberta Environment and Parks (1-800-222-6514)

Other information on entrance signs typically includes the hours and days of operation and a schedule of disposal fees. Other information signs may be posted at specific site facilities such as recycling depots, controlled burn pits, and at the landfill disposal cell.

Direction signs are used to guide customers to specific areas of the site. This may include signs posted along roads directing users to recycling areas or the working face. Additional direction signs are sometimes posted at the tipping locations to give customers further instructions or to give safety information.

Photo 2.4 – Entrance Sign
Photo Source: Tom Moore, Lesser Slave Lake

Photo 2.5 – Information Sign
Photo Source: Tom Moore, Lesser Slave Lake

Because customers may not pay attention to signs, landfill staff must watch for customer mistakes and stop and speak to them to explain the rules in person if necessary. Signs support the landfill staff in giving directions or conveying a message.

Photo 2.6 – Portable Safety Sign
Photo Source: Ray Juska, Newell

2.4 VALUE OF PUBLIC SUPPORT AND ACCEPTANCE

From a public relations perspective, a landfill can be a significant asset or a liability depending on how the landfill is managed and how well communication with the public and others is managed. When the relationship between the operators and the public is positive, there is more support and trust in the operations. Losing public support can lead to more regulatory scrutiny, legal issues, and difficulty gaining support for proposed solid waste management programs. It is best to involve the public at all stages of a landfill from siting of the facility through operations and into closure activities.

An open communication process helps to build public trust and reduce opposition to the site

Members of the public will become involved when they choose to. When there is poor communication, citizens may feel the need to speak to the media or their elected officials. The goal for owners and operators should be to engage the public in positive ways.

The most effective way to build public support is to manage the landfill and waste diversion programs to a high standard and to protect the environment.

Photo 2.7 – Open and Honest Communication
Photo Source: JLTechnical Services

Public involvement requires a two-way dialogue. This involves getting information out to the public while listening to the concerns and issues they have. Then it is important to address their concerns.

If a problem arises at the landfill, be honest about it and explain what actions are being taken and give realistic timelines as to when the problem will be corrected. For example, if a neighbour calls to report litter blowing on their property, arrange for clean-up of the litter as soon as possible. The operator may also review site operations to see if litter controls are working effectively.

Neighbours, residents or businesses that are adjacent to or nearby the landfill site are important stakeholder groups. Landfill sites are generally not a preferred neighbour. Concerns of neighbours typically include traffic, noise, dust, litter and odours. If the site conducts open burning or operates a contained waste-to-energy facility, smoke and air emissions may become an issue.

Keeping on good terms with neighbours is key to broader acceptance of the facility within the community. It is best to communicate with the public, and neighbours in particular, frequently, openly and honestly. Tools used for communication with neighbours might include:

- Newsletters
- A community liaison committee, meeting on a regular basis to discuss concerns, if any
- A call-out system so that should there be an event, such as a fire, neighbours can quickly be given the facts and have their questions answered

Community Liaison Committees

- Committees bring together interested or concerned community members (about 4 to 10 members) with landfill owner representatives and operators. Committees may: Have regular scheduled meetings
- Discuss activities and events since last meeting
- Discuss planned upcoming activities
- Discuss community concerns, if any
- Agree on action plans to address concerns

It is important that the landfill representative commit to, and follow up on, communicating back to members progress on action plans.

Keeping an open dialogue with landfill neighbours and the public in general can be helpful to keep them informed and quickly resolve concerns that might be raised. People who are uninformed or misinformed can mistrust site operations. Once trust is lost, it is very difficult to gain it back.

2.5 COMMUNICATING DATA AND TEST RESULTS

At times it may be necessary to provide the public with an interpretation of scientific data, such as groundwater quality analysis, landfill gas composition, or an analysis of a waste material.

Data interpretation and explanation is best left to professionals in the relevant field of study. This may be professionals in the employ of the landfill owner, but it is often wise to use a third party consultant to perform sampling and testing, and to provide the data interpretation. This can add credibility to the information. Landfill operators should not try to communicate information or answer questions on matters beyond their expertise. It is fine to explain that you will have to pass an individual on to another for such discussions.

When explaining data to regulatory agencies and other scientific groups, using technical language is acceptable as it is normally understood. When explaining scientific data to the general public, it is best to use non-technical language as much as possible. Use graphics or visual aids to help explain the data when possible. Be sure to address specific concerns that have been raised.

Explaining Concentrations – Use Analogies

1 part per billion is equivalent to 1 car in a line of cars that goes around the earth 100 times.

When explaining test results, take the time to explain how it relates to regulatory limits and impact on the environment. For example, when explaining the results of a groundwater monitoring program, state if groundwater is being impacted or not. It is also important to explain the significance of any impact.

In the event that a problem arises, have a strategy for communicating to the public. Explain:

- What the issue is
- The significance of the issue
- The corrective action plan
- A time-line for the corrective action

Provide regular updates on the progress and results of the corrective action until the situation is resolved.

2.6 HEALTH AND SAFETY AT LANDFILLS

Landfills can be dangerous places. Consider that at a landfill site:

- Heavy equipment operates in close proximity to ground staff and customers
- Many vehicles of different sizes and with drivers of varying skill are backing and maneuvering in the same space – and there are no lines painted on the surface for them to stay within
- Any manner of material can be in the incoming waste loads, including things that are sharp, dusty, heavy, explosive, combustible, and toxic
- The ground surface is irregular and strewn with waste materials creating many opportunities for people on foot to be tripped, fall, or injure themselves on something sharp

Incidents can involve employees, contractors and the public. Common incidents at landfills include:

- Slips, trips and falls
- Contact with heavy equipment working at the site (e.g. bulldozers, compactors)
- Contact with/between customer vehicles
- Contact with sharp objects (medical sharps, glass, metal)
- Accidents/Injuries caused by handling of bulky, hard to handle materials
- Exposure to chemicals, dusts, molds
- Conflicts with wildlife
- Medical emergencies (heart attack, stroke, asthma, etc.)
- Workplace violence incidents, and
- Fires

Photo 2.8 – Customers at Risk
Photo Source: JLTechnical Services

Serious incidents have occurred at landfills across North America that have caused severe injuries and deaths. Such incidents have included customers and employees run over by landfill equipment or other vehicles, falls into transfer containers, explosions, and inhalation of dangerous gases.

Because of the nature of a landfill, use of best practices in applying established safety conventions and adhering to safety legislation is very important.

2.6.1 The Occupational Health and Safety Act, Regulation and Codes

The Occupational Health and Safety Act, Regulations and Codes protect people working at and visiting landfills. Landfill operators should keep a copy of these documents at the landfill for reference. More information and tools that can be used to develop and maintain a safety culture at a work place can be found at Work Safe Alberta.

The Occupational Health and Safety (OH&S) Act sets out the minimum requirements for health and safety in Alberta workplaces. Officers enforce the legislation by issuing orders to employers.

Landfill operating policies and procedures cannot take precedence over the OH&S Act or Regulations. The OH&S Act can be found online at the Queen's Printer.

OCCUPATIONAL HEALTH & SAFETY REGULATION

The OH&S regulation describes the process for monitoring and enforcing the OH&S Act. Regulations are legally enforceable.

As of the publication of this study guide, the current version is Alberta Regulation 62/2003 with amendments up to and including Alberta Regulation 182/2013. The OH&S Regulation is available online at the Queen's Printer.

OCCUPATIONAL HEALTH & SAFETY CODE

The OH&S Code is a guideline to assist employers and employees in implementing and abiding by the OH&S Act and Regulation. Codes provide information on how to meet the regulatory requirements. The following of relevant parts of the code demonstrates diligence and safety awareness.

The OH&S Code is available on-line through Work Safe Alberta. An Explanation Guide may be purchased from Alberta Queen's Printer or viewed on-line at Work Safe Alberta.

2.6.2 Responsibility for Safety

Vehicle traffic, moving heavy equipment and exposure to potentially toxic waste materials are just some of the risks that landfill operators must deal with every day. Everyone at the landfill, including workers, contractors and customers need to be aware of their surroundings to avoid accidents or injury.

The landfill owner is responsible for making sure a comprehensive safety program is developed and implemented. Site managers, supervisors, and operators have a responsibility to ensure safety procedures are followed. Operating staff have a responsibility to work safely. Customers have a responsibility to adhere to safety rules established at the site. Everyone is Responsible for Safety.

EMPLOYEE SAFETY

All landfill employees are responsible to ensure their own safety as well as the safety of their co-workers, contractors and the general public using the site. Employees are required to follow safe work practices and procedures that have been developed for the site and put in place by management.

A safety program needs to include ongoing training of all landfill employees.

Employees must wear the applicable personal protective equipment (PPE) as required by their employer's safe work practices and procedures.

See further discussion in Chapter 6 about the risks associated with landfill gas.

Photo 2.9 – Heavy Equipment Too Close to Customers
Photo Source: JLTechnical Services

CUSTOMER AND VISITOR SAFETY

Many landfill customers are not trained or knowledgeable about the dangers at a landfill and need to be informed of site rules and procedures. Regular business customers, such as waste haulers, may be more aware, but they too must be informed of site-specific procedures. Waste management facilities must have policies and procedures in place to handle customer and visitor health and safety risks.

Common policies and procedures include:

- Children and pets must remain in the vehicle at all times
- No scavenging
- No smoking
- No loitering
- No speeding
- All loads must be secured
- '3-metre rule' - it is recommended that all customer vehicles have at least three metres between each other when off-loading. Staff should be trained and expected to require greater separation when safety dictates. For example, large dump trailers will require a larger distance due to their instability when dumping.
- Separate tipping areas for residential and commercial customers if possible
- Some facilities have transfer stations for residential customers and do not allow any residential traffic at the active face.
- All visitors (e.g. tours, inspectors) must sign in and sign out of the facility.
- Policies and procedures to ensure entering into confined spaces is done safely. (This is relevant, for example, to a consultant's technicians who may be entering a manhole to collect samples.)
- Emergency response procedures

Commercial and municipal fleet drivers should be required to wear the appropriate personal protective equipment (PPE) while on site, including:

- High-visibility clothing
- CSA approved footwear
- Gloves
- Some landfills require commercial haulers to wear hard hats as well

Visitors at the landfill may include tour groups, engineers, regulators, media, or other company or municipal employees. Visitors should be given a site orientation including safety during their visit. If they are going to be outside vehicles, they should wear appropriate PPE. The landfill should keep a supply of high-visibility vests and other PPE available for visitors.

2.6.3 Partnerships in Injury Reduction

Partnerships in Injury Reduction (PIR) is a voluntary program in which employer and worker representatives work collaboratively with government to build effective health and safety management systems. By improving health and safety, the social and financial costs of workplace injury and illness are reduced.

This program promotes health and safety through partnerships with safety associations, industry groups, educational institutions and labour organizations.

Photo 2.10 – Visitors with PPE
Photo Source: JLTechnical Services

In Alberta, a Partner in Injury Reduction is an association, corporation or organization that commits to taking a leadership role in health and safety by entering into a formal agreement with the Alberta government. The government and each partner sign a Memorandum of Understanding outlining the specific commitments to health and safety made by each organization.

Photo 2.11 – Prevent Injuries
Photo Source: JLTechnical Services

CERTIFICATE OF RECOGNITION (COR)

The Partnerships in Injury Reduction program awards Certificates of Recognition (COR) to employers that have developed a health and safety management system and that have met established standards. Participating employers must complete annual safety audits of their Health and Safety Program.

Basic facts about CORs:

- Employers must acquire and maintain a valid COR to earn a financial incentive through the Workers Compensation Board (WCB) (rates can be reduced by as much as 20%)
- Alberta corporations may require bidding contractors to hold a valid COR
- CORs are issued by the Government of Alberta

SMALL EMPLOYER CERTIFICATE OF RECOGNITION (SECOR)

The Small Employer Certificate of Recognition (SECOR) program provides an option for small employers to develop a health and safety management system identical to the PIR Program and receive a Certificate of Recognition (COR). In order to be eligible under the SECOR Program the employer cannot have more than ten employees and/or contractors in total.

BENEFIT OF THE COR AND SECOR PROGRAMS

COR and SECOR participation can benefit the employer through:

- Reduced WCB premiums
- Reduced lost time due to an accident or injury
- Reduced equipment and property damage

Benefits to the employee/contractor include additional safety training, less pain and suffering due to accidents and injuries, and a safe and positive work environment.

Landfill owners may require contractors that are bidding on jobs or projects to have a valid COR or SECOR. Not having a valid COR may eliminate them from the bidding process.

WORKING WITH CONTRACTORS

When a contractor is hired to operate the landfill or for a construction project at the landfill, it must be clearly identified who is the ‘Prime Contractor’. There must be a Prime Contractor when there are two or more contractors at a work site. A Prime Contractor has the overall responsibility for safety at a worksite.

By default, the owner is the Prime Contractor, but in some cases can transfer this responsibility to a contractor. Conditions set out in the OH&S Act and Regulation must be met. The transfer must be in writing. There cannot be two Prime Contractors responsible for one worksite. However, often a landfill site can be divided up into more than one worksite. For example, when a contractor is hired to construct a landfill cell, if the work-site for the cell construction can be isolated from the rest of the site, it may be possible to assign Prime Contractor responsibility for that worksite to the Contractor. Even so, there must be communication between the owner and the contractors to avoid conflicts. Each situation is unique and a landfill owner/operator should carefully review the requirements of the OH&S Act and Regulation to see that all requirements for assignment of responsibility are met.

Photo 2.12 – Contractor Safety
Photo Source: JLTechnical Services

Prime Contractor

Multiple employers carrying out interrelated work activities and/or whose activities may have a health and safety impact on each other, must understand which is the prime contractor for the site.

The owner of the work site is the prime contractor. The owner can decide if a hired contractor will be designated as prime.

The prime contractor has the overall responsibility for ensuring compliance with health and safety legislation at the work site.

2.6.4 Hazard Assessment and Control

A foundational principle of workplace safety is that of hazard assessment and control.

IDENTIFYING HAZARDS

A hazard is any situation, condition or thing that may be dangerous to the safety or health of employees, customers, and visitors at the landfill. A hazard has the potential to cause an injury, illness or loss.

Potential hazards at a landfill include safety hazards and health hazards.

- Safety hazards may include substances, processes, actions, or conditions that can endanger the safety of anyone at the worksite. This can include such things as potential for chemical burns, pinch points, slips and falls, electrical shocks, and more.
- Health hazards include chemical, biological, or psychological hazards which can cause health issues to exposed individuals. This can include hearing loss, lung damage, heat stroke, or other such problems.

The OH&S legislation requires employers to assess their work sites and identify existing or potential hazards prior to any work on a site. This is done by conducting a hazard assessment. A hazard assessment is written documentation of the hazards and methods to be used to control or eliminate the hazard. The recommendations for elimination or control of a hazard should include specific actions required to correct the problem. The employer is expected to involve the employees in the assessing, controlling and eliminating of any potential hazards. Injuries and ill health can ruin lives and result in additional costs to employees and employers because of impaired ability to work, lost production, machinery and equipment damage, and insurance cost increases. The OH&S Act and Regulation also include provisions for owners and their employees to be fined and/or prosecuted in court for serious non-compliance with legislation.

Photo 2.13 – Involve Employees in Hazard Assessments
Photo Source: JLTechnical Services

After the initial hazard assessment has been completed, further assessments should be conducted periodically to ensure employees are continuing to follow the correct procedures and that the equipment is in proper working condition. Additional hazard assessments are required:

- When a new work process is introduced
- When a work process or operation changes
- Before the construction of any significant additions or alterations to the work site

Once completed, the control mechanisms for the hazards must be communicated to the employees. The employees need to know what their responsibilities are in relation to the hazard assessment. The communication method may include briefing workers on a one-to-one basis, discussing the results at safety meetings, and posting the results in a location accessible to workers. When an employee is assigned a task they are unfamiliar with, they should be given an orientation on the task which includes identification of hazards and the safety procedures involved.

There are two types of hazard assessments.

The first type is an assessment completed on the task itself, sometimes referred to as a **formal hazard assessment.** An example would be fueling a piece of equipment. The organization must assess all of the hazards that would be associated with the task and implement control methods to eliminate hazards identified.

The second type is called a **site specific**, or **field level hazard assessment.** At work locations where the activities and conditions change frequently, employers and workers often rely on field level hazard assessments that are done on-the-spot. Field level hazard assessments are often important at construction sites, during road building activities, brush control activities, and where outdoor work activities are affected by changing weather conditions. This form of hazard assessment is done at the beginning of a work day or when a new job is started.

CONTROLS

If practical, hazards should be eliminated or controlled as close to where the problem is created as possible. If this is not possible, controls should be placed between the source and the employee. The closer a control is to the source of the hazard the better. For example, if a hazard is identified where clothing could become entangled in a drive shaft, the closest solution would be an effective guard placed immediately over/around the shaft. If a solution like this is not possible, hazards must be controlled at the level of the worker utilizing personal protective equipment and safe work procedures.

The three levels of control in order of preference include:

- **Engineering Controls:** The preferred method of control if elimination is not possible; physical controls implemented at the design, installation, or engineering stages (e.g. guards, automatic shutoff switches, etc.).
- **Administrative Controls:** Processes developed by the employer to control hazards (e.g. safe work practices, procedures to minimize hazard potentials, job scheduling and rotation, training, signage). These processes control the activities of employees.
- **Personal Protective Equipment (PPE):** Equipment used or clothing worn by a person for protection from health or safety hazards associated with conditions at a work site. Common PPE includes gloves, safety glasses, hard hats, steel-toed boots and high-visibility clothing. Some tasks require more advanced training and equipment, such as the use of fall protection harnesses and rigging. PPE must be used when engineering or administrative methods cannot fully control the hazards and must be used in conjunction with engineering and/or administrative controls. PPE does not eliminate the hazard, but will protect employees from the hazard.

The control of some hazards requires the combined use of all three control methods to reduce the hazard to the lowest hazard level practicable or achievable. Employers should use the combination of methods that achieves the greatest level of worker safety.

An excellent reference for employers and employees developing hazard assessment and control procedures for their worksite is Work Safe Alberta's Hazard Assessment and Control: a handbook for Alberta employers and workers. This best practices guidance document includes examples of completed formal and site specific hazard assessment and control forms. The blank templates developed by Work Safe Alberta are included here in Appendix 2-1.

SAFE WORK PLANS

There should be a safe work plan developed for every task and activity at a landfill site. Safe work plans evolve from hazard assessments or incident investigations. The plan will describe the nature of hazards involved and the work procedures required to be followed to minimize the risk of injury. Required PPE will be stipulated. Safe work plans should be reviewed and updated regularly and always when an operational change is introduced. Front line staff, especially those regularly involved in the task or activity should be involved in its development and trained in its use.

2.6.5 Incident Reporting and Investigation

An incident is an event or dangerous situation that either could have resulted in an accident or injury, or an event that resulted in an accident with or without property damage or personal injury.

Employers need to have a process in place for reporting and investigating incidents. It is important that incidents be both reported and investigated so that steps can be taken to prevent a repeat in the future. Involving front line staff in the reporting and investigation process can be an effective training tool. Employers participating in the Partnerships in Injury Reduction program are required to document all incidents/accidents and near misses and have a process for reviewing incidents to identify the actions necessary to avoid repetition.

A **near miss** is an unplanned event that did not result in injury, illness, or damage however it had the potential to do so. Only a fortunate break in the chain of events prevented an injury, fatality or damage; in other words, a miss that was nonetheless very near.

All accidents/injuries, near misses and dangerous situations should be reported to a supervisor. All should be investigated to identify cause and corrective measures to prevent an accident from occurring or re-occurring.

More serious incidents must be reported to Alberta Occupational Health and Safety. The OH&S legislation in Alberta requires that an employer contact Alberta OH&S immediately if an injury or incident results in the following:

- A death
- Results in a worker having to stay in hospital for more than two (2) days
- Involves an unplanned or uncontrolled explosion, fire or flood that causes or may cause a serious injury
- Involves the collapse or upset of a crane, derrick or hoist
- Involves the collapse or failure of any component of a building or structure

Incidents don't just happen - they are caused. They can be prevented if causes are eliminated and causes can be eliminated if all incidents including near misses are investigated. Unless the cause is eliminated the same situation will remain.

An incident investigation should determine what happened and what the cause of the incident was. An investigation should consider unsafe conditions, acts, or procedures and help to identify practical corrective measures. The purpose of an investigation should not be to find fault or lay blame, but rather to identify the basic causes of the incident so that controls can be put in place to prevent further occurrences.

When conducting an investigation, look for the 'root cause'. There may be more than one factor that came into play in an incident. What may, at first, appear to be the obvious cause may, in fact, be the result of other factors such as:

- Work procedure used
- Material, equipment, or tools and their condition
- Worker experience, skills, abilities, or physical and emotional state
- Weather conditions or other factors
- Application of policies and procedures
- Inadequate or ineffective policies or procedures

Documentation of incidents, the investigations that result, and action plans arising from them is important. A landfill site should have standard templates for conducting and documenting each step. A sample template from Work Safe Alberta is included here in Appendix 2-1.

2.6.6 Personal Protective Equipment

If a hazard assessment identifies that personal protective equipment (PPE) is required, the landfill manager must make sure that the landfill staff are wearing and using their PPE properly. PPE must be kept in good condition to serve the purpose for which it was intended, and should be replaced if it is damaged. For example, cracked eye protection, worn safety footwear, or excessively dirty high-visibility clothing should be replaced.

The landfill staff should be trained in the proper use and maintenance of PPE such as hearing protection, respirators, or eye protection. Where respirators are required, a fit testing program needs to be implemented. Fit testing must be conducted by properly trained individuals.

It is common practice for landfill employees to wear:

- CSA approved steel toed footwear
- High-visibility vests or clothing
- Hard hats
- Gloves
- Hearing protection
- Coveralls or clothing that covers their legs and body
- Eye protection

Photo 2.14 – PPE
Photo Source: JLTechnical Services

2.6.7 Emergency Response

Landfill operators need to be prepared for a variety of emergencies including:

- Vehicle or equipment accidents
- Medical emergencies
- Fires or explosions
- Violent behavior of customers or employees
- Severe weather
- Environmental releases

The landfill operating plans should include an Emergency Response Plan (ERP). This plan should identify appropriate responses to emergency situations and who takes responsibility for managing the emergency situation. An important part of such a plan is the establishment of communication protocols during an emergency.

The ERP should identify evacuation procedures for customers and staff from buildings, site facilities, and the site itself. A pre-identified place for everyone to meet, or 'muster point(s)' should be identified and a procedure established for a roll call to establish that no one has been left behind.

Emergency numbers should be posted and readily available to all landfill staff. In the event of an emergency, the roles of each individual needs to be identified and known. The landfill employees should conduct regular emergency drills so that when an emergency occurs, the staff is well practiced. Drills also provide opportunity to identify issues with response actions and allow for refining the response procedures.

In the case of severe weather, such as tornado warnings, there should be a plan for warning employees and for shelter of employees and customers.

An example of a detailed emergency response plan is available on the web page of SWANA Northern Lights.

APPENDIX 2-1

Templates:

Formal Hazard Assessment and Control Form

Site Specific (field level) Hazard Assessment and Control Form

Sample Incident Reporting and Investigation Form

Source: Work Safe Alberta

Formal hazard assessment and control (template)

Job/position/work type:						Date of assessment:
Assessment performed by: (names)						Reviewed/revised:
Tasks (List **all** tasks/activities of the job/position)	Hazards (List **all** existing and potential health and safety hazards)	Severity **S**	Likelihood **L**	Risk **R**	Controls (List the controls for each hazard: Elimination, Engineering, Administrative, Personal Protective Equipment)	Date implemented:

Severity:	Likelihood:	Risk:
How serious could the consequences be? **3** – It could kill you or cause a permanent disability, today or over time. **2** – It could send you to the hospital. **1** – It could make you uncomfortable.	How likely is it going to happen? **3** – It is highly likely. **2** – It might happen. **1** – It is unlikely.	Calculate the risk of hazards to prioritize preventive actions. Severity x Likelihood = Risk

This form is for example purposes only. Completing this form alone will not necessarily put you in compliance with the legislation. It is important and necessary that you customize this document to meet the unique circumstances of your work site. Further, it is essential that this document is not only completed, but is used, communicated, and implemented in accordance with the legislation. The Crown, its agents, employees or contractors will not be liable to you for any damages, direct or indirect, arising out of your use of this form.

Site-specific hazard assessment and control (template)

Company name:	
Work to be done:	Date of assessment:
Task location:	Emergency meeting location:

Identify the tasks and hazards below, and the plans to eliminate/control those hazards

Tasks (List **all** tasks/activities)	Hazards (List both health and safety hazards and consider surrounding area)	Plans to eliminate/control (List the controls for each hazard: Eliminate, Engineering, Administrative, Personal Protective Equipment)

Please print and sign below (all members of the crew) prior to commencing work

By signing this form, you acknowledge that you understand the hazards and how to apply the methods to eliminate or control the hazards.

Worker's name (Print)	Signature	Worker's name (Print)	Signature
Supervisor's name (Print)		Supervisor's signature	

This form is for example purposes only. Completing this form alone will not necessarily put you in compliance with the legislation. It is important and necessary that you customize this document to meet the unique circumstances of your work site. Further, it is essential that this document is not only completed, but is used, communicated, and implemented in accordance with the legislation. The Crown, its agents, employees or contractors will not be liable to you for any damages, direct or indirect, arising out of your use of this form.

Sample Incident Reporting and Investigation Form

Name of worker:
_____
Position: _____ Department: _____
Location of incident:
_____
Date of incident: _____Time: _____ am pm
Type of incident: Near miss ☐ Minor injury ☐ Serious injury ☐
Date incident reported: _____ Time : _____ am pm
Reported to:
_____
Nature of injury (if any):
_____
_____
____
Witnesses:
_____
_____
____

Damage to equipment or property:
_____

Description of incident:

Identified causes (direct, indirect, root)

Recommended Preventative Action:	
To be completed by:	Date:

Follow - up

By:	Date of follow-up:

Name of person investigating: _____

Signature: _____

03 Chapter

Regulation for Environmental Protection

Regulation for Environmental Protection

This chapter discusses the rules that have been put in place by the Province of Alberta and the Government of Canada to ensure that the management of waste in Alberta, including through the operation of landfills, is done in a manner that is protective of air, water and land (the environment), of health and safety (people) and of fish and wildlife.

It is important that landfill operators are aware of the many rules that they must adhere to in their roles. The discussion here is necessarily general to keep this manual to a manageable size. Effort has been made to identify all of the relevant legislation and the rules that flow from that legislation and also to highlight what the authors believe to be the most important aspects for landfill operators to be aware of.

This manual cannot replace the actual documented legislation and rules and landfill owners and operators are encouraged to refer to the most recent versions of those from the originating sources.

- Alberta documents are available at the Alberta Queen's Printer or at the AEP website.
- The Alberta Energy Regulator (AER) documents are available at the AER website.
- Federal documents are available at Government of Canada Justice Laws website.

Municipal bylaws may also apply to waste management facilities. Refer to local authorities for information.

Learning objectives of this chapter include:

- Understanding the need for regulatory control of landfill operations
- Understanding the mechanisms used by government to put those controls in place
- The relationship between the different regulatory tools used by government
- Gain familiarity with the most important elements of the regulatory framework applying to Alberta landfills
- Gain awareness of the full gamut of legislation and rules, provincial and federal, that come in to play at different operations depending on the specific site and activities undertaken there
- Understanding the importance of understanding the particular rules that apply to each landfill as set out in site-specific provincial Approvals
- Understanding the importance of monitoring and record-keeping to ensure rules are followed and that fact is documented

3.1 ALBERTA REGULATORY FRAMEWORK

Acts and regulations are made by government. Acts give government the authority to create regulations and other rules in support of the goals of the act. In general, the hierarchy of the various rules that govern how landfills are designed and operated are shown in Figure 3.1.

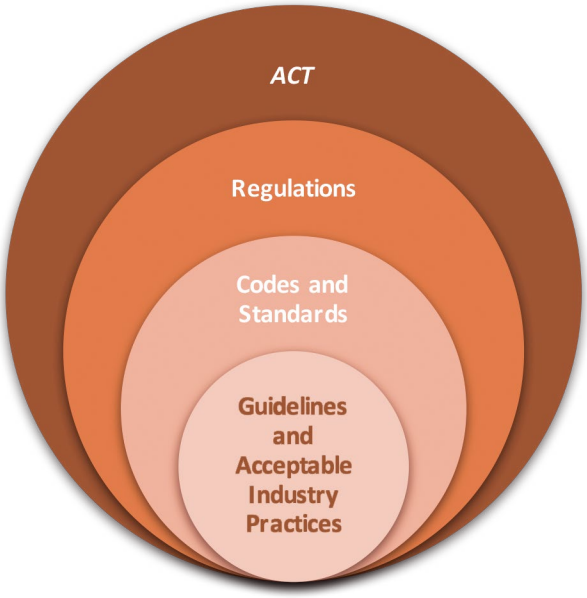


Figure 3.1 – Hierarchy of Rules that Govern Landfills

For further information on government processes involved in development and adoption of legislation, see the Citizen's Guide to the Alberta Legislature.

Alberta Environment and Parks (AEP) is the **principal regulator** of landfill facilities in Alberta. However, there is both provincial and federal legislation that applies to landfills in Alberta.

There are two other agencies that provide guidance to landfill operators in Alberta.

The **Canadian Council of Ministers of Ministers of the Environment** (CCME) develops and publishes **guideline documents** addressing areas of environmental protection that are important and common to all the provinces and territories of Alberta. Their guidelines are often adopted formally by the provinces through reference to them in provincial legislation.

The **Alberta Energy Regulator** (AER) is an independent agency of the Government of Alberta that has regulatory jurisdiction over matters relating to the development of energy resources, including oil and gas, in Alberta. Of relevance to landfill owners and operators, the AER has issued **Directives** that relate to the handling and disposal of waste materials arising from the activities they regulate.

Figure 3.1 summarizes the various regulatory bodies and the legislation, regulatory documents, guidelines and directives **that are relevant to landfill operators in Alberta** and are further discussed in this chapter.

3.2 THE ALBERTA ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACT

The Alberta Environmental Protection and Enhancement Act (EPEA) is the principal piece of legislation regulating landfills in Alberta. EPEA is not just about waste and landfills. It is about protecting the environment – air, land and water – in all activities within the province. In the context of this manual, the act gives government the authority to write regulations for appropriate management of waste. Figure 3.1 lists the many pieces of legislation and instructive documents that fall under EPEA which are relevant to landfill owners and operators. As is clear from the length of the list, there is much for owners and operators to be aware of within this important piece of legislation. The most relevant documents are further discussed in this chapter. Owners and operators are encouraged to become familiar with all the rules that apply to their particular operations.

It is important to know that EPEA also provides the powers of inspectors and investigators. These government staff have the authority to audit, inspect, and enforce requirements of the act and regulations. It provides the powers to issue orders and to apply penalties for non-compliance ranging from fines to requiring facility closure.

