Appendix F

Facility Operations and Maintenance Manual

DILLON CONSULTING

DILLON CONSULTING

CITY OF IQALUIT

Operations and Maintenance Manual (Draft)

Landfill and Waste Transfer Station

June 2019 | 19-9543 – Version 1.0

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

1.1 Background

The City of Iqaluit (City) is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste disposal requirements. Founded on a previously completed conceptual design and facility siting exercise, key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales, or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal, and some construction and demolition (C&D) wastes will also be shredded and/or baled for landfilling or transported south for recycling. The resulting solid waste bales and possibly a smaller amount of unbaled C&D waste will be trucked to an engineered balefill landfill site (Landfill) located approximately 6 km from the WTS.

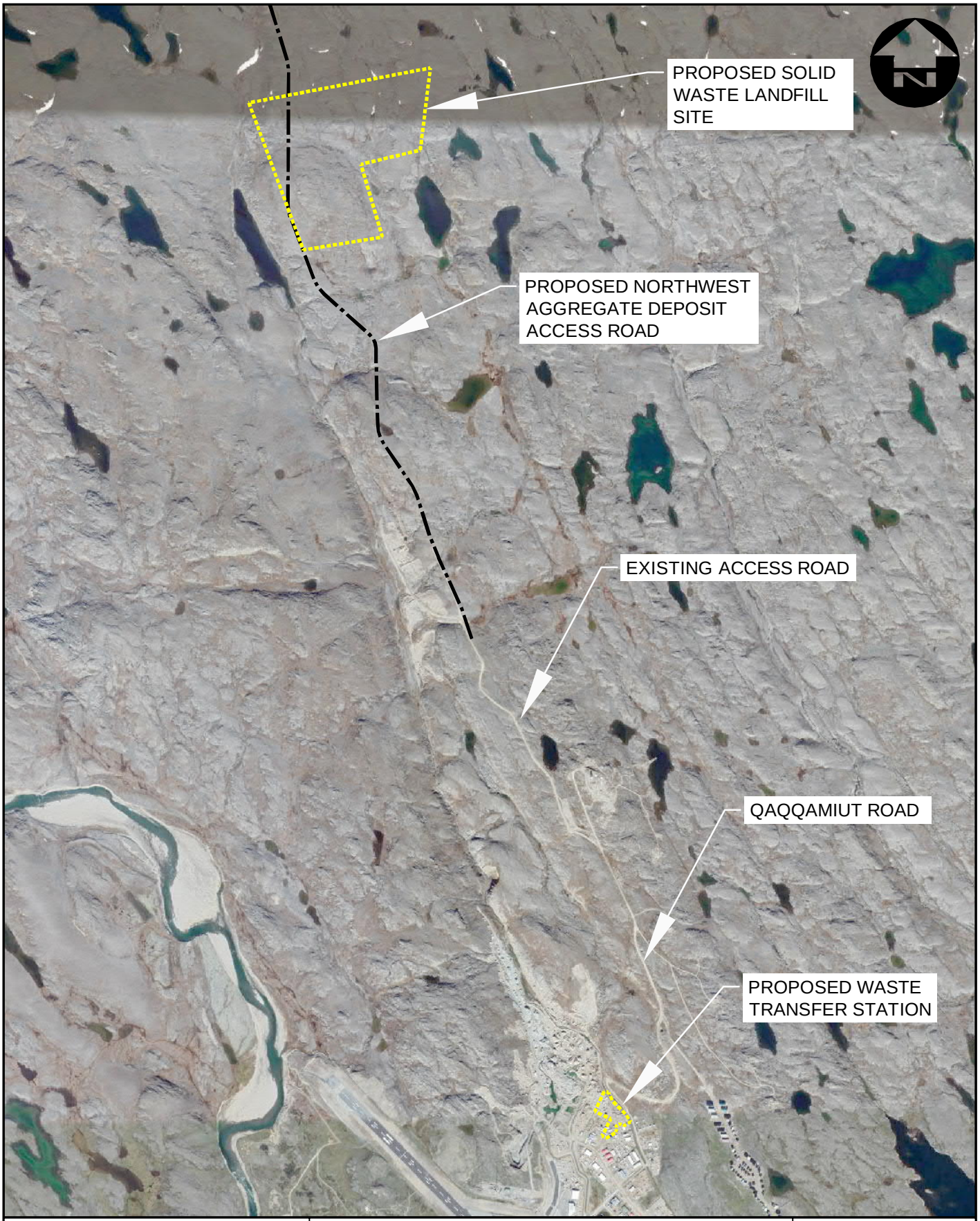
The overall site locations are presented on **Figure 1-1**, with the layouts for the WTS and the Landfill being provided on **Figures 1-2** and **1-3**, respectively.

Other planned features of the WTS include a public drop off area for household hazardous wastes (HHW) and a vehicle logger/compactor unit; in both instances allowing for the preparation of waste materials, prior to shipping to approved management facilities in the south.

The access road that will be used to reach the new Landfill has been designed by EXP Services Inc., who will also be providing Construction Contract Administration services for the construction of the road. It is anticipated that the construction of the road will be included in the new Landfill and WTS Contractor's scope of work.

To address their objectives, and following a competitive proposal process, the City engaged Dillon Consulting Limited (Dillon) to provide design and construction contract administration services to support the establishment of the WTS/baling facility and the engineered Landfill. The engineered Landfill will be designed for 75 years of operation but for the construction/build portion of the project only the first stage of the Landfill (Stage 1 Operational Landfill) will be constructed (e.g., first two cells and ancillary components to meet five and 10 year operational requirements, e.g., five years per cell).

Development of the proposed facilities is scheduled to occur during the 2020 and 2021 construction seasons, with facility commissioning in the fall of 2021.



DILLON CONSULTING

DATE: JUNE 2019	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
	TITLE: SITE LOCATIONS	FIGURE NO.: 1-1

FileName:c:\projectwise\working directory\projects 2019\50dbc\dms12727\199543-02-site-con-cover.dwg

BALE STORAGE AREA

CONSTRUCTION AND DEMOLITION DEBRIS PAD

SNOW STORAGE

BALES TO LANDFILL

CULVERT

SLIDING GATE

QAQQAMIUT ROAD

EMERGENCY GENERATOR

LIMIT OF SURVEY

0+200

5.0m

5.0m

WASTE TRANSFER STATION

PUBLIC DROP-OFF

PUSH WALL

5.0m

5.0m

0+100

TO PUBLIC DROP-OFF

SNOW STORAGE

MISCELLANEOUS METALS/WHITE GOODS STORAGE PAD

TIRE STORAGE

END OF LIFE VEHICLE AND MISCELLANEOUS METALS STORAGE

BALER LOGGER

APPROX. PROPERTY LINE

0+300

0+340

TO COMMERCIAL DROP-OFF

20.0m

HHW DEPOT

HHW STORAGE CONTAINERS

REUSE CONTAINER

20.0m

SITE OFFICE

22.9 x 3.0m

5.0m

5.0m

SCALES HOUSE

SCALE

SLIDING GATE (2 REQUIRED)

PERIMETER FENCE

PARKING AREA (10 SPACES)

SNOW STORAGE

1.0 c.m. BOULDER SPACED AT 5.0m (TYP.)

GREENHOUSE (FUTURE)

25.0m

10.0m

COMPOST PAD (FUTURE)

15.0m

0+000

KAKIVAK COURT

SNOW STORAGE

AREA FOR POTENTIAL COMPOST AND BIO-MASS EQUIPMENT

N7070900

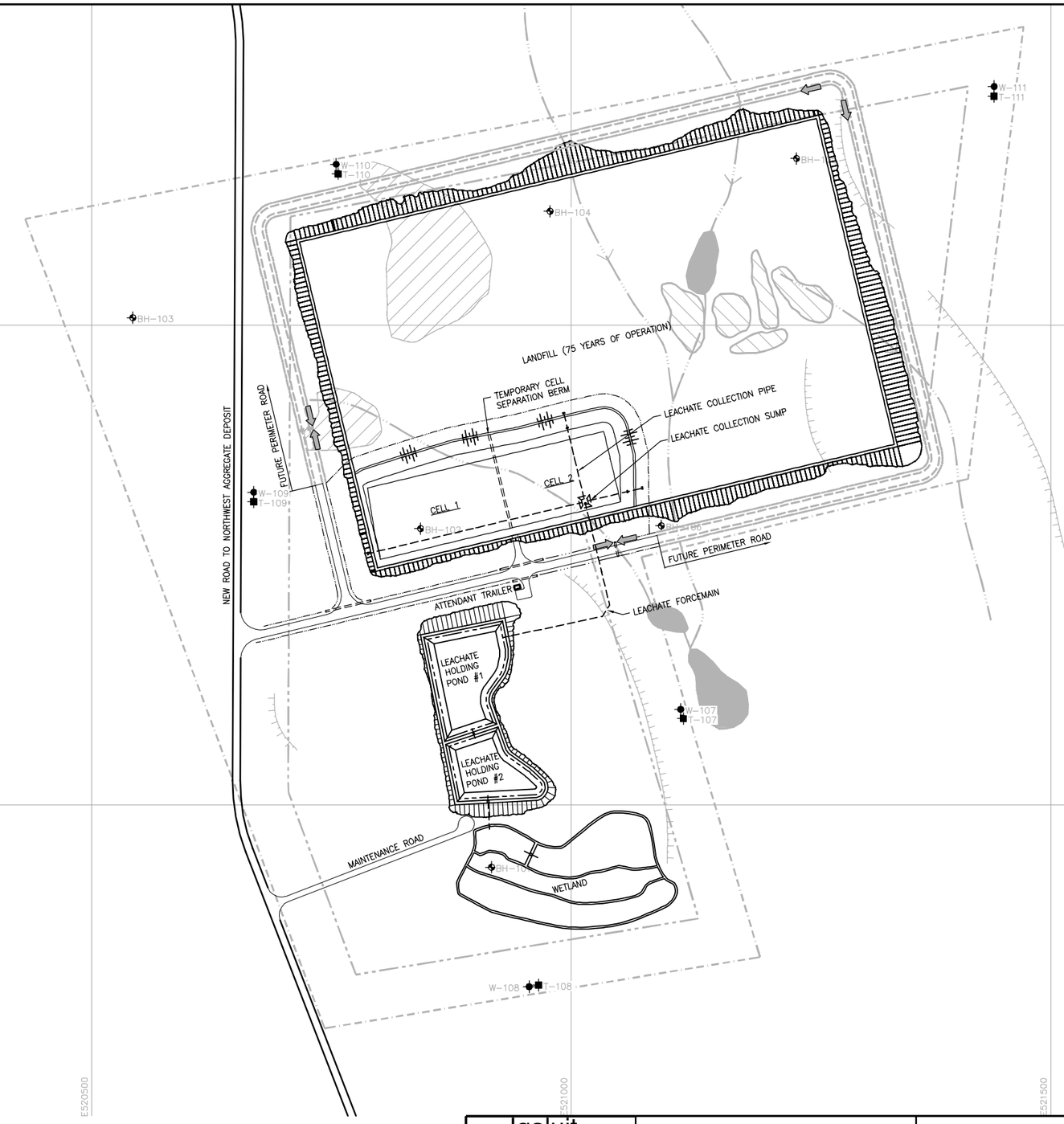
N7070800

N7070700

E522400

FileName:c:\projectwise\working directory\projects 2019\50dbcdms127281\199543-02-site-con-wts-proposed.dwg

Iqaluit	DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
	DATE: JUNE 2019	TITLE: WTS SITE LAYOUT PLAN	FIGURE NO.: 1-2



Iqaluit

DILLON CONSULTING

DATE JUNE 2019

PROJECT
IQALUIT LANDFILL AND WASTE TRANSFER STATION

PROJECT NO.
19-9543

TITLE
LANDFILL LAYOUT PLAN

FIGURE NO.
1-3

FileName::c:\projectwise\working directory\projects 2019\50dbcidms\127272-199543-02-site-con-proposed.dwg

1.2 Content

The Operations and Maintenance Manual addresses the following topics:

- Days and hours of operation
- Security and access control
- Staff and equipment
- Waste quantities and types
- Waste control
- Daily bale/waste placement
- Adverse weather conditions
- Initial life construction
- Nuisance control protocols, including litter, dust, noise, odour, birds, vector, vermin and wildlife
- Complaint response protocol
- Traffic control
- Fire prevention and response
- Surface water management
- Leachate management
- Landfill gas (LFG) management
- Inspection and maintenance program
- Record keeping
- Reporting
- Operations monitoring program
- Sample site logs and forms

The development of the site will be consistent with applicable regulations and policies for environmental protection. The facility has been designed with a composite liner system, leachate management system, surface drainage control and an environmental monitoring network.

It is noted that equipment-specific manufacturer's documentation, providing details on specific operational and maintenance requirements, is to be referred to along with the attached Operations and Maintenance Manual.

2.0 Facility Operations

2.1 Access Control

2.1.1 Hours of Operation

The City of Iqaluit Landfill and WTS is open Monday through Saturday, excluding holidays. The site is open to receive waste from 8:00 am to 4:00 pm Monday through Friday, and 8:00 am to 12:00 pm Saturday. Only the WTS will be accessible by the general public.

The site will be closed on the following holidays:

- New Year's Day
- Good Friday
- Easter Monday
- Victoria Day
- Canada Day
- Nunavut Day
- Civic Day (first Monday in August)
- Labour Day
- Thanksgiving
- Remembrance Day
- Christmas Day
- Boxing Day

Site equipment may operate beyond posted hours. The additional time may be necessary for processing of materials at the WTS preparation of the working area receiving waste and for other work defined by management personnel.

The operating hours are clearly posted on the entrance signs for both the Landfill and WTS, which also identifies the site name and the site telephone number.

2.1.2 Site Security

Due to the nature of the work undertaken at the Landfill and WTS, site security and safety is an important feature of the overall operation. Lockable gates are situated at various locations throughout both properties.

Keys/electronic access cards will be provided to persons employed by the City and directly involved with the operation of the WTS and/or Landfill, at the discretion of the Director of Engineering and Public Works or Manager of Solid Waste (Manager). A record shall be kept at the Scale House relating to who has keys, including contact name and phone number. A general visitor log (**Appendix A**) shall also be maintained at the Scale House.

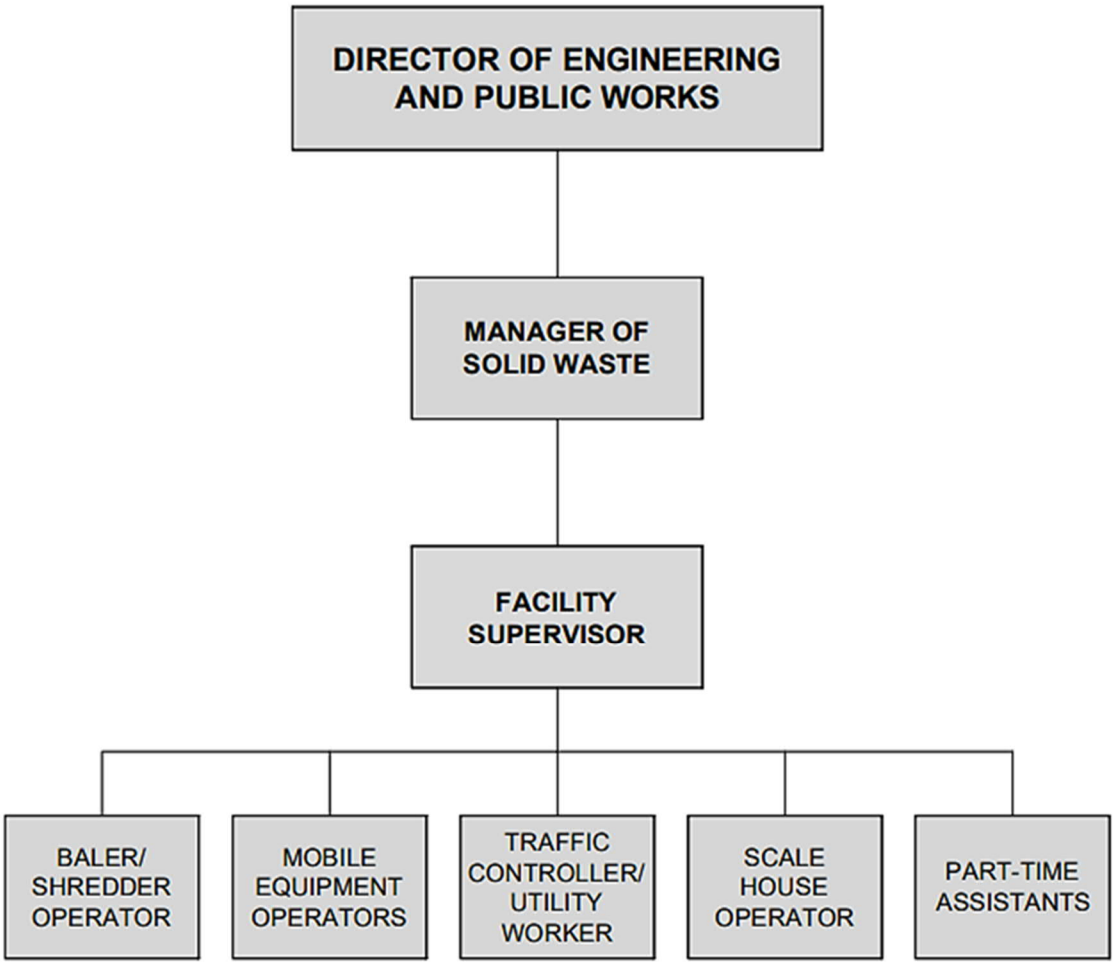
When either site is unattended, the gates will be closed and locked.

3.0 Personnel

3.1 Staffing

The Landfill and WTS will require full and part-time staff. In general, the facility requires a Manager, Facility Supervisor, Baler Operator, Mobile Equipment Operators, Scale House Operator, Traffic Controller/Utility Worker and Part-Time Assistants. An organization chart defining staffing and reporting responsibilities at the Landfill and WTS is presented in **Figure 3-1**. All employees will be properly trained in accordance with the tasks that they will be expected to complete.

Figure 3-1: Facility Organization Chart



A general outline of the minimum duties and responsibilities of each position follow. It is not intended to be comprehensive or to limit the employee's opportunity to expand their capabilities beyond this scope. It is also not intended to limit the employer's right to assign other duties.

3.1.1 Director of Engineering and Public Works

The Director of Engineering and Public Works assists the City's Chief Administrative Officer (CAO) and the Manager of Solid Waste in planning and coordinating operation at the Landfill and WTS, as they relate to:

- Developing operational budgets.
- Preparation of annual reports.
- Technical operation.
- Environmental monitoring.

3.1.2 Manager of Solid Waste

The Manager of Solid Waste is responsible to the Director of Engineering and Public Works for the operation of the facility. The Manager oversees and coordinates day-to-day operations at the site.

Reporting Relationships

Reports to: Director of Engineering and Public Works
Supervises: Landfill and WTS Personnel

Maintains Liaison with: CAO
Municipal Engineer
Citizen's Monitoring Committee (as applicable)
Purchasing Manager
Accounting Personnel
Payroll Clerk
Suppliers
Contractors

Duties and Responsibilities

The Manager shall:

1. Perform operations at the facility in accordance with the Operations and Maintenance Manual (latest approved version), applicable Engineering Drawings and the Water License issued by Nunavut Water Board (NWB), and in consultation with the CAO.
2. Ensure that only acceptable wastes, as indicated on the approved list for disposal, are permitted at the site, in consultation with the CAO and regulatory agencies.
3. Prepare regularly scheduled reports on progress and planning at the facility.
4. With the assistance of the CAO, prepare facility operating budgets and undertake staffing selections.
5. Communicate (as required) with NWB, including the forwarding of monitoring results.
6. Deal directly with the public, responding to disposal requests.
7. Coordinate site visits/tours.
8. Provide overall direction for daily site activities, including equipment and staff utilization.
9. Maintain the environmental monitoring program.
10. Coordinate the environmental sampling programs.
11. Ensure that site staff receive the required training.
12. Make recommendations to the CAO for major and minor repair work required for site equipment, as well as replacement of same.
13. Ensure that the site is maintained and operated in a clean and safe manner at all times, including regular collection of litter.

14. Ensure that solid waste bales and C&D debris materials are placed at the Landfill in accordance with the Operations and Maintenance Manual (latest approved version), and in consultation with the Municipal Engineer.
15. Coordinate the preparation of balefill areas for operation, including stockpiling cover material, and identifying the requirement for composite liner installation and the establishment of surface water control measures.
16. Ensure that there is no open burning of solid waste at the facility.
17. Perform other related duties, as may be assigned periodically by the CAO.

3.1.3 Facility Supervisor

Under the direction of the Manager, the Facility Supervisor is responsible for equipment and general site maintenance requirements at the facility.

Reporting Relationships

The Facility Supervisor reports directly to the Manager.

Duties and Responsibilities

The Facility Supervisor shall:

1. Perform operations at the facility in accordance with the Operations and Maintenance Manual (latest approved version), applicable Engineering Drawings and the Water License issued by NWB, and in consultation with the Manager.
2. Ensure that only acceptable wastes as indicated on the approved list for disposal are permitted at the site, in consultation with the Manager and regulatory agencies.
3. Be responsible for the maintenance of the facility machinery, including mobile equipment, the solid waste baler unit, material shredder/pelletizer, vehicle logger and related systems.
4. Make recommendations to the Manager for major and minor repair work required for facility equipment, as well as replacement of the same.
5. Ensure that the facility is maintained and operated in a clean and safe manner at all times, including regular collection of litter.
6. In coordination with the Manager, ensure that solid waste bales and C&D debris materials are placed at the Landfill, in accordance with the Operations and Maintenance Manual (latest approved version).
7. Be responsible for snow removal on the access roads within the site and other areas, as necessary.
8. Maintain the access roads to ensure there is reasonable access within the site and to the active Landfill at all times.
9. Be responsible for operating and maintaining the leachate handling equipment, and surface water control structures and facilities at the Landfill and WTS.
10. Undertake site security checks and report any problems to the Manager.