3.2.1 The Waste Control Regulation

As the name would suggest, the Waste Control Regulation is the principal piece of legislation governing waste management and thus landfill development and operation in Alberta. The Waste Control Regulation:

- Regulates the handling, storage, recycling and disposal of hazardous and non-hazardous wastes
- Defines what is hazardous waste
- Provides a classification system for landfills (Class I, II and III)
- Provides a classification system for composting facilities (Class I and II)
- Provides a financial security requirement for private landfills
- Puts in place the requirement for operators of waste management facilities to be certified by the province
- Establishes the various Codes, Standards, Guidelines and Acceptable Industry Practices listed in Figure 3.1 – the most relevant of which are discussed below

The regulation defines landfills by the type of waste they are allowed to receive. In general terms:

- A Class I landfill is a landfill for hazardous waste
- A Class II Landfill is a landfill for non-hazardous waste (Municipal landfills)
- A Class III landfill is a landfill which can only accept inert waste (construction and demolition waste)

Landfills in Alberta
In 2015, operational landfills include:
Class I landfills – 2
Class II landfills – 72
Class III landfills – 12

ALBERTA ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACT

Waste Control Regulation

- Code of Practice for Landfills
- Code of Practice for Land Treatment of Soil Containing Hydrocarbons
  - Standards for Landfills in Alberta
  - Alberta User Guide for Waste Managers
  - Guidelines for Landfill Disposal of Sulphur Waste and Remediation of Sulphur Containing Soils
  - Alberta Landfill and Composting Facility Operator Certification Guideline

Acceptable Industry Practices:

- Aerosol Cans
- Beneficial Use of Waste
- Car Wash Sump Wastes
- Dental Amalgam
- Fluorescent Lamps
- Industrial Sump and Pit Waste
- Importation of Hazardous Recyclables
- Disposal of Asbestos Waste
- Disposal of Biomedical Waste
- Coal Ash
- Designated Leachable Wastes in Alberta
- Importation of Hazardous Waste
- Chemically Treated Wood Waste
- Quality of Treated Waste of Contaminated Soil Used as Intermediate Cover at Class II Landfills

Approvals and Registrations Procedure Regulation

Activities Designation Regulation

Substance Release Regulation

Ozone-Depleting Substances and Halocarbons Regulation

Release Reporting Regulation

Pesticide Sales, Handling, Use and Application Regulation

Other Alberta Acts and Regulations:

Weed Control Act and Regulation

Climate Change and Emissions Management Act

Specified Gas Emitters Regulation

Specified Gas Reporting Regulation

Municipal Government Act

Water Act

Water Ministerial Regulation

Occupational Health and Safety Act

The Public Health Act

Canadian Council of Ministers of the Environment:

Guidelines for the Management of Biomedical Waste in Canada

The Alberta Energy Regulator:

Directive 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry

Federal Legislation Applicable to Waste Management in Alberta:

Transportation of Dangerous Goods Act

Canada Weights and Measures Act

Canadian Food Inspection Agency (CFIA) International Waste Directive

Canadian Food Inspection Agency (CFIA) Specified Risk Material

Migratory Birds Convention Act and Regulation

Fisheries Act

Figure 3.2 – Overview of Legislation and Regulatory Documents Relevant to Landfills in Alberta

CODES OF PRACTICE

A Code of Practice is a detailed set of requirements for a particular type of activity. Codes are often the relevant set of rules for small operations.

The Codes under the Waste Control Regulation provide clarity for various types of activities such as:

- Small landfills
- Composting facilities
- Small incinerators
- Land treatment of soil that has become contaminated with hydrocarbons (such as diesel, gasoline and other refined fuels)

If there are multiple types of activities occurring on a site, the operator may need to follow several codes.

All codes provide requirements for the type of operation, the volume and type of material that can be accepted, monitoring and record keeping requirements. Operators need to be able produce the records associated with these code-governed facilities if requested by the government. This may be in writing or during an inspection of the facility.

Following are summaries of several codes that apply to waste management facilities.

CODE OF PRACTICE FOR LANDFILLS

Every operating landfill must be aware of the Code of Practice for Landfills. It establishes requirements for Class II and III landfills that accept less than 10,000 tonnes per year of waste. The Code:

- Provides criteria for where a landfill can be sited in order to minimize environmental concerns (groundwater or surface water contamination) and issues with neighbors (states certain distances that it must be away from homes, schools, etc.)
- Describes what needs to be included in the design and construction of the landfill in order to protect the environment (liner, holding ponds, etc.)
- Specifies monitoring requirements
- Specifies what needs to be kept in records
- Have specific requirements for special waste such as asbestos, sulphur, hydrocarbons (if the landfill is permitted to accept these wastes)

The code also describes the closure and the post-closure monitoring that is required for a minimum of 25 years after the landfill has closed

Landfills located on Federal Lands

In Alberta, there are some facilities exempt from Alberta regulation. These are landfills and waste management facilities located on federal lands, such as First Nations reserves.

Landfills on federal lands require permits issued by Indigenous and Northern Affairs Canada and must follow rules set out in those permits. Several reserves are members of regional landfill authorities and may have waste transfer stations that are operated and managed to meet the requirements of the contracts with the authority.

CODE OF PRACTICE FOR LAND TREATMENT AND DISPOSAL OF SOIL CONTAINING HYDROCARBONS

The Code of Practice for Land Treatment and Disposal of Soil Containing Hydrocarbons outlines how these materials are to be handled and treated.

This code is only for facilities that are approved to treat soils containing hydrocarbons on site.

Landfill owners and operators considering accepting oilfield wastes for disposal should also investigate the requirements of the Alberta Energy Regulator, described in Section 3.10.

CODE OF PRACTICE FOR COMPOST FACILITIES

The Code of Practice for Compost Facilities outlines the design and operating requirements for compost facilities. It establishes the rules for facilities receiving less than 20,000 tonnes of material per year. It also defines monitoring requirements and establishes compost product quality Standards. This code applies at landfill sites that have on-site composting facilities. Such sites will also need to have operators holding a Compost Facility Operator Certificate.

Following all clauses in a Code of Practice can avoid non-compliance reports or environmental protection orders or enforcement orders for non-compliance.

STANDARDS FOR LANDFILLS IN ALBERTA

The Standards are similar to the Code of Practice but are more detailed than the code. The Standards for Landfills in Alberta include minimum requirements for Class I, II and III Landfills for:

- Development
- Operation
- Monitoring
- Closure
- Post-closure monitoring

The Standards apply to new landfills, new cells at existing landfills, and expansions at existing landfills, and provide the basis for approvals.

GUIDELINES

Guidelines provide detail for the management of specific materials or testing methodology.

Alberta Environment and Parks (AEP) publishes guidelines that may apply to waste management facilities. Guidelines provide best management practices. Guidelines do not use legal language, and use softer terms such as “should” and “may”. It is recommended, though, that landfill owners and operators follow guidelines where they apply as a due diligence approach. Some guidelines do become regulatory requirements if they are referenced in a regulation, a code, or in an approval.

A summary of guidelines most applicable to landfills in Alberta is provided in the sections below.

GUIDELINES FOR THE DISPOSAL OF ASBESTOS WASTE

Asbestos can be dangerous to human health. Landfills that accept asbestos must have appropriate training and personal protective equipment for workers. Workers must also record where asbestos is buried so that the area is not disturbed in the future. The Guidelines for the Disposal of Asbestos Waste provide details to the transportation, handling, and landfill disposal procedures for waste asbestos materials.

This is an example of a guideline that is referenced in a Code, the Code of Practice for Landfills, and therefore, **must** be followed.

GUIDELINES FOR LANDFILL DISPOSAL OF SULPHUR WASTE AND REMEDIATION OF SULPHUR CONTAINING SOILS

The Guidelines for Landfill Disposal of Sulphur Waste and Remediation of Sulphur Containing Soils provide guidance to waste generators and landfill operators for the remediation and proper disposal of sulphur contaminated solid wastes. It outlines disposal methods by burial in a landfill or land cultivation to neutralize acids which are formed by biological conversion of sulphur in the soil.

This guideline is also referenced in a code and so must be followed.

ALBERTA USER GUIDE FOR WASTE MANAGERS

The Alberta User Guide for Waste Managers is a guiding document to help facility operators determine if a waste is hazardous. It is very important to know what waste is coming into your landfill.

This guide describes test methods to determine if a waste is hazardous. The guide is referenced by the Waste Control Regulation and must be followed.

ALBERTA LANDFILL AND COMPOSTING FACILITY OPERATOR CERTIFICATION GUIDELINE

Landfills have the potential to cause harm to people and the environment. It is extremely important that Landfill Operators understand the importance of their work and what can happen if their landfill is not operated properly. The Government of Alberta has put in place a requirement for every operating landfill and compost facility to have one or more certified operators. These operators are to be trained to understand how best to operate their facilities to protect people and the environment.

Alberta Landfill and Composting Facility Operator Certification Guideline establishes the framework and requirements for certification of landfill operators and compost facility operators. Additional information about this program can be found on the AEP website.

An overview of the certification program is provided in Chapter 1.

BEST MANAGEMENT PRACTICE: MANAGING WASTE MANAGEMENT FACILITIES FOR BEARS AND WILDLIFE

While not technically a guideline document in the same sense as those above, this document is referenced here as it provides information of a similar nature with similar intent.

For landfills located in areas that may be frequented by wildlife, Managing Waste Management Facilities for Bears and Wildlife is a guidance document that describes what is considered to be best management practice to reduce conflict with bears and other wildlife. The document describes practices for fencing, site management and securing of dumpster bins, where used.

ACCEPTABLE INDUSTRY PRACTICES

Acceptable Industry Practices (AIPs) describe preferred and acceptable approaches for the handling and disposal or recycling of specific waste streams. They are relevant both to landfill operators and to waste generators to properly manage wastes which may have specific environmental or safety concerns.

Acceptable Industry Practices fact sheets are available on AEP's website. They have been created for:

- Aerosol cans
- Car wash sump waste
- Chemically treated wood
- Asbestos waste
- Biomedical waste
- The use of contaminated soil as intermediate cover at Class II landfills
- Others (listed in Figure 3.1)

3.2.2 Activities Designation Regulation

The Activities Designation Regulations (ADR) provides the criteria which determine what activities require **approval, registration**, or **notification** as part of the regulatory process. In the case of landfills, determining factors include the amount and type waste being handled and the environmental sensitivity of the location.

In Alberta there are three different processes:

- An **approval** is more complicated and will establish a rigorous set of rules for the development and operation of a particular landfill which will go beyond the minimum requirements of the Code of Practice.
- A **registration** is a simpler process that requires only that the facility follow the Code of Practice. This is the typical requirement for small Class II or Class III landfills.
- A **notification** applies to activities or facilities that are deemed to have low potential to impact the environment. Most transfer stations require only a written notification be sent to AEP.

Approval versus Registration

The owner of a landfill that receives 10,000 tonnes or less of waste per year is typically only required to obtain a **registration**. The landfill must be built and operated according to the conditions set out in the Code of Practice for Landfills. A registration does not have a renewal period. AEP has the power to require a full approval if it deems that a particular landfill, though small, poses high risk to the environment due to, for example, poor hydrogeological conditions.

The owner of a landfill that receives more than 10,000 tonnes of waste per year is required to obtain an **approval**. The approval can include conditions that are specific to the landfill. The landfill must be built and designed according to the approval conditions. Approvals typically have a 10-year renewal period. Approval conditions are subject to public comment and may be appealed.

3.2.3 Substance Release Regulation

The Substance Release Regulation defines acceptable and prohibited substance releases to air. Of most relevance to landfill operations are the rules around burning of materials. The burning of anything, with the exception of clean wood, will result in a reportable substance release. The burning of clean wood waste must also follow the regulation and cannot create dense smoke, odours, visibility issues or cause a nuisance to neighbours.

Burning of anything besides clean wood (or burnable debris) can result in human health issues and fines.

An unintentional trash fire at a landfill site should be considered to be a cause of a reportable substance release event and AEP must be notified as per the Release Reporting regulation.

Where a landfill owner operates a controlled burn area at a waste management facility, burning must comply with requirements of the Substance Release Regulation.

A Fact Sheet on burning waste is available on AEP's website.

3.2.4 Release Reporting Regulation

The operation of a landfill has the potential for spilling or releasing environmentally damaging substances in various ways, including:

- Leaks of hydraulic fluid, oil, antifreeze, and fuels from vehicles and heavy equipment
- Spills from on-site tanks
- Leachate spills or releases to surface or to the groundwater
- Litter spreading to surrounding properties
- Fires with prohibited debris

Any release or spill that has the potential to create an adverse effect (such as damage the environment) must be reported to government.

The Release Reporting Regulation specifies when and to whom a release or spill needs to be reported.

Not reporting releases can result in excessive environmental damage (if the damage from a release could have been minimized or fixed), fines or an order to shut down a facility.

3.2.5 The Ozone-Depleting Substances and Halocarbons Regulation

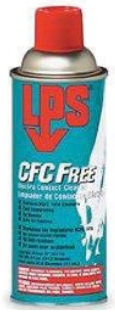
Many landfills accept freezers, air conditioners and refrigerators which are often referred to as "white goods". White goods containing refrigerants need to be kept separate from other waste products as they contain chlorofluorocarbons or halocarbons. Chlorofluorocarbons (CFC) or halocarbons impact the environment if released to air by damaging the earth's atmospheric ozone layer. The Ozone-Depleting Substances and Halocarbons Regulation establishes rules about how these chemicals must be handled.

White goods containing refrigerant must not be landfilled. They need to be stored separately and have the ozone depleting substances removed by a trained person. The regulation also applies to vehicles and heavy equipment that have air conditioners. If equipment air conditioning systems need repair or need to be re-charged you must have a certified technician do that work.

Once the CFCs have been removed from white goods, they can safely be recycled with other scrap metal.

Improper handling of CFC containing goods can result in human health issues and fines.

Special Note: Propane powered fridges and freezer units, often used in recreational vehicles, can contain ammonia gas. Ammonia gas has serious health and safety concerns and should not be released to atmosphere. Ammonia-containing units should be kept apart from other refrigerant-containing appliances and be de-contaminated by a technician certified to do so.



An **Ozone Depleting Substances Certificate** issued through the Heating Refrigeration and Air Conditioning Institute of Canada is required to qualify a person to recover refrigerants in Alberta. A landfill operator may obtain the certificate and purchase the required equipment for recovery of refrigerants, or may hire a qualified contractor. The contractor's certification should be verified.

3.2.6 Pesticide Sales, Handling, Use and Application Regulation

Pesticides are poisonous to humans and animals and are toxic to the environment. Some landfills use pesticides for weed control. Some landfills also collect empty pesticide containers delivered by area farmers. This regulation sets rules for the handling and use of these products.

The Pesticide Sales, Handling, Use and Application Regulation sets rules for the control of pesticides from the point of sale through to its application. Included in the regulation are specific requirements regarding the disposal of pesticide container materials and the disposal of treated seed or grains at landfills.

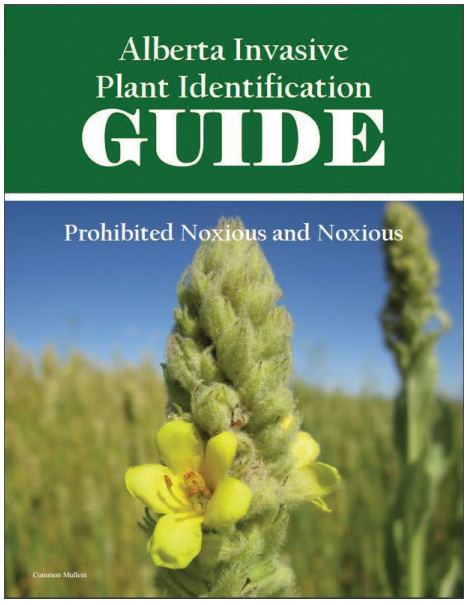
During an inspection good records can help prove intent and ward off fines.

3.3 *WEED CONTROL ACT* AND REGULATION

The *Weed Control Act* and its companion regulation aim to regulate noxious weeds, prohibited noxious weeds, and weed seeds through various control measures, such as inspection and enforcement, together with provisions for recovery of expenses in cases of non-compliance.

Landfill sites are susceptible to weed infestations since by the nature of their operation there are generally large areas of exposed soils, exposed to wind, birds and other means of seed distribution. The legislation establishes plants that are considered noxious weeds and others that are considered prohibited noxious weeds. Both provincial and local municipal officials are empowered to issue clean-up orders under this legislation.

A guide document has been developed to assist individuals in identifying noxious weeds.



3.4 *CLIMATE CHANGE AND EMISSIONS MANAGEMENT ACT*

The *Climate Change and Emissions Management Act* enables much of Alberta's strategy to reduce greenhouse gas emissions. Regulations and Standards under the Act provide the details of the rules and methods that must be applied.

The main sources of greenhouse gas emissions in landfill operations are:

- Release of landfill gas produced as waste decomposes
- Burning of fossil fuels in equipment operation

Emissions need to be quantified and reported for larger operations. If they are above a certain level the facility will be classified as a "large emitter" under the act. The Specified Gas Emitters Regulation under the *Climate Change and Emissions Management Act* has defined large emitters as facilities that emit more than 100,000 tonnes of greenhouse gases a year. Facilities would use the Technical Guidance for the Quantification of Specified Gas Emissions from Landfills to calculate these emissions.

Large emitters are required to reduce greenhouse gas (GHG) emissions. Some landfills reduce emissions through landfill gas recovery projects that result in the gas being either flared or used as an energy source. Large emitters, including landfills, also have the options of paying into the Climate Change and Emissions Management Fund or purchasing greenhouse gas reduction credits. Greenhouse gas reduction credits can be bought from facilities or projects that have extra to sell.

The Climate Change and Emissions Management Fund is administered by the Climate Change and Emissions Management Corporation (CCEMC) which has a mandate to use the fund to support new and innovative projects that will reduce GHG emissions in Alberta. Some waste management facility operators in Alberta have benefitted from financial support from the fund for new projects such as LFG collection and use.

This act and its regulations and standards describe how voluntary projects can quantify greenhouse gas reductions, which gives them the ability to sell credits to large emitters. Quantification protocols are used to guide various projects that have a net greenhouse gas reduction in Alberta. These protocols explain how greenhouse gas offsets can be calculated for certain projects. For example, composting organics instead of disposing in landfills can decrease greenhouse gases. The composting protocol explains how to calculate how much of a reduction can be used for a credit.

Some projects that can actively reduce greenhouse gases on landfill sites in Alberta include:

- Composting
- Recycling
- A landfill gas collection system (with flaring or use as an energy source)
- A solar energy project
- Wind power generation

The Specified Gas Reporting Regulation also establishes the detailed requirements for reporting by emitters of greenhouse gases. Any facility, including a landfill that releases more than 50,000 tonnes of greenhouse gas per year is required to file a report. For the purposes of this Regulation and the Act, greenhouse gas is reported as tonnes CO_2e (CO_2 equivalent). Different gases have different Global Warming Potential (GWP) factors. CO_2 has been assigned a GWP of 1. The methane in landfill gas has been assigned a GWP factor of 25. That means that the release of one tonne of methane will be reported as the release of 25 tonnes CO_2e.

3.5 *MUNICIPAL GOVERNMENT ACT*

The *Municipal Government Act* gives municipalities the responsibility to ensure there is proper management of waste within their boundaries. It also gives local governments (county, town, municipality) the ability to make rules that can affect operation of a landfill within their boundaries. Every landfill will have a land use bylaw or development permit that has been developed by the local government. There may be requirements for things such as:

- Setbacks (distance from town, houses, parks, etc.)
- Litter control
- Hours of operation
- Appearance
- Any other matter deemed important by that government

3.6 *WATER ACT*

The purpose of the *Water Act* is to support and promote conservation and management of water including its wise allocation and use. For example, a Water Act license is required to use or divert surface water or groundwater.

The act applies to landfill facilities where water is redirected or removed or where off-site drainage is impacted. The act defines what constitutes a water body and can affect development of a landfill near a water body.

Alberta also has established the Wetland Policy which is important to review if a landfill is being built or operated near a designated wetland.

3.6.1 Water (Ministerial) Regulation

The Water (Ministerial) Regulation includes requirements for drilling, monitoring well construction and borehole and monitoring well reclamation as they apply to landfill site investigations and groundwater monitoring programs.

Some sites that use water for things such as dust control may be required to report the amount of water that they use on the site, based on the water license.

3.7 *OCCUPATIONAL HEALTH AND SAFETY ACT*

Rules for health and safety in workplaces are set out in the *Occupational Health and Safety Act*, Occupational Health and Safety Regulation, and Occupational Health and Safety Code. Landfill site health and safety is fully discussed in Chapter 2.

3.8 THE *PUBLIC HEALTH ACT*

The *Public Health Act* is the act that prevails over every other Alberta Government act (Except for the Alberta Bill of Rights). Essentially this means that if a landfill may cause or is causing a public health threat, the Public Health Ministry can direct what actions are required to remove the threat.

3.9 CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT – GUIDELINES FOR THE MANAGEMENT OF BIOMEDICAL WASTE IN CANADA

These guidelines are referenced in the Code of Practice for landfills and in all landfill approvals and are therefore minimum requirements that must be followed at a landfill site in Alberta.

Biomedical waste in Alberta must be managed in accordance with the Guidelines for the Management of Biomedical Wastes in Canada. Untreated biomedical waste is not acceptable for disposal in Alberta.

These guidelines are published by CCME and provide recommended minimum practices for management of biomedical wastes. The Guidelines relate to:

- Waste reduction
- Segregation
- Collection
- Containment
- In-house movement
- Storage
- Transportation
- Disposal (on and off-site)
- Occupational health and safety issues

The Canadian Council of Ministers of the Environment (excerpt from CCME web page, March 29, 2016)

"CCME is the primary minister-led intergovernmental forum for collective action on environmental issues of national and international concern.

CCME is comprised of the environment ministers from the federal, provincial and territorial governments. The role of President of CCME rotates among the 14 ministers of environment on an annual basis. These 14 ministers normally meet at least once a year to discuss national environmental priorities and determine work to be carried out under the auspices of CCME. The Council seeks to achieve positive environmental results, focusing on issues that are Canada-wide in scope and that require collective attention by a number of governments. Since environment is constitutionally an area of shared jurisdiction, it makes sense to work together to promote effective results."

3.10 THE ALBERTA ENERGY REGULATOR

The Alberta Energy Regulator (AER) is an independent agency of the Government of Alberta which regulates the development of Alberta's fossil fuel and energy resources including:

- Oil
- Natural gas
- Oil sands
- Coal
- Pipelines

The AER has issued Directives that tell landfill operators how to deal with specific wastes. Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry is an important document that describes the requirements and processes for characterization, classification, transport, and disposal of oilfield wastes. The specific requirements for documentation and tracking (manifesting) are described in detail.

Oilfield waste that goes into a landfill has specific requirements depending on the level of contamination of the waste. It is important to know about these as there may be limitations on how and where this material can be placed or if it can be placed at all.

Other Directives that apply to waste operators include:

- Interim Directive 99-04 Deposition of Oilfield Waste into Landfills
- Interim Directive 2000 – 03 Harmonization of Waste Management
- Interim Directive 2000 – 04 Update to Requirements for the Appropriate Management of Oilfield Waste

Naturally Occurring Radioactive Material

Some wastes may contain Naturally Occurring Radioactive Material (NORM). In Alberta, most NORM is generated from oil and gas operations and is managed for the generator by specialty industrial waste management companies in accordance with rules established by the Alberta Energy Regulator. The material must be taken to approve treatment or disposal facilities. There are no disposal facilities for NORM in Alberta at the time of publication of this study guide.

For current information on managing and disposing of NORM within Alberta, contact AEP or the AER.

For more information on NORM, an overview is provided at the website of the Canadian Nuclear Safety Commission (CNSC).

3.11 FEDERAL LEGISLATION APPLICABLE TO WASTE MANAGEMENT IN ALBERTA

3.11.1 *Transportation of Dangerous Goods Act*

Some wastes have the potential to be dangerous to workers or the environment specifically during transportation. *The Transportation of Dangerous Goods Act* (TDGA) and its companion regulation, the Transportation of Dangerous Goods Regulation, establish rules around different types of hazardous wastes, what precautions must be taken when they are transported, and requirements for manifesting and appropriate marking (placarding) of vehicles transporting them.

Training is required for landfill staff who handle dangerous goods that are transported on or off site.

3.11.2 *Canada Weights and Measures Act*

At many landfills, waste weights are being used to calculate costs for clients. Under the provisions of the *Weights and Measures Act*, when fees are based on the scale readings, these scales must be certified on a prescribed frequency. An accredited service provider must perform the calibration and certification.

3.11.3 Canadian Food Inspection Agency (CFIA) International Waste Directive

Waste from other countries has the potential to contain diseases and invasive species of plants which can hurt people or the environment. Under provisions of the International Waste Directive, a landfill taking international waste must have a special CFIA permit to accept these wastes. This permit will specify the process for handling the international waste which may require specific personal protective equipment (PPE) and includes things like depth of burial and method of covering prior to compacting.

Waste removed from air flights arriving from other countries is an example of waste that must be managed as per the International Waste Directive.

3.11.4 Canadian Food Inspection Agency (CFIA) Specified Risk Material Guidance

The Canadian Food Inspection Agency (CFIA) established policies for management of specified risk material, or SRM. A landfill taking SRM must have a permit to accept this waste. The permit will specify the process for dealing with this waste including things like depth of burial and method of covering prior to compacting.

SRMs have the potential to spread diseases such as:

- Mad cow (Bovine spongiform encephalopathy – or BSE)
- Scrapie
- Chronic wasting disease

3.11.5 *Migratory Birds Convention Act* and Regulation

Many birds are protected under the *Migratory Birds Convention Act*. Some species, such as gulls, are attracted to landfills.

Nesting habitat for migratory birds must also be protected. If there is nesting habitat at or near a landfill, precaution must be taken. As an example Canadian Geese nesting pairs often find a habitat near or along landfill run off control ditches or in compost piles. The act requires they not be disturbed or moved unless a permit has been granted.

The regulation establishes the process through which landfill operators can obtain permits to manage birds at a landfill. Some types of bird control programs also require a permit from Alberta Fish and Wildlife. Operators should always check with the local office.

3.11.6 *Fisheries Act*

The purpose of the *Fisheries Act* is to protect fish and fish habitat. Should a landfill allow contaminated ground or surface water to discharge into fish bearing water, the penalties of the act may apply due to the requirement that:

"No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions ..."

3.12 REGISTRATIONS AND APPROVALS

3.12.1 Understanding Approvals

The Approval issued by AEP is a **site-specific** document that landfill staff must review, understand, and implement. It set outs the minimum requirements to which the site and its operators will be held accountable. The landfill manager and lead operators should establish the necessary programs, policies and procedures and deliver training so landfill staff knows what they need to do to comply with the approval. Many landfill authorities retain engineering consultants to update documents and recommend improvements to landfill operations to assist with meeting approval conditions. It is also advisable for landfill management to review the approval with AEP approvals staff to clarify the interpretation of clauses.

Approvals set out site-specific requirements. Clauses included in an approval may include additional or varied requirements to those included in the Standards, depending on site-specific conditions and concerns raised by the public or other stakeholders through the consultation processes leading up to issuance of the Approval.

Landfill approvals in Alberta typically follow an outline similar to the one shown in the box below. A more complete description of what is typically in each section is provided in Appendix 3-1 at the end of this chapter.

A landfill Approval in Alberta is a substantive and comprehensive document which makes it important but also helpful to landfill owners and operators as it clearly spells out many key obligations and expectations.

Landfills Approval Outline

Part 1 Definitions

Part 2 General
- Section 2.1 Reporting
- Section 2.2 Record Keeping
- Section 2.3 Analytical Requirements
- Section 2.4 Other

Part 3 Landfill Construction
- Section 3.1 General
- Section 3.2 Soil Conservation

Part 4 Landfill Operations, Limits, Monitoring and Reporting
- Section 4.1 General
- Section 4.2 Landfill Operator Certification
- Section 4.3 Operations Plan
- Section 4.4 Waste Acceptance
- Section 4.5 Special Waste
- Section 4.6 Nuisance Management
- Section 4.7 Leachate Management
- Section 4.8 Landfill Run-on and Run-off Management
- Section 4.9 Subsurface Landfill Gas Management
- Section 4.10 Domestic Wastewater
- Section 4.11 Landfill Monitoring and Reporting
- Section 4.12 Groundwater

Part 5 Landfill Closure, Reclamation, Post-Closure Care
- Section 5.1 Landfill Closure and Reclamation
- Section 5.2 Post-Closure Care

3.12.2 Understanding Registrations

A Registration is issued under the Code of Practice for Landfills and governs small landfills where a full Approval has not been required after review of the site concept by AEP staff. A landfill operating under a Registration is required to meet the general provisions set out in the Code. **The Code essentially takes the place of a unique site approval** and must be followed carefully as it sets out the minimum requirements to which the site and its operators will be held accountable. Landfill Managers need to see that all staff are trained with the responsibilities they have to ensure compliance with the Code. It is also advisable for landfill management to review the Code with AEP approvals staff to clarify the interpretation of clauses.

While not site-specific like an approval, the Code's universal requirements require that landfill staff follow an Operations Plan, that annual groundwater and surface water monitoring takes place and is documented. In some cases, subsurface landfill gas monitoring is required. An annual report and landfill operating record must be maintained. In most cases an engineering consultant will have assisted with the development of the Operations Plan so that it complies with the code, and will have developed a landfill monitoring plan for the **landfill** staff or a third party consultant to implement.

Many Operations Plans provide a variety of standard forms for the operators to use. Examples include:

- Daily, weekly, and monthly inspection
- Waste Inspection Audit
- Visitor Log
- Complaint log
- Leachate level
- Leachate removal record
- Special waste approval and disposal

3.12.3 Ensuring Compliance

Having well-trained staff who are completely familiar with the terms of a particular site's Approval or Registration (and the Code of Practice) is an important part of ensuring compliance.

Alberta Environment and Parks inspectors can be expected to visit sites from time to time and will issue instructions and compliance orders if they find any non-compliance issues. Many site owners and operators choose to verify compliance with their Approval/Registration and all regulatory requirements by retaining a specialty consultant to conduct regulatory compliance audits. Frequency varies, but once every three years is common. This enables owners and operators to correct deficiencies, if they exist, pro-actively, rather than after an AEP inspection. This approach also demonstrates to AEP and other stakeholders, such as the community, that the site is being diligently operated. Of course, a core benefit is in being aware of any issues which could lead to environmental impacts and dealing with them, hopefully before those impacts occur.

APPENDIX 3-1
CONTENT OF A TYPICAL LANDFILL APPROVAL IN ALBERTA

Part 1 Definitions

- The Definitions section includes descriptions to terminology used in the approval. It is recommended to review all the definitions before reviewing approval clauses as the interpretation of a definition can change the interpretation of the clause
- For example, the active landfill area is commonly interpreted as the landfill footprint by landfill operators, but in an approval, it may be defined as the landfill footprint, site roads, recycle areas, and the scale
- Another example where an approval may vary from standard landfill 'jargon', is the definition of litter. Landfill operators may call it litter, windblown debris, air jelly-fish, or some other term. The approval will call it 'Fugitive Waste'

Part 2 General

Section 2.1 Reporting

- The Reporting section includes the requirement to report contraventions, report any additional sample results taken above and beyond approval requirements, and to report if the landfill is going into receivership (bankruptcy)

Section 2.2 Record Keeping

- The Record Keeping section required that all analytical results are to be kept on record for a minimum of 10 years. This information should be saved in the Landfill Operating Record

Section 2.3 Analytical Requirements

- The Analytical Requirements section outlines which guidance documents 3rd party consultants and landfill operations staff are to use to sample and analyze waste, soils, water, and air samples. Also, that samples are to be analyzed at a certified laboratory

Section 2.4 Other

- The Other section includes miscellaneous clauses for cancelling the previous approval, that the clauses are severable (for legal action), and which documents and/or requirements takes precedence if there is a conflict between regulatory requirements

Part 3 Landfill Construction

Section 3.1 General

- The General section includes the main requirements for a consultant to follow for the design and construction of:
  - A landfill cell
  - Landfill cap
  - Leachate pond
  - Storm water management system
  - Groundwater monitoring system
  - Subsurface gas monitoring system
- It also requires the submission of construction quality assurance and control plans and a construction completion report for landfill cells, landfill caps, and leachate ponds.

Section 3.2 Soil Conservation

- The Soil Conservation section outlines that all topsoil and subsoil is to be stripped and stockpiled separately, and only used for landfill reclamation. So all landfill sites should have topsoil and subsoil stockpiles that are maintained for landfill capping

Part 4 Landfill Operations, Limits, Monitoring and Reporting

Section 4.1 General

- The General section the legal location of the site, the maximum top of waste elevations, and includes the overview of what activities are to be operated and maintained at the landfill site such as Class II cells, Class III cells, recycling and diversion such as:
  - Tire storage
  - Metal storage
  - Household hazardous waste storage
  - What infrastructure exists at the site such as the scale house and maintenance building(s)

Section 4.2 Landfill Operator Certification

- The Landfill Operator Certification section outlines what level of certification is required for the site and that a change in operators must be reported.