11. Inspect the public roads/areas surround the WTS, the Landfill access road, and the Landfill to recover any accumulation of garbage or other debris.
12. Recommend to the Manager the need for bird control, rodent, animal and odour control.
13. Ensure that there is no open burning of solid waste at the site.
14. Maintain records of site equipment usage and maintenance.
15. In coordination with the Manager, maintain the integrity of completed landfill cells and borrow areas.
16. Perform such other related duties, as may be assigned from time to time by the Manager.

3.1.4 Baler/Shredder Operator

Under the direction of the Facility Supervisor, the Baler/Shredder Operator is responsible for operating and maintaining the solid waste baler unit, material shredder/pelletizer, vehicle logger and related systems.

Reporting Relationships

The Baler/Shredder Operator reports directly to the Facility Supervisor.

Duties and Responsibilities

The Baler/Shredder Operator shall:

1. Perform operations at the facility in accordance with the Operations and Maintenance Manual (latest approved version), applicable Engineering Drawings and the Water License issued by NWB, and in consultation with the Facility Supervisor.
2. Ensure that only acceptable wastes as indicated on the approved list for disposal are permitted at the site, in consultation with the Facility Supervisor.
3. Make recommendations to the Facility Supervisor for major and minor repair work required for the solid waste baler, material shredder/pelletizer, vehicle logger, and related systems.
4. Maintain an operational record for the solid waste baler, material shredder/pelletizer, vehicle logger and related systems.
5. Ensure that the tipping floor and baling floor is maintained, and operated in a clean and safe manner at all times.
6. Periodically operate mobile equipment associated with site operations.
7. Perform such other related duties, as may be assigned from time to time by the Facility Supervisor and/or the Manager.

3.1.5 Mobile Equipment Operators

Under the direction of the Facility Supervisor, the Mobile Equipment Operators are responsible for operating and maintaining mobile equipment utilized for waste handling and disposal operations. At least two Mobile Equipment Operators will be on-site every day the facility is open to the public.

Reporting Relationships

Mobile Equipment Operators report directly to the Facility Supervisor.

Duties and Responsibilities

The Mobile Equipment Operators shall:

1. Perform operations at the facility in accordance with the Operations and Maintenance Manual (latest approved version), applicable Engineering Drawings and the Water License issued by NWB, and in consultation with the Facility Supervisor.
2. Ensure that only acceptable wastes as indicated on the approved list for disposal are permitted at the site, in consultation with the Facility Supervisor.
3. Be responsible for the operation and routine maintenance of the site machinery.
4. Make recommendations to the Facility Supervisor for major and minor repair work required for site equipment.
5. Ensure that the site is maintained, and operated in a clean and safe manner at all times.
6. Ensure that solid waste bales and C&D debris materials are placed at the Landfill, in accordance with the instructions of the Facility Supervisor.
7. Carry out activities for the maintenance and repair of access roads, snow removal, preparation of balefill areas, excavation and stockpiling of cover material, and the installation and/or repair of leachate collection and surface water control structures, as directed by the Facility Supervisor.
8. Advise the Facility Supervisor of the need for pest control.
9. Remove freon from refrigerators (and similar equipment) and specified liquids from vehicles, in accordance with applicable regulations.
10. Operate the HHW drop off facility.
11. Ensure that there is no open burning of solid waste at the site.
12. Perform such other related duties, as may be assigned from time to time by the Facility Supervisor and/or the Manager.

3.1.6 Traffic Controller/Utility Worker

Under the direction of the Facility Supervisor, the Traffic Controller/Utility Worker is responsible for directing the movement of vehicles delivering waste materials to the tipping floor within the WTS.

Reporting Relationships

The Traffic Controller/Utility Worker reports directly to the Facility Supervisor.

Duties and Responsibilities

The Traffic Controller/Utility Worker shall:

1. Direct incoming vehicles to the location on the tipping floor where solid waste is to be deposited.

2. Ensure that adequate signage and traffic control devices are in place in coordination with the Manager.
3. Direct the movements of waste delivery vehicles and their personnel within the transfer station compound in order to prevent conflicts with facility equipment operations.
4. Ensure that only acceptable wastes as indicated on the approved list for disposal are permitted at the site, in consultation with the Manager.
5. Segregate banned and salvageable materials noted on the tipping floor to designated storage areas.
6. Periodically operate mobile equipment associated with site operations.
7. Ensure that the area around the building and the tipping floor are operated in a clean and safe manner at all times, including regular collection of litter.
8. Perform such other related duties, as may be assigned from time to time by the Facility Supervisor and/or the Manager.

3.1.7 Scale House Operator

Under the direction of the Facility Supervisor, the Scale House Operator performs all duties related to the operation of the facility's scale component.

Reporting Relationships

The Scale House Operator reports directly to the Facility Supervisor or a designated member of staff.

Duties and Responsibilities

The Scale House Operator shall:

1. Identify and register vehicles within the computerized site data base.
2. Manage the customer billing system.
3. Collect tipping fees from customers on-site.
4. Inspect incoming waste in accordance with the Operations and Maintenance Manual (latest approved version).
5. Answer incoming telephone calls and requests for information, directing such requests as required.
6. Monitor use of the public drop off door at the WTS.
7. Clean and maintain the scale.
8. Perform such other related duties as may be assigned from time to time by the Facility Supervisor and/or the Manager.

3.1.8 Part-Time Assistants

Under the direction of the Facility Supervisor, the Part-Time Assistants are responsible for tasks assigned to them by a designated member of staff. These positions would typically serve to address periodic site maintenance requirements.

Reporting Relationships

The Part-Time Assistant reports directly to the Facility Supervisor or a designated member of staff.

Duties and Responsibilities

The Part-Time Assistant shall:

1. Perform duties as assigned by the Manager, Balefill Supervisor or a designated member of staff.

3.2 Training

Every Landfill and WTS employee will be trained to perform his or her job in a safe and environmentally responsible manner, in accordance with applicable regulations and City policy. Employees will be kept current with changes in regulations and technology through ongoing, comprehensive training courses, in such areas as regulations and the technical aspects of landfill operation. Specific training topics may include surface water control, leachate and LFG management, spill prevention, special wastes control, environmental monitoring and safety. A municipal employee's health and safety committee serves as a forum to identify potential concerns and define appropriate actions.

Continuing on-the-job training will be provided for all employees. The training will emphasize the safe and environmentally sound operation of the Landfill. A review of this Operations and Maintenance Manual will be a prerequisite for any employee before being declared eligible for work at the Landfill and WTS. All employees will be given safety training covering all equipment and systems, with which they will be expected to operate on a daily basis. The dangers associated with the use of protective equipment, methane (CH_4)gas and leachate handling, and the handling and precautions associated with special wastes, will also be included in the safety training. Documentation of the employee's participation in the safety and environmental training will be maintained in the employee's personnel file.

A training program for more specific tasks, such as those of the baler, shredder and mobile equipment operators, will be documented with written records of meetings and types of instruction. This instruction will include identification of special wastes and unacceptable wastes; emergency procedures in case of fire, spill or injury; confined space entry; respirator use and fit testing; and other issues that will periodically arise. All individuals must be trained in confined space entry and practice proper safety procedures, in accordance with applicable legislation and the requirements of the Nunavut Labour Standards Office. Documentation will also be kept on file at the Manager's office and reviewed annually for any necessary updates.

A general outline of some of the training that employees will require is found in **Table 3-1**. It is not intended to be a comprehensive list or to limit additional staff training, should legislation change, or limit the employer's or employee's right to require additional training.

Table 3-1: Staff Training Recommendations

Program	Position					
	Manager of Solid Waste	Facility Supervisor	Mobile Equipment Operators	Traffic Control/Utility Worker	Scale House Operator	Part-Time Assistants
WHMIS	✓	✓	✓	✓	✓	✓
Emergency First Aid	✓	✓	✓	✓	✓	✓
Confined Space Entry	✓	✓				

4.0 Site Structures

Primary structures associated with operations at the Landfill and WTS are illustrated on **Figures 1-2** and **1-3**. Infrastructure descriptions are subdivided as follows: 1) structures at/in proximity to the WTS are discussed in **Section 4.1**; and 2) structures associated with the Landfill are described in **Section 4.2**.

4.1 Waste Transfer Station

4.1.1 Facility Roads

The road network serving the WTS includes: 1) Kakivak Court, acting as the main access route and connecting the site to Federal Road; 2) parking and maneuvering areas around the perimeter of the WTS; and 3) a dedicated access to from the WTS compound to Qaqqamiut Road (as associated with the transport of baled waste to the Landfill). The perimeter of the WTS property is fenced with lockable access gates, situated at the Kakivak Court and Qaqqamiut Road entrances.

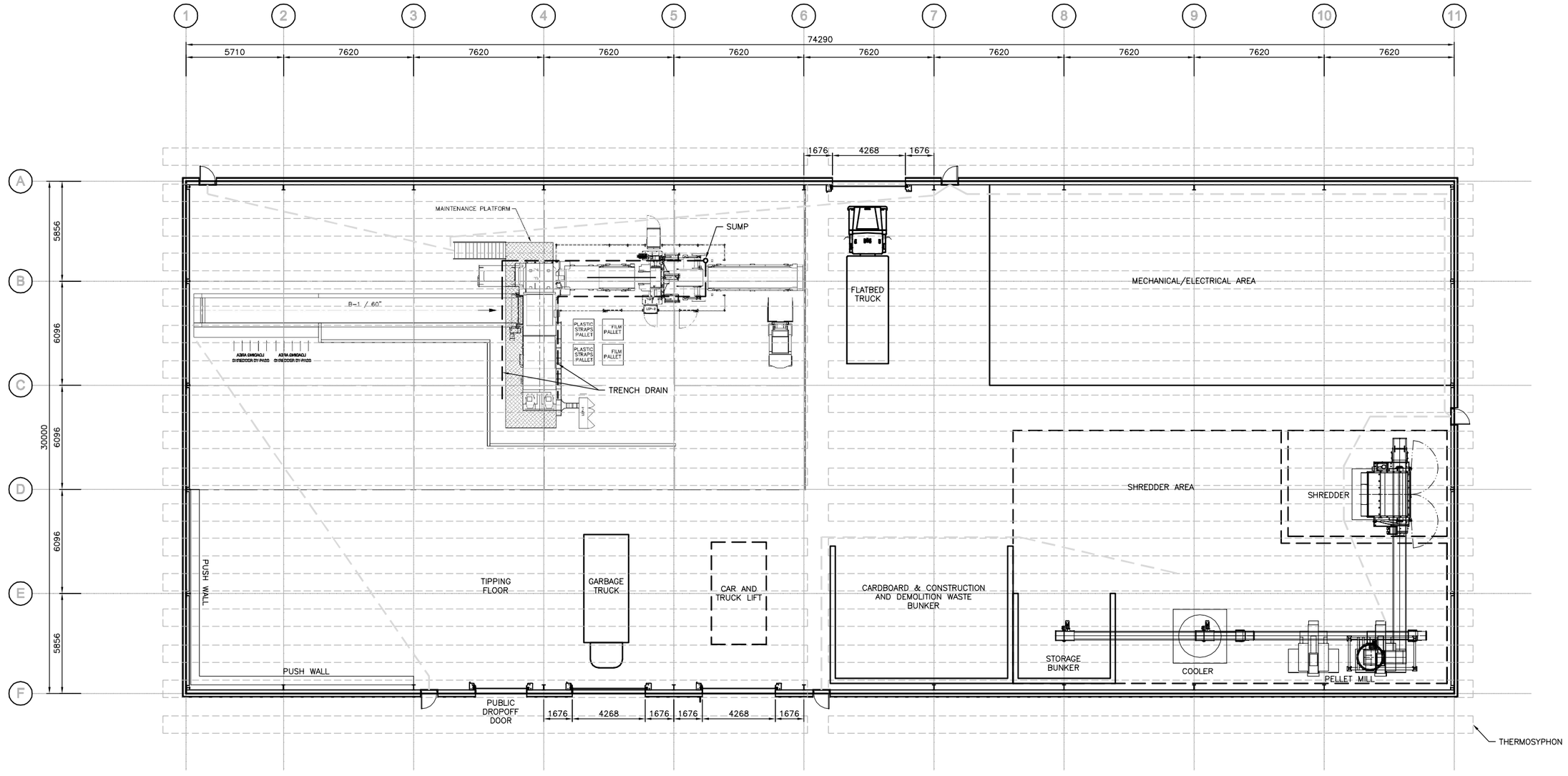
The facility roads/yard areas are private and their maintenance will be the responsibility of the City. Maintenance of the facility roads includes, but is not limited to, dust and mud tracking control, and snow removal/ice control.

4.1.2 Scale and Scale House

The Scale and Scale House are located southeast of the WTS Building. As described in **Section 8.2.1**, all vehicles entering the site are required to report to the Scale House. The Scale House, a premanufactured wood frame structure with electric heating, includes an elevated load inspection video camera and PC-based scale control/invoicing equipment. The Scale House entrance and exit ramps will have an asphalt surface.

4.1.3 WTS Building

The WTS Building is a pre-engineered steel, slab on grade structure with a total floor area of approximately 2200 m^2. With reference to **Figure 4-1**, the interior of the building is divided into five primary areas: 1) the **tipping floor** is used to allow haulage vehicles to discharge their loads within an enclosed area – it also includes a wall opening to allow for public drop off of refuse materials; 2) the **baling/bale loading area** is where the waste is compressed into wire-tied bales and transferred to the flatbed transport truck; 3) select materials are processed and stored in the **shredder/pelletizer area**; 4) end of life vehicles are prepared for compaction at the **car and truck lift area**; and 5) a variety of control systems and equipment, including a biomass boiler, are located in the **mechanical/electrical area**.



FLOOR PLAN
1:125

FileName:c:\projectwise\working directory\projects 2019\50\dbc\dms127261995431 01 arch.dwg

Iqaluit	DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
	DATE: JUNE 2019	TITLE: WTS INTERIOR LAYOUT	FIGURE NO.: 4-1

Due to the nature of operations, the concrete walls extend upward from the slab in the tipping floor portion (southwest corner) of the building. The tipping floor's concrete walls are 2.4 m high, permitting storage of solid waste against the inside of the building and allowing for a smooth durable surface to work against. The concrete walls around the remainder of the interior perimeter are 1.2 m in height to provide impact protection to the building structure from mobile equipment.

Due to issues associated with clogging and an objective to minimize the number of slab penetrations, there are no floor drains within the interior of the WTS; interior slab slopes are typically towards exterior overhead doors. Liquid on the floor (primarily from incoming waste and hauling vehicles) is continuously monitored by facility staff, using the absorbent capacity of the waste, as required. Cleaning of the floor via sweepers and other means is conducted, as required.

A primary source of liquid generation at the WTS, the waste baler (resulting from the compaction of the waste mass), includes a perimeter shallow trench in the slab around the unit. Liquid from the baler collects in the trench and is pumped to an adjacent tank for subsequent collection and transfer to the City's wastewater treatment plant (WWTP).

Mechanical and electrical features of the WTS building include the following:

- Interior heating requirements (using a hydronic system) are met using a biomass boiler that uses wood and cardboard pellets as a fuel. Back up requirements for the Site Office and select area interior areas of the WTS provided by a No.2 fuel fired hydronic heating unit. A 4880 L double wall aboveground tank situated outside the building provides fuel for the back up unit.
- Exhaust fans serving the interior of the WTS to provide general ventilation and achieve interior air quality requirements.
- Select use of radiant heaters in defined locations to address equipment requirements and to prevent the freezing of waste.
- Provision of interior fire protection, using a dry chemical system.
- Water requirements for interior building maintenance and equipment requirements addressed with an on-site storage tank. Staff washroom and shower facilities are located at the Site Office.

4.1.4 Site Office

A wood framed, premanufactured building, situated adjacent to the Scale House, serves as the Site Office. The building incorporates staff facilities, including the Facility Supervisor's office, a lunch room, a locker room and washroom/shower facilities. The building will be heated using the WTS's biomass boiler, and will be serviced with a water and wastewater tank.

4.1.5 Household Hazardous Wastes Depot and Storage

Steel intermodal containers, modified to address storage requirements for HHW materials, are situated in the southwestern area of the WTS yard. One 12 m (40 ft) container serves as a public drop off location, where a trained staff member records incoming quantities and directs the materials to an

appropriate initial storage location. As required, materials from the Drop Off Container are directed to one of three 12 m storage containers. Arrangements are made by the City for subsequent shipping to approved management facilities in the south, as quantities warrant.

4.1.6 Exterior Material Process and Storage Areas

The exterior yard area (gravel surface) includes equipment and locations for the processing and temporary segregated storage of select materials, including:

- Vehicle Baler/Logger unit (trailer-based).
- End of life vehicles awaiting decommissioning/crushing, crushed vehicles and salvageable metals.
- End of life vehicle and equipment tires.
- Baled waste (to address short-term instances when direct transport to the Landfill is not possible).
- A dedicated area for the potential future installation/operation of an in-vessel organics composting unit (including a curing area allowance).
- A dedicated area for the potential future development of a greenhouse.
- Snow storage areas to support yard clearing efforts.

4.2 Landfill

4.2.1 Landfill Access Road

A two lane, gravel surfaced road connecting the existing Qaqqamiut Road to the Landfill site is being established by the City, as a component of the Landfill and WTS project. The road will also provide access to the Northwest Aggregate Deposit, situated to the west of the landfill property.

With reference to **Figure 1-3**, two roads will extend off of the Northwest Aggregate Deposit road to access features of the Landfill;

- Main Landfill access and perimeter road.
- Leachate management system access road.

Lockable security gates are situated at the entrance of each access road, complete with identification signage. As new landfill cells are established, the perimeter road will be extended, as necessary. All site roads are two lane and gravel surfaced.

4.2.2 Landfill

A 22 ha area on a property approximately 5.5 km north of the WTS has been designated to serve as the disposal location for the City's baled municipal solid waste (MSW), select processed materials (e.g., tires, bulky items) and non-divertible C&D waste materials for 75 years. A primary design feature of the Landfill is the use of a membrane liner system with a dedicated leachate collection layer within the defined landfill footprint. The liner is scheduled to be installed in 15 (number to be refined during the

operational life of the facility) sequential sections or "cells" throughout the operational life of the site. As part of the initial construction effort for the Landfill (scheduled for the 2020 and 2021 construction seasons), the first two landfill cells, with a total area of approximately 2 ha, are to be installed. They have been designed to address the City's disposal requirements for the first 10 years of operation.

Detailed discussion on the Landfill liner system is provided in **Section 7.0**. A description of waste placement procedures at the Landfill is presented within **Section 8.3**.

4.2.3 Cover Borrow Area

Cover material required to support Landfill operations, including bale/waste covering and final grading, is scheduled to be acquired from the Northwest Aggregate Deposit.

4.2.4 Attendant Trailer

A premanufactured, wood frame trailer will serve as a shelter for site personnel, while they are at the Landfill. The trailer will include a wood stove and a composting toilet. No equipment will be stored within the trailer due to the remoteness of the location, and the potential for theft and/or vandalism.

4.2.5 Leachate Management System

The Landfill's leachate management system includes a leachate collection layer/piping within the cell liner, a collection sump with pump station manhole, a forcemain, two holding ponds and a wetland treatment area. Details on the leachate management system are presented in **Section 12**.

4.2.6 Monitoring Network

The Landfill includes defined monitoring locations for surface water and active layer water. With regards to potential impacts of landfill infrastructure to permafrost, a thermistor array is situated in the base of the liner systems for both the landfill and the two leachate lagoons.

<Monitoring program to be developed during Phase II – Preliminary Design.>

5.0 Mobile Equipment

Mobile equipment selection has been based on the evaluation of the operational functions to be performed, including activities within the WTS, within the WTS yard and at the Landfill. Beyond waste handling related activities, other mobile equipment use requirements include access road maintenance, snow removal and dust control. Equipment used as part of site operations is owned by the City. The listing of recommended site equipment is as follows:

1. Wheel Loader
    - 150 - 160 HP, diesel.
    - Provided with quick-detach forks, grapple bucket, plow blade, general-purpose bucket and landfill package.
    - For waste handling in the WTS yard, bale/waste placement at the Landfill, snow removal and road/yard maintenance.
2. Compact Wheel Loader
    - 110 – 120 HP, diesel.
    - Provided with quick-detach forks, grapple bucket, waste handling bucket (complete with rubber leading edge), plow blade, solid tires, transfer station package.
    - Waste/bale handling within the WTS, snow removal and yard maintenance.
3. Forklift
    - Electric.
    - 2500 kg lifting capacity.
    - Bale handling within the WTS including loading of the Bale Truck.
4. Bale Truck
    - 350 HP, diesel.
    - Tandem straight truck, flatbed.
5. Vehicle Baler/Logger
    - 175 – 215 HP, diesel.
    - Trailer-based unit.
    - Provided with hydraulic landing gears, knuckle boom material handler, bale density 400 to 1300 kg/m^3.
    - Crushing and baling end-of-life vehicles, white goods and miscellaneous metals.
6. Staff Truck
    - 4 x 4 Crew Cab, Super Heavy Duty.
    - Provided with snow plow attachment.

In addition, back up equipment will be available from local rentals and contractors, should anomalous situations dictate need for additional equipment. Routine maintenance and cleaning will be performed (as necessary) to keep equipment in good operating order.

A maintenance program exists for all on-site equipment and is to be performed in accordance with equipment manufacturer's guidelines. The City holds contracts with heavy equipment suppliers to provide all scheduled maintenance. Daily routine maintenance activities will be the responsibility of the mobile equipment operators. Routine activities will include (but not be limited to) the following:

Tires

- Check for debris imbedded in the tire, repairing or replacing, as necessary.
- Check tire wear condition.

Air Filters

- Check for dust clogging and replace, as necessary.

Radiators

- Check for dust and debris clogging and clean, as required.
- Check for punctures and repair or replace, as necessary.

Undercarriage

- Check for damage and repair, as required.

Hydraulic Lines

- Check for wear points, cracks and fitting leaks, replacing, as necessary.

6.0 Stationary Equipment

The following list identifies stationary equipment associated with waste processing activities within the WTS. Descriptions including maintenance requirements for other equipment/systems supporting WTS operation (e.g., biomass boiler/heating system, ventilation system, fire suppression system, electrical/control systems) are provided in manufacturer documents.

1. Waste Baler
    - Two ram configuration.
    - Peak throughput = 20 tonnes/hour.
    - Dual hydraulic pumps, 600 VAC 60 Hz electric TEFC motors.
    - Dedicated above floor conveyor.
    - Automatic wire tier.
    - Complete with bale wrap system.
2. Waste Shredder
    - Stationary, slow feed, shear-type unit.
    - Peak throughput > 10 tonnes/hour.
    - Twin drives, 600VAC 60 Hz electric TEFC motors.
    - Dedicated above floor conveyor.
    - Suitable for MSW including tires, wood pallets, furniture, C&D materials and old corrugated cardboard (OCC).
    - Direction of processed material to either the Pelletizer (wood and OCC) or to the Waste Baler for disposal at the Landfill.
3. Pelletizer
    - Accepts processed wood and OCC from the Waste Shredder.
    - Compresses processed material into a pelletized fuel suitable for the on-site biomass boiler.

7.0 Liner Development and Sequencing

7.1 Landfill Liner System

The four primary components of the landfill liner system, from the top down, consist of a **cushion layer**, **leachate collection layer**, a **geomembrane liner** and a **base layer**. These components are described below. Refer to **Figure 7-1** for a typical schematic of the composite liner system.

Cushion Layer
The cushion layer, 300 mm of 75 mm clear stone, provides the top working surface of the landfill cell and offers protection (e.g., vehicle/equipment movements, waste puncture hazards) to the underlying Leachate Collection Layer.

Leachate Collection Layer
The leachate collection layer consists of a granular layer (75 mm clear stone) with a total thickness of 300 mm and perforated HDPE collection piping. The perforated collection piping is placed at the bottom of the collection layer to collect and direct leachate to the collection sump.

Geomembrane Liner
A flexible geomembrane liner (80 mL textured HDPE) is situated under the leachate collection layer, as the primary barrier to leachate migration. The top and bottom of the flexible membrane liner is protected with a non-woven geotextile.

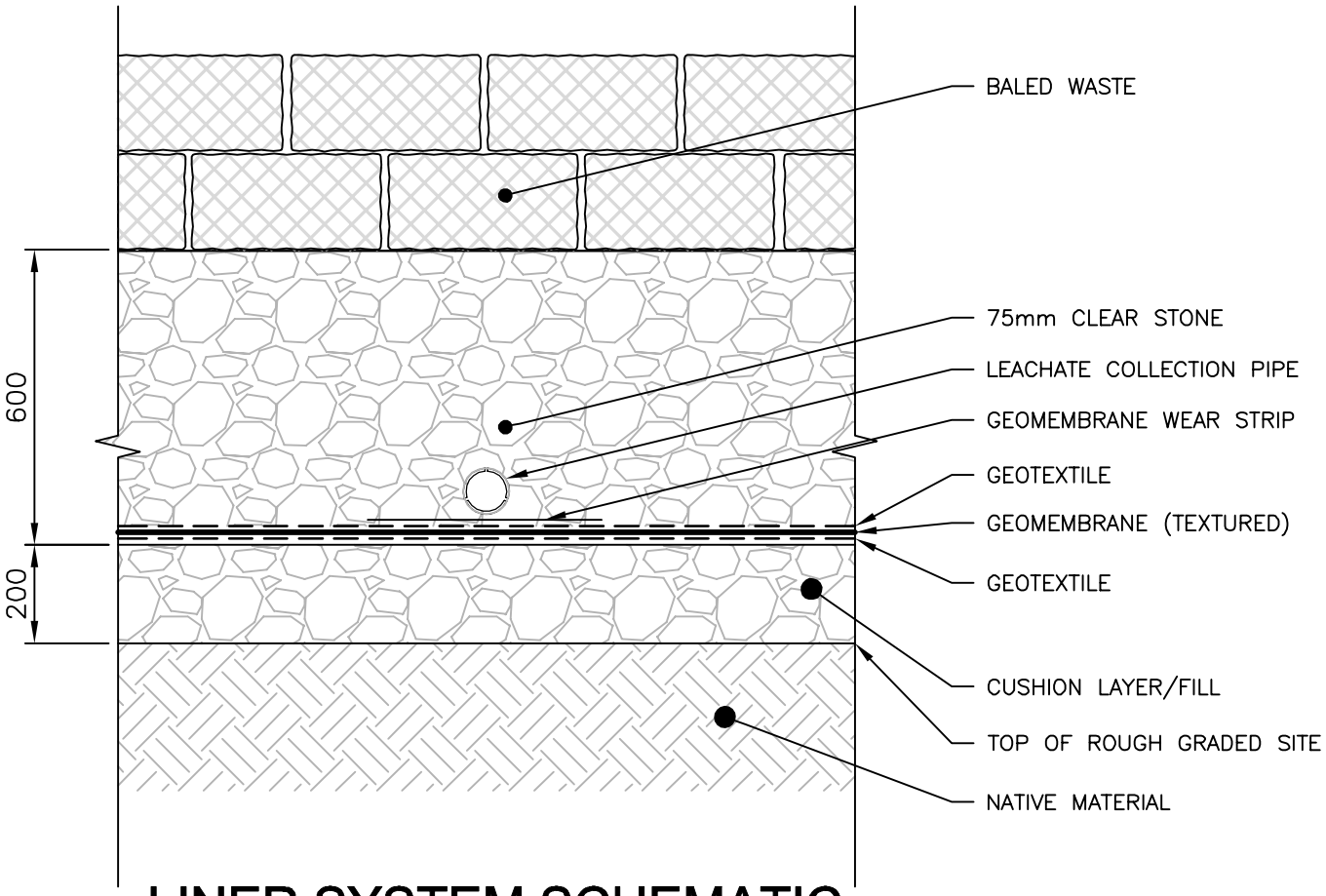
Base Layer
The entire liner system is constructed on an engineered base. The native material at the site will be graded, and a 200 mm thick granular grading pad will be placed over the native material. Additional compacted soils will be placed at the site, where required for grading. Where possible, a 1.5 m separation distance from the underside of the geomembrane and the seasonal high groundwater table.

To monitor potential impacts of the liner system to permafrost, a thermistor array is situated within the base layer.

Where required for soil separation, a geotextile will be placed below the base.

7.2 Liner Installation Sequence

The overall defined landfill footprint to accommodate 75 years of operation is approximately 22 ha in size. Within that footprint, a total of 15 disposal areas or cells (to be confirmed during the course of site development) have been identified. The first two designated cells in the overall sequence, Cells 1 and 2, are scheduled for installation during the 2020 and 2021 constructions seasons.



LINER SYSTEM SCHEMATIC

N.T.S.

DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
DATE: JUNE 2019	TITLE: LANDFILL LINER SCHEMATIC	FIGURE NO.: 7-1

FileName:c:\projectwise\working directory\projects 2019\50dbc\dms12727\11-199543-02-site-con-liner.dwg

Timing the installation requirement for the next lined area in the sequence is critical. Installation can only be practically completed during the non-winter months and adequate time must be allotted for the development of design documents, tendering and delivery of construction materials. The calculation to determine this timing is linked to defined bale placement requirements. Specific aspects of bale placement are discussed in detail in **Section 8.3**.

Tracking of disposal area utilization is the responsibility of the Manager. The primary elements of the installation timing calculation are as follows:

1. Referring to the Engineering Drawings, determine the remaining space (volume) available for the placement of bales. This estimate must incorporate bale placement requirements including perimeter side slopes and the pre-defined lift installation sequence. For example:
    - Remaining Volume (Vr) = 6,240 m^3
2. Confirm the number of bales of waste per week currently requiring disposal. If significant changes to the current volume of incoming waste are anticipated (i.e., accepting material from a new service area), then this value should be adjusted accordingly. Based on an average bale volume of 1.5 m^3, calculate the weekly bale disposal volume requirement. For example:
    - Bale Volume Requirement (Vbr) = 120 m^3/week
3. Divide the estimate of remaining balefill volume (1) by the weekly bale disposal volume requirement (2) to determine the number of remaining weeks of disposal space. For example:
    - Vr/Vbr = 6,240 m^3 / (120 m^3/week)
    - = 52 weeks

If it is determined that inadequate space is available to serve operations until late the following summer (i.e., August), then actions will need to be initiated towards the design and installation of the next lined disposal area in the sequence. For example, if the above sample calculation was completed in January 2022, the expectation would be that available balefilling space would be exhausted 52 weeks later in January 2023. Therefore, construction of the next disposal area would be necessary during the summer of 2022.

8.0 Waste Receiving, Placement and Sequencing

8.1 Types of Waste

8.1.1 Acceptable Wastes

Any waste disposal option has limitations with respect to the waste streams which may be handled in an environmentally safe manner. Limits must be placed on the types of waste accepted at a municipal disposal site, in order to protect the environment, the employees, the users and neighbours, as well as the equipment from damage, while simultaneously providing adequate levels of service.

The Manager shall allow only those materials to be accepted (for processing and/or disposal) at the Landfill and WTS, with the exception of unique circumstances reviewed in consultation with NWB, for which the facility has been designed to accommodate, namely, MSW. With reference to the Environment and Climate Change Canada (ECCC) document Solid Waste Management for Northern and Remote Communities, Planning and Technical Guidance Document, MSW is defined to include *"reusables, recyclables, compostables, and residual waste (i.e., garbage) from homes, businesses, schools, and other institutions."* With respect to the IWMF, this definition includes end-of-life vehicles, large appliances, salvageable metals, furniture, passenger vehicle tires, and C&D materials

The following materials may be received at the site; although, none of the items listed are considered suitable for routine baling/disposal. As a result, the Manager will specify in each case an appropriate disposal method and location. The Manager reserves the right to limit the amount of these materials received at any one time, or to define the material as non-acceptable waste and to specify management requirements.

1. Contaminated soils meeting the acceptance requirements of NWB Analytical test results for all candidate materials will be evaluated by the City and NWB. No material will be accepted for disposal until this evaluation has been completed. Subsequent management requirements for accepted soils will be defined on a case-by-case basis, in consultation with NWB.
2. Non-hazardous incinerator ash, fly ash and wood ash, when properly quenched and cooled. **Large quantities of ash may require special pre-treatment before being accepted at the site and may require special disposal methods**.
3. Electrical transformer casings on the condition that all oils have been removed consistent with applicable regulations and that the units have been rendered free of potentially hazardous materials. Salvageable casings will subsequently be held at the site's dedicated metals storage area.
4. Biomedical waste originating from human and animal health care facilities, providing it has been autoclaved or incinerated, and is packaged according to the Government of Nunavut Environmental Guideline for Biomedical and Pharmaceutical Waste (dated March 2014 or as amended).

5. Carcasses of animals weighing less than 25 kg.

All wastes not specifically fitting into the above categories, and not specified as unacceptable, will be referred to the Manager and NWB for recommendations as to their acceptability and appropriate disposal methods.

8.1.2 Non-Acceptable Wastes

Wastes, which present a danger to the public, staff, infrastructure or the environment at the WTS or Landfill, which require special disposal techniques, and which may interfere with the level of service to the public or are in contravention with regulatory stipulations, are not acceptable for disposal. In some cases, wastes which are acceptable in small quantities may not be acceptable in large quantities from a single generator because they may cause the level of service to other users to deteriorate and cause handling problems at the site, and increased environmental liability. To some extent, the acceptability of large quantity wastes must be at the Manager's discretion, depending on the ability to accommodate disposal without deterioration in the level of service. In cases where unacceptable wastes are identified, site staff will attempt to identify allowable management alternatives to material haulers.

All wastes which pose potential safety or environmental problems cannot be listed in their entirety. The Manager and site personnel, in general, must be wary of accepting wastes which could cause future operational problems and must watch for the inclusion of unacceptable wastes in regular loads of refuse.

A list of materials which **MAY NOT** be accepted at the Landfill or the WTS are as follows:

1. Explosives or highly combustible materials of any nature.
2. Gas cylinders, unless the valve has been removed and the cylinder properly drained by a professional trained in handling gas cylinders.
3. Radioactive materials.
4. Chemicals and chemical wastes, including sludges from water and wastewater treatment plants and other generators.
5. Any hazardous materials, which may be classed as corrosive, reactive, toxic or flammable.
6. Carcasses of animals weighing more than 25 kg.
7. Liquid wastes, including herbicides, insecticides or other sprays, paints, oils, and solvents.
8. Septic tank waste and sewage treatment plant sludges, unless a facility is specifically designed for their disposal or they have been pre-treated in accordance with the requirements of the Nunavut Water Board and/or other relevant regulatory authority.
9. Fish processing wastes.
10. Hot ashes.
11. Any liquids, or liquid waste, of a quantity greater than 5 L in any one load.
12. Dangerous goods as defined by the *Nunavut Consolidation of Transportation of Dangerous Goods Act* (e.g., poisonous substances, infectious substances, oxidizing substances).

13. Biomedical wastes that are not treated prior to disposal according to the Government of Nunavut Environmental Guideline for Biomedical and Pharmaceutical Waste (dated March 2014 or as amended).
14. Any other materials not listed as acceptable or conditionally acceptable with the approval of the Manager.

8.2 Waste Receiving and Processing

8.2.1 Waste Inspection and Control

All waste arriving at the WTS is subject to inspection for unacceptable materials (see **Section 8.1.2**). Inspection shall be conducted at the Scale House and on the tipping floor of the WTS. It is the responsibility of employees at the Landfill and WTS to be aware of wastes which are acceptable, and those that are unacceptable or hazardous to the staff and the general public.

The first opportunity for waste inspection and control at the WTS occurs at the Scale House, where the following procedures shall be employed:

- All incoming vehicles are required to report to the Scale House. Small, private residential haulers (i.e., cars or ½ ton pickup trucks) are directed to the small vehicle drop-off area located on the south wall of the tipping floor. Larger residential-source loads (i.e., ¾ ton pickup trucks, trailers) and all commercial waste haulers are weighed, charged based on the standard per tonne tip fee, and directed to the tipping floor for disposal.
- At the Scale House, all incoming loads are recorded using a computer-based tracking and billing system. Information collected includes waste type, origin and weight. Scale information is collected for materials destined for the WTS tipping floor, WTS material segregation areas and the Landfill.
- Incoming waste is subject to visual checking at the Scale House at the direction of the Facility Supervisor. A high-mounted video camera is provided at the Scale House for spot checks.
- The Scale House Operator shall advise the Facility Supervisor of any observed unacceptable waste.

The second opportunity for waste inspection control exists on the WTS tipping floor:

- Equipment operators and other staff will remain vigilant for unacceptable or potentially hazardous wastes during unloading, conveyor loading, and baling.
- All site operations personnel shall receive training to assist in recognizing unusual, un-acceptable and hazardous wastes.
- When a staff member encounters suspect waste on the tipping floor, baling shall cease until the material is segregated and appropriate action (as identified in the **Section 8.2.2**) is taken. The procedures outlined in the facility's Emergency Response Plan (ERP) (see **Appendix B**) may apply, if the waste is suspected to be hazardous.

In addition to these methods, thorough random checks may be performed on the tipping floor at the discretion of the Facility Supervisor:

- The Scale House Operator will inform the hauler that a random check is to be performed. If the hauler refuses, the vehicle will not be permitted entry to the site and will be selected for a check on its next visit. The Scale House Operator will record, as much information as possible, about haulers who refuse a random check.
- The selected hauler will be directed to an area on the tipping floor that is separate from all other incoming waste. Prior to dumping, the driver of the inspected vehicle will confirm the absence of unacceptable materials. An inspector (the Facility Supervisor or a designate) will examine the load for hazardous or unacceptable wastes.

8.2.2 Handling Unacceptable Waste

Unacceptable wastes may be classified as non-hazardous, potentially hazardous or unacceptable, and, depending on the time of discovery, may or may not be associated with a known hauler. The following outlines appropriate procedures for handling unacceptable waste:

- Non-hazardous, unacceptable waste delivered by a known hauler will be reloaded by the hauler, if necessary, and removed from the site.
- Non-hazardous, unacceptable waste delivered by an unknown hauler may be removed from the site, processed to render it acceptable, or accepted as a special circumstance at the discretion of the Manager.
- Suspected hazardous (and therefore unacceptable) waste delivered by a known hauler will be reloaded by the hauler, if necessary, and removed from the site. The responsible site staff will complete a Waste Inspection/Attempted Delivery of Hazardous Waste Form, included in **Appendix A**, and inform NWB of the attempted delivery.
- If reloading or further transporting of the suspected hazardous waste is considered unsafe, NWB will be contacted for direction. Costs associated with the attempted delivery will be borne by the hauler and they shall be notified that they will be financially responsible for removal of the waste.
- Suspected hazardous waste delivered by an unknown hauler (i.e., discovered at the site) will be transferred, as directed by the Manager to a portion of the tipping floor designed for storage of suspected hazardous waste. The waste will be tested by a qualified firm at the discretion of NWB and the final disposal options determined based on the results.

Depending on the nature and condition of the suspected waste, safe transfer to the holding area, may not be possible. NWB is to be contacted for direction. The costs will be borne by the City.

Further procedures for handling unacceptable and/or suspected hazardous wastes are provided in the ERP for the Landfill and WTS (see Appendix B).

Once a waste is suspected to be hazardous, the onus is on the hauler to demonstrate otherwise or remove the waste, at their expense. Repeat deliverers of unacceptable or hazardous wastes may be banned from the site at the discretion of, and for a period determined by the Manager and/or the City.

8.2.3 Waste Baling

Following the completion of inspection procedures, material on the tipping floor is pushed using a front end loader to the conveyor infeed. The rate of material transfer from the conveyor to the baler hopper is regulated by the Baler Operator. Similarly, the Baler Operator controls the hydraulic rams, wire tying device and bale wrapper associated with the baler.

Following ejection from the baler, the bales are transferred (utilizing a forklift) to a flatbed truck for transport to the balefill.

8.3 Waste Placement and Covering

8.3.1 Waste Placement

Utilizing the Landfill's access road, bales of municipal solid waste will be delivered by site personnel from the WTS to the active disposal area. With the possible exception of loads of unique or difficult wastes, waste delivery vehicles and/or the general public will not have access to the Landfill area.

The Landfill is constructed from a series of individual lifts. Bales are removed from the flatbed truck via a fork-equipped front end loader. A lift is constructed by stacking bales three to four high; the height limit being set by the reach limit of the front end loader. The total height of a four bale lift is approximately 3 m. During bale stacking, the bales are placed with their widest dimension perpendicular to the direction of balefilling. Processed (shredded) C&D materials can be placed in bale voids on perimeter side slopes with granular fill subsequently being placed to develop a base for the final landfill cap.

In order to allow for a minimum 4 (horizontal) to 1 (vertical) side slopes for the fill area, the bales must be staggered during placement, utilizing the arrangements shown on **Figure 8-1**. The required side slope is attained, while still providing efficient usage of the available disposal volume. The staggered arrangement should be maintained until the final design elevation is reached.

The horizontal top cover should be placed to provide between 2% and 4% grade. A minimum side slope of 1% should also be established on the horizontal surface towards the passive vertical faces to direct runoff away from the working face.

Elements relating to the progression of solid waste balefilling at the facility are illustrated on the Engineering Drawings. The Landfill area development basically follows a sequence of composite liner installation within a specified disposal area, the orderly placement (or stacking) of cells of baled solid

waste within the disposal area, installation of composite liner in the next required disposal area, and the repeat of the process until final grades are reached and the area is capped.

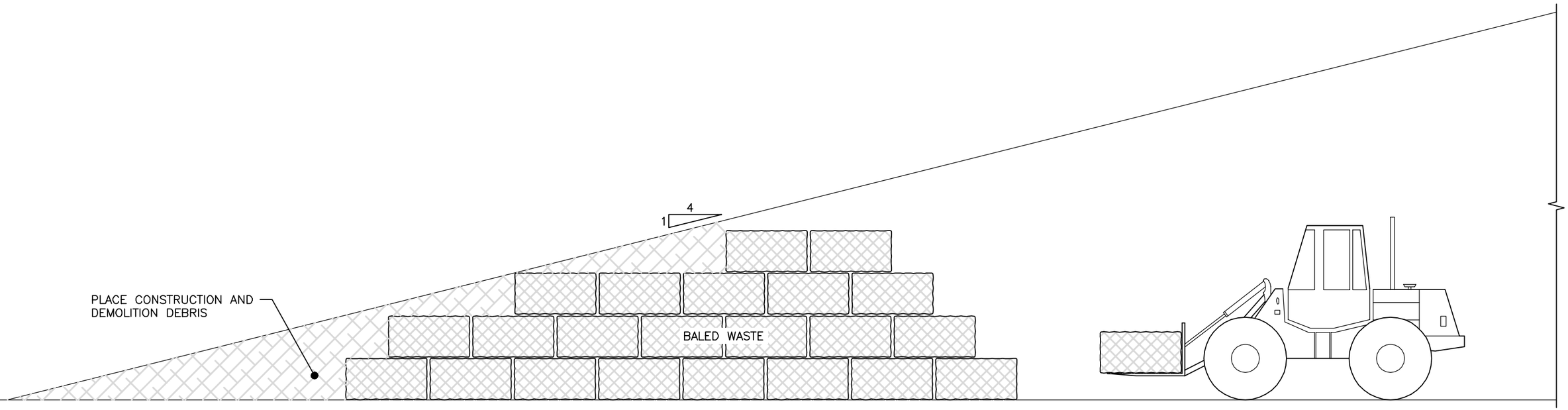
The staged, sequential development of the individual cells within the balefill area serves as the primary organizing factor in the facility's operation. The sequence established as part of the facility design is based on four main operational requirements:

1. To install the liner sequentially as defined cells.
2. To allow mobile site equipment access to all levels of the fill area.
3. To limit the height of vertical bale faces.
4. To achieve final design height (to allow for the installation of the landfill cap), as soon as possible.