Section 4.3 Operations Plan

- The Operations Plan section includes that the landfill must:
  - Develop
  - Maintain
  - Implement an Operations Plan

Due to the nature of the minimum requirements in the Standard and Approvals, consultants are typically contracted to prepare the Operations Plan and advise on monitoring and record keeping requirements. Operations staff should review and be trained with the Operations Plan and receive regular refresher training.

The basic content in the Operations Plan includes:

- Waste acceptance policies and procedures
- Waste that requires special handling
- Nuisance management
- Site safety
- Emergency response
- Environmental monitoring (leachate, surface water, groundwater, subsurface landfill gas)
- Wildlife Management Plan
- Liner Protection Plan
- Daily cover
- Record keeping and reporting

The Operations Plan must be reviewed and updated annually.

Section 4.4 Waste Acceptance

- The Waste Acceptance section outlines what waste is not permitted to be accepted for disposal, and, if it is received, the process for notifying AEP and having the prohibited waste removed.

Section 4.5 Special Waste

- The Special Waste section outlines the guidance documents to follow for specific special wastes such as:
  - Sulphur
  - Asbestos
  - Biomedical waste
  - Dead animals management
  - Hydrocarbon contaminated soils

Section 4.6 Nuisance Management

- The Nuisance Management section contains provisions for:
  - Fugitive waste (litter)
  - Odour
  - Dust
  - Active face management (minimized working face size, compaction, and cover)

The fugitive waste provisions will include litter retrieval clauses for on and offsite

Section 4.7 Leachate Management

- The Leachate Management section will include:
  - Clauses for the maximum leachate head level (30 cm above the lowest part of the cell liner)
  - Monitoring leachate head levels (frequency and location)
  - That leachate head levels must be managed to be below the maximum leachate head level after large precipitation events within 14 days
  - Sampling leachate (parameters)
  - Leachate disposal to approved wastewater treatment plants and/or deepwells
  - Onsite leachate management including evaporation and recirculation

Section 4.8 Landfill Run-on and Run-off Management

- The Surface Water Management section provides provisions for the run-on and run-off control systems, and that any water released offsite must meet the surface water release limits

Section 4.9 Subsurface Landfill Gas Management

- The Subsurface Landfill Gas Management section is typically developed and monitored by a consultant as part of the environmental monitoring plan. The section contains clauses that the landfill must develop and implement a subsurface landfill gas plan, and establishes subsurface landfill gas concentration limits at the property boundary and onsite structures

Section 4.10 Domestic Wastewater

- The Domestic Wastewater section outlines that any wastewater (seepage) generated onsite must be removed and disposed to an approved wastewater treatment facility

Section 4.11 Landfill Monitoring and Reporting

- The Landfill Monitoring and Reporting section includes the annual reporting requirements, hence, requires a summary of the annual operation and input from consultants for:
  - Groundwater
  - Surface water
  - Leachate
  - Subsurface landfill gas monitoring

  Due to the complexity of information required in approvals, consultant have been contracted to compile the annual reports for some landfill operations. The basic information required for monitoring and reporting which is required to be submitted to AEP by March 31 includes:
  - Leachate levels, quantity removed for disposal, quantity moved for onsite management, sample results
  - Subsurface landfill gas concentrations per monitoring event, trend analysis, and recommendations on improvement to system or if remediation required by a qualified professional
  - Landfill run off water quality upon release, quantity of water release, quantity of water used onsite (dust control, liner construction)
  - Landfill Operations tonnage disposed, tonnage removed from site (recyclables), detection of hazardous waste, tracking of waste disposed, cover management (type, soil used, etc.), fugitive litter (dates of litter picking), tracking size and location of active face daily
- The basic requirements for the annual report include:
  - A summary of the waste types stored
  - The deposition locations of special wastes for the year
  - A record of public complaints and the approval holder's response
  - A description of the operational problems and emergencies and how they were addressed for the year
  - The names and certificate numbers of the supervisory operators responsible for the operation of the landfill for the year

- An estimate of the landfill air space remaining based on survey results or amount of wastes received
- Summary of the information monitored for leachate, subsurface landfill gas, surface water, and landfill operations
- A summary of subsurface landfill gas monitoring data interpretation
- A groundwater monitoring annual report
- All landfill inspections records conducted
- A summary of the performance of the landfill run-on and run-off control systems
- A site map showing the status of the landfill operations at the end of the operating year, including but not limited to contour mapping, locations of active and inactive disposal areas, areas where a final cover has been placed, and location of new cell construction.
- A construction summary report for new cell construction
- A summary of update to the Operations Plan during the year and any proposed changes to the Operations Plan for the coming year
- Adjustments to environmental reserve fund necessary for final landfill closure and post-closure activities

Section 4.12 Groundwater

- The Groundwater section outlines the requirements for a third party consultant to develop, monitor, and report on a groundwater monitoring program. The program is typically developed to meet the requirement in the Standards. However, sites that have naturally poor groundwater or have contaminated groundwater from the landfill or other sources will need to have adjustments made to a typical groundwater monitoring plan. In some cases, there could be alternative performance standards or groundwater remediation required
- The general information provided in clauses in this section includes delineating a compliance boundary, developing a groundwater monitoring program (frequency, parameters, sample locations), and providing an annual groundwater monitoring report

Part 5 Landfill Closure, Reclamation, Post-Closure Care

Section 5.1 Landfill Closure and Reclamation

- The Landfill Closure section is applicable once landfill is approaching final closure, so there is no available room for waste disposal and final capping will be undertaken. This section includes clauses on the submission of a landfill closure plan, design for the final cap, and a final closure report once the landfill is capped

Section 5.2 Post-Closure Care

- The Post-Closure Care section includes what inspection and monitoring is required to maintain the integrity of the landfill cap and the annual reporting provisions for groundwater, subsurface landfill gas, and cap inspection activities

04 Chapter

Operation and Management

Operation and Management

A good landfill operation is safe, convenient for users, well-kept, protective of the environment, and satisfies all relevant regulations. To achieve these goals, it must be well managed and operated in accordance with an operations plan that reflects industry best practices and complies with the requirements of the site's approval or registration. This chapter focuses on these aspects of landfills in Alberta.

Learning Objectives

In this Chapter you will learn about:

- The environmental risks landfills pose to air, land and water
- Landfill operation plans
- Waste screening at waste management facilities
- Nuisance management including vectors, odours, noise, dust and weeds
- Weather issues including how to deal with rain, wind, cold and severe weather
- The importance of litter control and techniques to best manage it
- How to protect your landfill liner
- How to manage your airspace
- Collection, removal, treatment and disposal of leachate
- How to manage surface water on and off the landfill
- How to manage soil stockpiles and cover materials
- Best practices to manage recycling operations
- Equipment and equipment maintenance best practices
- How to manage and inventory facility supplies

4.1 IMPORTANCE OF FOLLOWING DESIGN

Today's landfills are sited and designed by engineers to exacting standards. Construction is carefully managed to ensure the design intent is captured and critical specifications are followed. Chapter 5 discusses landfill siting, design and construction in depth.

It is important for landfill managers to work with the facility engineer to understand the engineering design and to follow the design plan for the site. Varying from the plan can result in regulatory non-compliance issues and potential environmental impacts.

While initial development is generally overseen by the design engineer, many landfills are developed in stages with time passing and staff and engineers changing. It is important that over the entire course of the landfill's development, operation and closure that the design intent and details are followed. If changes are contemplated, they should only take place after review by a qualified engineer and, depending on the nature of change, approval by the regulator – in Alberta, Alberta Environment and Parks.

4.2 CONTENT OF A TYPICAL OPERATION PLAN

The operation plan for a landfill should be developed by qualified professionals, including the design engineer. The plan typically includes:

- Waste acceptance policies and procedures
- Nuisance management plan and controls
- Procedures for spreading, compacting and covering waste
- Emergency and site safety
- Surface water management
- Special waste handling procedures
- Wildlife management plan
- Liner protection procedures
- Leachate management plan
- Storage, processing, recycling, or composting procedures

In addition to the above, an operations plan needs to include development of the site over its operating life; including the phasing and sequencing of operations. Specific operation elements are discussed under the following topics. A detailed outline of the contents of an Operating Plan is provided in the typical landfill approval overview in Appendix 3-1.

4.3 TOPSOIL AND SUBSOIL SALVAGE AND STORAGE

Prior to construction of roads, parking areas, building sites, and new landfill cells, topsoil and subsoil must be stripped, salvaged and stored for future use. These two soil horizons (topsoil and subsoil) must be stored separately. The ultimate purpose is to use these soils to develop a final cover on the landfill with subsoil and topsoil to support vegetative growth.

Topsoil, or the "A" Horizon, is the surface layer of soil usually rich in organic matter, in which the majority of the plant roots are contained.

Subsoil is the "B" Horizon and are the soils directly below the topsoil. Subsoil contains less organic matter. Plant roots extend into the subsoil. Determining the dividing line between the two horizons can be difficult. A soils professional should determine existing topsoil and subsoil profiles prior to stripping. Depths and quantities can be determined with shallow test pits or hand auguring test holes. Stripping operations should be observed by the soils professional.

Topsoil should be stored on undisturbed topsoil, and subsoils on undisturbed subsoil surfaces. Stockpiles should be separated by at least one metre, and should be located away from other activities and in a well-drained location where they won't need to be disturbed.

To minimize erosion by wind and water, the soil stockpiles may be seeded with grass, or other plants such as clover. The landfill operators also need to be familiar with noxious weed growth on stockpiles and implement weed controls when needed.

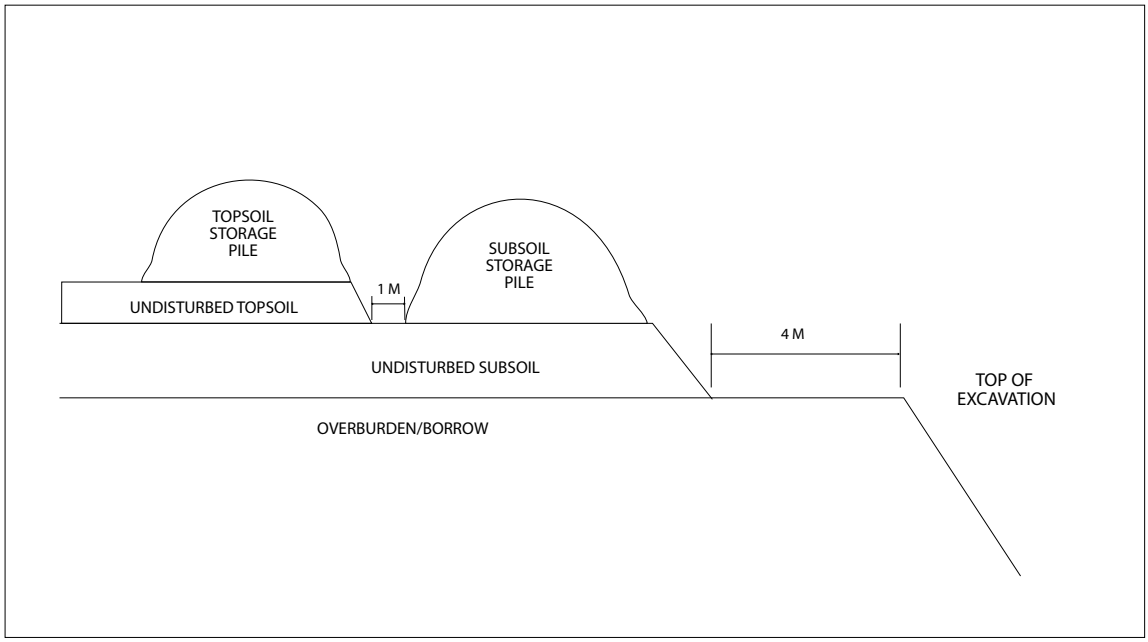


Figure 4.1 - Topsoil Piles Stored on Undisturbed Topsoil and Subsoil Piles Stored on Undisturbed Subsoil
Adapted from: Alberta Transportation Guide to Reclaiming Borrow Excavations, Dec. 2013

4.4 LANDFILL OPERATION

Once the landfill initial development has been completed in accordance with the engineered design, and the operations plan is complete, and the required regulatory approvals received, the landfill can begin operations.

4.4.1 Phasing and Sequencing

Apart from the smallest sites, most landfill are developed in a series of phases, with each phase filled in succession. As one phase is completed with a final cover and vegetation restored, a second phase is in operation, while a following phase is being prepared for construction. Figure 4.7 illustrates the concept.

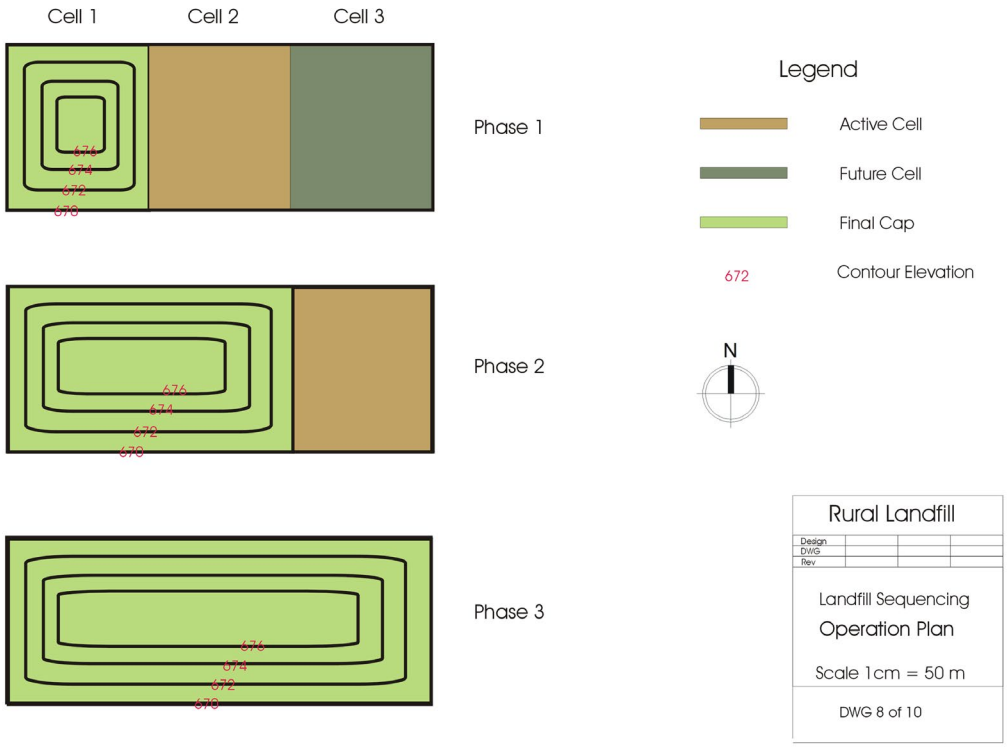


Figure 4.2 – Phasing Plan – Plan View
Source: JLTechnical Services

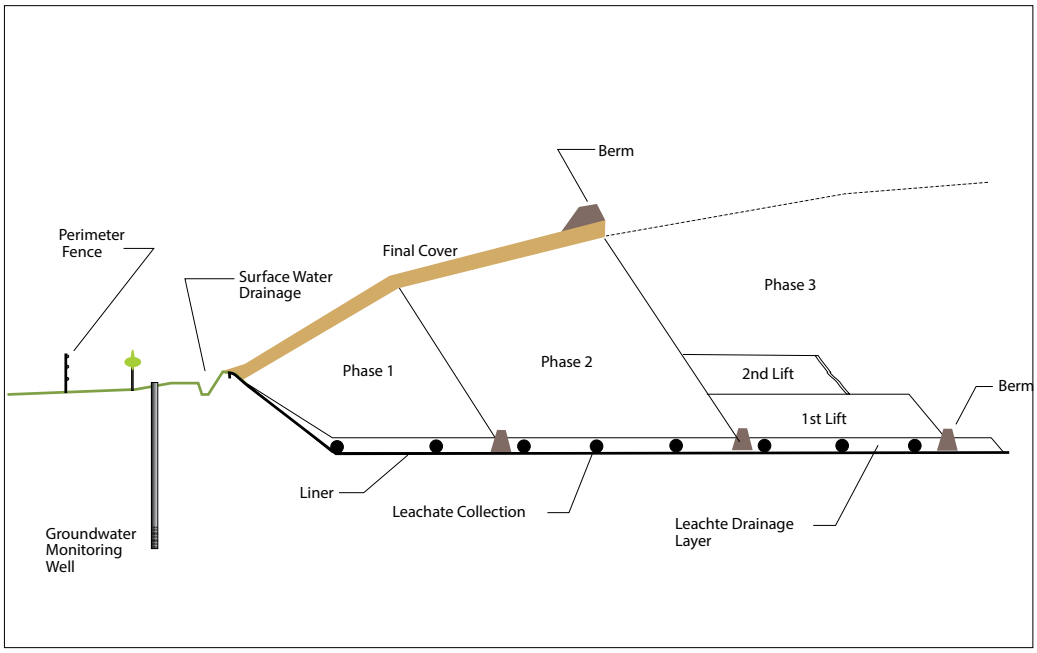


Figure 4.3 – Phasing of Development – Cross-Section
Source: JLTechnical Services

Often a completed phase will be covered with a temporary cover and left to settle for a period of time, sometimes years. If settlement is significant, more waste might be placed to bring the cell back to design grade before the final cap is placed. Stockpiling intermediate and daily cover soils on completed phases will recover airspace that can be re-filled at a later day by compressing the waste below.

4.4.2 Waste Acceptance Policies and Procedures

Some waste materials are not part of the Municipal Solid Waste (MSW) stream. These wastes include industrial wastes, oilfield wastes, sulphur waste and asbestos. They often contain chemicals and require waste characterization to determine if they are acceptable for the landfill under the terms of regulations, the landfill's approval, and the owner's policies. If these wastes have not been characterized, they should not be accepted. Some of these wastes are acceptable at a Class II landfill but require special handling. The industry has adopted the terminology of wastes which require "special handling", or, "special waste". The term is broadly used to describe a material that cannot be placed at the working face as part of routine operations. They may require processing (e.g. cutting of power poles into manageable size pieces, direct burying of asbestos and animal carcasses).

ACCEPTABLE WASTES

All landfill owners should have written policies for waste acceptance. The policy should identify the waste types that are acceptable and those that are prohibited. Besides those wastes prohibited by regulations or by the site approval, some landfills may have site-specific prohibitions that encourage waste diversion or prohibit a waste that the landfill is not equipped to manage.

Alberta legislation establishes the type of wastes acceptable for disposal in a landfill based on the classification of the landfill. The following is a generalized summary of the types of wastes that are acceptable at the three classes of landfills in Alberta.

Class I Landfill	Solid Hazardous Waste as defined in the Waste Control Regulation
Class II Landfill	Municipal solid waste
	Non-hazardous industrial solid wastes
Class III Landfill	Inert waste, such as construction and demolition waste

PROHIBITED WASTE

Table 4.1 provides a generalized, and NOT exhaustive, summary of the types of wastes that are prohibited for disposal at the three classes of landfills in Alberta.

Table 4.1 – Types of Waste Prohibited from Alberta Landfills

TYPE OF LANDFILL	PROHIBITED WASTE
Class I Landfill	• Liquid Hazardous Waste • Any waste prohibited from landfills by the Waste Control Regulation
Class II Landfill	• Hazardous waste or dangerous oilfield wastes • Liquids in containers greater than 5 litres • Untreated Biomedical waste • Domestic sewage • Waste with a flash point less than 61°C • Radioactive materials • Explosives
Class III Landfill	• Municipal solid waste • Putrescible waste or any waste that will decompose • Any waste that is prohibited from a Class I or II Landfill

Other wastes that may be commonly prohibited from a landfill include asbestos, lead acid batteries, used oil, sludges, ash, and specified risk materials (SRMs). SRMs are certain body parts (central nervous system) of domestic beef aged 30 months or older that may contain the disease – bovine spongiform encephalopathy (BSE), commonly known as mad cow disease.

4.4.3 Wildlife Management

Landfills can be frequented by wildlife in search of food. This includes bears, birds, foxes, coyotes, and rodents. To reduce the attraction to feeding animals, the best approach is to cover wastes quickly and thoroughly and keep a small working face. Eliminating standing water will reduce the attraction of wild animals and birds. It is also important to keep the surrounding area outside the landfill clean of waste that can attract animals.

Photo 4.1 – Electric Bear Fence
Photo Source: Tom Moore, Lesser Slave Lake

The Fish and Wildlife Division of Alberta Environment and Parks have published a Best Management Practice for managing landfills for wildlife including bears.

Keeping bears out of a landfill is not only important for the safety of the site employees and customers, but is also for the protection of the bears. Bears can have increased tooth decay when feeding on human foods, have lacerations when exposed to abrasive wastes, and can ingest toxins or materials that cause internal injuries. Bears that become habituated to the landfill and the presence of humans may have to euthanized – a decision and action only to be taken by Fish and Wildlife personnel.

In cases where a landfill is in a bear habitat, Alberta Fish and Wildlife recommends constructing an electric fence around the landfill. When building an electric fence for bears, a professional electric fence company should be used to design the fence for best results.

Where bears are persistent, a 1.8 M chain link fence with an electric fence may be required. The fence mesh should be buried below the ground to prevent bears from digging under the fences.

4.4.4 Controlled Burning

Where other options for managing wood waste are not available or practical, controlled burning is allowed at landfill and transfer station sites as long as the material being burned complies with the Substance Release Regulation. In general, the regulation allows burning of clean wood that is not treated, and prohibits open burning of materials that produce toxic smoke.

Photo 4.2 – Controlled Burning
Photo Source: Tom Moore, Lesser Slave Lake

Definitions for **burnable debris** and **prohibited debris** are included in the Regulation. More information on the Substance Release Regulation is in Section 3.2.3.

Open burning is only allowed when it is done where there is a fire break and it is separated from disposal operations, storage compounds, or buildings. The burn must be supervised from first ignition until embers are deemed harmless should a wind arise. For this reason, it is advisable to conduct controlled burning with manageable amounts of wood.

Controlled burning should not be done in forestry zones when there is a high forest fire risk and open burning is prohibited, or where smoke from burning may impact neighbours to the site.

Notification to local authorities, adjoining property owners, local fire departments, and the director for Alberta Environment must be provided at least seven days before burning will occur.

Burn pits are typically constructed with earthen berms. Two burn cells allow for more control, whereby inbound material can be directed away from a burn and be placed in a second cell that is not burning. Burning then alternates between the two cells. Burning should be limited to small well ventilated and turned piles.

Once burning is complete the ashes may be disposed in the landfill. Operators must take care to ensure there are no remaining hot coals in the ash which could ignite the landfill.

4.4.5 Signs

Signs are an important way to give instruction to customers and convey important safety and operational messages. Signs are fully discussed in Chapter 2.

4.4.6 Waste Screening

Waste screening procedures should be written to describe how prohibited waste is prevented from being accepted and disposed in the landfill. Screening procedures are also important to be able to direct landfill customers to the proper location for unloading and to identify loads that require special handling. All landfill employees will need to be trained on the procedures and be part of the process of preventing the disposal of prohibited wastes.

The scale house is the first point of contact with a customer and where waste screening begins. At a minimum, scale attendants will record vehicle identification (usually license plate number), inbound and outbound vehicle weight, material type, date and time. This information is part of the scale record. Some landfills will use cameras and video recording of vehicles on the scale and scale transactions.

Photo 4.3 – Illegal Disposal of Hazardous Waste
Photo Source: JLTechnical Services

SCREENING PROCESS

Scale attendants should ask basic questions when customers arrive:

- What is in your load?
- Where are you from (address)?
- Do you have any paint, oil, batteries, tires or liquids?
- Do you have any propane tanks, compressed gases, or liquids?
- Do you have any household chemicals or hazardous waste?
- Do you have any pesticide containers?

Attendants will direct customers to the right disposal area based on answers to these questions and the type of waste observed. If scale attendants have a concern with the customer or the load, the scale attendant can communicate with the landfill spotters or an operator to inspect the load before it is unloaded.

Tips that a load may contain prohibited materials include visible or noticeable:

- Sealed barrels or drums
- Powders
- Liquids or leaking containers
- Compressed gas cylinders
- Unusual chemical odours
- Container labels with a chemical name
- Containers with warning labels

Spotters and equipment operators also have a responsibility to watch for prohibited materials, both before it is unloaded, after it is unloaded, and while spreading the load. Good scale records can help identify a customer if a prohibited waste is identified after they leave the site.

CUSTOMER INFORMATION

The landfill customer base will depend on the area it services. The following categories describe most customer types a landfill may deal with:

- Public urban residential (self-haul small loads)
- Public rural, acreage, farm and ranch (self-haul)
- Commercial haulers (front end, roll off)
- Municipal (residential automated and manual collection)
- Oilfield and industrial (end dumps, tri-axle, pups, and wagons)

Waste Screening Tips by customer/load type

Public Small Loads	Watch for propane tanks, lawn mowers and garden equipment with gasoline tanks. Medical waste (sharps and dialysis waste) as well as household hazardous waste may also be a concern.
Public – Acreage, Farm, and Ranch	All of the above, plus watch for oil, batteries, chemicals, solvents, anti-freeze, treated seed, dead animals (including Specified Risk Materials).
Commercial Haulers	Often these are account-holding customers with whom scale attendants may be familiar. Drivers are usually aware of the landfill policies. The drivers should identify any loads that come from industrial collections. Visual inspection is difficult at the scale house and should be done at the working face or at a designated waste screening location.
Municipal – Residential Collection	Watch for propane tanks, lawn mowers and garden equipment with gasoline tanks. Medical waste (sharps and dialysis waste) as well as household hazardous waste are also a concern. Visual inspection is difficult at the scale house and should be done at the working face.
Oilfield and Industrial and Special Wastes	If industrial wastes such as oilfield wastes, sulphur, contaminated soil, and asbestos are accepted, they should be pre-approved for acceptance by the landfill manager before shipment. A consultant may be employed to provide assistance to interpret the waste characterization information provided.

The burden of proof is on the waste generator or customer. The customer must provide information that characterizes the waste, including a waste description and laboratory analysis.

The landfill operators may require random sampling and laboratory analysis of waste that is received.

4.4.7 Manifested Waste

For hazardous waste shipped to a Class I Landfill, the generator, the carrier, and the receiver must follow the procedures for hazardous waste manifests as outlined in the Waste Control Regulation and the Alberta User Guide for Waste Managers. No waste accompanied by this documentation should be accepted at a Class II or III landfill.

Oilfield waste, some of which may be suitable for disposal in a Class II landfill, is not regulated under the EPEA but rather by the Alberta Energy Regulator (AER). The AER has established rules for documentation, transport and disposal of those wastes. AER rules prohibit materials classified as Dangerous Oilfield Wastes (DOW) from disposal in Class II or III landfills.

The specialty service companies and laboratories that help industry deal with industrial wastes and contaminated materials from site clean-ups have developed and use processes that are largely parallel to the formal processes used for hazardous waste to deal with **non-hazardous waste**. The system provides documentation for the generator, the hauler, and the receiver (which may be a Class II landfill if the material satisfies the regulations) confirming that the material is acceptable for disposal in this fashion.

PRE-APPROVAL AND THE WASTE CHARACTERIZATION PROFILE

If a Class II landfill is receiving non-hazardous industrial waste, the landfill should require the customer to make application for disposal prior to shipment to the site. In these cases, a customer will complete a Waste Characterization Profile (WCP). Information captured on the WCP should include:

- Generator name and contact information, address of the waste location, as well as emergency contact information
- Waste description, the generating process, physical description and approximate volume. The method of transportation and how the waste is packaged (bulk, drums, sacks, or other)
- A statement confirming that the waste is not hazardous or dangerous oilfield waste; that it passes the paint filter test, whether it contains asbestos or not, or if it is radioactive
- The density, volume of hydrocarbons, chlorides, the flashpoint (less than or equal to 60.5°C), and pH (greater than) >2.0 and (less than) <12.5
- A description of the odor and intensity
- Any attachments such as Material Safety Data Sheets (MSDS), lab analysis or samples

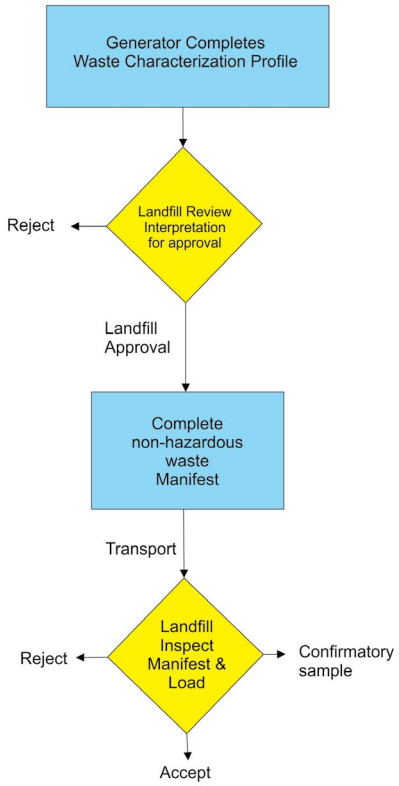


Figure 4.4 – Industrial Waste Acceptance Procedure
Source: JLTechnical Services

There should also be a summary of the findings of the laboratory analysis and any necessary instructions for the safe handling of the material (such as wearing of eye protection and gloves).

The WCP should include a statement by the generator or their representative certifying that to best of their knowledge the waste is not hazardous or a dangerous oilfield waste.

If acceptable for disposal, a WCP would be dated and signed by the landfill's authorized representative. An example of a WCP is provided in Appendix 4-1.

SHIPPING, RECEIVING AND THE MANIFEST SYSTEM

Once approved for acceptance the waste can be delivered to the landfill. It is a recommended practice that a landfill only accepts this waste accompanied by suitable documentation such as a **Non-Hazardous Waste Manifest (NHWM).** Landfills often develop their own forms for this purpose. Waste accompanied by a NHWM must be cross-referenced to an approved WCP. The manifest typically includes four completed and signed copies. Copies are distributed to:

- The hauler
- The customer (if different than the generator – such as a consultant)
- The generator

The original copy is retained by the landfill and becomes part of the landfill's annual record. Note that, unlike the process for hazardous waste, **there is no need to provide a copy to AEP**. Retention in the landfill operating records is, however, an important requirement.

A sample Non-Hazardous Waste Manifest is provided in Appendix 4-1.

There are generally four main parts to a manifest:

Generator information - generator name, address and contact information, location where the waste is being shipped from and emergency contact information. It should also reference the approved WCP number and should include an estimate of the quantity shipped. This section should also have the signature of the generator or their agent and date of shipment.

Transporter information - includes the transport company name and contact information as well as the driver's name, truck number, license plate number, contact information, date and authorized signature.

Material information – summarizing the information provided on the approved WCP, providing a general description (e.g. hydrocarbon-impacted soil), packaging or shipping means (e.g. drums, tarped dump truck) and other relevant information.

Landfill information - Upon receipt, the non-hazardous manifest should be reviewed to determine if the information is complete and the load matches the waste description and the approved WCP. The load at this point may still be accepted or rejected. Confirmatory sampling of the load may be taken. If accepted, the manifest should be dated and signed by the landfill authorized representative. The scale ticket number is recorded on the manifest along with the quantity (scaled net weight) and date.

Verification

The landfill operator may also have random samples taken and analyzed as a measure of due diligence and as a deterrent to unscrupulous haulers. For large volumes, such as when contaminated soils are being excavated and hauled, this may identify if the nature of the material has changed over the area of the site to the extent that it can no longer be accepted.