Additional information relating to site development is included on the Engineering Drawings.

As the balefill reaches the final grades proposed on the Engineering Drawings, settlement can be expected. The completed areas should be inspected on a regular basis, and any cracks in daily/intermediate cover or areas of ponding water should be regraded to maximize surface runoff. If necessary, additional cover material should be added to ensure positive surface drainage.

CH_4 gas is a by-product of solid waste anaerobic degradation. **Section 11.0** describes LFG vent installation and the Engineering Drawings present the proposed location of the vents.



TYPICAL LIFT DETAIL

1:75

DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WAASTE TRANSFER STATION	PROJECT NO.: 19-9543
DATE: JUNE 2019	TITLE: STAGGERED BALE PLACEMENT	FIGURE NO.: 8-1

8.3.2 Waste Covering

Acknowledging the baled and wrapped condition of the waste materials, the relatively limited amount of annual precipitation and a lack of available low permeability soil cover, the placement of locally-sourced aggregate cover over the waste bales is required only as a precursor to final capping. In select instances, at the discretion of the Manager, the placement of aggregate cover over a non-typical waste material (e.g., presenting a blowing litter, animal/vector attraction and/or litter generation risk) may be deemed appropriate.

8.3.3 Cover Borrow Areas

As noted in **Section 4.2.3**, cover material required to support the Landfill's operations, including bale/waste covering and final grading, is scheduled to be acquired from the Northwest Aggregate Deposit.

8.3.4 Inclement Weather

Wet weather operation may require the use of stockpiled crushed rock and (potentially) demolition rubble to maintain road access to the Landfill working face. This function should be undertaken to ensure reasonable access at all times, as required.

During the winter season, snow clearing of the Qaqqamiut Road, Northwest Aggregate Deposit access road and the two landfill infrastructures (Landfill and Leachate Management System) will be required. Similarly, ongoing snow removal the WTS access routes, as well as the general yard area, will be necessary. It is acknowledged that extreme snowfall/blizzard events could result in a temporary discontinuation of operations at the WTS and/or Landfill.

8.4 Surveying and Horizontal/Vertical Control

The landfill cell and footprint limits will be clearly defined in the field. To aid in the construction of the Landfill, permanent benchmarks have been established for horizontal and vertical control. The locations of these benchmarks are defined as a component of the Engineering Drawings.

As construction of the Landfill progresses, the Manager will utilize grades stakes to ensure that the construction is in accordance with the approved plans. The frequency of the staking is controlled by the size of the site and the volume of waste received. Due to settlement, stakes set on previously filled areas should not be used as temporary benchmarks for future staking. If the stakes are required for a long period, they will be checked and reset frequently.

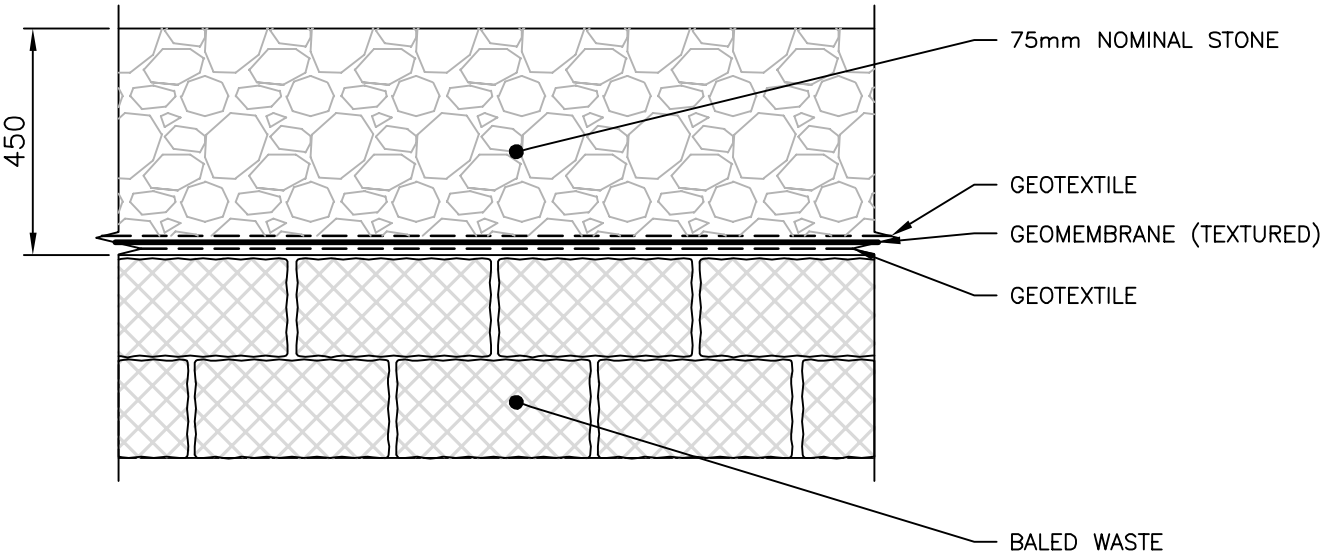
During application of final cover, elevation control will be established daily. The required thickness of final cover will be monitored using settlement plates placed at the top of the waste with painted gradations indicating the required layer thicknesses.

It is the Manager's responsibility to see that all necessary construction staking is accomplished and to apprise the equipment operators of their presence. The Manager will employ or engage the services of a qualified individual(s) to perform the day-to-day operational surveying needs of the site.

8.5 Landfill Cap

Upon achieving final design grades, future infiltration of precipitation into the waste mass (and thus the leachate collection system) will be mitigated through the installation of a landfill cap. The cap, as illustrated in **Figure 8-2**, consists of a surface drainage layer (450 mm of 75 mm clear stone) geomembrane barrier (60 mil textured LLDPE) and a base grading layer. A nonwoven geotextile is positioned above and below the geomembrane to provide protection during construction and closure activities.

As described in **Section 11**, vents will be installed at select locations in the final cap to allow for the release of LFG.



CAP SYSTEM SCHEMATIC

N.T.S.

DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
DATE: JUNE 2019	TITLE: LANDFILL CAP SCHEMATIC	FIGURE NO.: 8-2

FileName:c:\projectwise\working directory\projects 2019\50dbc\dms12727\11-199543-02-site-con-liner.dwg

9.0 Nuisance Control

9.1 Litter Control

Litter can be a significant problem at municipal solid waste disposal sites. At the facility, two factors will serve to reduce the problem significantly:

1. All incoming waste (with the exception of periodic bulky materials) will be handled within the WTS.
2. Waste arriving at the working face will be in high-density, wire-tied and plastic wrapped bales, with deposition occurring in an orderly "stacking" manner.

Acknowledging that a notable reduction in litter generation is expected at the City's site (over that associated with a standard landfill), a litter control program will still be maintained at this location. Litter control is best accomplished by a combination of proper disposal operations, litter retaining fences and a litter picking program. A clean, litter-free appearance will be maintained at the site at all times, not only for public relations, but also for efficient operation of the Landfill. Poor litter control would attract unwanted wildlife and contribute to surface drainage problems by blocking ditches and culverts.

In summary, litter control measures to be implemented at the Landfill and WTS include:

- Semi-permanent litter collection fencing shall be positioned around the active area to catch blowing litter (see Engineering Drawings).
- A vigorous litter collection and patrol program shall be directed by the Manager.
- Litter on fencing, on-site roadways, in ditches, in the WTS yard, and adjacent properties shall be monitored and collected on a minimum weekly basis.
- The arriving waste must be covered according to applicable City bylaws. Vehicles arriving uncovered shall be turned away.

9.2 Odour Control

Odours will be controlled at the facility by implementation of the following daily measures:

- Timely removal of waste from the WTS tipping floor (e.g., baled and delivered to the Landfill).
- Short-term storage of waste bales at the designated location within the WTS yard only in exceptional circumstances (e.g., extreme weather events or landfill access issues).
- Gas venting and collection systems (if necessary) shall be established and maintained in good working order (see **Section 11.2**).
- Leachate springs at the Landfill shall be promptly repaired.
- Complaints regarding odour shall be recorded (see **Appendix A**) and acted upon. Complaints shall also be correlated to relevant whether information.

Odour control will also be achieved by routine site inspections to identify and eliminate localized surface water ponding and/or surface water drainage problems. Should odours become a problem, an on-site evaluation will be performed and appropriate remedial actions taken based on results of the evaluation.

9.3 Dust Control

Due to transport and placement activities at the site, as well as the number of gravel surface roadways, dust control will be an important operational consideration. Dust control measures to be implemented at the Landfill and WTS include the following:

- The site shall be monitored daily during dry weather.
- Vehicle speeds shall be limited on-site to 10 kph within the WTS compound and at the Landfill, particularly during dry periods. Adequate signage shall be posted and limits enforced.
- On-site roads shall be maintained to minimize dust emissions.
- Asphalt surfaces (e.g., scale ramps) shall be routinely swept.
- Calcium chloride shall be applied to roads, as necessary. The rate of application shall be recorded, using the daily checklists (see **Appendix A**).

9.4 Vector and Bird Control

Solid waste disposal facilities can attract rodents and birds due to the availability of food and the potential for breeding habitats in the waste. Limiting the availability of food and void space, resulting from the compacted nature of the baled waste, will discourage their habitation.

9.4.1 Vector and Animal Control

Control measures include the following:

- Litter collection shall be conducted daily to mitigate the attraction of vectors and animals.
- If a baiting program is required for rodents, it shall comply with regulatory requirements regarding the use of pesticides.
- If burrowing animals utilize the leachate holding ponds as habitat, contact Nunavut Department of Natural Resources to determine the safest manner of removing the animals.

Acknowledging the potential risks, all staff assigned to duties at the Landfill shall be properly trained in bear safety.

9.4.2 Bird Control

Control measures include the following:

- Minimize potential roosting areas within the WTS (e.g., using netting and/or landing surface spikes).
- Litter collection shall be conducted daily.
- If the problem is persistent, a more intensive program shall be initiated, which may involve the use of noise generating devices.

9.5 Noise Control

All equipment powered by internal combustion engines have mufflers installed and will be maintained in accordance with manufacturer's recommendations.

Regular hours of operation at the WTS shall be restricted to a posted schedule acknowledging the use of back up alarms/indicators on mobile equipment.

9.6 Open Burning

Open burning of any material will not be permitted at the Landfill or WTS.

9.7 Indiscriminate Dumping

Waste is to be disposed at designated areas at the facility (i.e., WTS tipping floor, material storage areas or Landfill) only. When indiscriminately dumped materials are discovered, they are to be immediately relocated to the appropriate designated area.

10.0 Surface Water Management

10.1 General Description

Surface water at the Landfill is conveyed primarily via overland and sheet flow, ultimately concentrating into channel flow to the east of Sylvia Grinnell Territorial Park, at which point it flows southerly toward the Iqaluit Airport, ultimately discharging to the Koojesse Inlet at Frobisher Bay. Runoff from the WTS site follows the City's drainage network in a southerly direction and into Koojesse Inlet.

Surface water for the Landfill and WTS is classified in two categories:

Stormwater from Developed (Disturbed) Areas

- Includes any surface water from the WTS compound, active and non-active portions of the constructed Landfill, outside slopes of berms, access roads and capped areas. This water is collected in ditches and directed prescribed discharge points, as indicated on the Engineering Drawings.

Stormwater from Non-Developed (Undisturbed) Areas

- Surface water from undeveloped areas or right-of-way areas. This water is discharged directly off-site.

It is noted that precipitation coming in contact with waste materials (e.g., baled waste and C&D materials) will be captured within the Landfill's leachate collection system and will enter the site's surface water ditching.

10.2 Control Ditching

Surface water control is provided through permanent WTS compound/Landfill perimeter ditching, as well as interim/temporary ditching. All permanent ditching is designed to accommodate the peak 100 year return period stormwater flow condition. Permanent culverts are designed to accommodate peak 10 year return period stormwater flows. The interim ditching and culverts are capable of handling the peak five year return period stormwater flows generated on the site.

Noting the anticipated lack of fine grained, erodible soils at the Landfill or WTS, sedimentation control has not been identified as an issue of concern for the design of surface water management features. General operational procedures to limit the potential for negative impacts associated with erosion and sedimentation are incorporated in the Construction and Operations, Closure and Post-Closure Environmental Protection Plans for the Landfill and WTS project.

Primary operational requirements relating to the surface water control ditching include the following:

- Stable aggregate cover shall be maintained in the ditches and on other site surfaces.
- Positive flow shall be maintained away from all buildings.
- Ditches shall be maintained to prevent side slopes from sloughing.
- Ditches shall be kept free of debris, as required.
- Culvert headwalls shall be maintained.

11.0 Landfill Gas Management

11.1 General Description

CH_4 and carbon dioxide (CO_2) are the primary constituents of LFG and are produced by microorganisms within the balefill, under anaerobic conditions. Carbohydrates from paper, cardboard and similar materials are decomposed initially to sugars, mainly to acetic acid, and finally to CH_4 and CO_2. Other components of LFG include non-methane organic compounds (NMOC) and inorganic compounds. NMOC originate from the disposal of aerosols, paints, oils, solvents and similar products in the Landfill. Inorganic compounds, such as hydrogen sulphide, originate from the decomposition of reactive waste products.

LFG generation, including rate and composition, proceeds through four characteristic phases throughout the lifetime of a Landfill. The first phase is aerobic (e.g., with oxygen available) and the primary gas produced is CO_2. The second phase is characterized by O_2 depletion, resulting in an anaerobic environment where large amounts of CO_2 and some hydrogen are produced. In the third anaerobic phase, CH_4 production begins, with an accompanying reduction in the amount of CO_2 produced. Nitrogen (N_2) content is initially high in the balefill gas in the aerobic first phase, and declines sharply as the Landfill proceeds through the anaerobic second and third phases. In the fourth phase, gas production of CH_4, CO_2 and N_2 becomes fairly steady. LFG is typically described as comprised of 50% CH_4 and 50% CO_2; although, the percentage of each may vary considerably.

The phase duration and time of gas generation varies with site conditions (e.g., waste composition, cover materials, design, anaerobic state), and may also vary with climatic conditions such as precipitation rates and temperatures. Because CH_4 is combustible, it poses a greater risk to safety than CO_2. If vented in an uncontrolled manner, CH_4 can accumulate in enclosed spaces on, or close to, the disposal site. CH_4 gas is odourless, and because its density, is less dense than air. It rises until its movement is restricted by some impermeable medium. For example, in winter, the frozen surface of the ground may block the vertical escape of CH_4, forcing it to move laterally. Also, CH_4 is insoluble in water; therefore, it will not move below the groundwater table. This presents the risk of fire or explosion. Concentrations of CH_4 between 5 and 15% in air are explosive. With proper venting; however, CH_4 gas should not pose an unacceptable hazard. Research has shown that the rate of decomposition in landfills, as measured by CH_4 gas production, reaches a peak within the first two years and then slowly tapers off; although, continuing in many cases, for periods up to 25 years or more. Therefore, CH_4 venting must be accommodated during and after balefill completion.

It is expected that the low average annual temperature, relatively limited amount of annual precipitation, and the baled and wrapped configuration of the waste will tend to reduce the intensity of LFG generation at the City's site. Further, migration of permafrost into the waste mass overtime at the Landfill may serve to deter waste degradation all together. However, it is acknowledged that ongoing

effects associated with climate change (e.g., warmer and wetter weather in the north) could result in increased LFG generation rates in the future.

11.2 Landfill Gas Vents

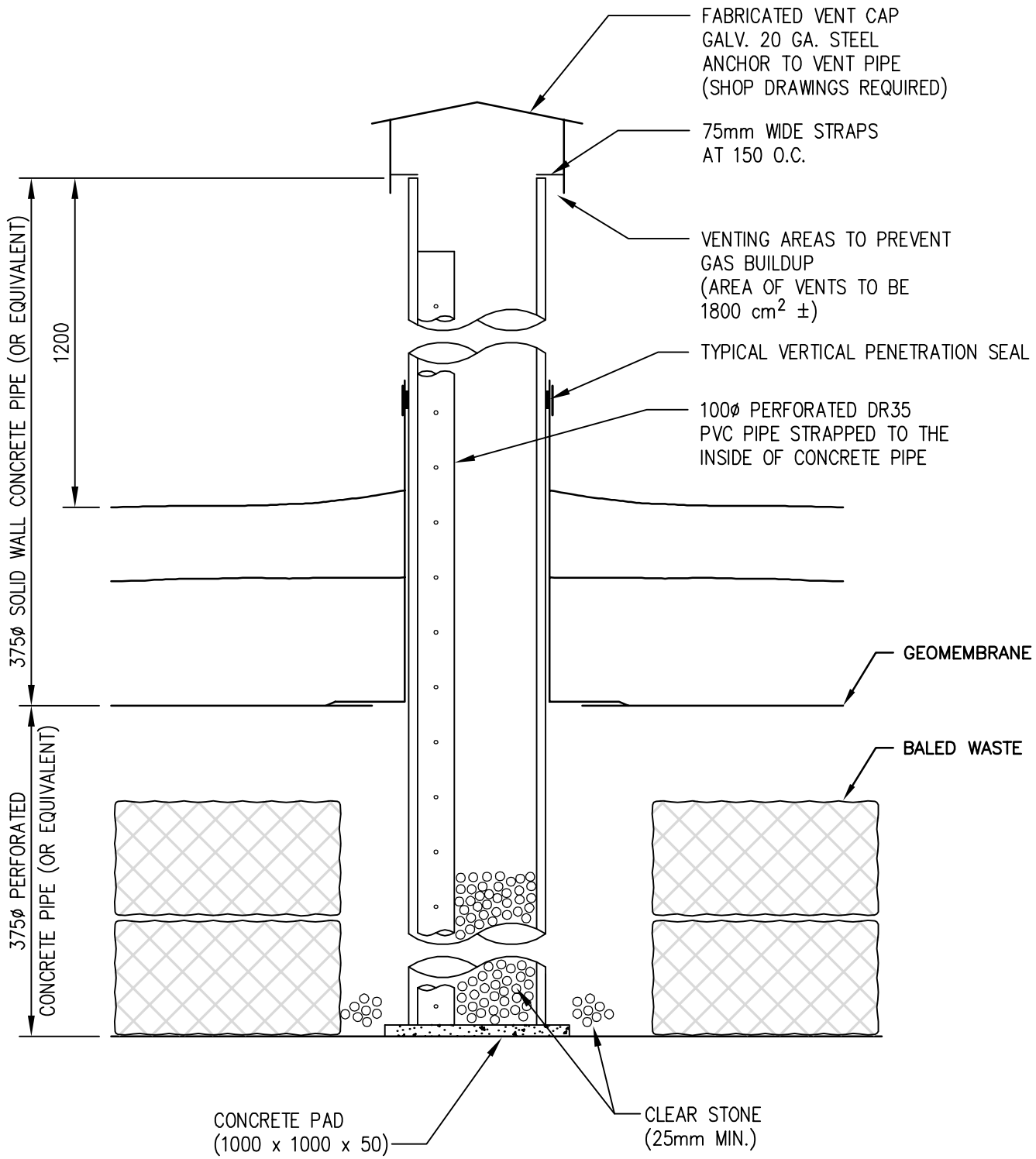
LFG vents will be installed, as specified throughout the fill area, to allow for the controlled discharge of this gas. Suggested locations for these vents are shown on the Engineering Drawings. The vents should be extended in height as the site is developed. Recommended construction details for a typical gas vent are provided in **Figure 11-1**.

If explosive concentrations of CH_4 are detected during the monitoring program, the ventilation capability of the vent itself, as well as the overall spacing of vents, should be investigated. It may become necessary to consider a positive type ventilation system (such as gas extraction), if the problem is not easily remedied.

CO_2 gas is not considered to present a high risk to safety with regards to above ground operations. However, since it is heavier than air, CO_2 will collect in the bottom of manholes, poorly vented trenches, and other below-ground areas. Therefore, site personnel should take appropriate precautions, such as the use of a respirator or forced ventilation, prior to entering these areas.

Primary operational requirements relating to LFG control include the following:

- LFG vents shall be installed in the Landfill area, according to spacing identified on the Engineering Drawings.
- CH_4 gas detection levels shall be monitored at each vent semi-annually and recorded within a database.
- The area immediately surrounding vents shall be checked periodically for surface water ponding. Regrading shall be conducted, as necessary.
- The structural integrity of the exposed portion of vents shall be monitored periodically to ensure they are maintained.



DILLON CONSULTING	PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO.: 19-9543
DATE: JUNE 2019	TITLE: TYPICAL LANDFILL GAS VENT	FIGURE NO.: 11-1

FileName:c:\projectwise\working directory\projects 2019\50dbc\dms12727\11-199543-02-site-con-liner.dwg

- The gas vents shall be inspected to ensure that the vent caps are properly fitted and maintained.
- The height of the vents shall be checked to ensure that vents extend a minimum of 1200 mm above grade at all times.
- If measured gas concentrations are within the explosive range, venting capacity shall be evaluated for those vents with explosive readings; alternatively, additional passive vents should be installed.
- If the measured gas concentrations are within the explosive range and the condition is not remedied by modifying the passive vent system, the use of a positive venting system shall be evaluated.

12.0 Leachate Management

As discussed in **Section 4.0**, leachate is created as a result of operations at the Landfill and WTS. Dedicated collection and storage systems serve each location. Management requirements for both locations are discussed in the following sections. Sampling and analysis requirements associated with leachate management are presented in **Section 13.**

12.1 Waste Transfer Station

Leachate within the WTS is generated during the waste baling process, as liquid is squeezed out of the waste mass. This liquid is collected via a shallow trench in the slab around the perimeter of the baling unit, with the effluent subsequently being pumped to a holding tank on the WTS floor. As required, this liquid is collected and transported to the City's WWTP for treatment.