Depending on the nature of the waste and the landfill's specific operating procedures, the waste may be tipped at the working face or it may be sent to a specific area of the landfill for special handling. A general description of the disposal location should be recorded on the manifest. The more precise location of disposal should be recorded according to a map grid system using a northing and easting reference, or may be recorded by latitude, longitude and vertical elevation using a GPS. Where the manifested waste is not disposed of in a specific known area (e.g. asbestos pit), the location of the waste should be documented. Many operators will mark the location with a stake or other marker until a surveyor can record the exact location.

UNDERSTANDING LABORATORY ANALYSIS AND REPORTS

The four main characteristics of a hazardous waste are:

- Ignitable
- Corrosive
- Reactive
- Toxic

Common laboratory tests include:

- Flashpoint for solid samples
- Paint Filter Test to determine if a waste is a liquid
- pH of solid waste materials
- Toxic Characteristic Leaching Procedure (TCLP) to determine leachable metals, BTEX, or other leachable constituents

Analysis should be conducted at a laboratory that is accredited by the Standards Council of Canada. Confirmatory lab analyses (C/A) is conducted by third party commercial laboratories. Most labs in Alberta will run Class II landfill "suites" of tests, the results of which should accompany Waste Characterization Profiles. Lab reports and a Certificate of Analysis should confirm the Class II Landfill criteria are met.

Laboratory reports should be interpreted by a qualified person. Consultants or in-house specialists with expertise in waste characterization should do this. Waste generators, carriers, and receivers may refer to the Alberta User Guide for Waste Managers to help in their interpretation of test results.

Some wastes are characterized based on their properties:

- Flashpoint
- pH
- Compressed gases
- Oxidizers

TCLP testing characterizes waste based on concentration limits.
For example, if TCLP testing establishes presence of lead at a level of 5 mg per litre or higher, the material is considered hazardous.

4.4.8 Random Load Inspections

Random load inspections have a two-fold purpose:

1. Diverting prohibited wastes from the site
2. Deterring unscrupulous haulers

Random load inspectors should assume the potential for hazardous waste being present and take the following precautions:

- Isolate the load from the public and other customers
- Wear the proper PPE (disposable coveralls, gloves, goggles, respirator)
- Document all actions
- Be prepared to remove any hazardous waste to a safe area for later removal by a licensed hazardous waste disposal company
- Notify other employees of a load inspection taking place

All records of waste types observed during a random load inspection, including non-hazardous waste types, should be documented and maintained in the landfill operating record. Photographs make a good record.

4.4.9 Rejecting Loads

If prohibited waste is observed, the details should be documented and notification given to the waste hauler and, if possible, the generator. If hazardous waste is detected, the landfill manager should report a non-compliance situation to the regulatory authority.

If a prohibited and/or hazardous waste has been determined to be on site it should be safely removed as quickly as possible in a safe manner, for the protection of your customers and employees. Although the responsibility for removal of a hazardous waste load is on the generator it is prudent to suggest options available to them. The landfill manager should keep a list of the Class I landfills, hazardous waste transporters, and hazardous waste transfer facilities in the area.

Rejected loads should either be returned to the generator or placed in a holding area until additional information is submitted. Discrepancies and actions taken should be documented and kept in the operating record for the landfill. A suspect load may be held on site and a representative sample taken for laboratory analysis and verification. The waste should be isolated and not mixed with any other wastes until the lab report confirms the characteristics of the waste.

4.5 NUISANCE MANAGEMENT

4.5.1 Vector Control

Vectors are insects, animals and birds that carry diseases. In Alberta, rat infestations at landfills are uncommon, but do occur. Landfill operators need to be diligent to watch for signs of rats and report any infestations to Alberta Agriculture at a toll-free number 310-RATS (7287). Other animal pests that can carry diseases include skunks and mice.

Insects, particularly flies and mosquitoes, are common at landfills and are known disease carriers. Fly larvae are often in the waste being delivered to the landfill. The practice of covering wastes with soil arose as a method to stop flies from emerging from uncovered waste piles.

Scavenging gulls are common at many landfills during summer months. Other scavenger birds include ravens and crows.

The main vector controls at a landfill include:

- Minimizing the size of the working face
- Applying daily cover
- Covering waste that attract flies, rodents and birds (e.g. meats, grains)
- Minimizing or eliminating standing water around the landfill

Bird controls used at landfills across North America, in addition to the above methods, include:

- Propane cannons to scare the birds
- Recorded sounds of bird distress calls or predator birds
- Flying kites over the landfill
- Occasional deployment of birds of prey, such as falcons, to make other birds fearful of the site

Photo 4.4 – Bird Controls at a Landfill
Photo Source: JLTechnical Services

4.5.2 Odour Controls

Odours at landfills can become a nuisance to adjacent landowners and residents. Odours can arise because of decomposing uncovered waste, stagnant leachate in storage ponds, leachate treatment, or emission of landfill gas.

Practicing good compaction and covering of the waste with soil is the primary way to control odours. If odorous waste is received at the landfill, such as an animal carcass, it should be covered immediately with other waste or soil. Collecting and utilizing landfill gas can help reduce emission of landfill gases and associated odours. Properly managing leachate systems to prevent odours is also a key component of odour management at a landfill.

4.5.3 Noise Control

Noise at landfills can be bothersome to nearby residents. Noise comes from landfill equipment and waste delivery vehicles. Landfill equipment should be well maintained so that it operates within the manufacturer's specifications. Reducing speed limits and maintaining good road surfaces can reduce vehicle noise as they move through the site.

The landfill designer may establish or use berms or tree buffers around the site perimeter to minimize noises off-site. Operations may also be limited to day-time hours so that noises don't interrupt quiet evening periods.

4.5.4 Dust Controls

Dust can arise from road traffic on gravel or soil road surfaces. Developing a landfill with permanent roads with paved or oiled surfaces can reduce road dust emissions. Some landfills will use a water truck to wet dusty road surfaces in hot dry temperatures. Other dust control methods include using commercial dust control measures such as the application of calcium chloride. These controls should be used with care so that surface water or groundwater quality monitoring systems aren't impacted.

4.6 NOXIOUS WEEDS AND WEED CONTROL

There are numerous weeds that are classified as "prohibited noxious" and "noxious" and must be controlled in accordance with the Weed Control Act (2008) Chapter W-5.1. Prohibited noxious weeds must be destroyed, and noxious weeds must be controlled. Landfill operators should work with local agricultural field men to identify and develop the appropriate controls for weeds to protect surrounding agricultural lands.

4.7 WEATHER ISSUES

The landfill operator needs to be prepared for all types of weather. Table 4.2 summarizes weather conditions and suggested pro-active measures.

Table 4.2 – Summary of Proactive Measure to deal with Various types of Weather

WEATHER	ISSUES	PRO-ACTIVE MEASURES
Hot and Dry	• Dust • Overheating equipment • Heat stroke	• Apply dust controls • Maintain equipment • Train employees and apply appropriate safety measures
Cold weather	• Non-starting equipment • Snow or ice on roads • Hypothermia/frost bite	• Winterize equipment, plug in overnight, fill fuel tanks at end of day • Clear roads of snow, sand icy surfaces • Issue proper clothing, train employees
High precipitation	• High run-off flows • Erosion • Leachate flows increase • Working face access difficult	• Site design, monitor storage ponds • Inspect ditches and cover for erosion, make repairs as needed • Monitor leachate levels and remove until 0.3 M head achieved • Keep a small working face • Spread wood chips over wet clays to provide traction • Standby equipment for towing
Strong winds	• Blowing litter • Blowing dust	• Use effective litter control fencing, cover the working face more frequently • Apply water or dust suppression chemicals; vegetate bare areas
Severe weather	• Lightning • Tornado or dangerous winds	• Stop operations until lightning passes • Take shelter (needs to be determined in emergency plans)

4.8 LITTER CONTROL

The public's view of landfills often has to do with their existing or past experiences when delivering wastes to a landfill. Untidy sites due to poor controls for the dumping of waste and lack of litter management programs can impact the public's perception of the site. Litter control has a major influence on the public acceptance of a landfill.

Poor litter control will lead to:

- Public complaints
- More inspections by regulators
- A less pleasant workplace for staff

Photo 4.5 – Poor Litter Control Gives a Negative Image
Photo Source: JLTechnical Services

Photo 4.6 – Good Litter Control Gives a Positive Image
Photo Source: JLTechnical Services

Furthermore, government regulators will respond to public complaints regarding litter on and around landfills, and they can also form immediate opinions about site management based on how well litter is controlled. Poor litter control can create a negative image and lead the inspector to conduct a more in-depth inspection of all aspects of the operation.

The impact of litter on the environment goes beyond visual. Litter that escapes the site can be washed away in water drainage systems and impact water resources. It can have impact on farm animals and wildlife. Litter that is created by uncontrolled dumping of waste can create other issues such as odours and animal scavenging.

4.8.1 Litter Sources

Litter related to landfill operations arises due to:

- Transport of unsecured waste loads to the landfill
- Uncontrolled dumping outside and inside the landfill
- Wind

Wind is a major contributor to litter at landfills. Understanding wind patterns, where litter blows to, and under what wind conditions litter is picked up by the wind. Table 4.3 shows different wind conditions and materials that can be blown about. Note that at higher wind speeds there can be safety concerns for both staff and customers due to flying debris.

Table 4.3 – Wind Conditions and Materials Affected

WIND DESCRIPTION	WIND SPEED (KM/HR)	WIND-BLOWN MATERIALS
Calm	Up to 10	Very light materials/dust
Light	10 to 20	Dry crumpled paper, empty plastic bags
Moderate	20 to 40	Lightweight empty boxes, flat cardboard, paper products, plastic film
Strong	40 to 60	Corrugated cardboard boxes, rigid or corrugated plastic sheets, plastic containers, paper products
Gale	60 to 90	Large boxes and flat sheets, brush, carpeting
Storm	90 to 117	Boxes, flat sheets, construction materials including plywood
Hurricane	Over 118	Almost anything

4.8.2 Litter Control Techniques

Litter controls at a landfill involve a number of measures to prevent and manage litter. This includes load management, unloading of wastes, working face management, litter control fencing and litter picking.

Off-site controls include by-laws and by-law enforcement of illegal dumping and securing loads in transport. Unsecured loads can be a major contributor to litter along roads leading to the landfill. Some landfills have implemented surcharges onto tipping fees for unsecured loads. Others work closely with by-law enforcement to encourage customers to secure loads.

Litter Control Measures

- Site design
- Load control
- Waste handling procedures
- Portable litter fences
- Semi-permanent fences
- Perimeter fences
- Working face procedures
- Limiting operations in high winds
- Retrieval of litter on and off-site

Photo 4.7 – Unsecured Loads Contribute to Road Side Litter
Photo Source: JLTechnical Services

Since much of the litter at a landfill results from wind, landfill operators need to develop effective controls in the operation of the working face. Some of the important principles to follow include:

- Minimize the amount of exposed waste by keeping a small working face
- If possible, during high wind conditions, use an alternative working face that is sheltered
- Partially compacting loose waste piles before spreading
- Use heavier waste materials to cover lightweight materials

Photo 4.8 – Loose Loads in High Winds at a Working Face
Photo Source: JLTechnical Services

- Spreading loads carefully and compacting as quickly as possible

It is helpful for the landfill operator to watch wind patterns on and around the landfill. There can be areas where wind speeds increase, areas of the site that are sheltered, and areas where turbulent winds are created. As a landfill changes over time, these patterns can change. Of key importance is to understand where litter blows to, and establish controls to minimize the impact.

Effective fencing systems at a landfill for litter control include:

- Portable catch fences placed next to the active working face
- Portable wind-screen fences placed upwind of the working face
- Semi-permanent fences downwind of site operations
- Perimeter fences around the site

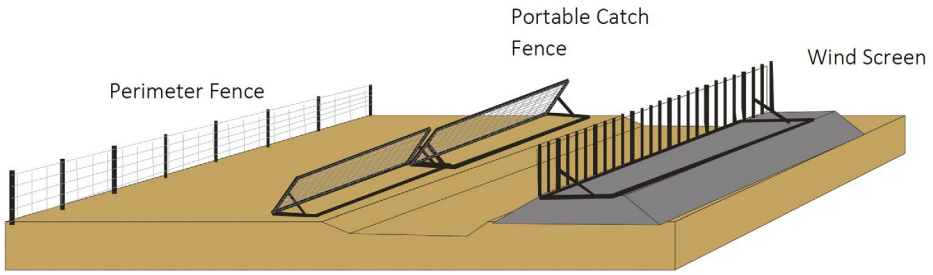


Figure 4.5 – Fencing Systems
Source: JLTechnical Services

Photo 4.9 – Multiple Litter Fences
Photo Source: Salbro Consulting, Lethbridge Litter Plan

"If you don't have a variety of litter fences at your landfill, yet you are complaining about litter, you are not dealing with the problem. You are just chasing symptoms."
Neil Bolton, MSW Management, July/Aug 2000

Photo 4.10 – Picking Litter Along Fences
Photo Source: JLTechnical Services

The final and a most important step of litter control is to retrieve litter that is along road ways or escapes the active landfill operations. Depending on the site, this may require a full-time litter crew to pick up litter. The more effective the controls are at the active working face, the less time it will take for picking litter.

Daily patrols should be done around the site perimeter, access roads, and public roads leading to the site. The priority for picking litter should be on adjacent properties and farmland, public roads, and then starting at the entrance gate and working from the site perimeter towards the active operating areas.

4.9 LINER PROTECTION

The construction of an engineered landfill liner and leachate collection system needs to be completed with great care and attention since it is the barrier that prevents contaminants escaping the landfill. The same great care and attention must be taken when operating a landfill to avoid damaging the system. Construction equipment and landfill operating equipment must not be permitted to operate directly on the cell floor.

After the liner and leachate system construction is completed, an initial lift of waste is placed over it. How this first layer is placed over the liner is of primary importance for the protection of the system. This first layer should be placed as a loose cushion layer, or what may be referred to as a 'fluff' layer. The waste material selected for this first layer should only consist of soft residential wastes. Objects such as boards, poles, or concrete must not be placed on the liner to avoid puncture of the liner or damage to the leachate collection systems.

Collection vehicles must not be allowed to drive on the unprotected cell floor. An access road must be installed with a wide temporary area constructed to allow trucks to maneuver. Waste is unloaded at the end of the road and pushed out with tracked equipment over the liner. The waste may be 'fanned' out across the liner until it is covered with at least 1 metre of waste before vehicles are allowed to drive into the cell.

Photo 4.11 – Fanning Out First Layer of Waste
Photo Source: Stantec

Compacted clay liners must also be protected from damage from drying out and from freeze-thaw cycles. Compacted clay liners can lose moisture in hot dry weather conditions resulting in desiccation and cracking. The cracks that form in the clay create a potential pathway for contaminants to pass through the liner.

Freezing of a clay liner can form ice lenses which can create cracks in the liner. Placing the first lift of loose waste on the liner will provide insulation and protect it from freezing or drying out. In order to prevent damage, it is a good practice to construct new liners in the warmer months of the year.

4.10 WORKING FACE OPERATIONS

The working face at a landfill is the active area of the site where solid waste is deposited, spread, and compacted on a given day. The working face is the main focus of activity at a landfill and can be congested with vehicles, equipment, and with customers and employees on foot. This is the area of the landfill where waste is exposed to wind, rain, and vectors. This means that a high level of attention must be given to safety and control of the working face.

Good working face practices include:

- Keep as small a face as possible
- Coordinate the orderly movement of trucks and equipment
- Keep the area graded and drained
- Maintain the optimum slope where the waste is spread and compacted

Day-to-day operations at a landfill should apply **the three C's:**

Control of the site and the waste received

Compaction of wastes

Cover the waste to minimize nuisances such as insects, birds, rodents, odours, litter, and fires

4.10.1 Unloading Waste

Traffic patterns should be established to maintain an orderly flow of vehicles by use of signs, barricades, and traffic cones. Spotters may be used to give directions and manage the flow. Vehicles should only unload to the rear to minimize use of space at the face, and should be kept at least 3 metres apart.

Vehicles may unload either at the toe or the top of the working face slope, depending on the access road configuration. For most operations, unloading at the toe of the slope is preferable for more effective control when spreading the waste by landfill equipment. Drivers should be directed back within 2 metres of the toe to unload so that waste is not spread around the site.

Trucks with mechanical unloading should be kept separate from vehicles with manual unloading as much as possible. End dump trucks should be kept at least 15 metres from other vehicles when unloading because of their potential to tip over.

The location used for mechanical trucks and manual unloading should be alternated so that the various types of waste are mixed throughout the landfill. This results in more uniform settling and encourages flow of liquid and gas through the landfill.

Photo 4.12 – Traffic Management at Working Face
Photo Source: JLTechnical Services

4.10.2 Spreading and Compacting

Compacting the waste on the working face is one of the most important functions at a landfill. The main factors influencing compaction of waste are:

- The nature of the waste material
- Weight of the compaction equipment
- Depth of each compaction layer
- Number of equipment passes over each layer

Waste is spread up-slope on the working face in thin layers, usually 30 cm thick. The equipment operator pushes the waste pile up the working face and lifts the blade to about 30 cm which allows the waste to 'flow' underneath as the machine moves ahead. Spreading waste in thicker layers greater than 60 cm results in bridging of underlying waste and results in lower compaction densities.

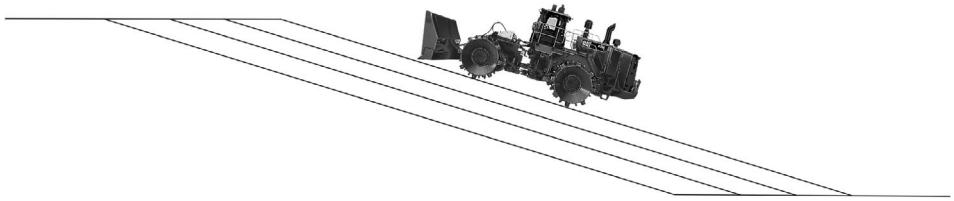


Figure 4.6 – Spread and Compact Waste in Thin Layers
Source: JLTechnical Services

Each layer of waste is compacted with three to five passes over the entire surface. This is accomplished by:

- operating the machine up a slope, and following the same track in reverse
- moving over a wheel width and operating forward up and down the slope in the same track
- moving over another wheel width (or track-width if using a bulldozer)
- repeating the process until the full width of the working face is covered

Figure 4.14 provides a visual description of this process.

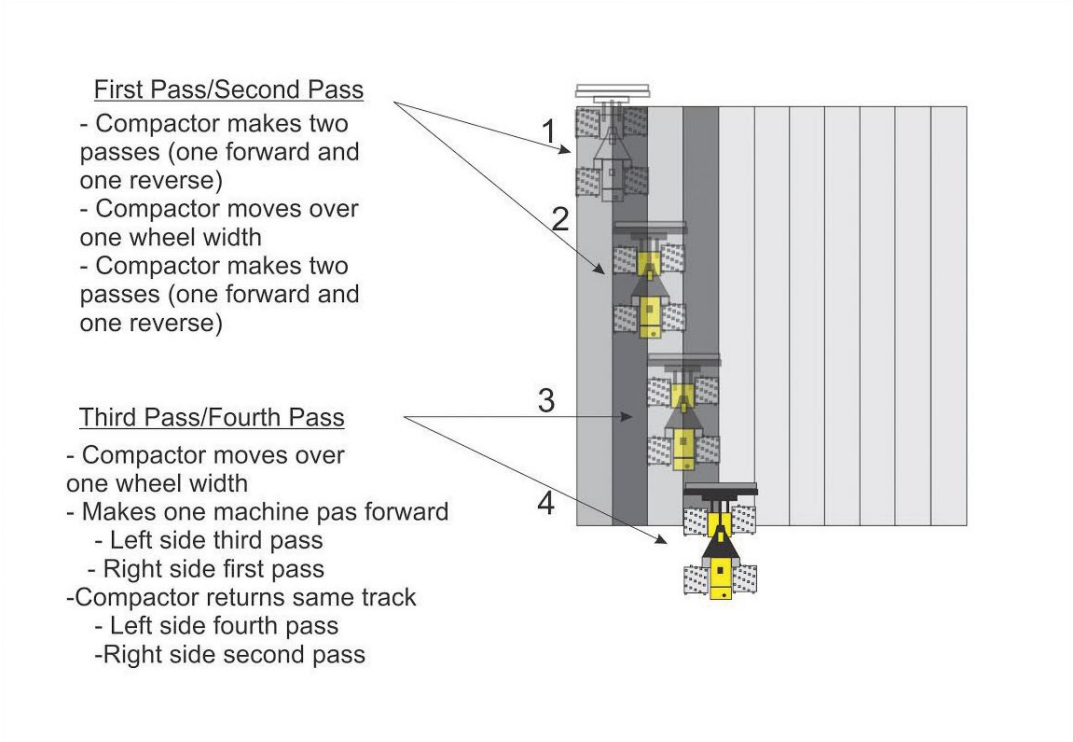


Figure 4.7 – Process for Compacting Waste
Source: JLTechnical Services

From many years of operating experience, it is universally understood that at least three passes are needed to achieve good compaction, and that little extra compaction is achieved beyond five passes. More passes result in little net gain in density with more wear and tear on equipment and fuel use. The effect of the number of passes on density is illustrated in the following chart.

The effect of layer thickness and the number of equipment passes on density is illustrated below.

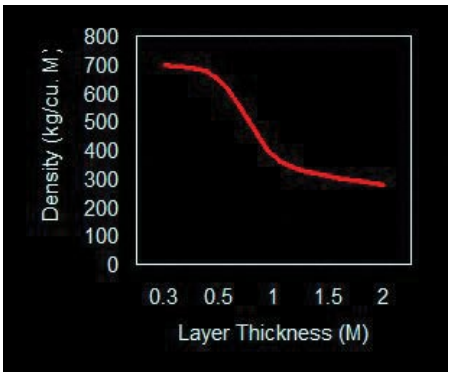


Figure 4.8 – Layer Thickness vs. Density
Source: US EPA

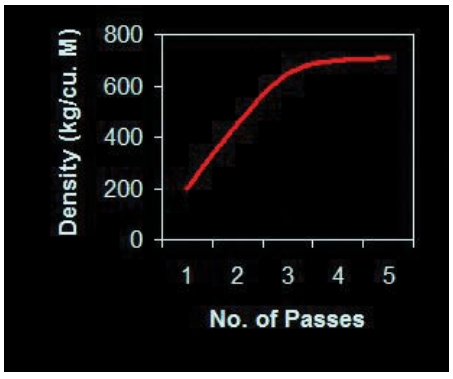


Figure 4.9 – Number of Passes vs. Density
Source: US EPA

4.10.3 Working Face Slope

The working face slope will depend on the type of equipment used. For small landfills that use a tracked machine to compact waste, a 3:1 or 4:1 slope may be more appropriate (for more information on slope calculations see Section 5.3). Working a tracked machine on a slope concentrates the machine weight and gives a higher concentrated ground pressure at the end of the tracks.

Where a landfill is equipped with a steel-wheeled landfill compactor, the flatter the slope the better. It can be difficult to climb steeper slopes with landfill compactors and compaction effectiveness is reduced. Operating these machines on flatter slopes distributes the machine's weight to all wheels.

Photo 4.13 – Steel Wheel Compactor on Flat Slope
Photo Source: JLTechnical Services

Photo 4.14 – Track Dozer on 3:1 Slope
Photo Source: JLTechnical Services

4.10.4 Daily Cover

Placing a soil cover over the compacted working face forms a cell. A **waste cell** is defined as compacted waste encased in soil. Soil cover on the working face is typically placed at a thickness of 150 mm.

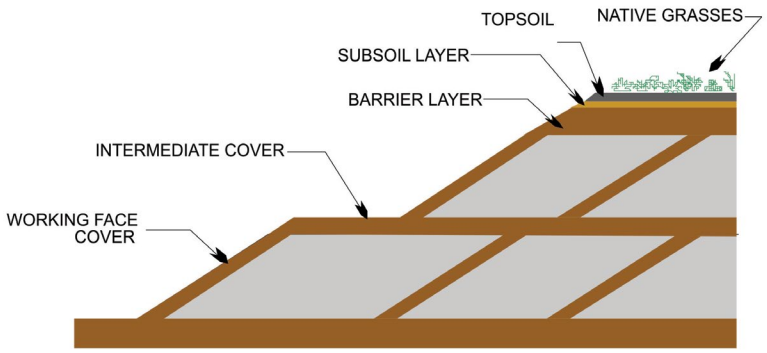


Figure 4.10 – Cover and Waste Cell Structure
Source: JLTechnical Services

On the top 'bench' of the working face, a thicker layer of soil of 30 cm should be placed where it will be used as a driving surface, or where the area will not be used for a longer period of time. This layer is called 'intermediate' cover.

Intermediate cover can create a barrier that restricts moisture migrating through the landfill and can result in perched leachate conditions. Prior to building daily cells over the intermediate cover, the soil layer may be pulled back, or breached, to allow a pathway for the moisture to flow downward to the leachate collection system.

The final cover is placed when the landfill is filled to the final design elevations. A typical final cover in Alberta includes **60 cm of compacted clay, between 35 and 80 cm of subsoil, and 20 cm of topsoil.**

ALTERNATIVE DAILY COVER

To reduce the amount of soil consumed by applying a daily cover, some landfills will apply alternate daily cover (ADC), which can either consist of waste materials suitable as cover or manufactured products.

Waste materials that are sometimes used as alternative daily cover (ADC) include:

- Mulched wood, or mulched wood mixed with soil
- Demolition materials such as asphalt or concrete rubble
- Hydrocarbon impacted soils
- Other materials as approved by the regulator

Manufactured products commonly used for working face cover include:

- Biodegradable plastic sheets
- Re-useable tarp systems
- Spray on fiber mulch
- Sprayed foams

Photo 4.15 – Fabric Alternate Daily Cover being applied (reusable tarps)
Photo Source: J&M Industries, Inc. and Tarpomatic

Photo 4.16 – Biodegradable Alternate Daily Cover
Photo Source: Roland Rusnell, City of Saskatoon

4.11 FIRES

A 2014 fire in Iqaluit cost nearly $3 million to extinguish with additional costs after the fire to treat water from the firefighting effort. The Delta Shake and Shingle landfill fire in British Columbia cost nearly $5 million in 1999. In 2013 a fire at the Kindersley Landfill in Saskatchewan cost $111,000 to fight with additional cost to the community for landfill assessments and a new regional landfill. A fire in a Class III landfill near Medicine Hat was reported to cost up to $2 million to extinguish.

There are many examples of landfill fires in Canada. The cost to the owner or community to battle a landfill blaze can be very high.

4.11.1 Fires in Landfill Buildings and Equipment

Fires can occur in buildings, vehicles, and equipment. In the event of a fire, all landfill employees need to know the proper response, building evacuation routes, and when to call the fire department.

Fires in buildings or on equipment can be the result of:

- Poor housekeeping (e.g. dust build up in hot engine compartments)
- Faulty electrical wiring or equipment
- Hot work (e.g. welding, grinding)
- Careless storage of flammable materials
- Careless smoking
- Sparks while fueling equipment
- Arson

Photo 4.17 – Landfill Compactor Fire
Photo Source: Roland Rusnell

It is important to maintain buildings and enforce smoking rules for the site. Equipment and vehicles should be shut down while refueling. Equipment should be kept in good repair. Engine compartments need to be cleaned regularly to remove dusty material and debris that could be ignited by hot engine parts.

There are several different classifications of fires (see Table 4.4). Different approaches to fighting a fire are used depending on the type of fire. Table 4.4 is provided for general information only. Staff should receive appropriate training before being tasked to fight fires.

Table 4.4 – Methods of Extinguishing Various Classes of Fires

CLASSES OF FIRES AND EXTINGUISHING	
Class A Fire	• Burning wood, paper, rags, rubbish or other combustible materials • Use a water hose, pump type water can, or fire extinguisher • Soak the fire completely – even smoking embers
Class B Fire	• Flammable liquids, oils and grease • Use ABC Extinguishers • Start at the base of the fire and use a swinging motion form left to right, always keeping the fire in front of you
Class C Fire	• Electrical equipment • Use ABC Extinguishers • Use short bursts on the fire • When the electrical current is shut off on a Class C fire, it can become a Class A fire if the materials around it are combustible

It is advisable to call the fire department for all fires. It is better to have fire services on route to the site in case a small fire becomes uncontrollable. Landfill staff should only try to extinguish small fires when it is safe to do so and when they've had appropriate training.

4.11.2 Landfill Fires

Landfills are at risk for fire and they face this risk everyday. There are several features of a landfill that create this risk including:

- Large amounts of available fuel
- Relatively large air voids that can capture flammable landfill gas and can supply enough oxygen to support smoldering underground fires
- Many potential ignition sources - further discussed below

SURFACE FIRES

There are many ways that a surface fires on can start on a landfill. Common ones include hot embers in waste loads (e.g. within ashes from a burn barrel), careless smoking at the working face, sparks from batteries or metal debris being compacted, and chemically reactive waste materials.

A surface fire can spread rapidly over a large uncovered working face. A fire's direction and rate of spread may be influenced by wind conditions. Fires will burn up slopes more quickly than down a slope. If the fire becomes hot enough, it can burn below the surface and into the interior of the landfill. Soot and other particulate matter can become airborne and drift in the direction of the wind. As the fire builds in heat, airborne particles will become larger and smoldering, airborne bits can spread the fire off the working face. A fire can 'jump' tens of metres at a time.

The smoke can contain thousands of chemical compounds, many of them toxic. Exposure to this smoke threatens the health and safety of landfill staff, customers and the fire fighters. Drifting smoke plumes can result in decisions by emergency response services to require evacuation of nearby homes or businesses.

Photo 4.18 – Surface Fire at a Landfill
Photo Source: JLTechnical Services

Practices that can prevent serious surface fires include:

- Screening for hot loads
- Immediate separation and isolation of any smoldering or burning materials from the working face
- Prohibiting smoking by staff AND customers at the working face
- Good equipment housekeeping and maintenance

SUBSURFACE FIRES

Fires can start or move deep into a landfill. Landfills have pockets of air and landfill gas that, if the proper conditions exist, can support combustion deep within the landfill. Fires that burn below the surface of a landfill can be very deep and can continue to smolder for months or even years. These fires are the most difficult and costly to extinguish. For this reason, it is important that the landfill operation is managed to prevent these fires from occurring.

Subsurface fires may be identified by the odour of smoke or visual observation of smoke emanating from the surface. The landfill surface may show signs of settlement in an area of a subsurface fire. A safety concern may result since the smoldering waste can burn a cavity and the landfill surface can collapse under the weight of

equipment or a person.
Where there is a landfill gas collection system or monitoring system in the landfill, increased landfill temperatures and increases in carbon monoxide in the gas may be an indicator of a subsurface condition that can lead to a subsurface fire, or may be an indication that there is an active fire.

Subsurface fires may be the result of burial of undetected burning embers or burning waste in the landfill. Because it is under the surface, these fires will emit less smoke and flames are not visible. Firefighters and operators may falsely assume the fire is extinguished. They need to be diligent in finding where the fire has moved and fully extinguish it. A fire watch should be put in place for the next several days after a fire is believed to be extinguished.

Subsurface fires may also be caused by spontaneous combustion when air is allowed to enter the landfill. This can occur at sites where there is inadequate soil cover and poor compaction. It can also occur where landfill gas is over-extracted and air is drawn into the landfill.

Photo 4.19 – Subsurface Fire
Photo Source: JLTechnical Services

Practices to help prevent subsurface fires include:

- Prevent burial of burning material
- Avoid smothering a surface fire on the working face
- Proper compaction of the waste
- Applying soil cover on the landfill
- Proper management of landfill gas systems

FIRE RESPONSE

Landfill operators should develop a fire response plan with the local fire department. The fire department typically provides a first response role. Once the fire department is on site, the commanding fire chief takes control. Initial activities by landfill staff should be focused on re-directing customers and preventing the fire from spreading.

Photo 4.20 – Landfill Fire Response
Photo Source: JLTechnical Services

Fighting a surface fire may involve one or more pumper trucks from the fire department, a dozer or loader and trucks or scrapers to haul soil. A water supply for pumper trucks is needed and should be a part of the site development plan. Pumping water onto a burning working face is not usually effective in extinguishing the fire. Water may help suppress the fire and control the spread, but burning waste should be:

- Removed (often pushed with a tracked bulldozer) from the working face to a separate area
- Spread out in thin layers
- Doused with water
- Each layer smothered with soil

The working face should be closely inspected for any remaining hot materials. If available, thermal imaging can be used to confirm there is no remaining fire. The working face should then be covered with soil before it is re-opened to customers.

While spreading and smothering activity is ongoing, there may be open flames. Water should be ready to cool equipment. Spotters need to watch for burning material carried on track cleats, hanging on buckets or blades, or overheated hydraulic lines on the machine. The spotter needs to communicate with the equipment operator. Training and a safe work plan is a must for firefighting activities like this.

Landfill fires are seldom extinguished with only water. Effective fire response includes:

- Separating the burning waste
- Isolating it and spreading it out
- Dousing with water and smothering with soil

Extinguishing a subsurface fire is more complicated and can be very expensive. The most common method of extinguishing a subsurface fire is by overhaul (excavation of burning materials), spreading, dousing and smothering. Stubborn or very large or very deep fires are sometimes best kept contained (not excavated) until a specialty firm can develop a plan of attack and be hired to bring in the necessary equipment and trained manpower.

Overhaul is the systematic excavation of the waste fill and hauling the burning waste to a prepared pad where it can be spread out. The laydown area, or area that the burning material is spread on, needs to be large enough to handle the volume anticipated. The laydown area will need to be designed to drain to a storage pond for water that runs off the dousing operation.

The excavated hot materials will need to be spread, doused and smothered bit by bit. When it is confirmed that all burning material is excavated from the landfill, the area should be covered with an intermediate soil cover. The burned material may be gathered and placed back in the landfill when it is assured there is no risk of re-ignition. Fire watch should be put in place for several days after a fire has been dealt with. This calls for one or more staff people to be present at the location 24/7 and tasked with watching for signs of re-ignition.

Photo 4.21 – Subsurface Fire
Photo Source: Warren Bobbee, Emergency Management Consultant for the District of Katepwa

Photo 4.22 – Spread, Excavate, Douse and Smother
Photo Source: JLTechnical Services

4.12 MANAGING AIRSPACE

Airspace is defined as the volume of space that is approved at a landfill for disposal of solid waste. This commonly used term comes from the idea that this space is occupied by air. As the landfill is filled with waste, airspace is depleted.

Airspace is the most valuable asset a landfill has. Its value can be determined by the cost of siting, permitting, constructing, operating, and closing the landfill. Each cubic metre of airspace has a cost and a value. There can be opposing views on managing the airspace:

- Maximizing revenue while minimizing operating time frame in which most expenses occur
- Maximizing the operating life of a landfill to maintain the airspace asset as long as possible

In both cases, managing the airspace is essential. For example, achieving high compaction rates will result in more overall revenue and it can extend the operating life of the landfill.

Monitoring of airspace use includes recording the amount of waste disposed and the volume of airspace consumed. These two numbers are needed to calculate compaction density.

Example of Density Calculation:

Annual waste disposed: 35,000 tonnes (t)

Note: 1 tonne = 1000kg

Airspace Consumed: 50,000 cubic metres (m^3)

Density = $\frac{\text{Weight (t or kg)}}{\text{Volume}(m^3)} = \frac{35{,}000}{50{,}000} = 0.700$ t/ m^3, or 700 kg/ m^3

A simple method of monitoring and predicting remaining landfill airspace is to use a capacity demand curve. This method can be used to plan future landfill cells or landfill replacement needs. It can also be used for planning diversion programs to extend the landfill operating life.

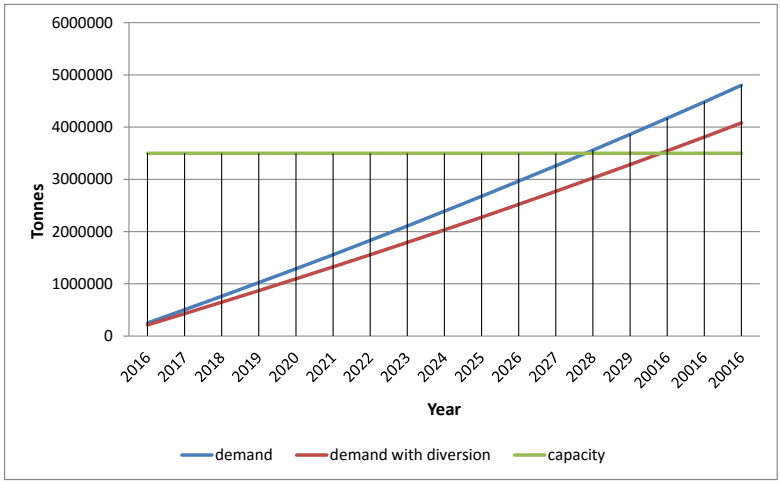


Figure 4.11 – Capacity-Demand Curve
Source: JLTechnical Services

Maximizing the landfill airspace involves a number of techniques that include:

- Efficient site design: the most efficient design is a square shape which allows for maximum volume of airspace per hectare
- Maximizing the initial compaction density of solid waste when it is placed in the landfill
- Maximizing the depth of the landfill: Overlying waste compresses the waste below over time
- Surcharging fill areas with soil stockpiles: use areas not completed on the landfill for stockpiling cover soils
- Diverting recyclable and compostable materials
- Minimizing soil use for cover by using alternative daily cover

Example of Airspace Value

A 40 hectare landfill receives 50,000 t of waste per year at $60/t tip fee. Compaction density is 750 kg/m^3. By using alternative daily cover, the landfill operators have gained an additional depth of airspace equivalent to 0.5 metres over the entire site.

Additional airspace:	200,000 m^3
Additional capacity:	150,000 t
Additional operating life:	3 years
Additional revenue:	$9 million

4.13 LEACHATE MANAGEMENT

Leachate is liquid that drains from a landfill. As moisture passes through the waste, organic and inorganic compounds become dissolved and suspended in the water. This is similar to the concept of hot water passing through coffee grounds to brew coffee. The contaminants in the leachate can potentially cause groundwater and surface water contamination if it is not properly controlled.

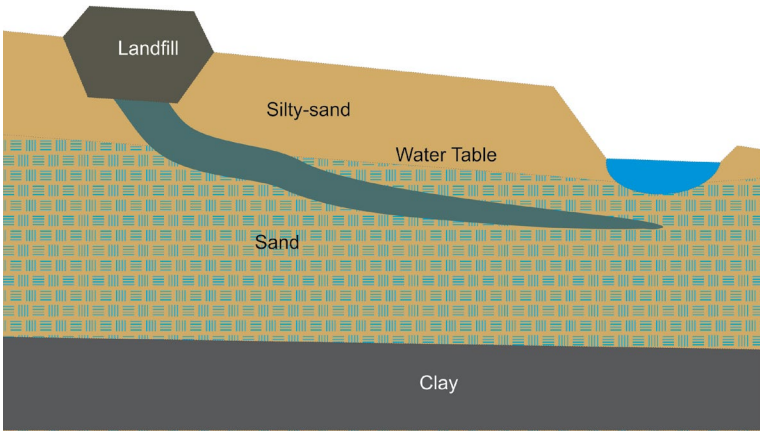


Figure 4.12 – Leachate Contamination of Groundwater
Source: JLTechnical Services

The typical characteristics of leachate are shown in table 4.5.

Table 4.5 – Leachate Characteristics and Range Based on Landfill Maturity
Adapted from: Handbook of Solid Waste Management, Second Edition, George Tchobanoglous, Frank Kreith et al

	VALUE, mg/L (except pH)		
	New Landfill <2 years		Mature Landfill >10 years
Constituent	Range	Typical	Range
BOD (5-day Biochemical Oxygen Demand)	2,000 – 30,000	10,000	100 – 200
TOC (Total Organic Carbon)	1,500 – 20,000	6,000	80 – 160
COD (Chemical Oxygen Demand)	3,000 – 60,000	18,000	100 – 500
TDS (Total Suspended Solids)	200 – 2,000	500	100 – 400
Organic Nitrogen	10 – 800	200	80 – 120
Ammonia Nitrogen	10 – 800	200	20 – 40
Nitrate	5 – 40	25	5 – 10
Total Phosphorus	5 – 100	30	5 – 10
Ortho Phosphorus	4 – 80	20	4 – 8
Alkalinity	1,000 – 10,000	3,500	200 – 1,000
pH	4.5 – 7.5	6	6.6 – 7.5
Total Hardness	300 – 10,000	3,500	200 – 500
Calcium	200 – 3,000	1,000	100 – 400
Magnesium	50 – 1,500	250	50 – 200
Potassium	200 – 1,000	300	50 – 400
Sodium	200 – 2,500	500	100 – 200
Chloride	200 – 3,000	500	100 – 400
Sulfate	50 – 1,000	300	20 – 50
Total Iron	50 – 1,200	60	20 – 200

Leachate management begins with siting a landfill where there are thick clay deposits to minimize the migration of liquids through the soils to the groundwater. It also includes the design of a liner and leachate removal system, and drainage system to protect surface water quality. How a landfill is operated is also a key part of managing leachate and preventing environmental contamination.

Figure 4.20 illustrates how water moves into and out of a landfill.

As shown, water enters landfills by:

- Infiltration of precipitation through the top surface
- Lateral infiltration of groundwater (limited by an installed liner)
- Run-on of surface water (limited by good site design)
- Being present in the waste when it is deposited

Water leaves landfills by:

- Run-off from areas that are covered with daily, intermediate, or final cover
- Evapotranspiration (direct evaporation to the air as well as by uptake by plants)
- Leakage (limited by an installed liner)
- Extraction as leachate for treatment and disposal

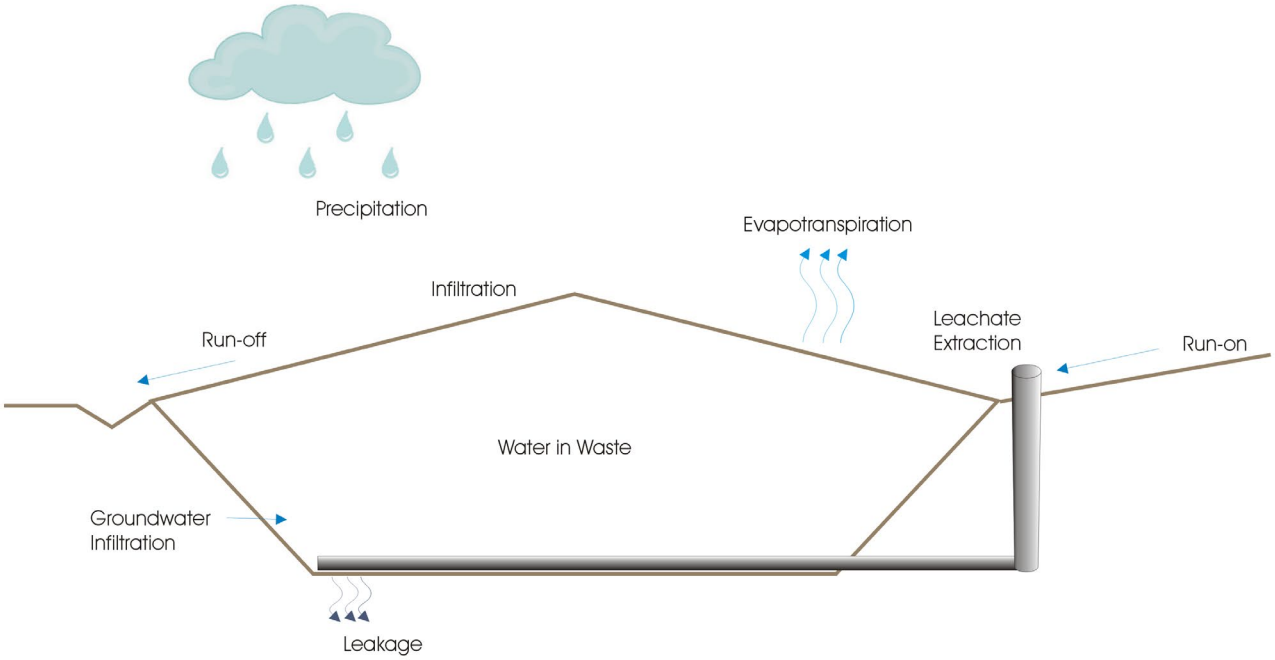


Figure 4.13 – Leachate Production in a Landfill
Source: JLTechnical Services

Operators can reduce leachate production through actions such as:

- Prohibiting the disposal of bulk liquids in the landfill (as dictated by Alberta legislation)
- Maintaining run-on and run-off controls (e.g. keep ditches clear and free-flowing)
- Placing cover soils on non-active areas and ensuring the surface drains off the landfill
- Minimizing the size of the working face
- Covering the face daily

4.13.1 Liners and Leachate Collection Systems

Liners and leachate collection and removal systems are standard components of most modern landfills. Liners create a barrier to minimize the escape of leachate to underlying soils and groundwater. A single liner is comprised of compacted natural clay soils (compacted clay liner). In some cases, a synthetic liner is laid directly on the surface of the compacted clay, creating what is referred to as a composite liner. Synthetic materials are typically High-Density Polyethylene (HDPE), although other materials such as Low-Density Polyethylene (LDPE) or Polyvinyl Chloride (PVC) may be used in some circumstances.

Leachate collection systems include perforated piping systems and a layer of drainage material to convey liquids on the bottom of the landfill to drain to a collection point, or sump, where it can be pumped out of the landfill for treatment.

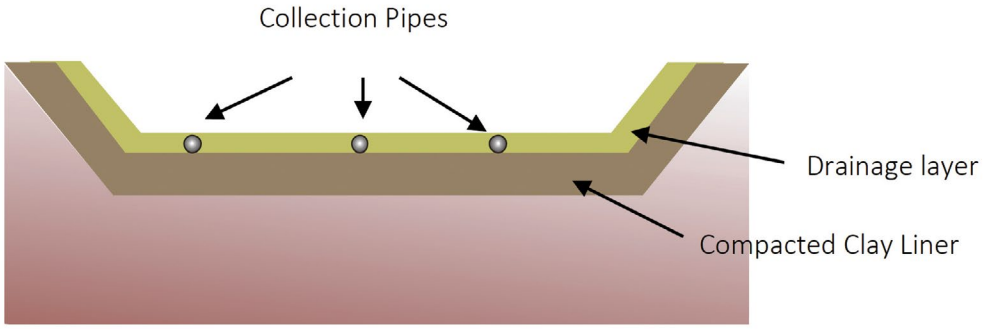


Figure 4.14 – Single Compacted Clay Liner
Source: JLTechnical Services

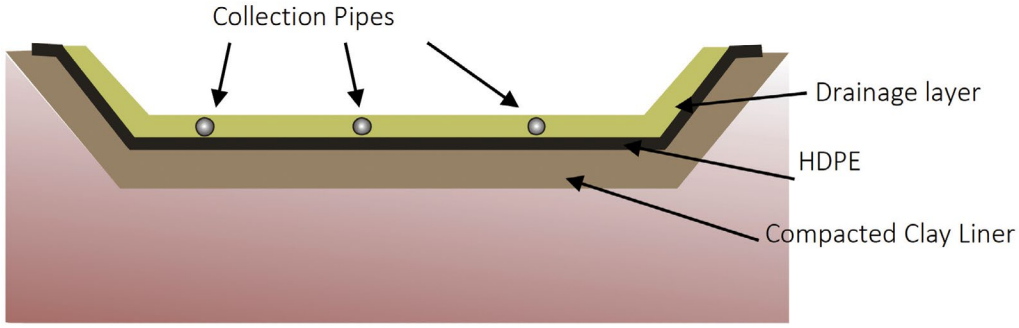


Figure 4.15 – Single Composite Liner
Source: JLTechnical Services

Photo 4.23 – Construction of a Compacted Clay Liner and Leachate Collection Pipe
Photo Source: Leduc Landfill

Photo 4.24 – Drainage Layer Being Placed Over a Liner
Photo Source: Mary Stewart, City of Red Deer

MAXIMUM LEACHATE HEAD

The landfill engineer will design the liner and leachate collection system so that the leachate head (or depth) can be maintained at no greater than 300 mm over the liner. This is known as the 'maximum leachate head'. Maintaining a low leachate head further reduces the potential for leachate to escape the landfill because it minimizes the liquid pressure on the liner. In some circumstances, the landfill design may allow for the maximum allowable leachate head to exceed 300 mm. If this is the case, it will be stated in the landfill approval.

Leachate head is measured from the top of the liner and doesn't include the bottom of sumps and pipe trenches. The head can be measured by logging liquid level in sump risers or manholes. A rise in leachate head may occur several days after a rainfall event. Operators need to be aware that this can occur and be prepared to remove leachate to lower the head to acceptable levels. If the leachate head exceeds the maximum allowed, the operator has 14 days to lower the head to approval limits. The design generally provides leachate system risers or manholes from which leachate can be pumped to reduce levels. Extracted leachate must be properly treated or disposed of.

LEACHATE SEEPS

Landfills will sometimes experience leachate 'seeps' – breakout of liquid leachate from the above grade surface of areas that may already be completed and capped or be covered with intermediate cover soils. This is generally caused by leachate flow being directed to the perimeter by layers of impermeable soil either placed as waste material or used daily or intermediate cover. When a seep is found, it needs to be dealt with. It should be brought to the attention of the site manager and an engineer should develop a remedial plan. The plan may involve excavation of the area, installation of intercept trenches, drilling of drain holes through the area down deeper into the landfill. Each situation requires an engineering assessment. Until it is remediated, leaking leachate should be contained and removed for treatment.

Photo 4.25 – Leachate Seep
Photo Source: JLTechnical Services

4.13.2 Leachate Treatment and Disposal

Leachate cannot be discharged directly to the environment. It must first be treated. Treatment options for leachate depend on a number of issues including:

- Volume and strength of leachate
- Type of waste in the landfill
- Age of the landfill
- Site location and location of sewage treatment works
- Capital and operating consideration

Options for treatment include:

- Discharge to a municipal waste water treatment facility
- On-site physical, chemical, or biological treatment
- Passive evaporation with aeration in holding ponds
- Active evaporation utilizing landfill gas
- Re-circulation in the landfill, if it has been designed for that purpose

Photo 4.26 – Leachate Loading Station
Photo Source: JLTechnical Services

Discharging to a municipal waste water system will require approval from the local authority and treatment plant operators. It may require pre-treatment of the leachate, or may be subject to discharge volume limits.

Another option for leachate is disposal by deep well injection. Deep wells are approved by the Alberta Energy Regulator according to Directive 051: Injection and Disposal Wells.

4.14 SURFACE WATER MANAGEMENT

Rainfall and snow-melt are the most significant sources of moisture that produce leachate. The design and operation of a landfill needs to focus on managing surface water and minimizing infiltration into the landfill. Water that has been in contact with waste should be considered contaminated and will need to be managed to avoid contamination of surrounding surface water systems.

Run-on is the term used to describe water that runs onto the landfill, or would if not controlled so that it doesn't. Design controls involve diverting this water in perimeter drainage systems around the landfill development. These drainage systems are typically designed around the site perimeter, or around specific development phases of the site. Run-on water that does not come into contact with waste can be diverted directly to surrounding natural drainage systems without release controls.

Run-off is the term used to describe water that runs off of the landfill. Water that runs off of the active landfill operations may contain contaminants from coming in contact with wastes. If contaminated, this water cannot be released directly to the environment.

Run-off water may be collected in drainage systems around the active operation and drained to surface water control ponds. Water can be sampled and tested and, if the approval allows, discharged to natural water bodies if it meets water quality guidelines.

4.14.1 Surface Water Control Ponds

Surface water control ponds for run-off systems are part of all new landfill designs for the management and controlled release of surface water. Pond storage capacity is designed to manage the run-off from at least a one in 25 year, one-hour duration storm event. It is important that the landfill operator maintains this amount of available storage in the control ponds.

Current day landfill designs include one or more sedimentation ponds that drain into a holding pond. Suspended solids settle out in the sedimentation pond, and release of surface water from the holding ponds is controlled. A filtration berm between the two ponds may be used to filter out potential contaminants. Such berms use porous materials such as fine gravels or sands and compost.

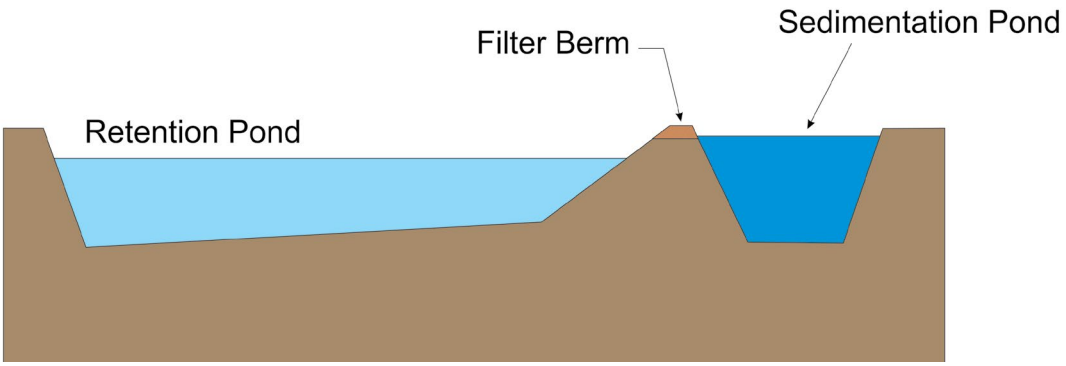


Figure 4.16 – Surface Water Control Ponds
Source: JLTechnical Services

4.14.2 Release of Surface Water

Release of surface water from the site differs for run-on water and run-off water. Run-on water that hasn't been in contact with the active areas may be diverted directly to receiving water bodies. It should be noted that any diversion of a natural drainage system, or addition of water to an existing drainage system, usually requires an approval under the Water (Ministerial) Regulation.

Water that runs off active areas of the landfill should be sampled and analyzed prior to release from storage ponds. In the event that a storage pond overflows because of unusually high rainfall, the landfill manager should report the overflow to Alberta Environment and Parks.

4.14.3 Water Quality Parameters for Planned Release

The release limits for surface water are identified in the Standards for Landfills in Alberta. These limits are listed in Table 4.6 below. Laboratory analysis is required to determine if water in ponds and at sampling points meets these limits before it is discharged from the site.

Table 4.6 - Surface Water Release Limits
Source: Alberta Standards for Landfills in Alberta

PARAMETER	RELEASE LIMIT
pH	6.0 – 9.5
Total Dissolved Solids (TDS)	2500 mg/L
Total Suspended Solids (TSS)	25
Ammonia (Total)	5.0
Chloride	250
Sodium	200
Sulphate	500
Chemical Oxygen Demand (COD)	50
Oil and Grease	No visible sheen

Specific site water quality objectives may be more or less stringent depending on the background quality of receiving waters. This will be identified by the landfill engineering consultant and specified in the landfill approval.

Landfill operators should apply measures to minimize the amount of run-off water that comes into contact with waste by minimizing the size of the working face.

4.15 MANAGING SOIL STOCKPILES AND COVER MATERIALS

Soils, other than topsoil and subsoil is stockpiled at a landfill for use as cover materials, either daily, intermediate, or the barrier layer for the final cover. Clay soils may also be stockpiled for construction of clay liners. Table 4.7 describes soil types and their general properties.

Table 4.7– Soil Type Performance as Cover Materials
Adapted from: Solid Waste Landfill Design Manual, Washington State Department of Ecology, Parametrix, Inc., 1987

SOIL TYPE PERFORMANCE AS COVER MATERIALS						
PROPERTIES E – EXCELLENT; G – GOOD; F – FAIR; P – POOR	GENERAL SOIL TYPE					
	CLEAN GRAVEL	CLAYEY-SILTY GRAVEL	CLEAN SAND	CLAYEY-SILTY SAND	SILT	CLAY
Prevents rodents from burrowing or tunneling	G	P-G	G	P	P	P
Keeps flies from emerging	P	F	P	G	G	E
Minimizes infiltration	P	F-G	P	G-E	G-E	E
Minimizes gas venting	P	F-G	P	G-E	G-E	E
Drainage material	G	P	G	P	P	P
Liner material	P	P	P	P	F	E

As landfill cells are excavated, the site engineer will select soils suitable for construction of liners and leachate collection systems, and build remaining stockpiles to be used for cover operations. Other soil may be delivered to the site from construction sites or environmental remediation projects. Clean, uncontaminated soils should be stockpiled according to their properties and intended uses. Soil from remediation projects may be contaminated and be suitable for daily and intermediate cover within the landfill containment, but not for construction of liners and roads. These soils should be stockpiled separately and located where they will be convenient for cover operations.

Clay, sand, gravel and other soil stockpiles should be placed on a prepared subgrade surface so that topsoil's and subsoils aren't contaminated with the other soil types.

Where it is possible, soil stockpiles can be placed on fill surfaces that won't be active for lengthy periods. Placing soil stockpiles over waste fill can help to consolidate the underlying waste and help create additional airspace after the stockpiles are moved.

The landfill manager will need to track soil stockpiles and monitor use of soil used for operations. This can be done by simple measurements of the stockpiles and calculating volumes, or can be done with surveys and volume calculations using a CAD (computer-aided drafting) system by the site engineers.

4.16 MANAGING RECYCLING AND SPECIAL WASTE OPERATIONS

Many landfill sites include facilities for collecting recyclables and special waste, including household hazardous waste. Metals are often set aside in designated areas for recycling through a local scrap dealer. If the community has a recycling program, some sites also function as drop off depots for household recyclables.

In Alberta, the Alberta Recycling Management Authority (Alberta Recycling) is responsible for the management of recycling programs for tires, electronics and paint and paint containers. Alberta Recycling also manages the Household Hazardous Waste (HHW) program on behalf of Alberta Environment and Parks. Most municipalities in Alberta participate in some or all of these programs.

Collection sites, including those at landfills and transfer stations, are registered with Alberta Recycling and are required to meet certain criteria in their operations to be eligible for pickup of material and receipt of program collection incentives. Pickup of tires, e-waste and paint is provided by processors registered with Alberta Recycling. The collection site selects a processor for each program and works with them for collection and pickup.

4.16.1 Tire Collection and Storage

Tire drop-off and storage areas should be easily accessible to the public. There needs to be enough room for tire recyclers to load trucks to transport to end users. Operators of acceptable tire collection facilities do not have to pay for tire removal. The landfill operator does need to monitor storage areas and keep a neat and organized collection site.
Tires are to be stored according to The Provincial Fire Code for Tire Storage as follows:

- Scrap tires to be stored outside.
- Maximum size of individual tire piles is 300 m^3 and 100 m^2 in area, and a maximum pile height of 3 m.
- Clearance space of at least 6 m between piles.
- Clearance of at least 15 m away from property lines and buildings.
- Pile shall not be located beneath power lines.

Photo 4.27 – Orderly Tire Collection Site
Photo Source: Alberta Recycling Management Authority (Alberta Recycling)

4.16.2 Electronics Collection and Storage

Landfill owners and operators should work with registered electronic processors when setting up a collection site. A collection site operated by a municipality is eligible for a handling fee payment from Alberta Recycling for eligible materials delivered to a processor registered with Alberta Recycling. Collection sites should be accessible to site users and electronics processors for pick up. Signs should be posted that clearly identify acceptable electronic products.

Photo 4.28 – Proper Storage of Electronics
Photo Source: Alberta Recycling

Photo 4.29 – Unacceptable Electronics Storage
Photo Source: Alberta Recycling

Electronics that are ineligible in the Alberta Recycling program may still be collected by some processors. If collected, these products should be stored separately according to the processors requirements and not recorded as Alberta Recycling program materials, since Alberta Recycling will not provide handling fees for non-program materials.

4.16.3 Municipal Paint Collection and Storage

Paint collected for the Alberta Paint Recycling Program are to be stored with secondary containment. Paint processors supply approved storage containers. Paint that is stored on wooden pallets or in unapproved containers doesn't qualify for incentives under the program.

Spray paint cans should be stored in separate containers from paints and paint containers. Clear directions should be given to users with clear signs and supervision.

Photo 4.30 – Paint Stored in Proper Containers
Photo Source: Alberta Recycling

Photo 4.31 – Paint Separated by Type
Photo Source: Alberta Recycling

4.16.4 Household Hazardous Waste Collection and Storage

To participate in the HHW program in Alberta operations must register with Alberta Recycling and operate their collection and storage operations in accordance with regulations and good practice. Requirements include:

- Keeping potentially reactive chemicals in separate containments
- Secondary containment for all materials (there are specially-designed 'tub' containers for this purpose)
- Sort materials in accordance with program requirements so that each can be sent to the most appropriate disposal facility
- Bulk package items for shipment in drums or other approved containments per the program requirements

4.16.5 Pesticide Containers

An organization called CleanFARMS partners with agriculture retailers and municipalities to collect empty commercial pesticide and fertilizer containers. Containers that are collected include clean and empty containers that are less than 23 L. Containers larger than 23 L should be returned to the point of sale.

Preparation by the farmer includes:

- Puncture and triple rinse or pressure rinse the container
- Remove caps and metal handles on fertilizer pails

Photo 4.32 – Covered Pesticide Storage Site
Photo Source: Ray Juska, Newell Regional Landfill

4.16.6 Other Landfill Recycling Operations

Landfill operations may include other recycling programs for: cardboard, paper, plastics, glass, and household metals. This can be done by providing drop-off containers for residents for the different materials. Collection of these materials will need to be coordinated with community recycling operations to process and market the materials.

Most landfills stockpile bulky metals for recycling. Good separation of these metals can help marketing the metals to scrap metal dealers. This may mean separation of tin, steel, non-ferrous and automobile parts. It is best to coordinate metal separation and storage requirements with the metal dealers for best results.

White goods are typically stored separately from other metals. Refrigeration, air conditioning units, and water coolers will require removal of CFCs by a qualified technician. CFC removal may be done by trained and certified in-house staff with specialized equipment. Many sites chose to have the work done by qualified contracted services.

4.16.7 Equipment

Equipment is needed at a landfill for the following primary operations:

- Spreading and compacting waste
- Excavate and haul soil
- Spread, and compact soil
- Dust control
- Fire control
- Materials handling

Equipment is also needed for road maintenance, snow removal, vegetation maintenance, and litter control. Construction is typically done by separate contractors who will supply the required equipment.

Common equipment at landfill facilities includes:

- **Landfill compactors** – steel wheeled specialty machines designed for waste spreading and compaction
- **Bull dozers** – versatile for waste and cover soil spreading; for isolating early-stage surface fires; functional for waste compaction
- **Wheel loaders** – often with multiple types of buckets and attachments such as forks – versatile for moving containers, pallets, soils, waste and other materials
- **Backhoe** – for trenching as in installing or repairing underground utilities such as culverts, piping for landfill gas systems
- **Dump truck (or sometimes extra-capacity off-road trucks)** – for general use in moving soils and residual materials
- **Roll-off truck** – for moving and dumping roll-off bins if used as collection containers on site, as in a residential transfer station
- **Water truck** – spray water for dust suppression, fire fighting, water plantings and landscape beds

4.16.8 Maintenance

There are three types of equipment maintenance:

- **Preventative:** Scheduled maintenance according to hours operated
- **Predictive:** using predictive indicators to plan repairs
- **Reactive:** Repair when something breaks

Reactive maintenance will result in unplanned equipment downtime and a shorter operating life cycle for the equipment. Preventative maintenance is typically carried out according to the manufacturer's recommendations. Predictive maintenance is based on equipment performance measures, such as oil contamination, fuel consumption, service loading, and operating hours.

It is important to maximize the operating time and minimize the downtime for equipment. The cost of downtime not only includes the cost of repair, but also includes the cost of lost production and/or the need to hire temporary replacement equipment.