12.2 Landfill

The Landfill's leachate collection and treatment system, as described in **Section 4.2**, incorporates several components, including the leachate collection layer/perforated pipe system within the disposal area liner system, collection sumps/manholes, two holding ponds and an engineered wetland.

> WARNING!
>
> LEACHATE IS POTENTIALLY HAZARDOUS.
>
> Take appropriate safety precautions when handling or working near leachate or when entering confined spaces, such as the use of protective clothing, breathing apparatus, and ventilation.

Primary operational requirements relating to leachate management at the Landfill include the following:

- The leachate collection manhole includes a removable, rail-mounted submersible pump, complete with connection piping to a forcemain. One pump will be the duty pump with the second as a back up. The manhole includes a float system (complete with a control panel) to trigger pump operation, when leachate depths warrant.
- The forcemain will direct leachate to Holding Pond #1, with subsequent flow through Holding Pond #2 and final discharge to a defined wetland treatment area south of the ponds.
- The pump will be powered by a small portable generator. Staff will bring the generator to the site each morning and energize the system. Prior to leaving the site at the end of the day, the generator will be disconnected and returned to the WTS for storage.
- The manhole pump system will be operated during the period of the year when leachate is being generated and flows into the manhole (e.g., June 1 to October 1). Upon the confirmation of freeze up conditions in the fall, the pump will be removed from the manhole and the forcemain will be decommissioned (drained) for the winter. Assessment of leachate generation

status (e.g., observations within the manhole) shall commence in the late spring, confirming when active pumping efforts should be initiated.

- A complete inspection of the leachate collection system elements (manhole, pump, holding ponds and wetland) shall be conducted on an annual basis.

13.0 Site Monitoring

13.1 Surface Water and Active Layer Water

<To be developed during Phase II – Preliminary Design.>

13.2 Leachate

<To be developed during Phase II – Preliminary Design.>

13.3 Landfill Gas

Once vents have been installed, LFG samples shall be collected on a semi-annual basis. Analysis shall be limited to CH_4 concentration. Additional parameters may be identified at a future date, in consultation with NWB.

13.4 Permafrost Condition

<To be developed during Phase II – Preliminary Design>

14.0 Facility Records

Maintaining facility records is important for operational decisions related to both daily activities and long-term facility management. Copies of all records shall be kept at the WTS Office and up-to-date for inspection subsequent reporting purposes. The following records should be maintained as a minimum. It is noted that the daily and weekly checklists discussed in this section (and presented in **Appendix A**) provide an efficient and concise means to maintain an operational record:

1. Incoming Material Quantities – All materials entering the WTS are weighed prior to subsequent handling. A computerized data base serves to consolidate all collected information by source and material type allowing for subsequent reporting. Weigh scale information can be used for determining waste compaction values, soil to waste ratios, trends in waste generation and general quantification of the waste stream.
2. Site Visitor Log – All visitors accessing the Landfill or WTS are to be registered in the site visitor log (see **Appendix A**). The log book will be held at the Scale House.
3. Correspondence – A filing system shall be maintained to keep any correspondence associated with site operation.
4. Financial – Complete records of budget forecasts and actual expenditures must be maintained for the operation. This information is to be summarized in an annual report, as well as forecasts for the upcoming year.
5. Site Operations Log – The site log will consist of the daily and weekly checklists (see **Appendix A**), as well as periodic print-offs (i.e., monthly) of Scale House records. Other operations forms, including weather logs, waste inspection forms, complaint forms, can also be incorporated into the site log. It is recommended that the log itself take the form of a binder, allowing for the easy addition of documentation. The landfilling log will be held and maintained by the Manager.
6. Weather – Records relating to temperature, wind conditions and precipitation shall be recorded daily, using a standardized form (see **Appendix A**).
7. Liner – When landfill cell liner installation is required, a topographic survey of the base area shall be performed prior to liner construction. The area to receive the liner shall be graded according to the dimensions and elevations shown on the Engineering Drawings. Installation of the liner system shall be undertaken by personnel/firms experienced in the application of the specified materials. Installed sections of liner shall be tested for quality control, as indicated in the specification. Record engineering drawings of the area shall be prepared each time the liner is installed. Inspection records documenting quality control during liner installation shall be maintained by the City. A section of liner capable of accommodating one year of landfilling shall be installed at a minimum. The determination of timing requirements associated with installation of the liner system is discussed in **Section 7.2**. A sketch of the location of landfilling, with respect to the liner, shall be developed on an annual basis.
8. Compaction Control – To monitor site operations on a yearly basis, overall compaction of the balefill shall be examined. A topographic survey of the active soil borrow area and the active Landfill area, shall be conducted annually to determine the volume occupied. Survey drawings

generated, as part of this undertaking, shall provide an annual record of site development. Using the weigh scale records, as well as the overall degree of compaction of the balefill, shall be determined.

9. Landfill Cap – When an area reaches final design elevation, a topographic survey shall be conducted to establish final grade. Similar to the disposal area liner, the landfill cap installation shall be undertaken by experienced, qualified personnel with quality control testing being completed, as noted in the specification. All landfill cap installations shall include the completion of record engineering drawings. Other features that shall be noted on the record drawings include locations of CH_4 vents, leachate collection system elements and surface water runoff ditches. The requirement to install or cap an area shall be forecasted at least 12 months in advance of design and construction for the cap.
10. Leachate Control – Documentation shall include leachate quality test results, sketches showing the progress of installation of the leachate collection network, leachate pumping and volumes.
11. LFG Control – Documentation associated with the development of the gas vents within the Landfill area, including location of the gas vents/gas recovery infrastructure and data on periodic gas sampling, shall be maintained.
12. Surface and Active Layer Water Monitoring – A database of all surface and active layer monitoring results, including water quality and monitoring point integrity information, shall be maintained.
13. Bird/Pest Control – If control measures are undertaken, all activities are to be recorded on the daily and weekly checklists.
14. Reports – As directed by the Director of Engineering and Public Works, written facility reports shall be prepared by the Manager. Annual material disposal/diversion reports, based on site weigh scale records and in accordance with the requirements of NWB, shall also be prepared.

15.0 Summary Schedule of Activities

<To be developed during Phase II – Preliminary Design.>

16.0 Emergency Response Plan

An ERP applicable to operations at the Landfill and WTS is attached as **Appendix B**.

Appendix A

Forms

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station

Complaint Response Form[1]

Complainant: _____ **Date Received:** _____

Repeat Complainant[2] (Y/N): _____

Address: _____ **Time Received:** _____

_____ **Received By:** _____

Phone No.: _____ **Form Completed By:** _____

Date of Complaint: _____

Time of Complaint and Noted Weather Conditions: _____

_____

Delivery of Complaint: ☐Phone Call ☐Letter ☐Personal Visit ☐Email/text

Nature of Complaint: _____

_____

_____

_____

_____

_____

_____

Suggested Response: _____

_____

_____

_____

Actions Taken: _____

_____

_____

_____

_____

_____

Complaint Received By (Sign & Date): _____

Written Acknowledgement By (Sign & Date): _____

Notes:

1) A blank complaint response form is to be provided to a complainant upon request. The form can then be completed by the complainant and distributed as desired.

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station
VISITORS LOG

Date	Visitor's Name	Company Name	Reason for Visit	Time In	Time Out

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station

WASTE INSPECTION/ATTEMPTED DELIVERY OF UNACCEPTABLE WASTE FORM

PART A – INSPECTION

Date/Time of Delivery: _____

Date/Time of Inspection: _____

Hauling Firm/Vehicle Owner: _____

Driver's Name: _____

Contact Phone Number: _____

Vehicle License Plate: _____

Size of Load (i.e., tonnes, cubic metres): _____

Source of Waste (as stated by Driver): _____

_____

Type of Waste (as stated by Driver): _____

_____

Inspection Location: _____

Inspection Observations: _____

_____

Suspected Unacceptable Wastes? (Yes/No; **If Yes, complete Part B**) _____

PART B – SUSPECTED UNACCEPTABLE WASTE

Suspected Type of Unacceptable Waste: (as stated by Inspector): _____

Action Taken: _____

_____

Comments: _____

_____

	Inspector	**Driver**
Signature:	_____	_____
Date:	_____	_____

Inspector: Write "refused" in space for driver's signature if driver refuses to sign form.

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station

FACILITY WEEKLY OPERATIONS CHECKLIST
to be completed with reference to the Daily Facility Checklists

Checklist for Week Ending: _____ Completed by: _____

Date Completed: _____

Item	Acceptable Condition? (Y/N)	Comments/Action
1. Mobile Equipment		
2. Litter Control		
3. Pest Control		
4. Dust Control		
5. Site Entrances		
6. Site Roads		
7. Scale/Scale House		
8. Office Building		
9. WTS Tipping Floor		
10. WTS Stationary Equipment		
11. WTS General Interior/Exterior		
12. WTS Yard and Ditching		
13. WTS Yard and Ditching		
14. Active Landfill Disposal Cell		
15. Landfill Staff Shelter		
16. Fire Safety Equipment		
17. Health and Safety Procedures		
18. Waste Placement (incl. cell location)		
19. Landfill Perimeter Berms		
20. Leachate Management System		
21. Landfill Surface Water Ditches		
22. Surface/Active Layer Monitoring		
23. Odour Control		
24. Completed Area		
25. Weekly Landfilled Tonnage		
26. Weekly Diverted Tonnage		
27. Unacceptable Loads		
28. Personnel		
29. Complaints		
Other Issues/General Comments:		

Notes:
1. Acceptable Condition – Item/Issue is within guidelines established by the Operations Manual and/or Operating Authorization and/or good practice.

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station

FACILITY DAILY OPERATIONS CHECKLIST
***to be completed daily with Daily Weather Log**

Date: _____

(A) Morning (Beginning of Working Day) Completed by: _____

	Item	Acceptable Condition? (Y/N)	Comments/Action
1.	Mobile Equipment		
2.	Stationary Equipment		
3.	Landfilling Cell		
4.	Site Entrances		
5.	Site Roads		
5.	WTS Buildings		
6.	WTS Yard Area		
7.	WTS Heating Fuel		
8.	Leachate Management System		

Other Issues/General Comments:

Notes:

1. Acceptable Condition – Item/Issues within guidelines established by the Operations Manual and/or Operating Authorization and/or good practice.

(B) Afternoon (End of Working Day) Completed by: _____

	Item	Information
1.	Working Cell Location (note sequence number)	
2.	Total Baled/Landfilled Tonnage	
3.	Major Haulers (names)	
4.	Number of Private Loads	
5.	Number of Commercial Loads	
6.	Total Diverted Tonnage	

Other Issues/General Comments:

City of Iqaluit - Iqaluit Waste Management Facility
Landfill and Waste Transfer Station
DAILY WEATHER LOG

Log Completed on: _____ _____ _____ Time: _____
Day Month Year

Log Completed by: _____

Weather Record for: _____ Next Day Forecast

Temperature: High___C Low___C Temperature: High___C Low___C

Wind Velocity: _____km/h Wind Velocity: _____km/h

Precipitation	Accumulation	Cloud Cover	Precipitation	Predicted Accumulation
☐ Rain	_mm	☐ Sunny	☐ Rain	_mm
☐ Freezing Rain	_mm	☐ Partly Sunny	☐ Freezing Rain	_mm
☐ Snow	_mm	☐ Partly Cloudy	☐ Snow	_mm
☐ Other	_units	☐ Cloudy	☐ Other	_units

Action Required Due to Weather Conditions		
	Personnel Required	**Comments**
☐ Snow Removal		
☐ Road Sanding/Salting		
☐ Dust Control		
☐ Litter Control		
☐ Slope Stabilization		
☐ Ditching		
☐ Equipment Servicing Description _____		
Other (Specify) _____		

Appendix B

Emergency Response Plan
(to be attached when finalized)

Appendix C

Facility Approval
(to be attached when provided)

DILLON CONSULTING

Appendix G

Facility Risk Assessment Report

DILLON CONSULTING

CITY OF IQALUIT

Facility Risk Assessment (Draft)

Landfill and Waste Transfer Station

June 2019 | 19-9543

Table of Contents

Figures

Tables

Appendices

1.0 Purpose of the Facility Risk Assessment

1.1 Background

In the Request for Proposal (RFP) under Phase I – Pre-Design, a Facility Risk Assessment (FRA) is to be completed that "identifies risk and potential mitigation measures for environmental, health & safety (H&S), geotechnical, facility infrastructure, and operational aspects of the landfill and waste transfer station (WTS) and their operations." As part of the pre-design stage, the underlying objective of the FRA is to inform decision making when it comes to the various deliverables in Phase I as shown in **Figure 1 –1Error! eference source not found.**.

Figure 1-1: Goal of Facility Risk Assessment

1.2 Assumptions

Information was obtained from the following sources to complete the FRA:

- Discussions with the Design Team Leads;
- Facilitated BowTie workshop session held on May 8, 2019; and
- Publically available databases, documents and records, as identified and referenced within this submission.

1.3 Facility Risk Assessment Team

The FRA Team consisted of the following individuals:

- Dave Poole – Certified Risk Manager (CRM) with over 25 years of experience developing risk management strategies and providing strategic advisory services.
- Farhad Shams – Risk Analyst with four years of experience conducting project risk assessments and business analysis.

The FRA Team was supported by the Senior Review/Technical Advisors.

1.4 Limitations

To complete the FRA, information was obtained from the following sources:

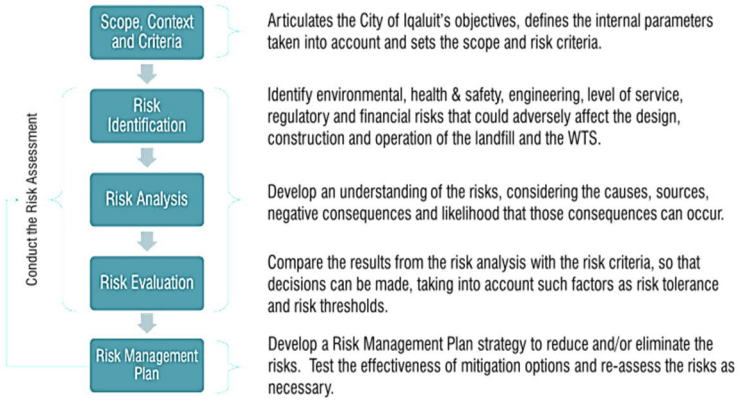
1. Solid waste, building and facility, leachate management, water resources/hydrology, hydrogeology, and environmental and regulatory subject matter experts; and
2. Publically available documents and records at the time the FRA was completed.

While every effort was made to minimize potential errors and omissions, there are some limitations. These limitations are noted, where applicable in the report.

2.0 Risk Management Framework and Process

Dillon employed a standardized, systematic and transparent risk assessment and management process from ISO3100:2018 Risk Management – Guidelines, as shown in **Figure 2 –1**, which is both a step-wise and iterative process. In the beginning, Dillon worked with the City of Iqaluit (the City) to define the scope, context and criteria, which formed the basis to conduct the risk assessment. Conducting the risk assessment was designed as a collaborative and facilitated process to ensure that all the relevant risks are identified, properly analyzed and evaluated.

Figure 2-1: Outline of ISO31000:2018 Risk Management Guidelines



The objective of the FRA is to assess the risks associated with the design, construction, and operation/maintenance of the solid waste landfill and the WTS facility. In addition, closure and post-closure of the solid waste landfill were taken into consideration. Based on discussions with the City, the FRA will look at risk from the following perspectives (herein called Risk Receptors):

- Public and employee Safety
- Financial Loss (Capital and Operational)
- Reputation
- Business Interruption/Level of Service
- Environmental
- Legal
- Technical

Risk is calculated as:

Risk Score = Likelihood x Impact

In order to calculate the "Risk Score", the following Risk Criterion was developed for each of the above-referenced Risk Receptors, taking into consideration both Likelihood and Impact, as shown in **Figure 2 –2**. The one exception is with "Technical" – which is a risk factor that we used to categorize the overall technical risks associated with the design and construction of the solid waste landfill and the WTS. There is no "likelihood" component to quantifying the Technical risk; therefore, a corresponding Risk Score – Technical was not calculated.

Figure 2-2: Risk Assessment Criterion

RISK ASSESSMENT CRITERION

Likelihood/Vulnerability

The likelihood is used to analyze the vulnerability level. The likelihood or the probability that an asset will be impacted based on current conditions.

Score	Descriptor	Probability	Frequency	Likelihood
1	Remote	0% - ≤ 20%	May occur less than once in 35 years	May happen in only exceptional circumstances
2	Unlikely	> 20% - ≤ 40%	May occur once in 25 to 35 years	Could happen sometimes, but not likely.
3	Possible	> 40% - ≤ 60%	May occur once in 15 to 25 years	Might occur.
4	Likely	> 60% - ≤ 80%	May occur once in 5 to 15 years	Likely to occur.
5	Almost Certain to Occur	> 80% - ≤ 100%	May occur once in 1 to 5 years	Expected to occur.

Criticality/Impact

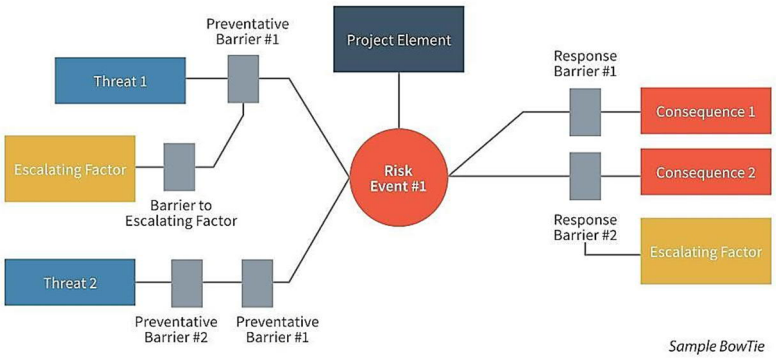
		Risk Receptors							
Score	Descriptor	Public and Employee Safety	Financial Loss (Capital)	Financial Loss (Operational)	Reputation or image	Business Interruption / Level of Service	Environmental	Legal	Technical
1	Low	No injuries - Near miss	≤ $ 200K	≤ $ 2K	No external attention	1-2 days	Short term no impact offsite	Legal action not likely	Proven technical approach; meets applicable standards; commonly applied technology
2	Moderate	Minor injuries to small number of staff or public	>$ 200K - ≤ $1.5M	>$ 2K - ≤ $15K	Individual complaint	3 days - 1 week	May impact offsite and ecosystem – Small scale < 1 month	Minor legal issues, non-compliances and breaches of regulation	Proven technical approach; meets applicable technical standards; previously applied in Northern Canada
3	Significant	Medical treatment / Employee Reportable Injury	>$1.5M - ≤ $5M	>$15K - ≤ $50K	Multiple individual complaints.	1 week - 2 weeks	Offsite and ecosystem impacted – Duration up to 1 year – Repairable	Serious breach of regulation with investigation with prosecution or moderate fine	Proven technical approach; meets applicable technical standards; never been applied in North Canada
4	Serious	Partial disability, hospital treatment (i.e. surgery)	>$5M - ≤ $10M	>$50K - ≤ $100K	Frequent complaints	2 weeks - 1 month	Extended range – Long-term impact – May regenerate in ten years	Major breach of regulation Major litigation	Proven technical approach; meets applicable technical standards; not commonly applied technology
5	Severe	Death or permanent total disability	> $10M	> $100K	Media attention	> 1 month	Long-term severe irreparable environmental impact - Over extended range beyond site	Significant prosecution and fines Very serious litigation including class action	New, untested, and unique technical approach

Figure 2-3: Risk Matrix

Likelihood					
	low 5	medium 10	high 15	very high 20	very high 25
	low 4	medium 8	high 12	high 16	very high 20
	very low 3	low 6	medium 9	high 12	high 15
	very low 2	low 4	low 6	medium 8	medium 10
	very low 1	very low 2	very low 3	low 4	low 5
	Impact				

The BowTie methodology was utilized to "Conduct the Risk Assessment", where the design, construction, operation/maintenance and the closure/post-closure Project Elements were defined, from which various Risk Events were identified.

Figure 2-4: Sample BowTie



Taking into consideration the Threats, Preventative and Response Barriers, each Risk Event can result in one or more "Consequences". For each Consequence, the Total Risk Score is calculated by summing the individual Risk Scores for each of the seven Risk Receptors (excluding Technical). This will allow the FRA to risk-rank each Consequence based on the Total Risk Score. The higher the Total Risk Score, the higher priority for that specific Consequence.

3.0 Project Description

3.1 Overview

The City is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste disposal requirements. Founded on a previously completed conceptual design and facility siting exercise, key elements of the project include a solid WTS within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal, and some construction and demolition (C&D) wastes will also be shredded and or baled for landfilling, or transported south for recycling. The resulting solid waste bales, and possibly a smaller amount of unbaled construction and demolition waste, will be trucked to an engineered balefill landfill site (Landfill) located approximately 6 km from the WTS. The vehicles transferring the waste bales will access the road leading to the Landfill site from the WTS to avoid having the transfer vehicle travel through the City.

Other planned features of the WTS include a public drop-off area for Household Hazardous Wastes and a vehicle logger/compactor unit; in both instances allowing for the preparation of waste materials prior to shipping to an approved management facilities in the south.

The access road that will be used to reach the new Landfill site has been designed by EXP Services Inc., who will also be providing Construction Contract Administration services for the construction of the road. It is anticipated that the construction of the road will be included in the new Landfill and WTS contractor's scope of work.

The engineered Landfill will be designed for 75 years of operation but for the construction/ build portion of the project, only the first stage of the Landfill (Stage 1 Operational Landfill) will be constructed (e.g., first two cells and ancillary components to meet five and 10 year operational requirements [i.e., five years per cell]).

Development of the proposed facilities is scheduled to occur during the 2020 and 2021 construction seasons, with facility commissioning in the fall of 2021.

3.2 Hazard Identification – Solid Waste Landfill

A summary of the primary project elements for the solid waste Landfill that fall under the design, construction and operational categories are provided in **Table 3 –1**, which formed the basis for defining the Hazards in the BowTies.