The life cycle for heavy equipment varies with the application it is put to. For example, a machine working in a harsh environment, such as moving or compacting trash in a landfill, may operate reliably for 10,000 hours. In a less challenging application, such as road-building, its useful life may be considerably longer. Every machine will reach a point where rising maintenance costs and increased downtime dictate that it be replaced.

The landfill owner can decide to replace it with a new machine, or may consider a rebuild. A complete rebuild can give another 10,000 hours of equipment operating life at less expense than a new machine purchase. A

disadvantage of a rebuild is that it will not bring the machine up to the latest technologies that may have evolved since its manufacture.

If it is assumed that 50 percent of the total lifetime cost of a machine is the cost to own the machine, and the remainder is the operating cost over its operating life, it makes sense to maximize the operating life of the machine. Developing and maintaining a good maintenance program is essential to achieve that objective. It can also be effective in reducing repair costs for the machine, and further reduce the machine life cycle costs.

BASIC MAINTENANCE PROGRAM

Within the control of landfill operators is one of the most important aspects of equipment care – maintenance of fluids. Considering that the cost of fluids and filters is a small component cost of a machine's lifetime cost, it is the most effective investment in a machine's maintenance program.

The maintenance program for each individual machine should be developed based on the manufacturer's recommendations.

The equipment operators should perform a pre-shift walk-a-round check. This can vary with different machines, but includes:

- Check fluid levels
  - ✔ Hydraulic fluids
  - ✔ Crankcase oil
  - ✔ Radiator coolants
  - ✔ Transmission oil
- Tracks, tires, wheels
- Radiators
- Air filters
- Undercarriage
- Hydraulic hoses
- Lights
- Windows
- Start and listen
- Check gauge function

Photo 4.33 – Operators Must Perform Daily Checks
Photo Source: Joe Angevine, Foothills Regional Waste Management Facililty

Spill Kits

Spill kits contain absorptive materials to contain liquid spills. It is good practice to have spill kits on all equipment to be used should the unit leak fluids, and also to deal with other liquid spills that may happen in the work area. Operators must be trained in spill kit use and spill clean-up.

Operators should also perform end of shift duties including:

- Filling fuel tanks
- Ground blades and buckets
- Set brakes and locks
- Clean dirt and debris
- Check for leaks
- Secure the machine
- Report any issues

Issues that landfill operators need to pay particular attention to include:

- Excessive tire wear and punctures

- Wire in tracks and drive train
- Brush and debris in tracks or on the drive train
- Excessive wear in gears, sprockets, bearings, etc.
- Clogged radiators and air filters
- Undercarriage damage
- Broken lights and windows

Scheduled maintenance programs will typically include more thorough machine checks and servicing. Table 4.8 is an example of potential elements at different scheduled intervals. Each site should develop its own programs for each piece of equipment with input from equipment manufacturers/vendors and from assigned qualified mechanics.

Table 4.8 - Example Maintenance Program for Landfill Equipment

Daily	Circle check – as above, at start and end of shift, visual walk-around, lights, safety components, brakes, clean windows, body damage, fluid levels and lubrication as needed, spill kits are in place and fully stocked
Weekly	Lubrication and mechanical servicing Checking components and parts
Monthly	All elements of weekly checks Power wash exterior, engine compartment and drive components Inspect and clean cabin including foot pedals and rests, windows, emergency equipment Inspect fire suppression equipment and first aid supplies
Quarterly	All elements of monthly checks Inspect all high wear components
Annually	All elements of quarterly checks Thorough machine check

4.17 MANAGING FACILITY SUPPLIES/INVENTORIES

The landfill manager will need to also manage supplies and inventories for the site. This includes shop supplies, equipment spare parts, oils, greases, and fuel. This will require a tracking system to ensure supplies are ordered and delivered before there are shortages.

Fuel storage supplies will need to be monitored. Maintaining a record of supplies delivered and fuel used will be need to determine supply on site, but also can help determine fuel demand and delivery frequency. With consistent fuel usage, delivery of fuel supplies can be scheduled with the vendors.

Spare parts for equipment should include frequent consumables such as oil, grease, filters, hoses, or light bulbs. An inventory of parts should be maintained, and as parts or supplies are consumed, it should be recorded. A simple inventory spreadsheet is provided in Table 4.9.

Table 4.9 – Example Inventory Spreadsheet

INVENTORY ID	NAME	DESCRIPTION	VENDOR	QUANTITY IN STOCK	QUANTITY ON ORDER	EXPECTED DELIVERY
N0002	Oil	CK-4	Jerry's Equipment	4 cases		

APPENDIX 4-1

Sample Waste Characterization Profile

Sample Non-Hazardous Waste Manifest

Town of Example
Waste Disposal Services Department
WASTE CHARACTERIZATION PROFILE (Example)

1. Generator Information	
Generator:	
Site Address:	City/Province/Postal Code:
Mailing Address:	City/Province/Postal Code:
Contact: Phone:	Email:
2. Transporter Information	
Transporter:	
Address:	City/Province/Postal Code:
Contact: Phone:	Email:
3. Invoicing Information *Email invoice to:	
Company:	Invoicing Contact:
Address:	City/Province/Postal Code::
Technical Contact: Phone:	Email:

4. Shipping Information

Load Volume: _____ **Packaging:** □ tanker, □ drum(s), □ yd bag/box, □ tote(s). □ roll-off(s), □ pallet(s),
Frequency: □ weekly □ monthly □ quarterly □ yearly □ one-time Other _____

5. Physical Characteristics

Waste Common Name: _____

Detailed Description of Process Generating Waste: _____

Physical Composition: % liquid % sludge % solids; **Color:**

pH: □< 2.0 □2.0 - 4.9 □5.0 -10.0 □10.0 -12.4 □ ^12.5 **Odour:** □ none □ mild □ strong

Flash Point: □<140°F □140° - 200°F □ >200°F □ N/A **Layer:** □ single □ bi-layered □ multi-layered

6. Waste Characterization

Is this an Alberta listed Hazardous Waste**?** Yes □ or No □

Attachments:
□ Virgin Product - Material Safety Data Sheet (MSDS)
□ Laboratory analysis results
□ Other (describe) _____
Laboratory determination of material classification: _____

7. Certification

I hereby certify that all information submitted and documented in this profile, including attached information, is complete, factual and an accurate representation of the waste described herein and that all known or suspected hazards have been fully disclosed and I am an authorized agent of the generator. Generator agrees to indemnify and hold harmless the Town of Example for any claims, liabilities, damage and costs including, but not limited to, attorney's fees, arising out of or in any way related to breach of the above certification by the generator.

I authorize Town of Example personnel to obtain a sample from any waste shipment for purposes of verification and confirmation.

_____ _____
Printed Name Company

_____ _____ _____
Authorized Signature Title Date

PART A - GENERATOR	**Document #10101**
ISSUED TO:	Town of Example NON-HAZARDOUS WASTE MANIFEST
COMPANY NAME BUSINESS ADDRESS CITY/TOWN PROVINCE and POSTAL CODE	
ADDRESS OF SITE WASTE SHIPPED FROM	

MATERIAL DESCRIPTION	W.I.D. #	WCP #
SPECIAL HANDLING SPECIAL INSTRUCTIONS	SPECIAL INSTRUCTIONS	

IS THE WASTE A DECLASSIFIED HAZARDOUS WASTE THROUGH TREATMENT? YES □ NO □	WHAT WAS PRODUCT I.D. NUMBER AND HAZARD CLASS PRIOR TO DECLASSIFICATION? I.D. NUMBER HAZARD CLASS
Generator signature certifies that the accompanying load contains no hazardous waste as defined in the following acts and the relevant regulations prescribed thereunder: • Alberta Environmental Protection and Enhancement Act • Transportation of Dangerous Goods Act (Federal) • Transportation of Dangerous Goods Control Act (Alberta) • Public Health Act (Alberta)	NAME OF AUTHORIZED PERSON: (print name) SIGNATURE: PHONE NO.: *DATE:*

PART B - CARRIER

COMPANY NAME	BUSINESS ADDRESS	CITY PROVINCE
COMPANY PHONE #	DRIVER'S NAME (Print Name)	
LICENSE PLATE #	DRIVER'S SIGNATURE	DATE

PART C – RECEIVER – TOWN OF EXAMPLE LANDFILL

DATE	SAMPLED		QUANTITY RECEIVED (KG)	SCALEPERSON SIGNATURE	COMMENTS
	YES	NO			
1.					
2.					
3.					
4.					
5.					
TOTAL					

INFORMATION:

1. Hazardous waste loads will NOT be accepted.
2. Non-hazardous solid wastes NOT accompanied by a Manifest will be refused
3. Alberta Environment Pollution Control (24 hrs) 1-555-555-5555.
4. .Alberta Environment, Chemical Assessment (Office Hours) 555-555-5555.
5. Alberta Environment, Industrial Spill Reporting (24 Hrs) 555-555-5555.
6. Alberta Transportation & Utilities Dangerous Goods Control (24 hrs) 555-555-5555.
7. All charges to be paid by cash, Visa, Master Card, Interac or on approved account.

WHITE-COPY-RECEIVER YELLOW COPY - CARRIER PINK COPY - GENERATOR

05 Chapter

Landfill Siting, Design and Construction

Landfill Siting, Design and Construction

It is important that the siting, design and operation of landfills is practiced such that they protect:

- Public health and wildlife
- Water, soil and air
- Surrounding land and neighbours from unacceptable nuisances
- Ecologically sensitive areas

Today, landfills in Alberta must be designed by qualified professional engineers. Design of a landfill involves more than just reproducing 'off the shelf' design details. Every landfill setting is different. Siting of a landfill is often the most challenging part of a new landfill project for both the owner and their engineers.

After siting and initial development, the project is not over. Landfills are like an ongoing construction project. After the initial development, it falls to the landfill owner, his/her manager(s) and the landfill operators to continue to follow the landfill design and operations plan as developed by the designing engineer.

Landfill operators need technical knowledge and skills in order to do their part.

Learning Objectives

In this Chapter you will learn about:

- What's involved in siting a landfill
- Important design features of modern landfills and how they must be operated and maintained
- How to interpreting engineering maps and drawings
- Basic survey techniques
- Mapping and recording of special waste disposal
- How to do geometric calculations that are useful in landfill operations
- Closure and post-closure of a landfill and the role of operators in preparing the site

5.1 LANDFILL SITING

Present day landfills are sited by qualified professionals who take into consideration the natural geology, topography, and surrounding land uses. A professional engineer takes this surrounding environment into consideration and designs the site to prevent the escape of contaminants into that environment. A technical investigation is undertaken that includes review of existing topographical and geological information, drilling of boreholes and installation of monitoring wells, conducting surface topography surveys and mapping of relevant features.

Information necessary to determine if a site is suitable includes:

- Surface topography, drainage patterns, and natural or man-made water bodies (canals, streams, rivers, or drainage channels)
- Surrounding land use and adjacent development
- Domestic and municipal water well information within five km of the site
- Profile and depths of topsoil and subsoil
- Geologic and hydrogeological information including geologic formations, depth to groundwater, hydraulic conductivity of geologic formations, and direction and rate of groundwater flow

In Figure 5.1 below the geology of an area is shown for a proposed future landfill. Wells to measure and monitor groundwater are drilled and the upper layers of groundwater are mapped and taken into consideration. In this example we see that there is some depth of undisturbed soils labeled unsaturated overburden which overlies a layer saturated by groundwater. Below that layer is bedrock.

The Engineer will perform tests on the soil and water to determine the existing conditions. Then, based on these test results a design for the landfill liner system and leachate collection system will be developed. In the drawing, a concept of the liner in place and the ultimate shape of the full and finished landfill is superimposed to illustrate what the landfill will look like in the future using this design.

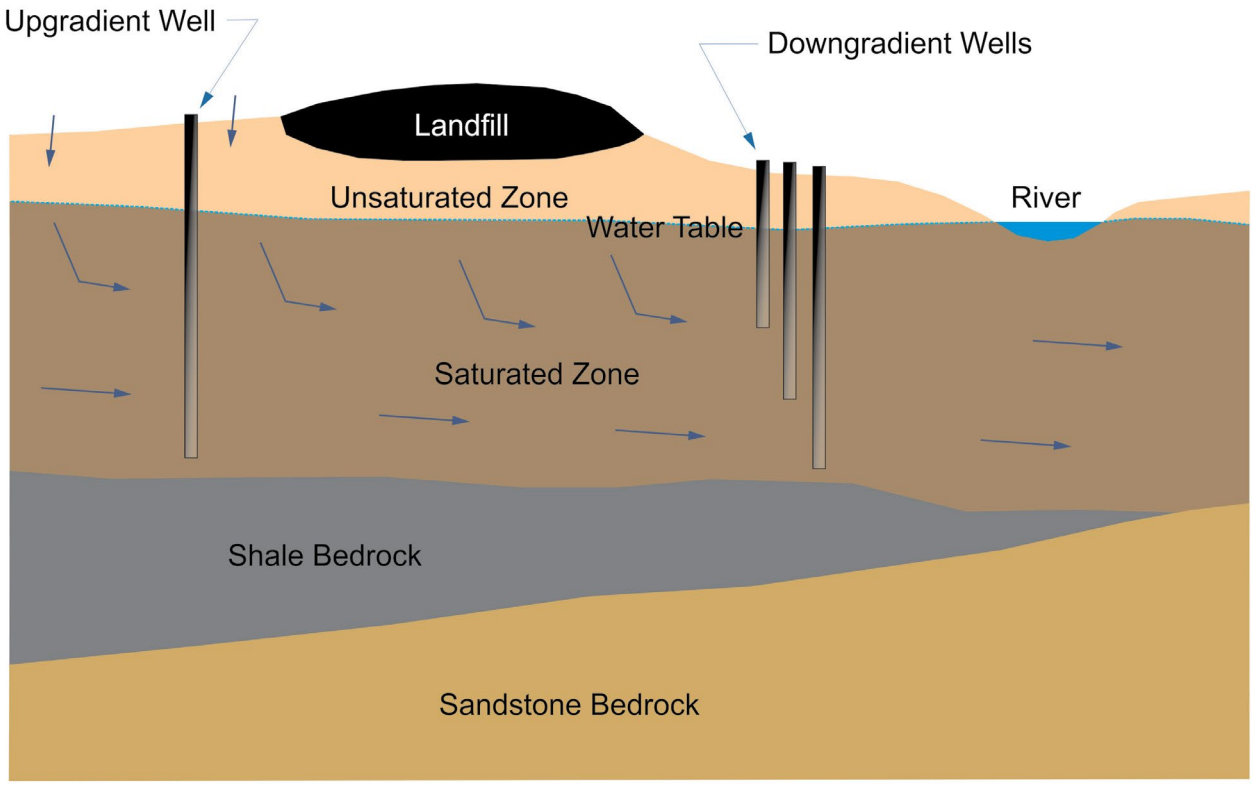


Figure 5.1 – Geological Setting
Source: JLTechnical Services

Preferred sites for landfills meet the following conditions:

- At least 100 metres from land subject to slope failure
- At least 300 metres from permanent natural or man-made water bodies
- Not within a ravine, coulee, or gully
- Where there is at least 30 metres or more of soil that has a hydraulic conductivity of 1 x 10^{-8} or metres/second (m/s) or lower below the bottom of the landfill and an underlying significant aquifer (water bearing zone with high hydraulic conductivity)
- At least ten metres of clayey soil with a hydraulic conductivity of 1 x 10^{-8} m/s or lower immediately below the liner

An ideal site may not always be possible, and engineers will need to prepare designs that include special features (e.g. double synthetic liner systems with leak detection) required to protect the surrounding environment.

Hydraulic conductivity is a measure of a soil's capacity to transmit water. Coarse grained soils, such as gravel, will transmit more water than fine grained soils, such as clays. A stated conductivity of 1 x 10^{-8} m/s means that using the specified test method, water would move through the soil very slowly – 1/100,000,000 of a metre per second.

5.2 ENGINEERING DESIGN

To prepare a landfill design, the engineer will review all relevant information including:

- Existing and future waste types and quantities
- Hydrogeological information (groundwater information and geological profiles)
- Topographical maps, surrounding land use, and drainage patterns
- Climate data (including precipitation)
- An evaluation of the expected production and characterization of leachate
- An evaluation of expected landfill gas generation and composition
- Zoning restrictions and Regulations

The term **'Dry Tomb'** has been adopted to describe landfills built and operated to minimize the amount of moisture that enters the landfill. This reduces the amount of leachate production and thus risk of ground and surface water contamination. Dry tomb landfills are the most common approach to landfill design and operation in North America.

Over the past decade or so some landfills in North America have been developed as what has been named **'Bioreactor Landfills'**. These complex designs feature leachate recirculation and water introduction to accelerate the degradation of the waste mass, shorten the period of time that gas and leachate is produced, and harvest landfill gas produced for energy uses. Bioreactor landfills are not commonly used in Alberta and are beyond the scope of this study guide.

The engineer will design the cell location and orientation based on the site topography, soil types and groundwater depth. The design will identify the vertical and horizontal limits for the landfill cell. Liner systems will be designed based on site-specific requirements for protection of groundwater. The design will specify liner materials, thickness, and leachate collection systems. The design report will include specifications for construction.

A landfill liner minimizes the leakage of leachate and landfill gas from the landfill. Leachate collecting on a liner is removed through the leachate collection system and further reduces the potential for leakage from the landfill.

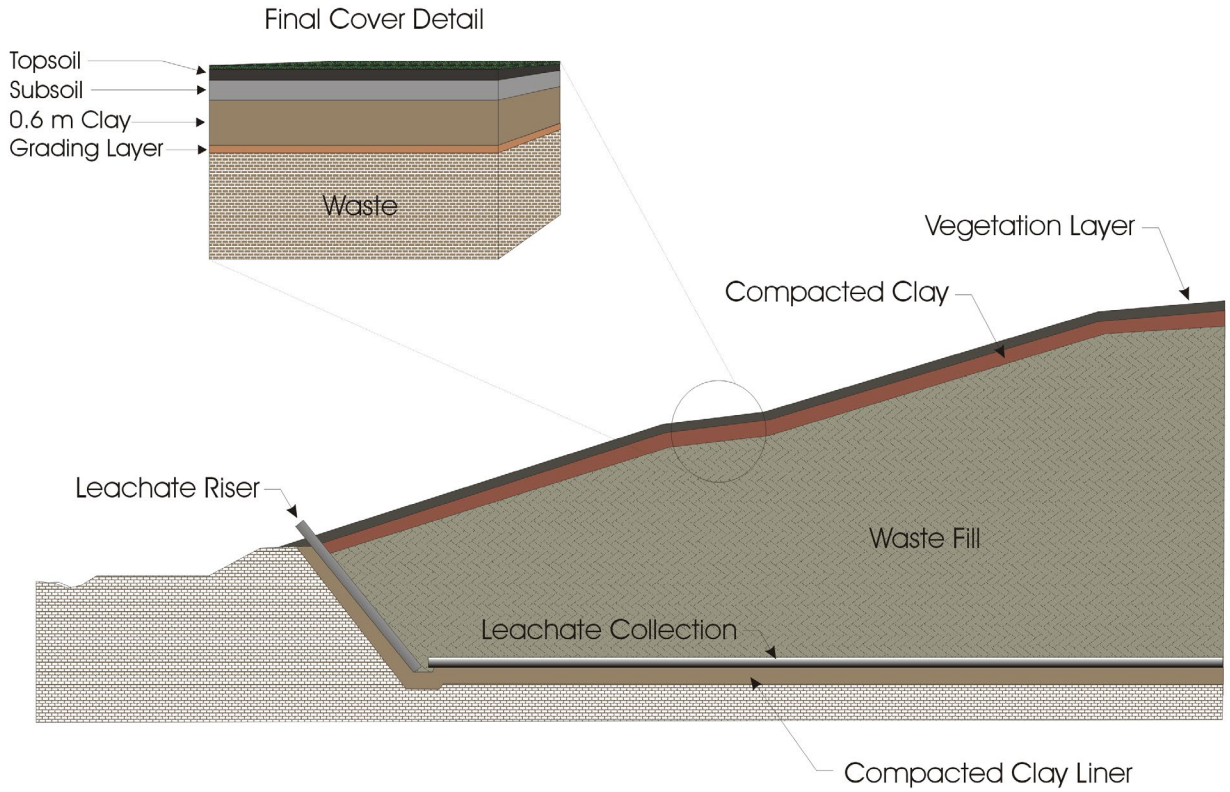


Figure 5.2 – Illustration of Lined Landfill with Leachate Collection System
Source: JLTechnical Services

An engineering design package will typically include:

- Grading plans for liners and leachate collection systems
- Landfill contour and cross-section plans (excavations, sequential fill plans, completed fill surfaces)
- Detailed plans showing site features
- Construction details and specifications
- A preliminary final closure plan and end use plan

On the following pages are three examples of typical formal engineering drawings for a landfill showing the basics of general site layout, cell base contours, planned final contours, and landfill cross-sections.

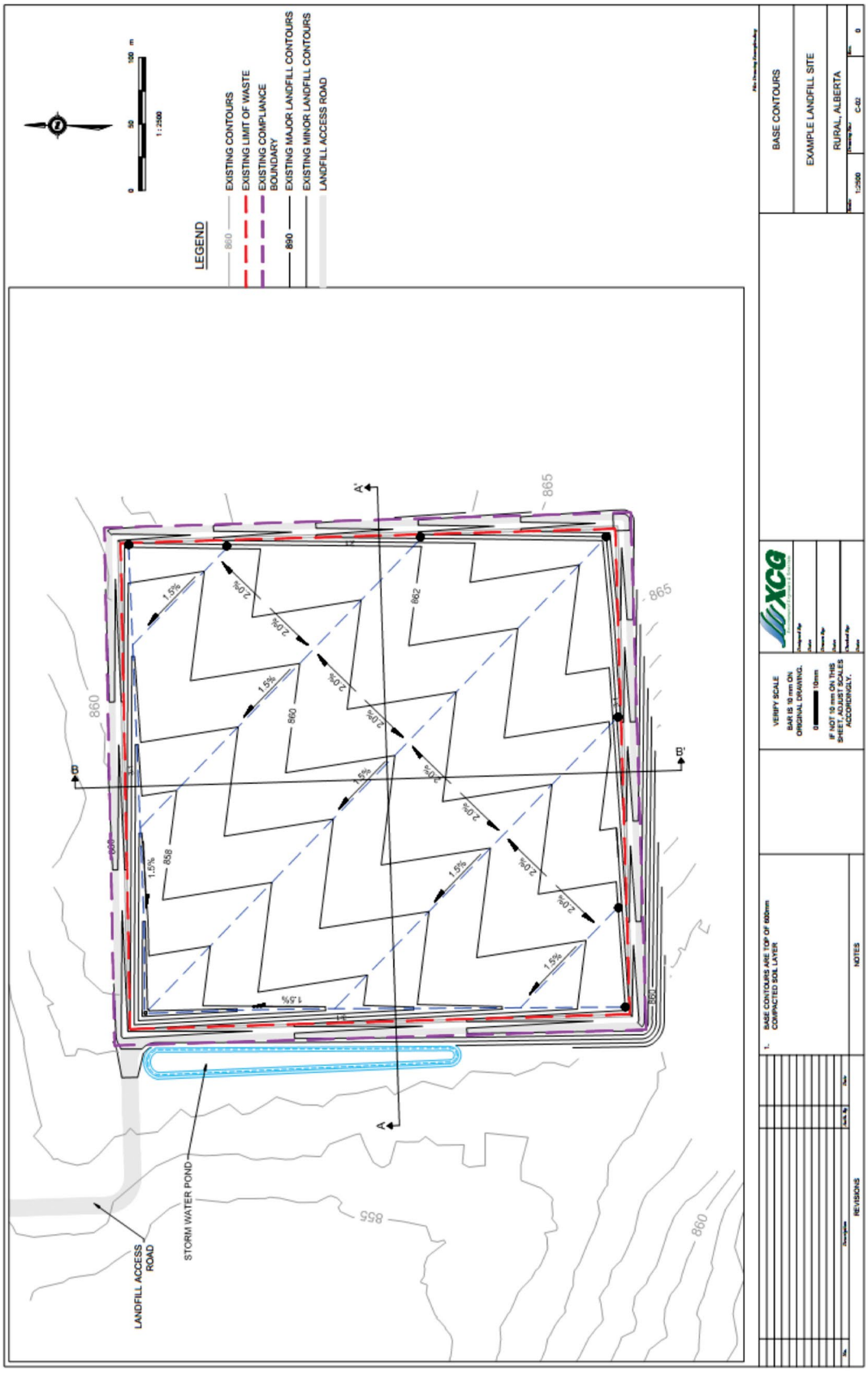


Figure 5.3 – Typical Landfill Design Drawing – Base Contours
Source: XCG Consulting

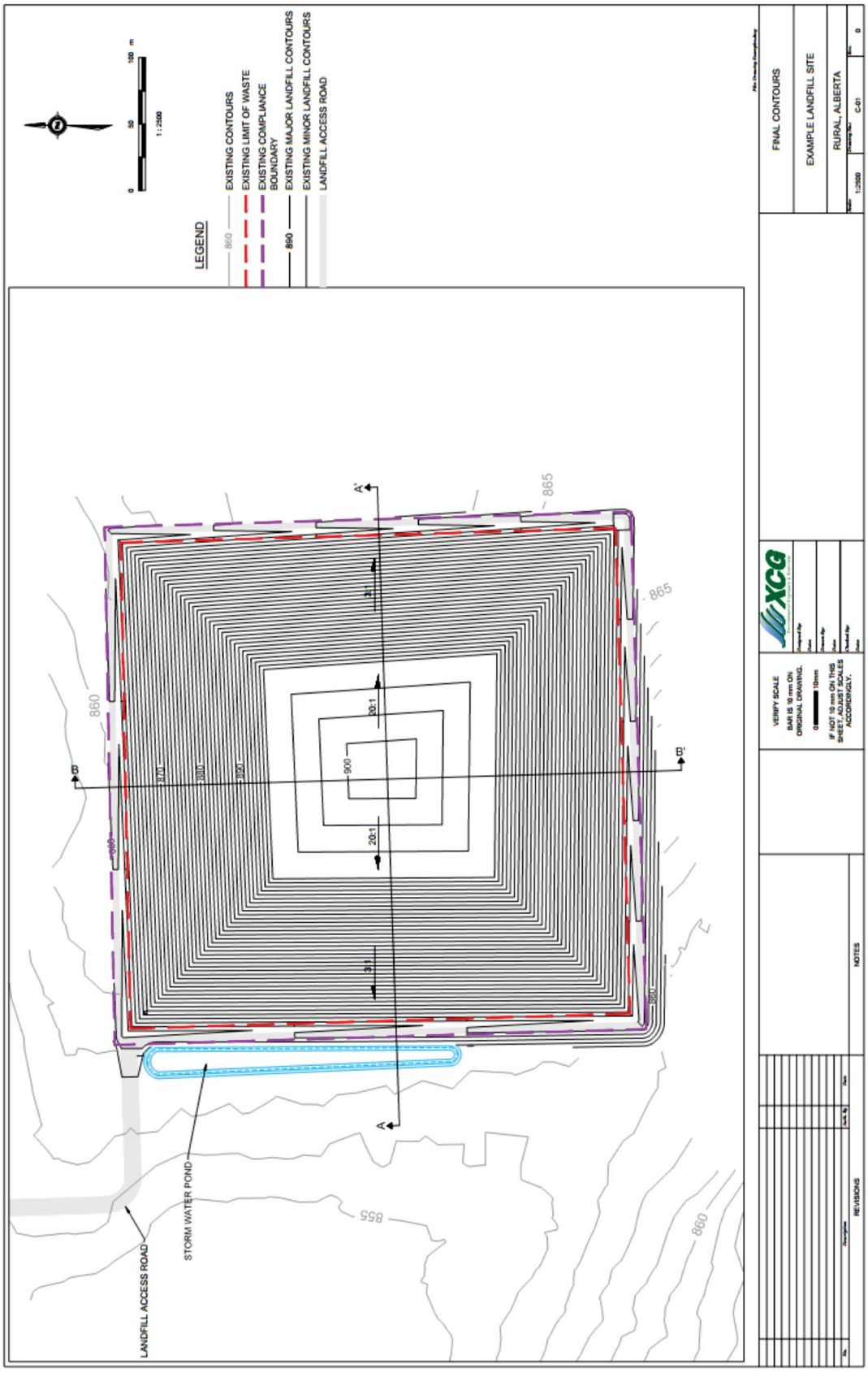


Figure 5.4 – Typical landfill design drawing – final contours
Source: XCG Consulting

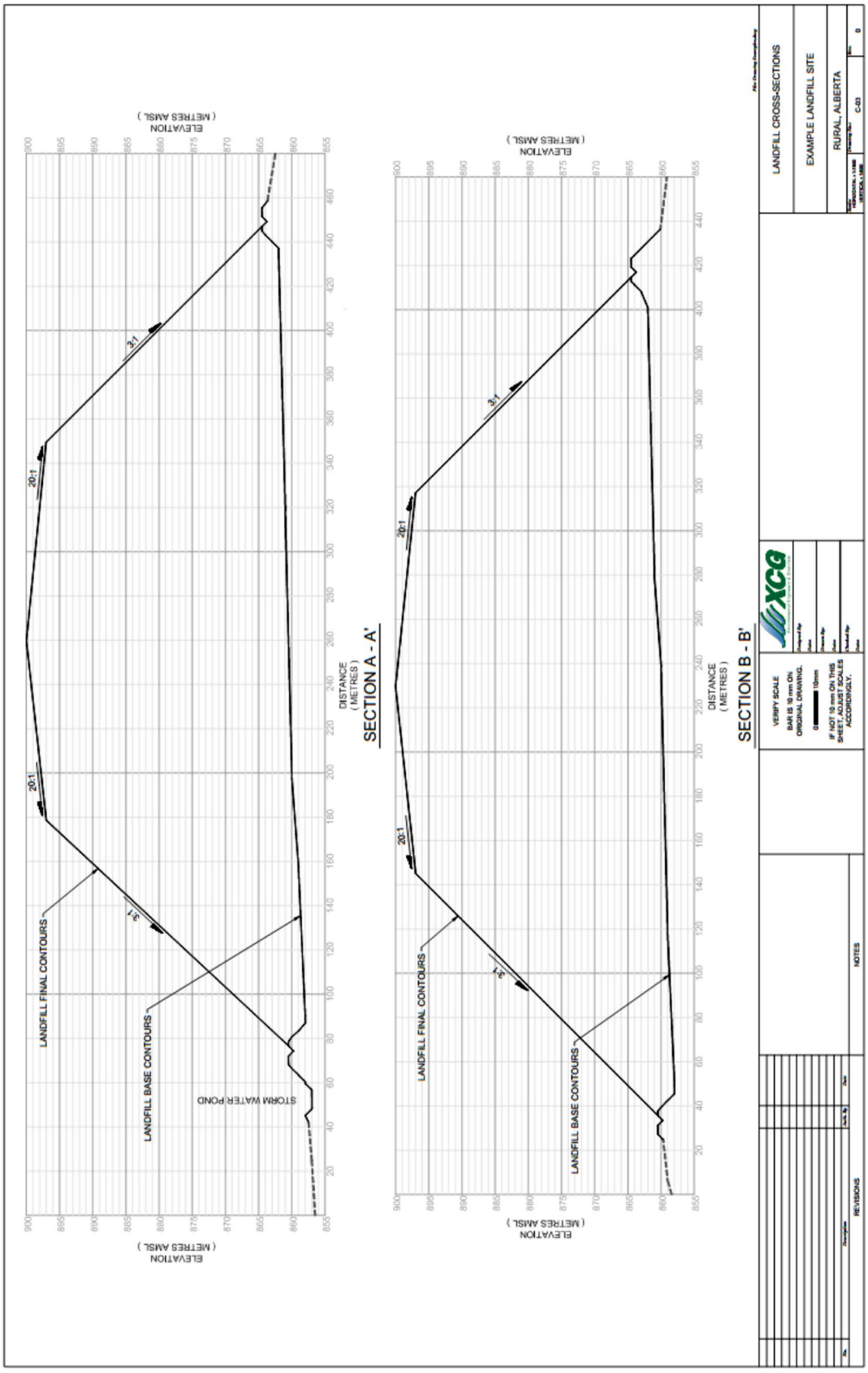


Figure 5.5 – Typical Landfill Design Drawing – Landfill Cross-Sections
Source: XCG Consulting

5.3 INTERPRETING MAPS AND DRAWINGS

It is important that a landfill is built and operated as set out in the approved engineering design. The design is based on established engineering principles and takes into account important regulatory requirements. A landfill operator should work closely with the landfill engineer. The ability to understand key aspects of engineering drawings will improve communication with the engineer. The skill will also be useful in ensuring day- to- day operations match the intent of the design.