Table 3-1: Cross Reference Landfill Project Elements with Identified Hazards

List of Project Elements	Hazards Used in BowTies
Design and Construction	
Access Road	**Ancillary infrastructure** – not brought forward to risk assessment. Apply standard design and construction practices to monitor and mitigate risk of impact to cost and/or schedule.
Equipment Storage Building	
Staff Shelter – Trailer	
Landfill Liner System	**Landfill Liner System**
Water Monitoring System	
Landfill Cells	
Landfill Leachate Collection System	**Leachate Treatment System**
Leachate Holding Pond (outside of Landfill)	
Leachate Treatment System	
Temporary Power from Portable Generator	**Landfill Liner System** **Leachate Treatment System** **Ancillary Infrastructure**
Operations, Maintenance, Closure and Post-Closure	
Placing Waste in the Balefill on a Periodic Basis	**Landfill Liner System**
Filling Cell with Waste Bales	
Permanent Cap Placed on the Filled Cell(s)	**Leachate Treatment System** **Landfill Liner System**
Building New Cells	**Landfill Liner System**
Leachate Collected and Pumped to Holding Pond	**Leachate Treatment System**
Treatment Process of Leachate	
Placement and Maintenance of Closure Cap	**Closure/Post-Closure** – at the pre-design stage, these project elements were grouped under this general hazard category.
Closure Cap – Surface Drainage System	
Water Monitoring System	**Landfill Liner System**

3.3 Hazard Identification – Waste Transfer Station

A summary of the primary project elements for the WTS that fall under the design, construction and operational categories are provided in **Table 3 –2**, which formed the basis for defining the Hazards in the BowTies.

Table 3-2: Cross Reference Waste Transfer Station Project Elements with Identified Hazards

List of Project Elements	Hazards used in BowTie
Design and Construction	
Pre-Engineered Steel Building	Waste Transfer Station (WTS) – at the pre-design stage, these project elements were grouped under this general hazard category.
Exterior Office/Trailer	
Scale House Kiosk	
Building Cooling System - under slab	
Water Monitoring System	
Water Tank and Septage Tank	
Fire Protection System	
Baling Equipment	
Shredder and Pelletizer	
Building Heating System	
Weigh Scale	
Household Hazardous Waste - Temporary Storage	
End of Life and Metal Logger (crushes metal in to a cube)	
Mechanical Ventilation	
Electrical Systems	
Communications/Alarm, Internet Systems	
Operations and Maintenance	
Collecting and Hauling Municipal Solid Waste and Cardboard to WTS	Waste Transfer Station (WTS) – at the pre-design stage, these project elements were grouped under this general hazard category.
Weighing Waste	
Shredding and Pelletizing Waste Wood and Cardboard	
Shredding and Baling Tires, Metal, and C&D Waste	
Delivering Waste to the Pre-Engineered Building for Temporary Storage	
Waste Delivered to Baling Unit	
Compressing Waste and Plastic Wrapping	
Transfer to Balefill	
Processing End of Life Vehicles	
Pelitized Wood and Cardboard Deliverd to Biomas Boiler	

4.0 Risk Assessment Results

4.1 Solid Waste Landfill

4.1.1 Development of Risk Events

Based on the Hazards identified in **Table 3 –1**, the following Risk Events (or Top Events using BowTie terminology) were identified (see **Table 4 –1**).

Table 4-1: List of Top Events – Solid Waste Landfill

List of Top Events - Landfill	Hazard	Rationale for Inclusion in FRA
Liner system failure	Landfill Liner System	The failure of the liner system is typically viewed as being a plausible "worst-case" scenario for the ongoing operation and management of solid waste landfills.
Not meeting regulatory requirement for discharge	Leachate Treatment System	There is a degree of uncertainty regarding the regulatory requirements that need to be met and the potential for discharge requirements to change over time.
Delay in regulatory approval of the Landfill	Landfill Liner System	There is a degree of uncertainty regarding the regulatory requirements that need to be met when it comes to the approval of the liner design. Given the lack of clarity, there is the risk of delays.
Not meeting regulatory approval requirements	Closure/Post-Closure	There is a degree of uncertainty regarding the regulatory requirements that need to be met and the potential for closure/post-closure requirements to change over time.

4.1.2 Findings – Top Events

A total of four BowTies were generated, one for each of the four Top Events, which are appended to the report (see **Appendix A**). Based on the analysis of both the Threats and the Consequences, the Total Risk Scores for each of the four Top Events are summarized in **Table 4 –2**.

Table 4-2: Summary of Total Risk Scores for Top Events – Solid Waste Landfill

Top Event – Solid Waste Landfill	Total Risk Score
Liner system failure	84
Not meeting regulatory requirement for discharge (Leachate Treatment System)	58
Delay in regulatory approval of the Landfill	44

Top Event – Solid Waste Landfill	Total Risk Score
Not meeting regulatory approval requirements (Closure/Post-Closure of the Landfill)	40
Total =	**226**

The highest risk to the design, construction, operation and closure/post-closure of the solid waste landfill is "Liner System Failure". Combined with the Top Event – *Delay in Regulatory Approval of Landfill* for the liner system, the highest overall risk for the solid waste Landfill is the liner system.

4.1.3 Findings – Consequences

A total of 10 individual Consequences were identified and analyzed based on the four Top Events that were identified. **Table 4 –3** shows these ranked in order of Total Risk Score, from highest to lowest. Three Consequences scored the highest, two of which are associated with the Top Event – *Liner System Failure*. The third Consequence – Contamination of Surface Water is associated with the Top Event – *Not Meeting Regulatory Requirement for Discharge* [Leachate Treatment System].

Table 4-3: Summary of Risk Scores per Consequence – Solid Waste Landfill

Consequences	Reputation or image	Financial Loss (Capital)	Financial Loss (Operational)	Environment	Business Interruption /Level of Service	Legal	Total Risk Score
Active layer water contamination	6	6	6	6	6		30
Leachate bypasses the monitoring system	6	6	6	6	6		30
Contamination of surface water	6	6	6	6	6		30
Additional leachate treatment and monitoring required	4	6	6	6	6		28
Regulatory intervention	6	6	6		6		24
Delays in construction	9	9				6	24
Contamination of surface water and active water	4	6	6	4			20
Modifications to existing leachate treatment system	4	6	6	4			20
Need to redesign (Liner System)	6	6					12
Need to divert waste to existing landfill	8						8
Grand Total	**59**	**57**	**42**	**32**	**30**	**6**	**226**

The Risk Receptor that had the greatest influence on the Risk Profile for the solid waste Landfill is "Reputation or Image", followed closely by Financial Loss (Capital). This reflects the greatest exposure to the City, as it applied to all 10 Consequences. No exposure to "Public and Employee Safety" over and above what would be considered an inherent risk to operating a solid waste Landfill was identified.

4.2 Waste Transfer Facility

4.2.1 Development of Risk Events

Based on the Hazards identified in **Table 2**, the following Risk Events (or Top Events using BowTie terminology) were identified (see **Table 4 –4**).

Table 4-4: List of Top Events – Waste Transfer Station

List of Top Events - WTS	Hazard	Rationale for Inclusion in FRA
Unintentional Interaction between People, Equipment and Waste	WTS	Concentration of mobile equipment, stationary equipment and employees within the main building presents a safety risk.
Equipment Failure	WTS	Given the remoteness of Iqaluit and ability to mobilize equipment, there are challenges to ensure level of service and operational readiness is maintained.
Foundation Issues	WTS	Due to the structural requirements for the foundation to support the equipment combined with the geotechnical and permafrost challenges, there are unique risks and challenges to designing and constructing the foundation.

4.2.2 Findings – Top Events

A total of three BowTies were generated, one for each of the three Top Events, which are appended to the report (see **Appendix B**). Based on the analysis of both the Threats and the Consequences, the Total Risk Scores for each of the three Top Events are summarized in **Table 4 –5**.

Table 4-5: Summary of Total Risk Scores for Top Events – Waste Transfer Station

Top Event – WTS	Total Risk Score
Unintentional Interaction between People, Equipment and Waste	102
Equipment Failure	64
Foundation Issues	61
Total =	227

The highest risk to the design, construction and operation of the WTS is "Unintentional Interaction between People, Equipment and Waste".

4.2.3 Findings – Consequences

A total of four individual Consequences were identified and analyzed based on the three Top Events that were identified, ranked in order of Total Risk Score, from highest to lowest in **Table 4 –6**. One Consequence (Facility Shutdown) scored the highest.

Table 4-6: Summary of Risk Scores per Consequence – Waste Transfer Station

Consequences	Business Interruption/ Level of Service	Reputation or image	Legal	Financial Loss (Operational)	Public & Employee Safety	Financial Loss (Capital)	Environment	Total Risk Score
Facility Shutdown	28	18	19	18	8	14	8	113
Injury/Fatality	12	15	15	6	15			63
Direct Waste to Landfill	8	8		8			4	28
Building Replacement	5	5	5	4		4		23
Grand Total	53	46	39	36	23	18	12	227

The Risk Receptor that had the greatest influence on the Risk Profile for the WTS is “Business Interruption/Level of Service", followed closely by “Reputation or Image”. This reflects the greatest exposure to the City, as it applied to all four Consequences. However, “Financial Loss (Operational)” is also applicable to all four Top Events.

4.3 Common Hazards for Solid Waste Landfill and Waste Transfer Station

4.3.1 Development of Risk Events

Four common Top Events were identified (see **Table 4 –7**) to both the solid waste Landfill and the WTS; therefore, they were grouped together and analyzed.

Table 4-7: List of Top Events – Common Hazards for Solid Waste Landfill and Waste Transfer Station

List of Top Events	Rationale for Inclusion in FRA
Fire	The final facility must minimize the chances of fires. Based on historic challenges at the City’s existing disposal site, fire management is a concern.
Vectors and Wildlife Nuisance	Vectors and wildlife nuisances are ongoing challenges and the risk associated with them need to be properly identified, analyzed, and mitigated within the design, construction, and operation of both the Landfill and the WTS.
Litter/Unmanaged Debris	Buffer zones and litter/debris management are critical elements within the closure and decommissioning plan for the Landfill, but also an operational risk for both the Landfill and the WTS.
Unacceptable Off-Site Odour	Sensitivity of Iqaluit residents to odours is a risk that needs to be mitigated.

4.3.2 Findings – Top Events

A total of four BowTies were generated, one for each of the four Top Events, which are appended to the report (see **Appendix C**). Based on the analysis of both the Threats and the Consequences, the Total Risk Scores for each of the four Top Events are summarized in **Table 4 –8**.

Table 4-8: Summary of Total Risk Scores for Top Events – Solid Waste Landfill/Waste Transfer Station

Top Event	Total Risk Score
Fire	228
Vectors and Wildlife Nuisance	119
Litter/Unmanaged Debris	90
Unacceptable Off Site Odour	58
Total =	**495**

The highest risk is associated with Fires, followed by Vectors and Wildlife Nuisance.

4.3.3 Findings – Consequences

A total of nine individual Consequences were identified and analyzed based on the four Top Events that were identified. **Table 4 –9** shows these ranked in order of Total Risk Score, from highest to lowest. One Consequence (Injury/Fatality) was ranked the highest.

Table 4-9: Summary of Risk Scores per Consequence – Waste Transfer Station/Solid Waste Landfill

Consequences	Reputation or image	Financial Loss (Operational)	Legal	Business Interruption /Level of Service	Financial Loss (Capital)	Environment	Public & Employee Safety	Total Risk Score
Injury/Fatality	30	10	25	20			25	110
Resident Complaints	45	10	16			15	5	91
Regulatory Intervention	19	16	15		15	6		71
LF Liner Damage	12	9	6	9	9	9		54
Facility Shutdown	15	12		12				39
Equipment Damage	9	9		9	9			36
Building Damage	9	9		9	9			36

Consequences	Reputation or image	Financial Loss (Operational)	Legal	Business Interruption /Level of Service	Financial Loss (Capital)	Environment	Public & Employee Safety	Total Risk Score
Unknown Waste Material Requiring Management		10	10	5		5	5	35
Damage to Leachate Management System	3	6		2	6	6		23
Grand Total	142	91	72	66	48	41	35	495

The Risk Receptor that had the greatest influence on the Risk Profile is “Reputation or Image”, even though it only applies to seven of the nine Consequences.

5.0 Risk Management Plan

In order to develop a robust Risk Management Plan, the outputs from the BowTies were analyzed based on the preventative and response barriers that were identified for the Threats and Consequences. The idea is to determine which barriers are referenced and utilized to most often. The top three specific risk management measures for the solid waste Landfill, WTS and combined WTS/solid waste Landfill are provided in **Table 5 –1**.

Table 5-1: Top 3 Specific Risk Management Measures – By Hazard/Top Event

Risk Management Measures	Hazard/Top Event
Solid Waste Landfill	
Proactive communication with regulators	• Closure/Post-Closure/Not meeting regulatory approval requirements • Landfill Liner System/Liner system failure • Landfill Liner System-Design/Delay in regulatory approval of the Landfill • Leachate Treatment system/Not meeting regulatory requirement for discharge
Incorporate climate change in design criteria	• Closure/Post-Closure/Not meeting regulatory approval requirements • Leachate Treatment system/Not meeting regulatory requirement for discharge
Installation of groundwater treatment system, enhanced groundwater monitoring system & additional safety considerations in design.	• Closure/Post-Closure/Not meeting regulatory approval requirements • Landfill Liner System/Liner system failure • Leachate Treatment system/Not meeting regulatory requirement for discharge
Waste Transfer Station	
Additional spare parts	• WTS/Equipment failure
Routine Maintenance	• WTS/Equipment failure
O&M Procedures & Isolation from the Public	• WTS/Unintentional interaction between people, equipment, and waste
Waste Transfer Station/Solid Waste Landfill	
Divert waste to the existing landfill	• LF/WTS/Fire
Proactive communication with regulators	• LF/WTS/Litter/Unmanaged debris • LF/WTS/Unacceptable off site odour • LF/WTS/Vectors and wildlife nuisance
Establish a citizens liaison committee	• LF/WTS/Litter/Unmanaged debris • LF/WTS/Unacceptable off site odour • LF/WTS/Vectors and wildlife nuisance

A summary of all specific risk management measures is presented in **Tables 5 –2** to **5 –4**, ranked in order of importance based on the number of times it is referenced in the individual BowTies.

Table 5-2: List of Risk Management Measures - Solid Waste Landfill

List of Specific Risk Management Measures	Preventative Barrier No. of Times Referenced	Response Barrier No. of Times Referenced	Total
Proactive communication with regulators	2	7	9
Incorporate climate change in design criteria	3		3
Installation of a ground water treatment system		2	2
Enhanced ground water monitoring system		2	2
Additional safety considerations in design	1	1	2
Additional research	1		1
Define operations process	1		1
Initial placement of bales	1		1
Design considerations for permafrost	1		1
Surcharge new cells with bales during winter	1		1
Additional safety considerations in treatment system design	1		1
Animal control procedures	1		1
Installation QA/QC	1		1
C&D waste handling procedure	1		1
QA/QC definition in contract	1		1
Site security measures	1		1
O&M procedures	1		1
Fire response plan	1		1
Regular inspection of cap	1		1
Geotechnical investigation		1	1
Structural reinforcement of liner design	1		1
Geothermal analysis	1		1
Waste inspection procedures	1		1
Ground water monitoring system		1	1
Include surface water diversion elements in the Landfill design	1		1
Grand Total	**24**	**14**	**38**

Table 5-3: List of Risk Management Measures – Waste Transfer Station

Row Labels	Preventative Barrier No. of Times Referenced	Response Barrier No. of Times Referenced	Total
Adequate spare parts	3		3
Routine maintenance	3		3
O&M procedures	2		2
Isolation from the public	2		2
Backup oil-fired boiler	1		1
Design consideration for insulation to handle heat from concrete	1		1
Capacity to be considered in design	1		1
Design of site traffic flow	1		1
Identification of design modification opportunities	1		1
Direct delivery to the Landfill		1	1
Mitigative procedures considered in design	1		1
Discontinue collection		1	1
Public education campaign	1		1
Regular inspection	1		1
Waste inspection procedures	1		1
Extended operation time	1		1
Life expectancy considered in design	1		1
H&S plan		1	1
Having H&S equipment in place		1	1
Grand Total	**21**	**4**	**25**

Table 5-4: List of Risk Management Measures – Waste Transfer Station/Solid Waste Landfill

Row Labels	Preventative Barrier No. of Times Referenced	Response Barrier No. of Times Referenced	Total
Divert waste to the existing the Landfill		3	3
Proactive communication with regulators		3	3
Establish a citizens liaison committee		3	3
Personnel training	2		2

Row Labels	Preventative Barrier No. of Times Referenced	Response Barrier No. of Times Referenced	Total
On-site extinguishers	2		2
H&S plan		2	2
Waste inspection procedures	2		2
Fire response plan	2		2
Define operations process	2		2
Provide dumpster at the WTS gate for after hours delivery	1		1
Installation of a landfill gas management system	1		1
Site security measures	1		1
Waste segregation covering procedures	1		1
Direct delivery to the Landfill	1		1
Modifying leachate management system	1		1
Repair liner (as practical)		1	1
Fencing	1		1
Standing contract with hazardous waste management firm		1	1
Ongoing litter collection program		1	1
Installation of bird control features	1		1
Equipment maintenance schedule	1		1
LF inspection and maintenance protocols	1		1
Grand Total	**20**	**14**	**34**

6.0 Conclusions

6.1 Conclusions – Top Events

The highest overall risk is operational-based associated with the management of Fire, Vectors and Wildlife Nuisance, as shown in **Table6 – 1**. More specifically for the WTS, the highest risk is safety – Unintentional Interaction between People, Equipment and Waste. More specifically for the Landfill, the highest risk is Liner System Failure.

Table 6-1: Ranking of Top Events based on Total Risk Score

Top Events	Total Risk Score
Fire (at the solid waste Landfill and WTS)	228
Vectors and wildlife nuisance (at the solid waste Landfill and WTS)	119
Unintentional interaction between people, equipment, and waste (at the WTS)	102
Litter/Unmanaged debris (at the solid waste Landfill and WTS)	90
Liner system failure (at the solid waste Landfill)	84
Equipment failure (at the WTS)	64
Foundation issues (at the WTS)	61
Unacceptable off-site odour (at the solid waste Landfill and WTS)	58
Not meeting regulatory requirement for discharge (at the solid waste Landfill)	58
Delay in regulatory approval of the Landfill	44
Not meeting regulatory approval requirements (closure/post-closure)	40

6.2 Conclusions – Consequences

As shown in **Table 6 –2**, the highest risk to the City, from a Consequence perspective is "Injury/Fatality" followed by "Facility Shutdown", driven by the following Top Events:

- Injury/Fatality
  - Top Event – Unintentional interaction between people, equipment, and waste
  - Top Event – Fire
  - Top Event – Vectors and Wildlife Nuisance
- Facility Shutdown
  - Top Event – Unintentional interaction between people, equipment, and waste
  - Top Event – Fire
  - Top Event – Foundation Issues
  - Equipment Failure

Table 6-2: Ranking of Consequences by Total Risk Score

Consequences	Total Risk Score
Injury/Fatality	173
Facility shutdown	152
Regulatory intervention	95
Resident complaints	91
LF liner damage	54
Building damage	36
Equipment damage	36
Unknown waste material requiring management	35
Leachate bypasses the monitoring system	30
Active layer water contamination	30
Contamination of surface water	30
Direct waste to the Landfill	28
Additional leachate treatment and monitoring required	28
Delays in construction	24
Damage to leachate management system	23
Building replacement	23
Contamination of surface water and active water	20
Modifications to existing leachate treatment system	20
Need to redesign	12
Need to divert waste to the existing Landfill	8
Grand Total	**948**

6.3 Conclusions – Risk Criteria

Based on the individual Risk Scores per Consequence category, the risk profile for the City is outlined in this section. It needs to be kept in mind that the Risk Scores take into consideration the existing and proposed specific Risk Management measures; therefore, the Risk Scores reflect the remaining "Residual Risks" that the City can utilize to determine appropriate risk acceptance levels going forward.

Public and Employee Safety – is ranked "Medium", mainly driven by:

- Serious injury to a fatality due to close proximity of employees with mobile and fixed equipment at the WTS.
- Public safety risk at the solid waste Landfill due to litter and debris issues.
- Fire at either the WTS or the solid waste Landfill.

Financial Loss (Capital) – is ranked "Medium", mainly driven by:

- Potential for delay in regulatory approval of liner system design.
- Equipment failure at the WTS and delays in getting spare parts.
- Fire at either the WTS or the solid waste Landfill.

Financial Loss (Operational) – is ranked "Medium", mainly driven by:

- Equipment failure at the WTS and delays in getting spare parts.
- Odour and litter complaints by residents.
- Fire at either the WTS or the solid waste Landfill.

Reputation or Image – is ranked "Medium", mainly driven by:

- Equipment failure at the WTS and delays in getting spare parts.
- Potential for delay in regulatory approval of liner system design.
- Regulatory intervention to address unacceptable off site odours at either the WTS or the solid waste Landfill.

Business Interruption/Level of Service – is ranked "Medium", mainly driven by:

- Equipment failure at the WTS and delays in getting spare parts.
- Foundation issues resulting in the WTS building being replaced.
- Fire at either the WTS or the solid waste Landfill.

Environmental – is ranked "Low", mainly driven by:

- Fire resulting in damage to the liner system.
- Failure in the liner system.
- Discharge requirements not being met at the leachate treatment system.

Legal – is ranked "Medium", mainly driven by:

- Serious injury to a fatality due to close proximity of employees with mobile and fixed equipment at the WTS.
- Fire resulting in serious injury or fatality at either the WTS or the solid waste Landfill.

6.4 Conclusions – Technical Risk

Based on the current 30% design of the solid waste Landfill and the WTS, the Technical Risks range between "Significant" to "Serious" due to the following:

- Limited regulatory direction and/or relevant precedent facilities in arctic climates to support the definition of landfill liner and leachate treatment system design requirements.
- Uncertain impacts (e.g., reduction and/or delay) to the generation of landfill gas and leachate due to the wrapping of solid waste bales with plastic prior to placement in the landfill, as well as potential migration of permafrost into the placed waste mass.

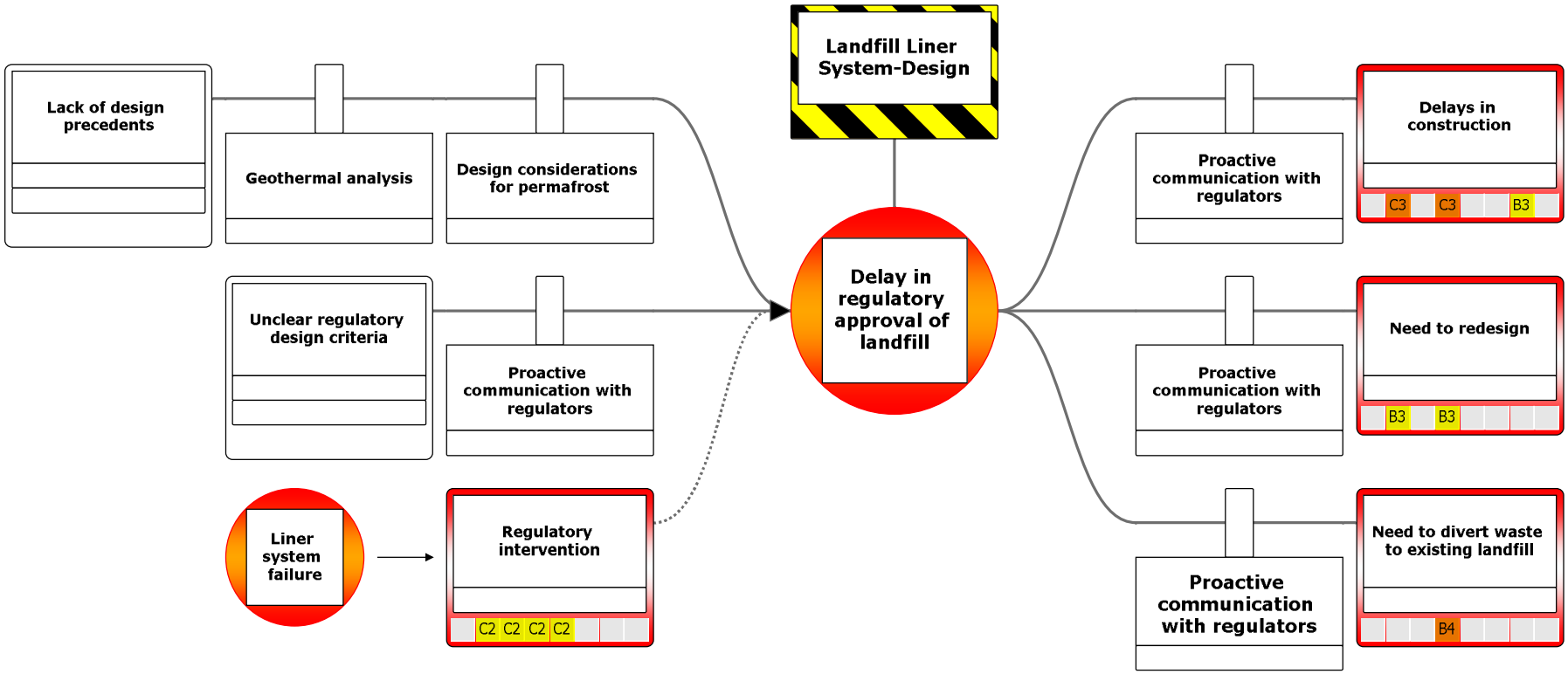
- Challenges designing the landfill liner foundation given uncertain future interactions with underlying permafrost (e.g., migration into the waste mass or heating/melting by the decomposing waste mass).
- Uncertainties associated with climate change, with noted emphasis on the melting of permafrost and resulting impacts to Landfill and WTS stability.

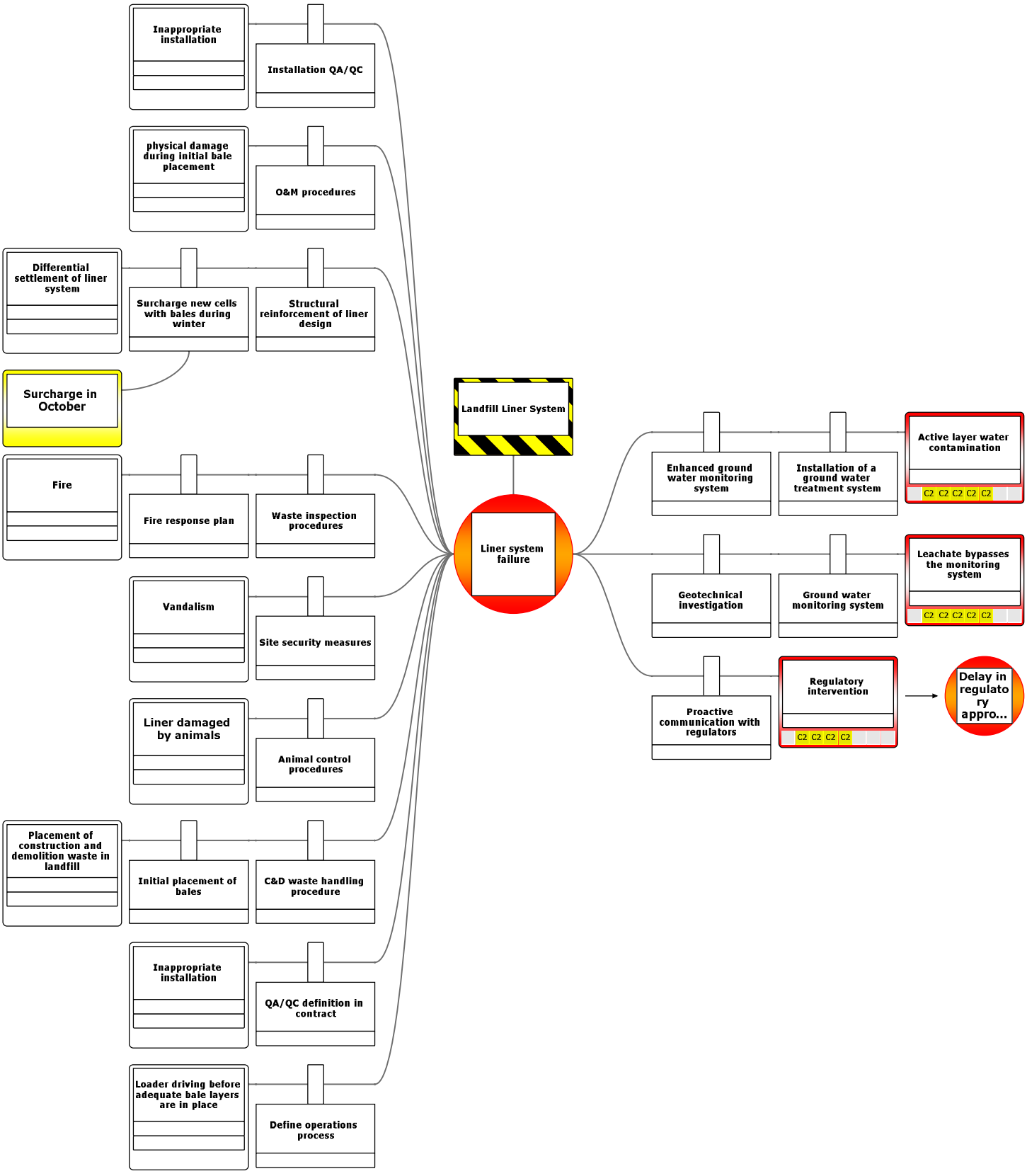
Appendix A

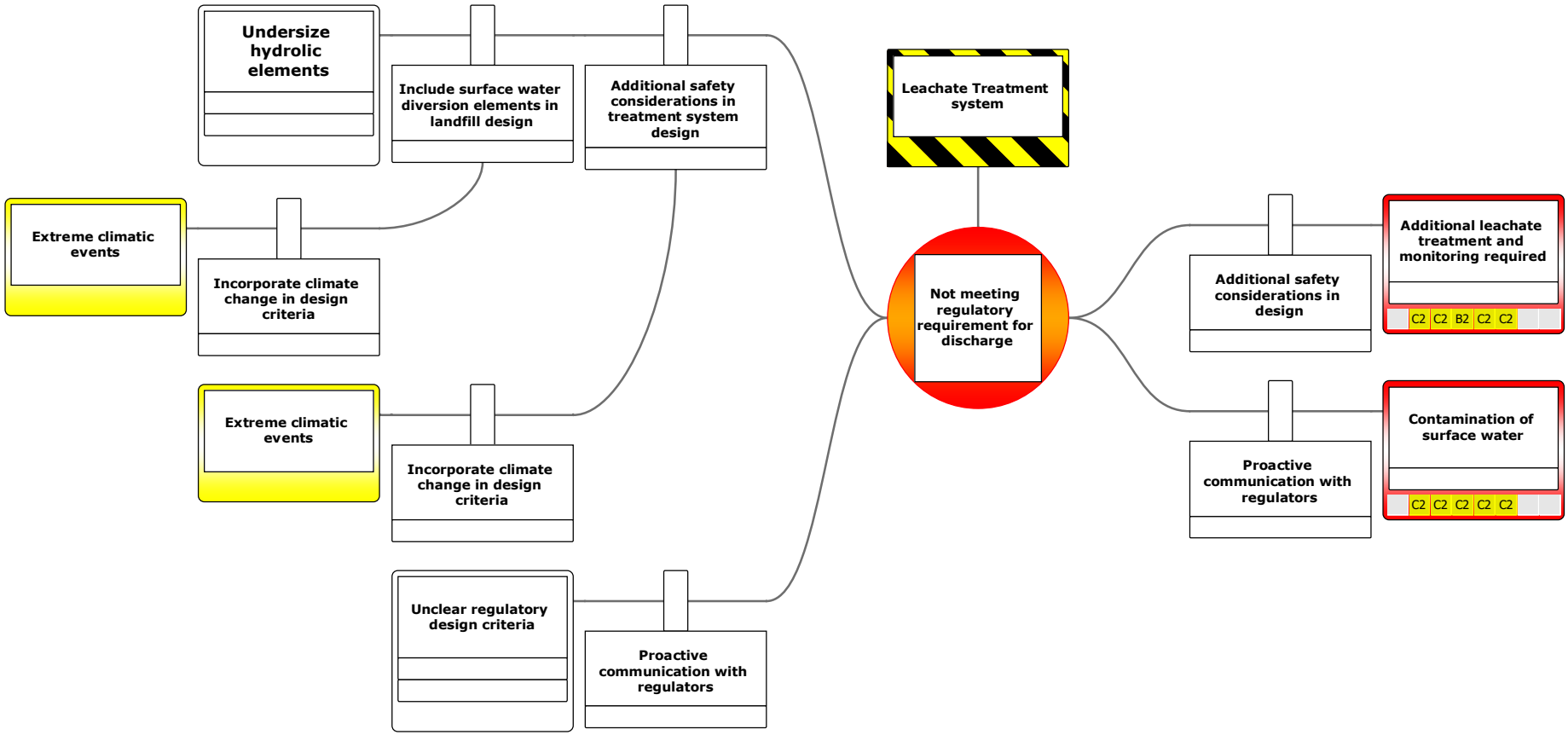
BowTies – Solid Waste Landfill

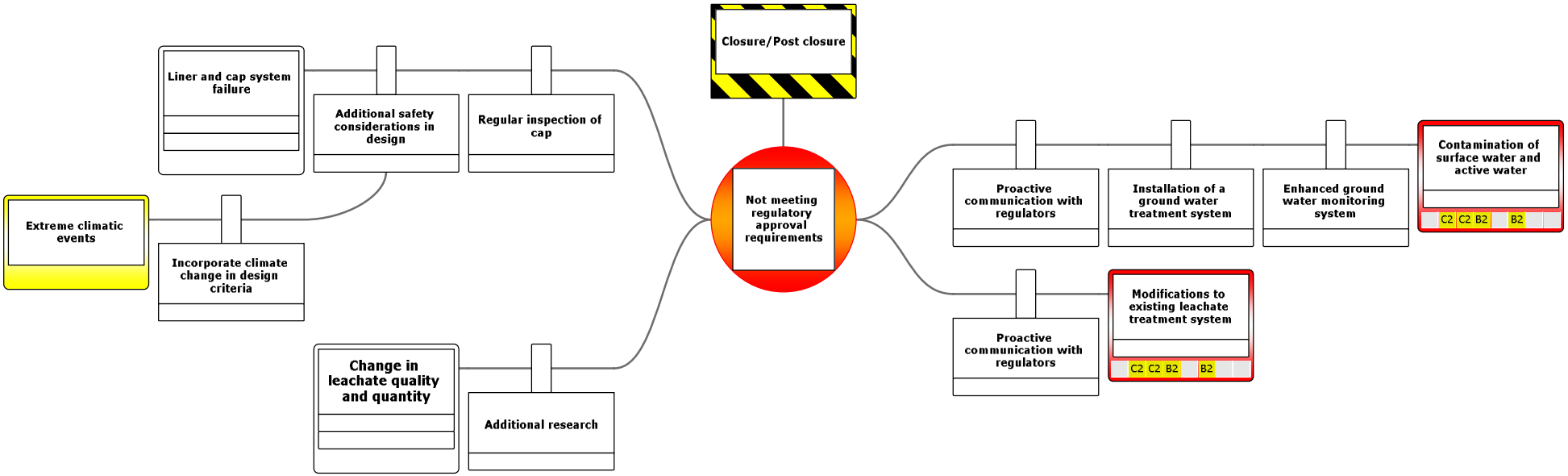
DILLON CONSULTING

Bowties – Solid Waste Landfill




Landfill Liner System
Liner system failure
Inappropriate installation
Installation QA/QC
physical damage during initial bale placement
O&M procedures
Differential settlement of liner system
Surcharge new cells with bales during winter
Structural reinforcement of liner design
Surcharge in October
Fire
Fire response plan
Waste inspection procedures
Vandalism
Site security measures
Liner damaged by animals
Animal control procedures
Placement of construction and demolition waste in landfill
Initial placement of bales
C&D waste handling procedure
Inappropriate installation
QA/QC definition in contract
Loader driving before adequate bale layers are in place
Define operations process
Enhanced ground water monitoring system
Installation of a ground water treatment system
Active layer water contamination
C2 C2 C2 C2 C2
Geotechnical investigation
Ground water monitoring system
Leachate bypasses the monitoring system
C2 C2 C2 C2 C2
Proactive communication with regulators
Regulatory intervention
C2 C2 C2 C2
Delay in regulatory appro...


Undersize hydrolic elements
Include surface water diversion elements in landfill design
Additional safety considerations in treatment system design
Leachate Treatment system
Extreme climatic events
Incorporate climate change in design criteria
Not meeting regulatory requirement for discharge
Additional safety considerations in design
Additional leachate treatment and monitoring required
C2 C2 B2 C2 C2
Extreme climatic events
Incorporate climate change in design criteria
Proactive communication with regulators
Contamination of surface water
C2 C2 C2 C2 C2
Unclear regulatory design criteria
Proactive communication with regulators

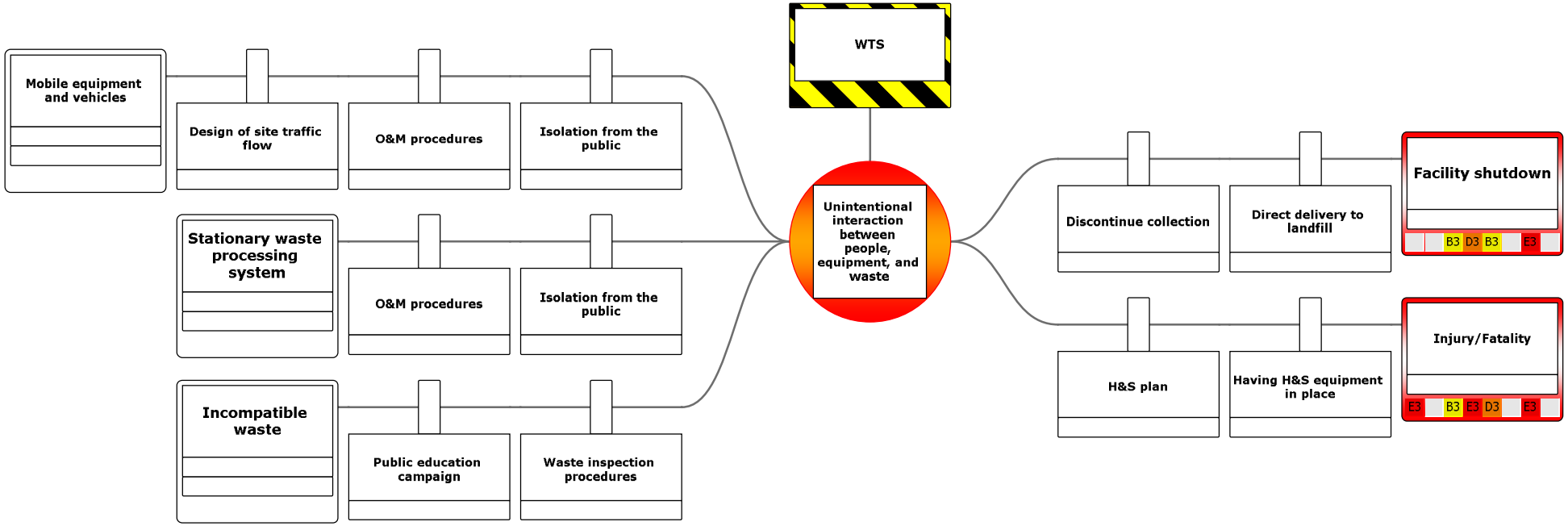

Closure/Post closure
Liner and cap system failure
Additional safety considerations in design
Regular inspection of cap
Extreme climatic events
Incorporate climate change in design criteria
Change in leachate quality and quantity
Additional research
Not meeting regulatory approval requirements
Proactive communication with regulators
Installation of a ground water treatment system
Enhanced ground water monitoring system
Contamination of surface water and active water
C2 C2 B2 B2
Proactive communication with regulators
Modifications to existing leachate treatment system
C2 C2 B2 B2