An engineering drawing provides important information.

For most landfills the design will be presented using several drawings as well as a volume of bound construction specifications. A complete set of both drawings and specifications should be kept at the site for reference. It is common, though, to print off certain key ones, like the general site layout, so it can be used by operations staff in discussion of day to day plans.

Referring to Figure 5.3, the title block on the drawing tells:

- Drawing title (Base Contours)
- Facility name (Example Landfill Site)
- Scale (1:2500)
- Drawing number (C-02)
- Revision number and description, if any
- Notes and other important general information

On a site plan or layout drawing, a **north arrow** will show orientation to the real world. A drawing **legend** may be included to help interpret the plans. In Figures 5.3 and 5.4, the legend identifies what some different line styles mean.

5.3.1 Understanding Scale

It is not possible to draw major facilities, such as a building or a landfill cell, on paper without drawing them at a reduced scale. In real life, the width of a landfill cell may be 200 metres, while on the drawing the width is represented by a line 20 cm long. The scale may be indicated on the drawing as 1 centimetre (cm) = 10 metres (m) or as a ratio of 1:10,000 (one to ten thousand). These are just different ways of saying the same thing.

Example 1: Drawing Scale is 1 cm = 10 m

If the length of an object on paper is 6 cm, how long is the object in the real world?

If 1 cm = 10 m, then
6cm = 6 x 10 m = 60 m

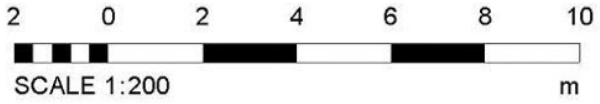
Example 2: Scale is 1:1,000

If the length of a distance on paper is measured as 6 cm, what is the real world distance?

If 1 cm = 1,000 cm, then
6 cm = 6 x 1,000 cm = 6,000 cm, or since 100 cm = 1 m this implies that 6000 cm = 60 m there are 100 cm in a metre, 60 m.

Note that the two examples give the same answer. In the first, the units are different – in this case, centimetres to metres. In the second example, the ratio is always based on a common unit of measure. In this case centimetres were used, but if the paper distance were stated as 60 mm, the answer would be the same. Try it!

Scale bars – drawings sometimes have a scale bar, similar to this:



One can transfer the scale bar increments on to a piece of cardboard or paper to make a 'ruler' that matches the drawing scale and use it to make approximate measurements on the drawing.

CAUTIONS

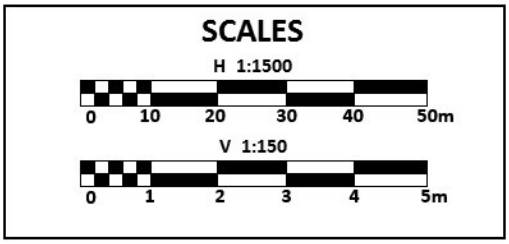
1. Errors due to drawing reproduction size – As full size engineering drawings can be large and clumsy to work with; it is common that reduced scale drawings are printed for day to day use. But when printed on a paper size different than the original drawings, the stated scales are no longer accurate. The 'ruler' of a scale bar remains accurate since the bar itself will have been reduced by the same amount as the drawing. It is useful to have scale bars on altered-scale prints.
2. Measurements taken from or transferred to a drawing should be considered approximate only. Where an actual dimension is indicated on an engineer's drawing that figure should be taken as precise.

Cross-Sections and Exaggerated Vertical Scale

Landfill drawings will always include one or more cross-sections and may include 'elevation' views. A cross-section can be thought of as the view one would have if a cut were made down through the landfill and the material on the near side of the cut removed, giving a clear view of the vertical cut face. An elevation view is the view one would have standing some distance from the landfill and looking horizontally towards it.

In both cases, it is common to depict these views with an exaggerated vertical scale. On Figure 5.3 the horizontal scale is 1:1500, the vertical scale is 1:500 - an exaggeration factor of three. This is done to make low grades more apparent and to better illustrate features such as thin layers (500mm of topsoil might be little more than the width of a pen line at 1:1,000, but at 1:100 it is 5 mm thick on the drawing – enough to be apparent to the reader.) Watch for scale notations like this one to identify drawings with different horizontal and vertical scales.

It is important to be aware of these situations when interpreting slopes and grades and calculating volumes – as discussed below.



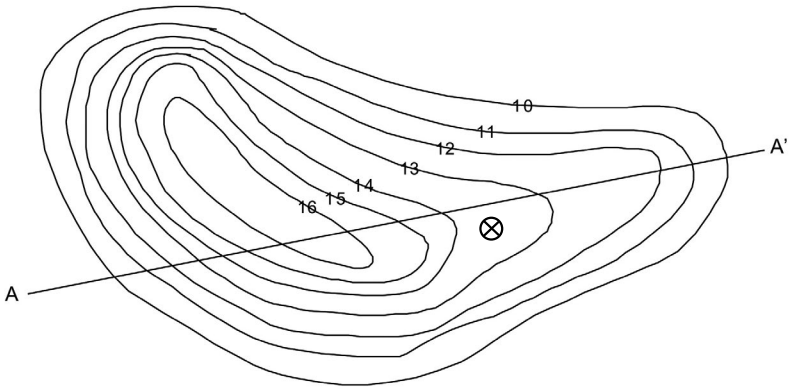
Interpreting Contours

Contour lines are used on drawings to show elevation. All points along a contour line are the same elevation. The elevation of a contour line is indicated right on the line. In some cases, not every line has the elevation indicated. With the understanding that contour lines are always at the same elevation interval from adjacent lines, the reader of the drawing can determine the elevation of the lines between by a simple calculation. For example, if one line is indicated as being at elevation 10m, there are four lines with no figure on them, and then a line indicated as 12.5m, then one can determine that the four unlabeled lines are at elevations 10.5, 11, 11.5 and 12. The 0.5m difference between contour line elevations is referred to as the "contour interval". Contour intervals vary depending on the scale and intent of the drawing.

Besides ground surface elevations, contours are also used to show sub-surface features such as top of groundwater table and top of geological formations, such as bedrock. They can be used in design drawings to show proposed final elevations of fill areas and the design for the base of a landfill.

Useful information for interpreting contour line drawings:

- Contour lines never cross each other
- Closely spaced contour lines indicate steeper slopes
- Wider spaced contour lines indicate flatter slopes
- Contour lines in a circular shape can either show a hill or a depression
- V-shapes on contour maps indicate valleys or ditches



⊗ Water well
1 metre contour interval

Figure 5.6 – A Mound Shape Represented by Contours
Source: JLTechnical Services

Problem:
In the example shown, what would the elevation be at the location of the water well?

Answer: Since the well is located half-way between two contour lines, the elevation can be interpreted to be approximately 13.5 m.

Contours and Cross Sections

As described earlier, a cross section is what you would see if you could cut through the landfill and look at the cut face. In Figure 5.6 above, the line labeled A-A' indicates the location of the cross section shown below. If the drawings have been created using CADD (Computer Aided Design and Drafting) the cross section as below is easily generated by the software. Note the exaggerated vertical scale. Cross sections can also be generated manually by measuring the distance between contour lines on a drawing and plotting the points on a grid similar to that seen on Figure 5.7.

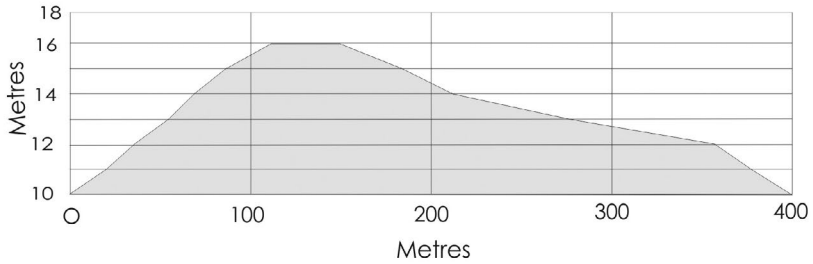


Figure 5.7 – Landfill Cross-Section
Source: JLTechnical Services

Slope and Grades

Though the two terms are technically interchangeable, when talking about landfills, the term slope is typically used for steeper surfaces, such as side slopes of ditches or of the landfill itself. The term grade is typically used to talk about lower slopes, such as road grades.

Slope is calculated as a ratio of horizontal distance to vertical distance. For example, if a horizontal distance of five metres is measured, and over that distance there is a one-metre change in elevation (vertical distance), the slope is written as 5:1. Calculating a slope is simply dividing the horizontal distance by the vertical distance.

Slope vs Grade
2:1 slope = 50%
3:1 slope = 33%
4:1 slope = 25%
5:1 slope = 20 %
20:1 slope = 5%

Calculating a Grade
If a roadway climbs two metres in elevation over a horizontal distance of 40 metres, the grade can be determined using the formula “rise over run x 100”. In this case the ‘rise‘(or vertical distance) is 2 metres and the ‘run’ (horizontal distance) is 40 metres. 2/40 = 0.05 metres per metre. To convert this to a percentage: 0.05 x 100 = 5%. If measuring the roadway slope in the downward direction, the ‘rise’ would be negative two metres and the grade would be -5%.

Grade is typically calculated as a percentage

Basic Survey Techniques

There are several types of surveys used in development and construction of a landfill. These include:

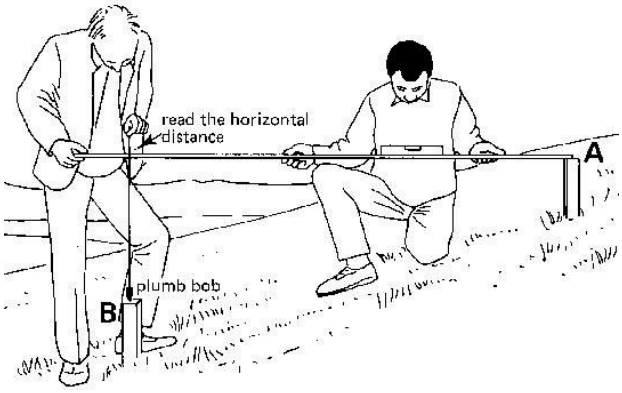
- **Topographical survey:** used to establish ground elevations and distance
- **Geodetic survey:** establish global coordinates
- **Cadastral survey:** legal surveys
- **Construction survey:** used to lay out construction projects

A landfill operator will normally have a survey team perform the required surveys, but may need to perform some basic surveying to manage the fill operations.

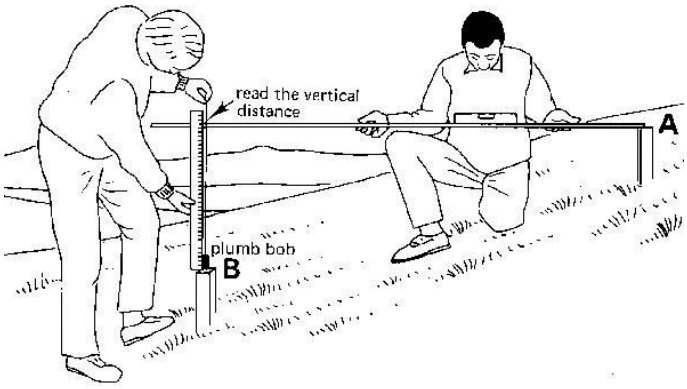
Photo 5.1 – Topography Survey with GPS
Photo Source: JLTechnical Services

Horizontal and Vertical Distance Measure

Operators may need to measure distances in the field. When measuring horizontal distance on a slope, true distance is measured on a flat plane. The vertical difference between the two horizontal points can be measured to determine slope. Though the technique illustrated below is seldom used today, the concept is well demonstrated. An important tool for an operator is a surveyor's 'chain' – which is a long metal tape measure on a reel.



Measure Horizontal Distance



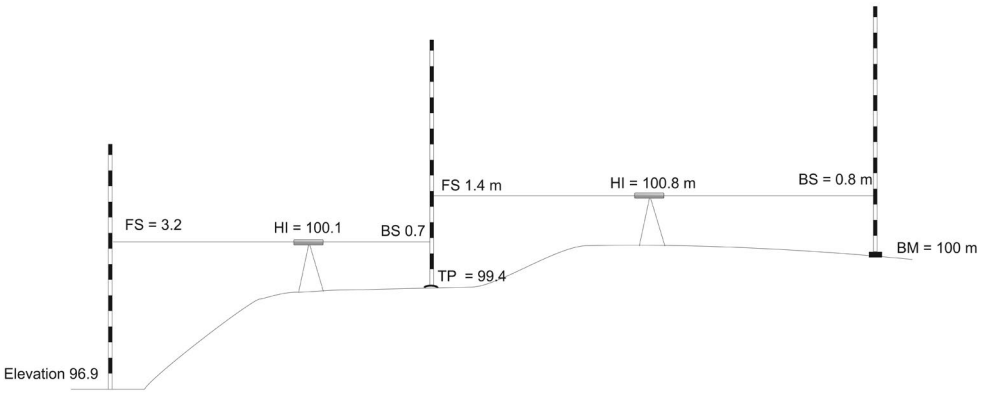
Measure Vertical Distance

Figure 5.8 – Accurate Measurement of Horizontal and Vertical Distances
Source: Irrigation Water Management: Training Manual No. 2, Elements of Topographic Surveying
Food and Agriculture Organization of the United Nations
C. Brouwer, International Institute for Land Reclamation and Improvement, and
A. Goffeau, J. Plusje, M. Heilboem, FAO Land and Water Division

Rod and Level

Rod and level is a classic survey technique which has largely been replaced by newer technologies, but is still in use. The rod is simply a special flat stick with boldly marked graduations on it – like a heavier and longer "yard stick". The level can be thought of as a low power telescope with a bubble level attached so that it can be set to view on a perfectly level plane. The level typically mounts to a portable tripod for stability. The surveyor sets the level and then takes readings of the rod, held by an assistant, using the cross-hairs in the scope.

A rod and level can be useful to a landfill operator to determine elevation difference, or to check an elevation of a fill surface or bottom of a cell. In most cases, the operator will rely on the site engineer to perform this work. The following figure illustrates how a rod and level is used.



Terminology
HI = Height of instrument
TP = Turning Point
BM = Bench Mark
BS = Back Sight
FS = Fore Sight

Figure 5.9 – Use of Rod and Level
Source: JLTechnical Services

In this example, an established benchmark (BM) is the starting point. In surveying, a benchmark is a point with a known elevation. In practice, surveyors typically establish several benchmarks at a worksite. A typical benchmark is an iron bar driven into the ground in an area that will not be disturbed by construction activity. After driving the bar, the surveyor carefully establishes its elevation and records it in a log book for later use.

The level is set between the BM and a point with an unknown elevation. The instrument is leveled and a back sight (BS) reading is made on the rod. In this case the BS reading is 2.45 m. The height of the instrument (HI) can then be calculated as 100 m + 2.45 m = 102.45 m. The rod is moved to the point of an unknown elevation and a fore sight (FS) is taken. In this case the FS reading is 0.6 m. The elevation on the ground is then determined as 102.45 m – 0.6 m = 101.85 m at the turning point (TP). With the TP elevation now known, the surveyor can, if necessary to reach a higher final point of interest, move the level (Station B), take a back sight on the rod held at the turning point and repeat the process.

If horizontal distance measurement is required, such as would be necessary if one wished to calculate the slope of the surface, a surveyor's chain could be used applying the technique illustrated in Figure 5.5.

Global Positioning System

Global Positioning System (GPS) uses a network of orbiting satellites to establish both horizontal and vertical coordinates. GPS is a powerful tool.

Engineers use sophisticated and accurate GPS systems for topographical surveys and establishing construction layout and grade stakes.

GPS systems can also be installed on equipment and used to mark locations and grade to establish elevations. Specialized landfill GPS systems have been developed for landfill compactors to track equipment movement over waste and the associated change in elevations. This helps operators to maximize compaction densities.

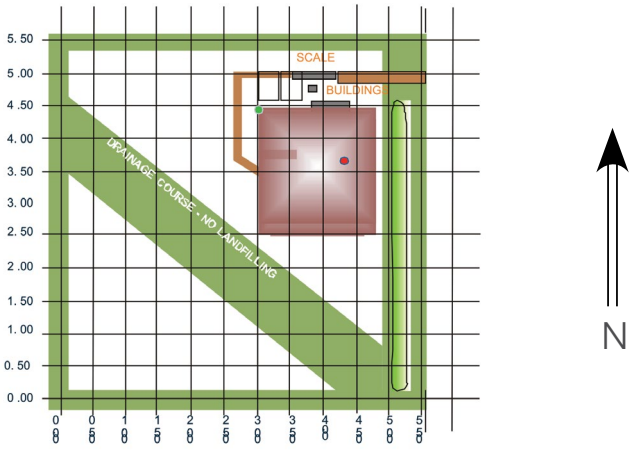
Photo 5.2 – GPS in Landfill Compactor
Photo Source: Jennifer Barnfield, County of Grande Prairie

Mapping and Recording Special Waste Disposal

'Special waste' is waste material that is acceptable under environmental regulations for the particular class of landfill being operated, but has characteristics that dictate that it be dealt with particular care. Asbestos is one example. While regulations allow for asbestos waste to be deposited in a Class II landfill in Alberta, an operator will wish to take special steps to comply with standards and protect current and future staff from exposure. Asbestos is deposited into a specially excavated pit within the landfilled waste and covered immediately. The location is recorded so that if future operations call for the area to be excavated or drilled in to, the asbestos can be avoided.

These locations can be recorded on landfill plans and maintained in the landfill operating record. Using GPS is a good way to record locations by longitude, latitude, and elevation.

If GPS systems are not available, the operator may note the location of the waste by reference to a landfill grid system. The site engineer would put a grid of stakes or similar markings near the working area and provide the operator with a grid map that can be used to mark the location by referencing the stakes. The elevation of the waste in the fill area may need to be surveyed with a rod and level, or may be estimated based on the most recently established elevations of the working area. The operator should work with the site engineer to set up a program for mapping of waste.



Example:
The red dot marks the location of land-filled special waste. Using the grid map, it is located at grid location:
3.53 N and 4.25 E

Elevation can be determined from a ground survey.

Figure 5.10 – Typical Landfill Grid
Source: JLTechnical Services

Basic Landfill Calculations

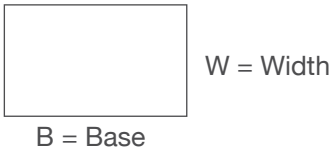
There are common shapes that landfill operators may need to calculate the areas and volumes for. This includes:

- Volume of truck boxes
- Volume of round barrels and leachate storage manholes
- Volume of soil stockpiles
- Volume of disposal trenches
- Area of a working face
- Volume of cover soil

Areas of Shapes

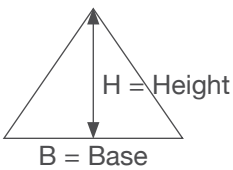
Surface areas are calculated by different formulae for different geometric shapes. Area is expressed in square units (metres squared).

Area of a Rectangle: Base x Width



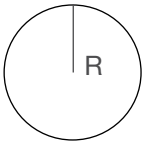
If B = 8 m, and W = 12 m
Area = 8 x 12 = 96 square meters

Area of a Triangle: ½ Base x Height



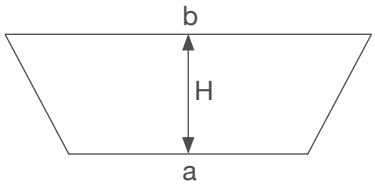
If B = 12 m, and H = 4 m
Area = ½ x 12 x 4 = 6 x 4 = 24 square meters

Area of a Circle: π x Radius^2,or πR^2,or π x R x R



If the radius of a circle is 1.5 m, what is the area?
π = 3.14
Area = 3.14 x 1.5 x 1.5 = 7.065 square metres

Area of a Trapezoid: ½ (a+b) x height

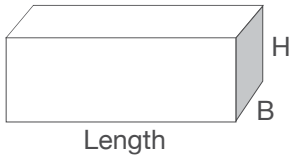


If a = 15 m, b = 20 m and H = 8 m, what is the area of this trapezoid?
A = ½ (a+b) x H = ½(15+20) x 8
A = ½ x 35 x 8 = 140 m^2

Volume of Shapes

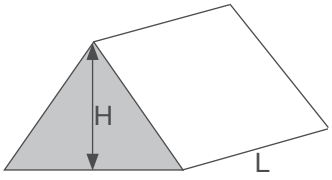
For regular shapes, in general volume is calculated by multiplying the end area of an object by its length. Volume is expressed in cubic units (example: metres cubed, m^3).

Volume of a box: V = Base x Height x Length



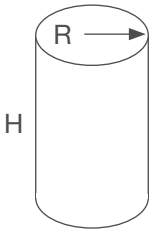
If the end area of a cube, BxH = 7.065 m^2, what is the volume, if length is 2.5 m?
Volume = end area x height
Volume = 7.065 m^2 x 2.5 m = 17.66 m^3

Volume of a triangular prism: V = ½ B x H x L



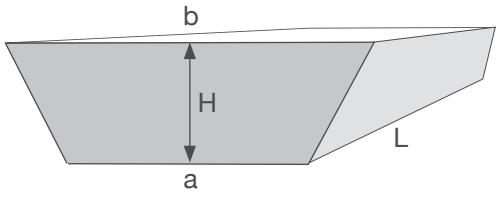
If the end area of a prism is 24 m^2, what is the volume, if length is 15 m
Volume = end area x length
Volume = 24 m^2 x 15 m = 360 m^3

Volume of a cylinder: πr^2 x height



If the end area of a cylinder, πR2=24 m^2, what is the volume if length is 15 m?
Volume = end area x length
Volume = 24 m^2 x 15 m = 360 m^3

Volume of a trapezoid prism: ½(a+b) x H x L



If the end area of a trapezoid prism, ½(a+b)=140 m^2, what is the volume, if length is 40 m?
Volume = end area x length
Volume = 140 m^2 x 40 M = 5600 m^3

Calculating Density

Landfill airspace can be defined as the volume of space on a landfill permitted for the disposal of municipal solid waste (MSW). This space is initially occupied by air which will eventually be displaced by the disposed waste — thus the term "landfill airspace."

While there are other density calculations a landfill operator may need to calculate, compaction density of waste is one unique and important to landfill operations. It can be determined by calculating the volume of airspace filled and measuring the weight of waste that was placed in that airspace. An engineer can use survey data to determine the volume of airspace filled between surveys, and by using scale records, the weight of waste placed in that same time frame.

Waste density is calculated by dividing the weight of waste by the volume of airspace it occupies. The formula is:

$$\text{Density} = \frac{\text{Weight of waste (kg)}}{\text{Volume of airspace } (m^3)}$$

Example Density Calculation:
If a landfill cell volume is 150,000 cubic meters, and the amount of waste disposed in the cell is 105,000 tonnes, what is the density of the waste?
First: Convert tonnes to kilograms
Note there is 1000 kg in a tonne
1000 kg/tonne x 105,000 tonnes = 105,000,000 kg

$$\text{Density} = \frac{W}{V} = \frac{105{,}000{,}000 \text{ kg}}{150{,}000 \ m^3} = 700 \text{ kg}/m^3$$

5.4 CLOSURE AND POST-CLOSURE

Landfill closure occurs when a landfill facility ceases to receive waste materials. Typically, this happens when the landfill reaches final capacity (no remaining airspace). Portions of a landfill may be closed when the design capacity for that area of the landfill has been filled. Landfills may also be closed for other reasons such as environmental concerns, encroaching development on lands surrounding the landfill facility, or for financial reasons.

It is important that landfill operations staff have knowledge of and understanding of the landfill closure and end use plans as they can have a significant impact on final closure costs, constructability and long-term cover system performance.

The final closure of a landfill needs to provide long-term protection of the environment and meet specific requirements of Alberta regulations and the operating approval for the site. Key considerations include protection of groundwater and surface water, avoiding erosion of the soil cover, control of air emissions, and control of rodents, insects, scavenging birds.

The final closure should take into consideration the end-use of the site after closure. End uses are varied, but examples include golf courses, nature or recreation parks, parking lots, etc. A closed landfill is shown in Photo 5.3. The waste material has been covered with engineered soil layers and planted with trees, plants and grasses.

A landfill operator needs to have a good understanding of both the long-term development plan and the ultimate closure and end use concepts for the site. The landfill operations can have a significant impact on final closure costs and final cover system performance. For example, if final side slopes are considered during placement of the waste it may reduce or eliminate the need for slope re-grading and re-contouring at closure.

Photo 5.3 – Closed Landfill Site
Photo Source: Roland Rusnell, City of Saskatoon

5.4.1 Scheduling of Closure Activities

The Code of Practice for Landfills in Alberta states that closure must be completed within one year of the end of landfilling activities or after the landfill reaches final design elevation. Closure activities should start within 180 days after the last waste is placed, and it should be completed no later than 180 days after closure commences.

The Standards for Landfills in Alberta requires that a Detailed Final Landfill Closure Plan must be submitted at least 180 days prior to anticipated final closure.

As discussed in Chapter 4, for large landfills, closure activities are progressive and should take place as the landfill develops. The engineering plan should identify each phase of the landfill and the plan for placing a final cover on each phase. The final cover and construction of associated closure works, such as storm water drainage systems, is constructed with each phase of the landfill. Progressive closure may be undertaken in numerous stages, depending upon the size and geometry of the landfill.

Benefits of progressive closure include reduced leachate generation and thus risk of leachate breakouts (leakage from above grade side slopes), reduced odour potential, financial benefit of spreading closure costs over the site operating life, and aesthetic considerations.

5.4.2 Elements of Final Closure

Final closure of a landfill site includes multiple elements and will vary from site to site depending upon size of the site, leachate management systems, location, etc. However, in general landfill closure activities will include the following:

- Final grading and filling of settled areas
- Constructing the final cover
- Planting vegetation and establishing erosion controls
- Constructing permanent storm water drainage systems
- If necessary upgrading or installing leachate and landfill gas infrastructure
- Installing environmental monitoring systems
- Decommissioning unnecessary facilities or components

5.4.3 Final Landform

The final landform of a landfill will have been determined by the design engineer before the operational approval is requested. The landform will take into account geotechnical considerations such as slope stability as well as the maintainability (erosion minimization, vegetation management) of the form and the intended end us of the site. Typically landfill side slopes are set at a maximum of 30 percent (approximately 3 Horizontal: 1 Vertical). The crest of the landfill is designed to be completed with a minimum 5 percent grade to accommodate settling and minimize the potential for water collecting in a depression. Figure 5.9 below shows a typical final landfill cross-section.

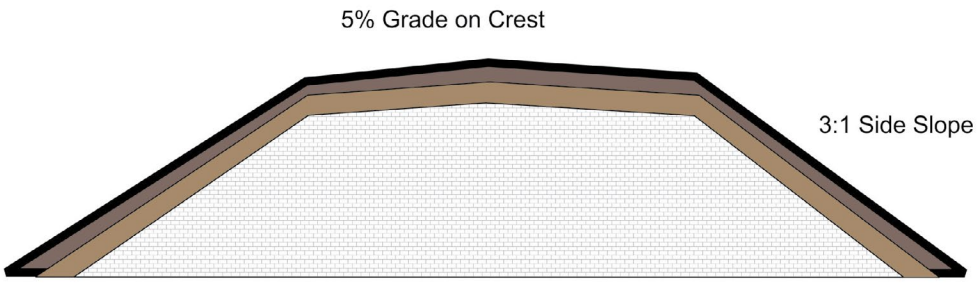


Figure 5.11 – Typical Final Landfill Slopes
Source: JLTechnical Services

As wastes compress and decompose in the landfill, settlement will occur. This can happen over many years after closure. Settlement can be 10 percent or more of the total depth the landfill. In deep landfills, the final grade on the crest may be set at 10 percent or more to allow for this settlement without the loss of positive drainage.

Side slopes steeper than 30 percent can result in cover erosion and slope instability. If outside slopes are built steeper than 30 percent during operations, significant increases in closure construction costs can result because of the need to re-grade. Alternately, flatter slopes (e.g. 20 to 25 percent) reduce the risk of cover erosion and slope failure, but significantly less airspace is available for landfilling. It is important that landfill operators know the development and closure plan and that slopes are periodically checked and adjusted to accommodate settlement that may have occurred since initial placement.

5.4.4 Importance of the Landfill Cover System

A landfill cover system is placed over the top of the landfill when final design grades and elevations are reached. This can be at the time of final landfill closure, or may be constructed progressively with each landfill phase.

A well designed and constructed final cover system will:

- Minimize infiltration of precipitation into the waste mass, and thus reduce leachate generation
- Provide a good growing medium for revegetation
- Accommodate long-term landfill settlement
- Promote surface drainage
- Minimize erosion
- Minimize risk of slope failure
- Separate underlying waste from vectors (animals and insects)
- Improve aesthetics / reduce visual impacts
- Minimize long-term maintenance
- Provide a useable space for parks or other planned uses after closure

5.4.5 Typical Landfill Cover

Landfill cover designs vary and depend upon numerous site-specific factors. There is no "one size fits all" cover system. The minimum cover system in Alberta, illustrated in Figure 5.10, is constructed from the bottom up as follows:

- A grading layer (often the same soils used for intermediate cover)
- 600 mm compacted clay barrier layer
- 350 to 850 mm subsoil layer
- A 200 mm topsoil layer

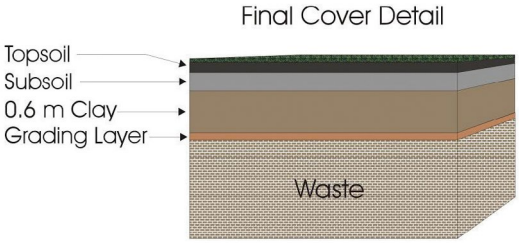


Figure 5.12 – Typical Final Cover
Source: JLTechnical Services

The cover is then seeded with vegetation.

The primary purpose of the topsoil and subsoil layers is to create suitable root zones to promote the growth of vegetation which protects the underlying barrier layer. Vegetation reduces infiltration, wind erosion and maintains cover stability. The primary purpose of a barrier layer is to reduce water infiltration, discourage burrowing vectors (rodents and insects), and control escape of landfill gas and odours.

The final cover system should be designed by the landfill engineer. There are other cover systems that can be used that serve a specific purpose based on the design of the landfill, and that can enhance the performance of the cover by further reducing infiltration of precipitation and optimizing the control of landfill gas. Advanced covers often add a synthetic (plastic) layer to the design.

5.4.6 Post-Closure Period

The post-closure care period - the duration of time during which the site must be actively monitored and cared for - is a minimum of 25 years. However, that care period must continue until all of the following criteria are satisfied:

- Groundwater quality performance standards for each parameter (potential contaminant) are met within the groundwater compliance boundary
- Subsurface landfill gas concentrations are below explosive limits as at subsurface gas monitoring locations
- The leachate constituents are:
  a. below the upper groundwater quality control limits established for each parameter
  b. parameters not naturally present in groundwater are not detected in three consecutive sampling events
- The accumulated volume of leachate is equal to or less than the previous years accumulated volume of leachate for five consecutive years

With respect to leachate generation and landfill gas migration, the potential contaminating lifespan of a landfill can be considered to be the period of time during which a landfill will generate contaminants at concentrations that may have an unacceptable impact if discharged to the surrounding environment (after which the waste has stabilized). By these criteria, the post-closure care period can be significantly longer than the 25-year minimum.