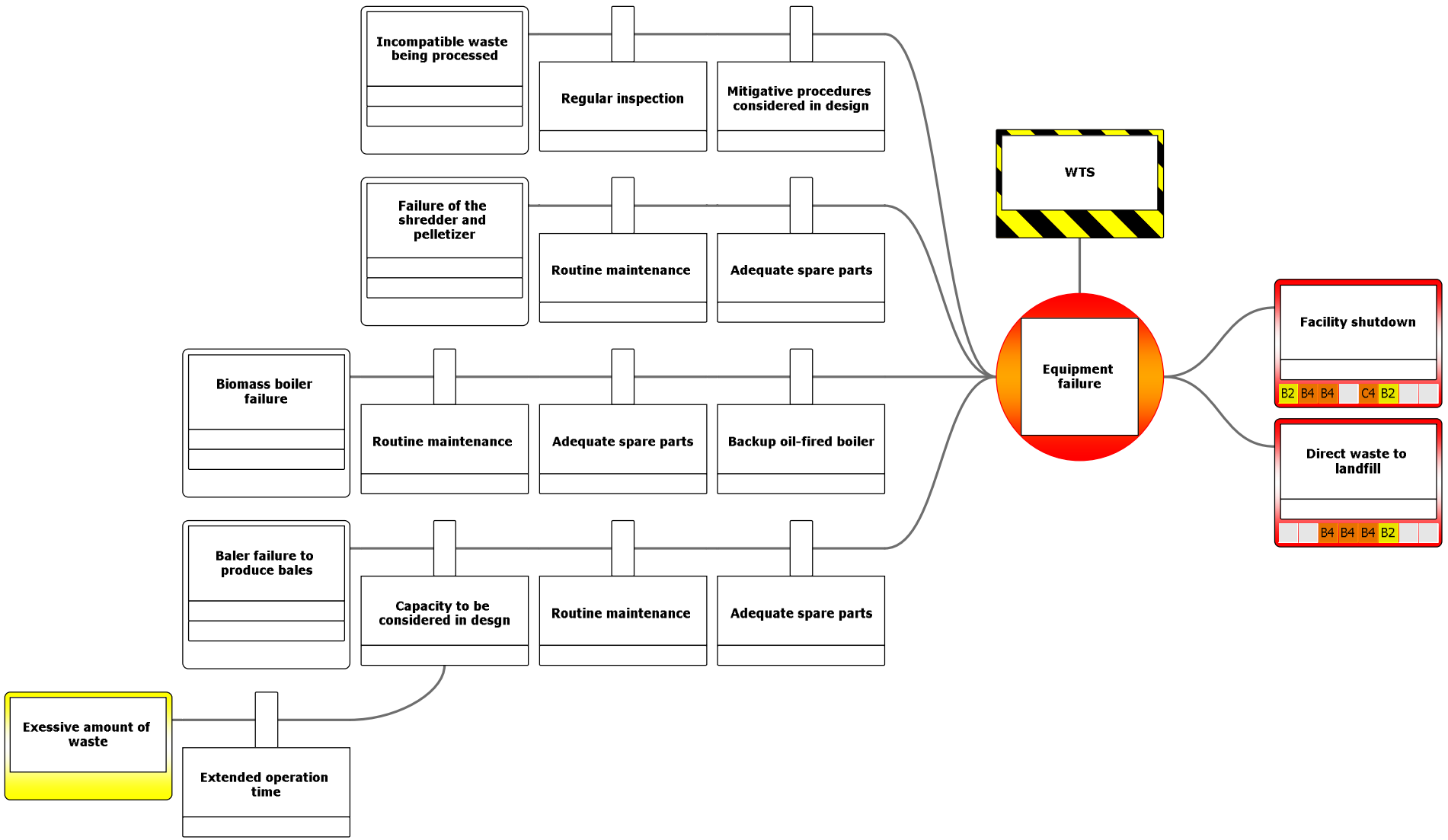
Appendix B

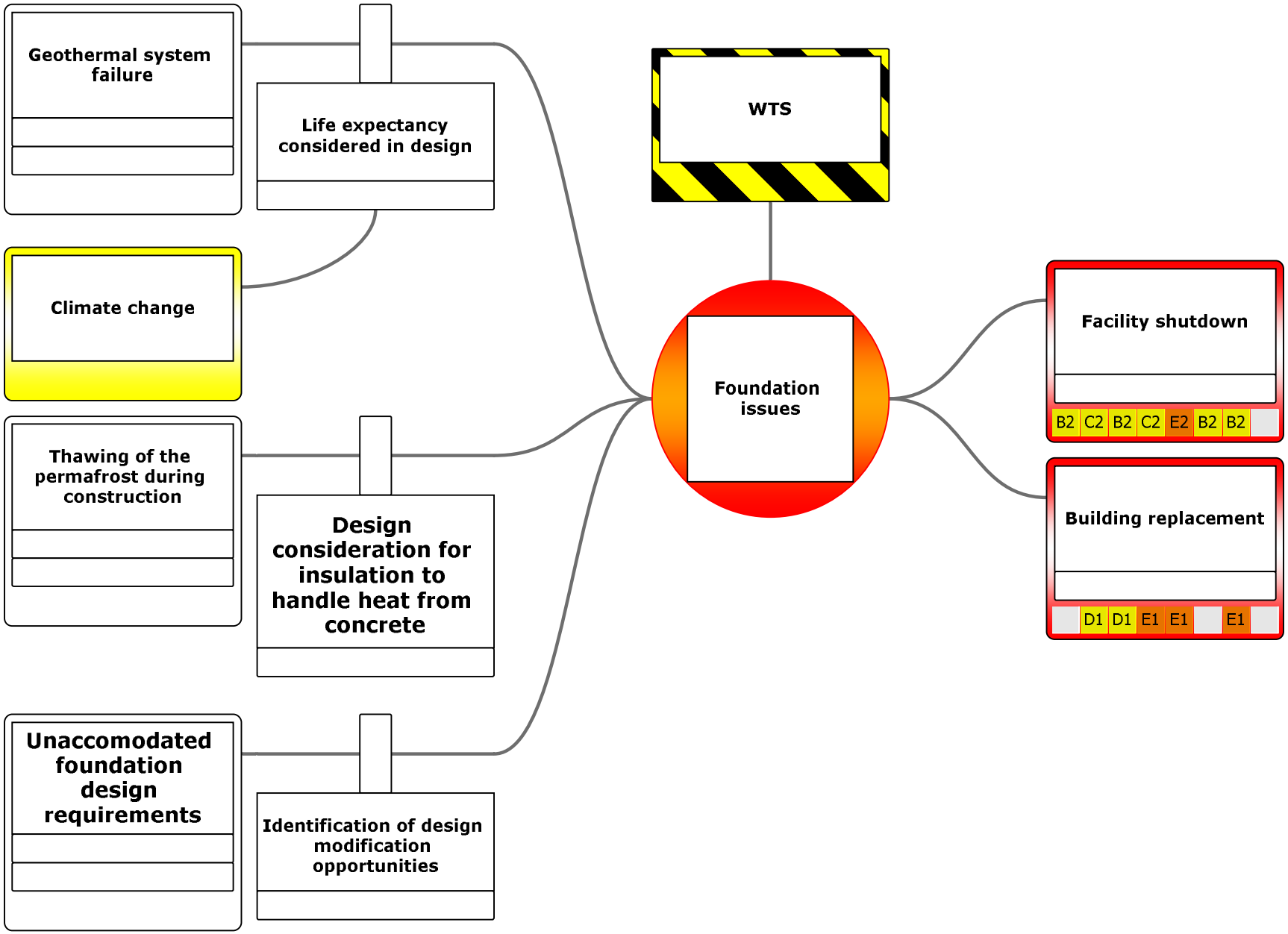
BowTies – Waste Transfer Station

DILLON CONSULTING

Bowties – Waste Transfer Station




Incompatible waste being processed
Regular inspection
Mitigative procedures considered in design
Failure of the shredder and pelletizer
Routine maintenance
Adequate spare parts
Biomass boiler failure
Routine maintenance
Adequate spare parts
Backup oil-fired boiler
Baler failure to produce bales
Capacity to be considered in desgn
Routine maintenance
Adequate spare parts
Exessive amount of waste
Extended operation time
WTS
Equipment failure
Facility shutdown
B2 B4 B4 C4 B2
Direct waste to landfill
B4 B4 B4 B2

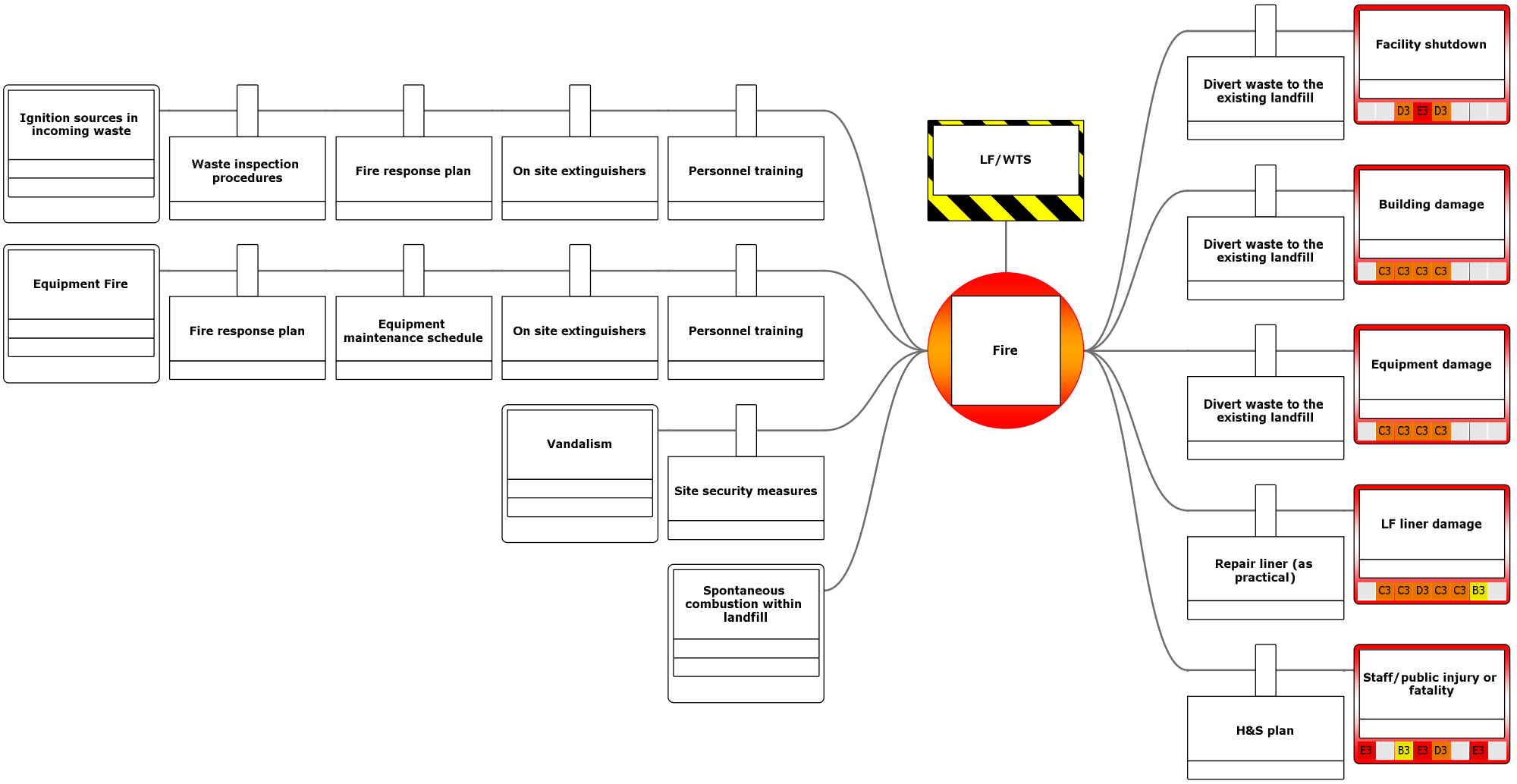

Geothermal system failure
Life expectancy considered in design
Climate change
WTS
Thawing of the permafrost during construction
Design consideration for insulation to handle heat from concrete
Foundation issues
Facility shutdown
B2 C2 B2 C2 E2 B2 B2
Building replacement
D1 D1 E1 E1 E1
Unaccomodated foundation design requirements
Identification of design modification opportunities

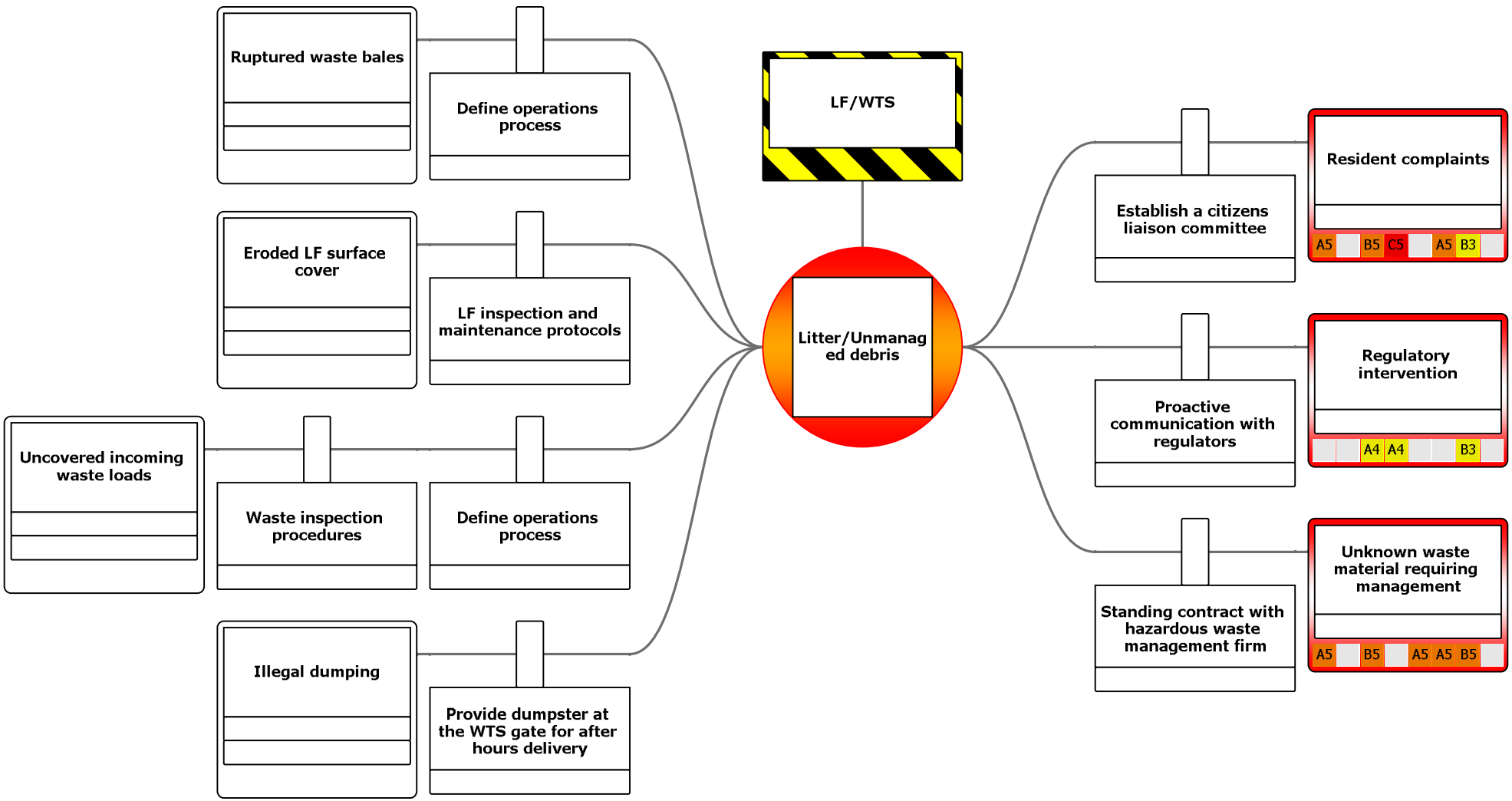
Appendix C

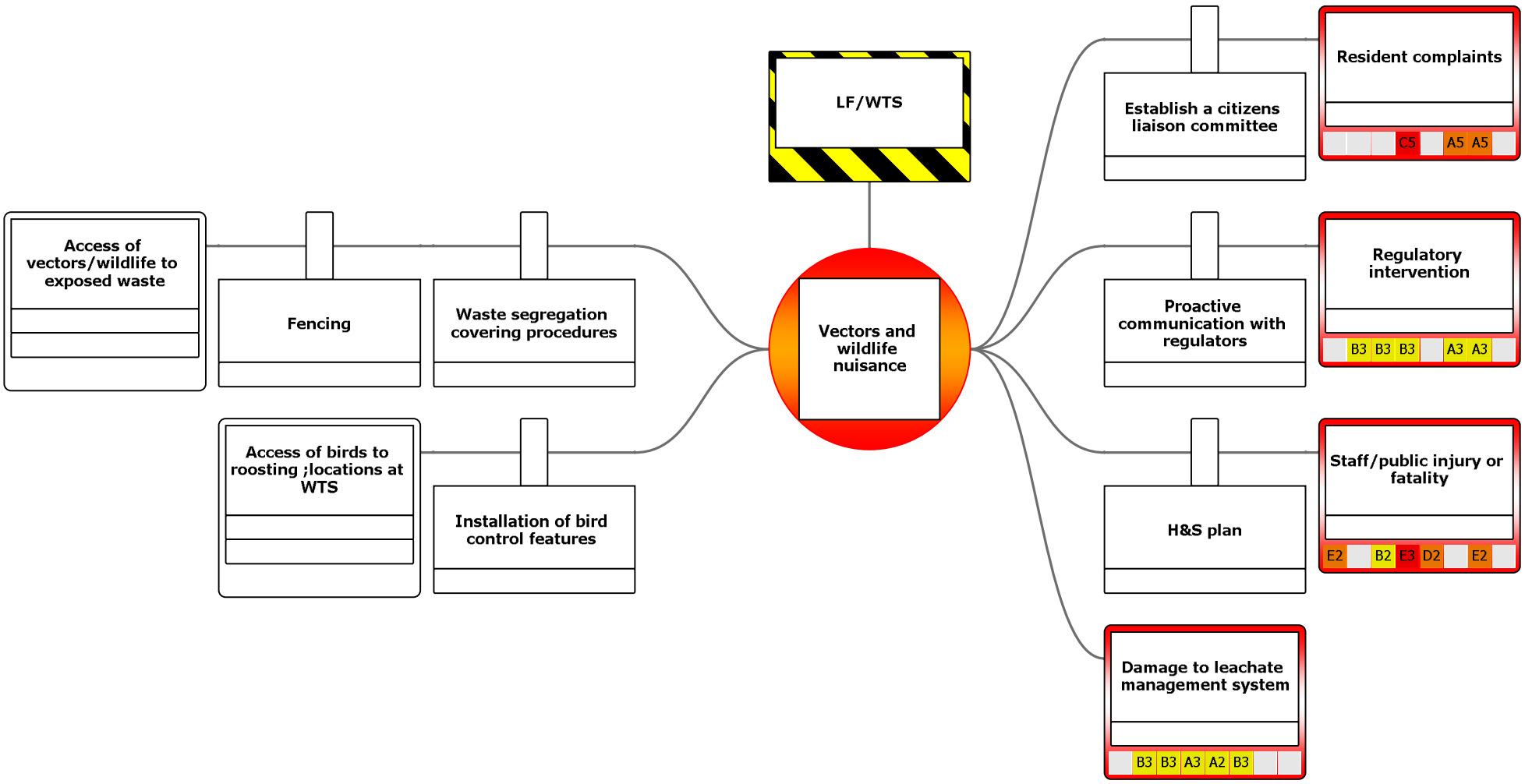
BowTies – Common Hazards for Solid Waste Landfill and Waste Transfer Station

DILLON CONSULTING

BowTies – Common Hazards for Solid Waste Landfill



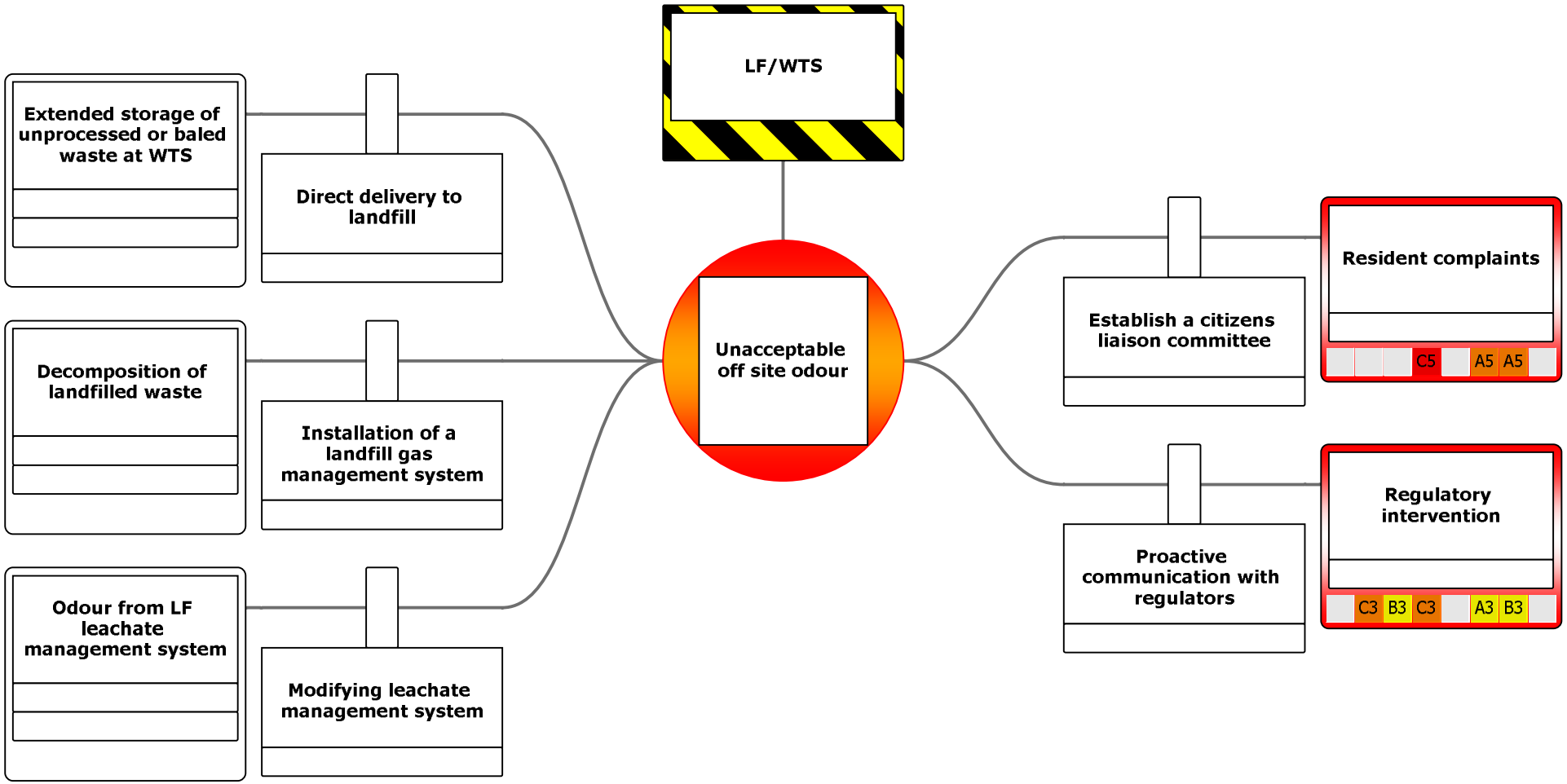

LF/WTS
Litter/Unmanaged debris
Ruptured waste bales
Define operations process
Eroded LF surface cover
LF inspection and maintenance protocols
Uncovered incoming waste loads
Waste inspection procedures
Define operations process
Illegal dumping
Provide dumpster at the WTS gate for after hours delivery
Establish a citizens liaison committee
Resident complaints
A5 B5 C5 A5 B3
Proactive communication with regulators
Regulatory intervention
A4 A4 B3
Standing contract with hazardous waste management firm
Unknown waste material requiring management
A5 B5 A5 A5 B5


LF/WTS
Vectors and wildlife nuisance
Access of vectors/wildlife to exposed waste
Fencing
Waste segregation covering procedures
Access of birds to roosting ;locations at WTS
Installation of bird control features
Establish a citizens liaison committee
Resident complaints
C5 A5 A5
Proactive communication with regulators
Regulatory intervention
B3 B3 B3 A3 A3
H&S plan
Staff/public injury or fatality
E2 B2 E3 D2 E2
Damage to leachate management system
B3 B3 A3 A2 B3

Appendix H

Investing in Canada Infrastructure Program Reports

DILLON CONSULTING


LF/WTS
Extended storage of unprocessed or baled waste at WTS
Direct delivery to landfill
Decomposition of landfilled waste
Installation of a landfill gas management system
Odour from LF leachate management system
Modifying leachate management system
Unacceptable off site odour
Establish a citizens liaison committee
Resident complaints
C5
A5
A5
Proactive communication with regulators
Regulatory intervention
C3
B3
C3
A3
B3