5.4.7 Post-Closure Care and Monitoring

During the post-closure period, inspection and maintenance of the final cover system, drainage system, and vegetation must be undertaken. Leachate control systems must continue to be operated including maintenance of the collection system and removal and treatment of the leachate. Landfill gas control systems, if they are installed, must also be operated throughout the post-closure period as long as landfill gas is generated.

Environmental monitoring, including leachate, groundwater, surface water and soil gas monitoring must continue throughout the post-closure period. This is to evaluate the performance of the closed landfill, monitor effects on the surrounding environment, and to determine when the landfill has stabilized and post-closure care can

end. Most owners and operators of active and closed landfills retain specialty firms to design and execute the environmental monitoring programs.

A Post-Closure Care Plan provides a summary of closure activities, regulatory requirements, post-closure inspection protocols, maintenance, monitoring and reporting procedures for the landfill throughout the post-closure contaminating lifespan and waste stabilization period.

Post-closure care and monitoring must follow a Post-Closure Care Plan which should include plans for:

- Maintaining the integrity of the final cover systems
- Maintaining surface water drainage systems
- Remediating areas affected by subsidence and differential settlement
- Erosion control
- Maintaining vegetative cover
- Facility inspections
- Maintaining and operating:
  - o Monitoring systems
  - o Leachate collection and removal systems
  - o Landfill gas control systems

Some of the same activities required for post-closure care may also apply to an active landfill for those areas of the site that have been closed. A key element of the implementation of this plan is regular ongoing inspection. Elements to be inspected regularly include:

- Final cover (health of vegetation, erosion, cracking and settlement)
- Buffer zones (area between edge of landfill and property boundary or security fencing)
- Drainage systems and stormwater ponds
- Leachate management systems
- Site security and fencing
- Access roads
- Environmental monitoring systems including groundwater monitoring wells and soil gas probes

The results and observations of all inspections should be recorded and filed for inclusion in the required Annual Post-Closure Care Report. This report includes the following (at a minimum):

- Summary of inspections
- Details on any repairs and maintenance of the final cover system and vegetation
- A report of any remedial or corrective actions taken
- Annual environmental (e.g. leachate, groundwater, surface water, and soil gas) monitoring report

06 Chapter

Monitoring, Control and Reporting

Monitoring, Control and Reporting

Landfills are designed with features to prevent emissions of contaminants to land, air and water. They are operated using techniques to achieve the same objective. To ensure that these measures are effective, it is important to monitor air and water in and around the site, to install and operate further controls where necessary, and to document details of operations and monitoring results.

Learning Objectives

In this Chapter you will learn about:

- Landfill gas generation, composition, monitoring and control
- Leachate production, minimization, characteristics, and monitoring leachate in your landfill
- Surface water quality sampling and meaning of analytical results
- Groundwater monitoring including monitoring well sampling and groundwater analysis
- Record keeping and regulatory reporting

6.1 LANDFILL GAS

A landfill is full of many items that decompose. The biological decomposition of organic materials results in gaseous products. Organic materials in landfills include:

- Food waste
- Yard debris
- Paper products
- Wood products

Since most decomposition occurs inside a landfill where there is no oxygen present (no oxygen can be referred to as anaerobic conditions), landfill gas is produced. Landfill gas consists primarily of carbon dioxide and methane. Trace amounts of other gases arise from landfilled chemicals and reactions that can occur between different materials in the fill. Small amounts of oxygen and nitrogen may be present in landfill gas, due to air that has been trapped in spaces in waste. If there is an active gas management system drawing a vacuum on the landfill, air can also be drawn in to the system.

If organics are diverted from disposal, less landfill gas will be produced and the landfill gas composition could be different than without an organics diversion programs.

6.1.1 Landfill Gas Composition

The typical composition of landfill gas by percent of volume is shown below (Figure 6.1):

Methane (CH_4)	40 to 60%
Carbon Dioxide ($C0_2$)	35 to 45%
Oxygen (O_2)	0 to 5 %
Nitrogen (N_2)	0 to 10%
Trace Constituents	Typically, less than 1%

The properties of landfill gas constituents are shown in table 6.1.

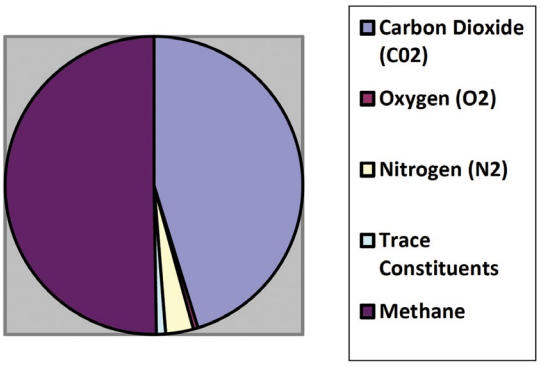


Figure 6.1 Typical landfill gas composition
Source: Technical Guidance for the Quantification of Specified Gas Emissions from Landfills, Alberta Environment and Parks

Table 6.1 – Properties of Landfill Gas Constituents

Methane	A by-product of anaerobic decomposition. It is a colourless, odourless, and tasteless gas. It is lighter than air, and insoluble in water. It is explosive at concentrations between 5percent and 15 percent by volume in air.
Carbon Dioxide	A by-product of both aerobic and anaerobic decomposition. It is colourless and odourless. It is heavier than air and it is non-combustible.
Oxygen and Nitrogen	Typically less than 10 percent combined volume. Nitrogen is normally at a higher proportion than oxygen. High nitrogen and oxygen concentrations are usually because of air intrusion into the landfill, or into landfill gas monitoring and collection systems.
Trace Constituents	Includes compounds such as hydrogen sulphide and mercaptans, which create the distinctive odour of landfill gas. Other compounds found in landfill gas may have harmful or toxic properties.

Landfill gases can continue to be generated over many years. The conditions that affect the rate at which landfill gas is produced and the amount that is shown in Table 6.2.

Table 6.2 – Factors that Affect Landfill Gas Volume and Rate

Waste Composition	The more organic wastes that are present in the landfill, the more landfill gas will be produced.
Volume of Waste	The more waste volume, the more gas is produced.
Age of Refuse	More recently buried waste produces gas at a higher rate than older more stabilized waste.
Presence of Oxygen	Methane gas is only produced in areas of the fill where oxygen is no longer present. Oxygen is depleted quite rapidly once an area is buried deeply or capped with soil.
Moisture Content of the Waste	With higher moisture in a landfill, decomposition occurs more rapidly and produces landfill gas in higher amounts more rapidly.
Temperature	Decomposition processes produce heat and increase temperatures inside the landfill. Bacterial activity increases with higher temperatures producing more gas.

6.1.2 Health and Safety Issues with Landfill Gas

Density

Depending upon the gas composition, landfill gas can either be lighter or heavier than air, which means it can act similar in nature to both natural gas (lighter) and propane (heavier). As a result, landfill gas can accumulate in either low-lying spaces (e.g. utility vault boxes) or high spaces (e.g. building roof peaks and attics). This creates risk of explosion and of asphyxiation (see below).

Solubility

The components of landfill gas (LFG) can dissolve in water to varying degrees. Methane is only slightly soluble in water while carbon dioxide is significantly more soluble. As a result, LFG lateral migration only occurs above the groundwater table, with groundwater below acting as a relatively impermeable barrier.

Flammability

A primary constituent of landfill gas is methane which is a highly flammable gas. Methane gas is explosive in air at concentrations ranging from 5 percent (lower explosive limit or LEL) to 15 percent on a volumetric basis (upper explosive limit or UEL). The minimum oxygen content that is required for methane to burn is approximately 14 percent.

Asphyxiation

If landfill gas settles in enclosed, confined spaces, or low-lying regions with poor air circulation, such as excavations, there is a significant risk to human health and safety due to the potential for asphyxia since the gas displaces the air.

Asphyxia is the condition caused by lack of oxygen. Depending on the degree of exposure, a person experiencing asphyxia will become light-headed and may lose consciousness. Death may occur if oxygen is not restored quickly enough.

Toxicity

Some constituents of landfill gas can result in acute toxicity if exposure occurs at sufficiently high concentrations or durations. Hydrogen sulphide is such a gas. However, hydrogen sulfide typically does not represent a health hazard at the levels found in LFG, especially when it is diluted in the atmosphere. However, H_2S monitoring with a specialized detector is recommended before entering a space that may contain LFG.

Corrosion

Some elements of landfill gas have the potential to cause corrosion. As an example carbon dioxide, which is soluble in water can form carbonic acid. This potential should be taken into account when designing and specifying equipment and infrastructure at landfill sites.

Odour

Trace elements present in landfill gas are responsible for some of the odours associated with landfill operations. Landfill gas odours are primarily caused by hydrogen sulphide and mercaptan (thiol) compounds, which are present in trace quantities in LFG. These compounds may be detected by sense of smell at very low concentrations.

6.1.3 Atmospheric Emissions and Issues – Greenhouse Gases

Landfill gas can escape to the atmosphere from a landfill through cover materials or it can migrate laterally from the landfill and be emitted from surrounding soils to the air. In Photo 6.1, landfill gas is observed on the surface of a landfill forming bubbles in standing water. Photo 6.2 shows stressed or dying vegetation on a closed landfill slope which may be a sign of landfill gas escape to the atmosphere. In this case, the LFG replaces the air that plants require in the root zone.

Photo 6.1 – Gas Bubbles on Landfill Surface
Photo Source: JLTechnical Services

Photo 6.2 – Vegetation Stress Due to Landfill Gas
Photo Source: JLTechnical Services

There are negative environmental issues associated with landfill gas escaping to the atmosphere:

- Methane gas is a greenhouse gas and is considered to be 25 times as potent as carbon dioxide
- Landfill gas contains odorous compounds and can be a source of odour complaints
- Landfill gas that is lost to the atmosphere cannot be recovered for beneficial energy uses
- Escaped gas can migrate along the ground and collect in depressions or below grade structures creating an explosion and health risk
- Escaping gas can kill the vegetation planted as part of the landfill closure plan
- Escaped landfill gas can contain trace amounts of toxic gases

Photo 6.3 – Gas Venting at Landfill Perimeter
Photo Source: Michelle Jelinski

6.1.4 Subsurface Emissions and Issues

Landfill gas will travel along a "path of least resistance". This means that if there is an easier way for it to go, it will move there. These pathways include:

- Permeable soils such as sand and gravel as there are spaces between the soil particles
- Pipeline or utility trenches
- Cracks and fissures in heavier soils (low permeable materials and bedrock)

When gas pressures inside the landfill are greater than the pressure outside (atmospheric pressures) gases will escape. Landfill gas can migrate underground long distances unless it vents to the atmosphere or is stopped by a barrier. The escape of landfill gas can affect vegetation around the landfill. Photo 6.3 shows landfill gas venting through snow cover outside the landfill footprint.

As described earlier, if landfill gas is allowed to migrate into enclosed spaces, such as buildings, crawl spaces, or manholes, it can become an explosion and health risk. If the methane in the landfill gas concentrates at levels between 5% and 15% by volume in the enclosed space, an ignition source can result in a violent explosion. For this reason, it is important to monitor the perimeter of the landfill for subsurface gas migration. It is also important to monitor on-site building structures and enclosures (Figure 6.2).

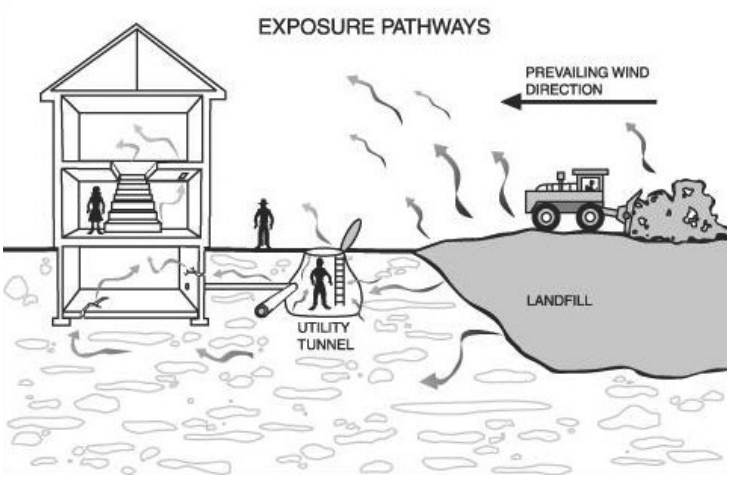


Figure 6.2 – Landfill Gas Exposure Pathways
Source: Agency for Toxic Substances and Disease Registry (ATSDR), Landfill Gas Primer, 2001

In 1969 a gas explosion occurred in an armoury built close to a landfill site in Winston-Salem, North Carolina. The explosion killed three people, and twenty-five were injured (Parker, 1987).

Spaces such as leachate manholes or condensate pump stations generally meet the OH&S definition of a confined space and should only be entered by trained personnel with a proper confined space entry safe work plan. This applies on any work site, but is especially important at a landfill where landfill gas may be present. These spaces should be locked and have warning signs.

During rain events, clay cover soils are less permeable and can reduce gas ventilation. The same can occur in winter with frozen soil cover. In these cases, lateral landfill gas migration can increase unless ventilation or gas collection systems are in place.

Photo 6.4 – Safety Notification
Photo Source: JLTechnical Services

6.1.5 Controls

The main methods for controlling landfill gas at a landfill include:

- Physical barriers like clays or impermeable synthetics
- Controlled ventilation with or without flaring
- Active collection (using suction blowers) with flaring or energy recovery

Landfill liner systems and final cover systems create barriers that restrict landfill gas migration or escape. However, the gas must escape in some way, so it is best to control it with appropriate systems.

If landfill gas is migrating laterally through soils around the landfill, a barrier or passive trench may be constructed to limit or intercept the gas movement. Such a barrier may include compacted clays and liners, or may be constructed as a cement/bentonite slurry wall. (A cement/bentonite slurry wall is a technique where a mixture of bentonite, a highly impermeable clay, and cement fill an excavated trench and sets to create a barrier to water movement.) Passive gas collection and venting systems may also be incorporated along the perimeter of a landfill to relieve gas pressures in the soil.

Passive Controls

Passive venting (example in Figure 6.3) is used where there is insufficient methane volume or concentrations to sustain burning of the gas. This may be more commonly seen at older and smaller landfills. Venting systems installed in the landfill can reduce gas pressures and help to reduce the risk of uncontrolled lateral subsoil gas movement.

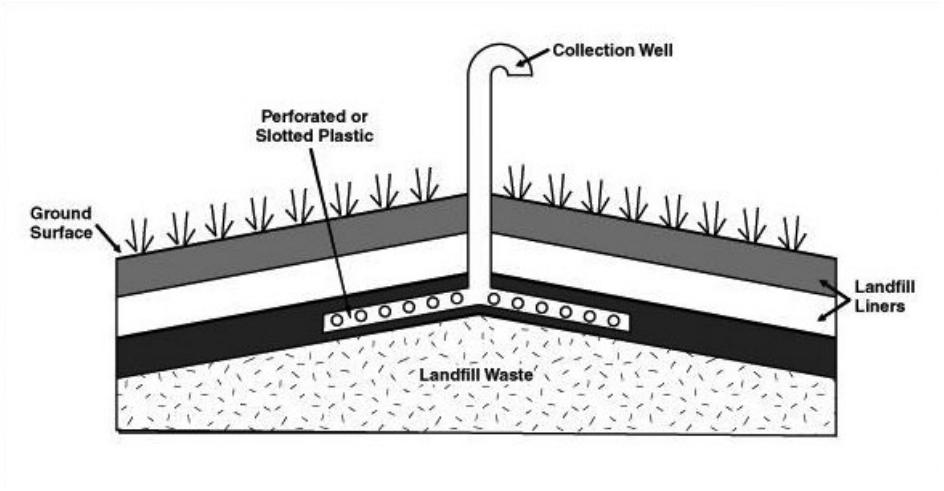


Figure 6.3 – Passive Gas Vent
Source: ASTDR – Landfill Gas Primer

Active Controls

An active gas system uses a network of gas wells connected with collection pipes. The gas is extracted from the landfill by mechanical suction blowers. The collected gas may be burned in a flare or collected for energy uses.

The most common wells used for landfill gas collection at closed landfills are vertical extraction wells installed into completed landfill areas prior to placement of final cover. Vertical wells can also be installed in active landfills with vertical extensions as the landfill surface rises (Photo 6.5)

Photo 6.5 – Typical Vertical Landfill Gas Well
Photo Source: Michelle Jelinski, P.Eng.

Photo 6.6 – Installation of Horizontal Gas System
Photo Source: Michelle Jelinski, P.Eng.

Horizontal gas extraction trenches are constructed with horizontally laid perforated pipes in trenches within the waste fill, or in a gas collection layer beneath the final cover (Photo 6.6).

Gas collection pipes are connected to the well heads and blower systems convey the gas to the flare station or gas utilization system. Because landfill gas carries high water vapor levels, condensate removal points are needed to prevent blockages in the pipes because of water gathering at low points.

Gas Combustion and Utilization

Landfill gas may be combusted rather than vented to the atmosphere. Depending on the type and design of the combustion flaring device, the gases that are harmful to the environment can be reduced by up to 99.9 percent.

Flare systems can either be open flame candlestick flares, or enclosed flares. (Photos 6.7 and 6.8)
A candlestick flare looks somewhat like a burning candle – a tall shaft with a flame at the top. The visible flame is sometimes a concern to site neighbours, which is one reason enclosed flares are used.

Enclosed flares are more complex than open flame flares. These flares consist of multiple burners enclosed in

Photo 6.7 – Candlestick Flare
Photo Source: JLTechnical Services

Photo 6.8 – Enclosed Flare
Photo Source: Michelle Jelinski, P.Eng.

a fire-resistant walled chamber that extends above the flame. Gas and air mixtures in an enclosed flare can be controlled, which makes combustion more complete.

Either type of flare requires a propane or natural gas 'pilot flame' to maintain consistent burning.

Landfill gas can be used to replace non-renewable fuels. Landfill gas can be used directly or as an augmentation to other fuel for:

- Boilers
- Cement manufacture
- Greenhouse heating
- Other purposes

The more common use for landfill gas is power generation. Landfill gas from mature areas of a landfill will have a high enough concentration of methane to run specially designed reciprocating engines that can drive electrical generators. Other technologies such as micro-turbines are also used.

Landfill Gas to Compressed Natural Gas (CNG)

The Rodefeld Landfill (Dane County, Wisconsin) removes CO2 and other constituents to produce a high grade gas with about 88 percent methane. The gas is compressed and used to fuel waste collection trucks and other County vehicles.

6.1.6 Perimeter Subsurface Monitoring

Monitoring for landfill gas around the perimeter of a landfill is a requirement for municipal landfills. The intent of perimeter monitoring is to provide the ability to detect any migration of landfill gas through the soil beyond the landfill itself, especially if it may reach adjacent properties. It also provides for early detection near buildings where landfill gas can potentially collect.

Capital Power utilizes landfill gas from Edmonton's Clover Bar Landfill to produce 5 megawatts of renewable energy. The power produced is sold to the City of Edmonton. The facility enables Capital Power to offset its carbon emissions.

Permanent landfill gas probes can be installed in drilled boreholes. These are engineered to allow soil gases to enter the borehole. Well casings are perforated and bedded in granular material to allow soil gases to enter the well. A valve is installed in the well cap to which gas sampling equipment can be connected. A protective outer casing is installed similar to water monitoring well installations.

Field measurements are taken with a gas metre specifically designed for measuring landfill gas components (methane and carbon dioxide).

For more detailed analysis, gas samples can be collected and sent to a laboratory.

When conducting gas monitoring programs, weather conditions and barometric pressures should be recorded since they influence gas movement.

Photo 6.9 – Electricity Plant Fueled with Landfill Gas
Photo Source: JLTechnical Services

Installation of landfill gas monitoring wells should be done by qualified personnel. The location of gas wells should be in areas where landfill gas is most likely to move to, such as known sand lenses or areas where the water table is deep. Wells are often installed near on-site buildings and along the property lines. Detectors are also often installed within buildings and structures.

Photo 6.10 – Typical Landfill Gas Monitoring Well
Photo Source: JLTechnical Services

Photo 6.11 – Portable Multi-Gas Meter
Photo Source: JLTechnical Services

6.2 CONTROLLING LEACHATE PRODUCTION AND LEACHATE MONITORING

Leachate is defined in the Standards for Landfills in Alberta as liquid that has been in contact with waste in the landfill cell and has undergone chemical or physical changes. Landfill leachate chemistry varies with the type and age of waste the liquid leaches from. See Chapter 4 for greater detail on the types of contaminants found in leachate and the range of concentrations found.

SAMPLING LOCATION	LIMITS
At the landfill property boundary	50% of LEL*
In an on-site building or immediately outside the foundation of the building or structure	20% of LEL*
In an off-site building or enclosed structure or in the area immediately outside the foundation of the building or structure	1% of LEL**

* Lower explosive limit (LEL)

Limits for landfill gas tests are outlined in the Standards for Landfills in Alberta as in the table 6.3. Detection at or above these limits requires that remedial actions be taken.

Table 6.3 Landfill Gas Tests and Detection Limits which Require Remedial Actions

6.2.1 Leachate Composition

In general terms, leachate is composed of a number of compounds, most predominantly:

- Organics
- Nitrogen compounds
- Chlorides
- Phosphates
- Metals
- Dissolved solids

6.2.2 Control of Leachate

The amount of leachate generated in a landfill is dependent on the amount of liquids that enters the landfill. Sources of liquid include:

- Moisture in the waste that is disposed
- Rain and snow melt water
- Surface water that runs on to the landfill
- Groundwater infiltration.

Site design and construction plays a significant role in the generation of leachate and control of produced leachate. Landfill operators' role is to operate the control systems as intended and operate the landfill so as to minimize the opportunities for water or other liquids to enter the landfill cells.

Municipal solid waste, when it arrives at the site, contains moisture of about 25 percent to 50 percent depending on recent precipitation events and season. This source of liquid into a landfill is beyond the control of landfill operations staff.

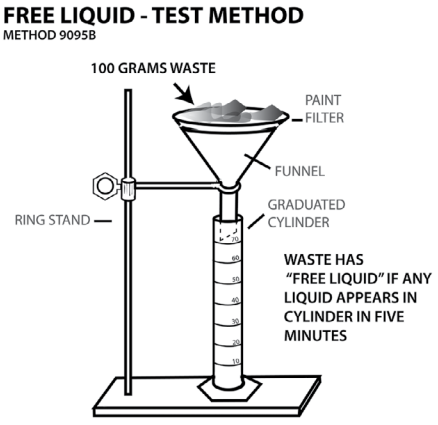
The site design should prevent surface water from running on to the landfill. Site operations should minimize the amount of waste directly exposed (i.e., minimize the active working face) to rain and snow. Site operation should ensure covered surfaces (both daily and intermediate cover) are adequately sloped to drain water. Groundwater intrusion potential is limited by selection of sites with groundwater tables below the bottom of the landfill liner.

Significant sources of liquids can be:

- Septic waste
- Sewage sludge
- Car wash sump waste
- Industrial liquids
- Sludge

Septic wastes are prohibited from disposal in landfills in Alberta. The disposal of bulk liquids is also prohibited from landfills, unless it is allowed in a specific landfill approval.

To determine if a watery soil sludge is acceptable for disposal, the paint filter test (Figure 6.4) is used. The sludge is placed in the filter and left to drain for 5 minutes at room temperature. If any liquid drains into the glass cylinder after 5 minutes, the waste is defined as a liquid waste and is not acceptable at the landfill.



Source: www.epa.gov

Figure 6.4 – Paint Filter Test
Adapted from: US EPA Method 9095B

6.2.3 Monitoring Leachate Within the Landfill

As discussed in Chapter 4, too much leachate can lead to leakage through the landfill liner. The landfill operator must monitor the level of leachate in the landfill. According to standards, leachate depth cannot reach more than 0.3 metres (12 inches) over the liner.

The method of monitoring the leachate will depend on the design of the leachate system. The leachate system should be designed by the site engineer. The leachate extraction system needs to be operated to reduce excess levels if found.

6.2.4 Groundwater and Surface Water Monitoring

Leachate poses a potential environmental risk when it escapes into the environment around a landfill and enters watercourses or the groundwater. A site-specific environmental monitoring program monitors for impacts on water in the area surrounding a landfill. A monitoring program is developed according to the Standards for Landfills in Alberta. This program typically includes, at a minimum, groundwater and surface water sampling and analysis.

Leachate Indicators

A number of parameters can be used as indicators of the presence of landfill leachate in groundwater and surface water. An indicator parameter of landfill derived impacts should ideally be a constituent of leachate which is subject to minimal affects attributed to attenuation (such adherence to soil particles) so that it can signal the early migration of a leachate plume.

Chloride is often a preferred indicator parameter for Class II landfills as it is typically present in landfill leachate at elevated concentrations, is highly mobile in groundwater and is not easily attenuated.

Surface Water Monitoring

The objective of a surface water monitoring program is to detect changes in surface water quality and/or movement of affected water off the property.

Surface watering sampling is typically done by taking 'grab samples' at surface water bodies (e.g. ponds) located on or next to landfill facilities and in streams or creeks running through or adjacent to a landfill property. In the event of a stream or creek running through a landfill property, typically, two samples are taken: one upstream (before) of the landfill, representing, and one downstream (after). The laboratory (analytical) results for the two samples are compared to see if the water has been affected.

Photo 6.12 – Surface Water Sampling
Photo Source: JLTechnical Services

Sampling is done by an environmental technician or trained landfill person. The samples are placed in sealed bottles and submitted to a laboratory for analysis. The presence of indicator parameters, such as chlorides, may indicate that leachate has impacted the water body. If water has been affected, further investigation is required to both confirm and develop a plan to correct the mechanism that has let that happen.

Groundwater Monitoring

The objective of the groundwater monitoring is to demonstrate that there is no impact on groundwater from the landfill or, if there is, the early detection so that remedial action can be taken.

Groundwater monitoring wells are drilled in to water-bearing formations surrounding the landfill.

Groundwater monitoring wells (Figure 6.5) are installed at a minimum of one up-gradient (upstream) location and two down gradient (downstream) locations. The number of monitoring well installations required at a landfill site is dependent upon the size of the facility and the hydrogeology of the site.

Photo 6.13 – Typical Groundwater Monitoring Well Riser
Photo Source: JLTechnical Services

A portion of a groundwater monitoring well is screened so water can get into the well. Typically, monitoring wells are extended above ground and protected by a steel riser as shown in Photo 6-14.

Groundwater monitoring wells are sampled using a strict protocol that includes the following steps:

- Inspection of the groundwater monitoring well for damage or other evidence of vandalism or tampering (groundwater monitoring wells should always be equipped with locks)
- Purging of well by removing three well volumes
- Extraction of the groundwater sample which is placed directly into laboratory sample bottles

Both purging and collection of the sample is done by trained technicians with specialized equipment.

The laboratory results for the up gradient (upstream) samples are compared to the down gradient (downstream) results to see if leachate indicators are present. The presence of elevated leachate indicators may mean that leachate is entering the surrounding environment and should be further investigated to both confirm the findings and develop a remediation plan.

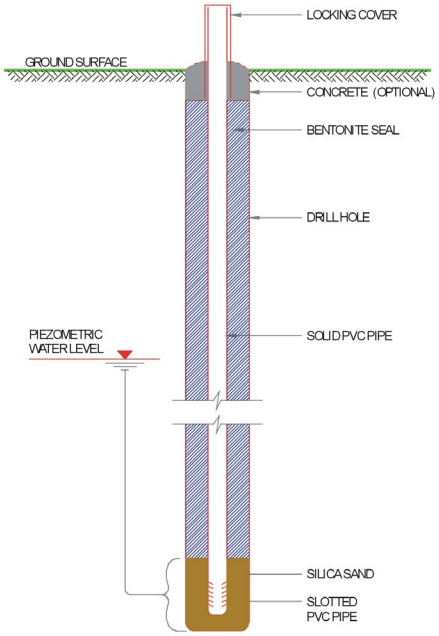


Figure 6.5 – Typical Groundwater Monitoring Well Construction
Source: JLTechnical Services

6.3 RECORDS AND REPORTS

Reporting of landfill related activities is required under the Standards for Landfills in Alberta. Different reporting elements are to be recorded on a daily, monthly and annual basis. Records of operations or Operating Records must be collected throughout the operational phase of the landfill life (up to the time of final closure). It is common to develop templates or checklists for consistency in the records.

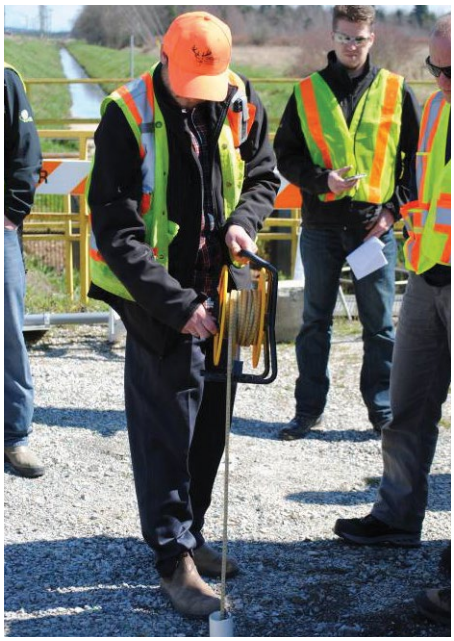


Photo 6.14 – Measuring Depth of Groundwater
Photo Source: Bill Epp

6.3.1 Daily

Daily records on landfill activities must be recorded and retained for inspection if requested by the regulator. Typical daily reports and logs may include the following:

- Daily scale house tonnage records and vehicle counts
- Health and Safety hazard assessments, tailgate meeting, near-miss report and incident reports
- Deposition location of wastes requiring special handling (e.g. asbestos, road kill, etc.)
- Incidence of odor or other air quality concerns
- Leachate breakouts or other potential releases to the environment
- Hot load or incident of fire

It is noted that in the event of fire, spill, leachate breakout, or other release to the environment, the landfill owner or person responsible shall immediately notify AEP. A written report must be submitted within 7 calendar days of becoming aware of the incident.

6.3.2 Monthly

Monthly inspections of the landfill facilities typically include:

- Environmental controls
- Landfill cover (erosion, seeps or vegetative stress)
- Infrastructure (e.g. storm water ponds, leachate management systems, etc.)

6.3.3 Annual

The landfill owner is required to prepare an annual report summarizing activities over the previous calendar year. This report at a minimum should include the following:

- Types and quantities of waste disposed
- Location of wastes requiring special handling
- Environmental monitoring reports, including surface water and groundwater monitoring records, and landfill gas monitoring results, if gas monitoring is required or voluntarily undertaken by the landfill manager

A large facility operating with a full approval may be required to submit and provide more detailed information, including:

- A summary of the waste types accepted
- Submitting an online report on waste accepted
- The deposition locations of special wastes for the year
- A record of public complaints and the approval holder's response
- A description of the operational problems and emergencies and how they were addressed for the year
- The names and certificate numbers of the supervisory operators responsible for the operation of the landfill for the year
- An estimate of the landfill air space remaining based on survey results or amount of wastes received
- Summary of the information monitored for leachate, subsurface landfill gas, surface water, and landfill operations
- A summary of subsurface landfill gas monitoring data interpretation
- A groundwater monitoring annual report
- All landfill inspections records conducted
- A summary of the performance of the landfill run-on and run-off control systems
- A site map showing the status of the landfill operations at the end of the operating year, including but not limited to contour mapping, locations of active and inactive disposal areas, areas where a final cover has been placed, and location of new cell construction.
- A construction summary report for new cell construction
- A summary of update to the Operations Plan during the year and any proposed changes to the Operations Plan for the coming year
- Adjustments to environmental reserve fund necessary for final landfill closure and post-closure activities

Alberta Government

Landfill Operator Certification

STUDY GUIDE