Appendix D

Assessment of Leachate Treatment Options Report

DILLON CONSULTING

CITY OF IQALUIT

Triple Bottom Line Assessment of Leachate Treatment Options (Draft)

Landfill and Waste Transfer Station

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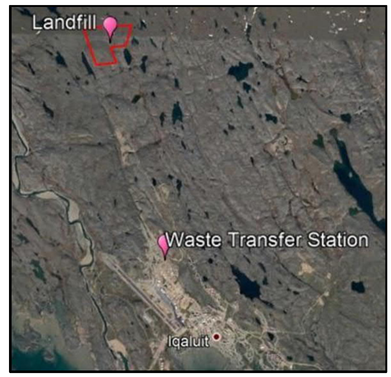
1.0 Triple Bottom Line Assessment for Leachate Treatment Alternatives

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 located approximately 6 km from the WTS (see **Figure 1**). 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.

Figure 1: Facility Site Locations



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 site. 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).

As a component of the predesign effort, Dillon completed a triple bottom line (i.e., financial, social and environmental) impact assessment on alternatives to manage leachate generated by the City's new solid Waste Landfill (henceforth knows as 'the Site'). Consistent with the methodology described in Dillon's February 2019 proposal, the assessment utilized a weighted-criteria approach to arbitrate between the costs and benefits of alternatives considered. The weighted-criteria approach allocated 'points' consistent with the percentage value attributed to the assessment area. High point scores are preferable. As a result, points are allocated for potential benefits and areas with minimal or no impact, while negative impacts reduce point scores.

The Triple Bottom Line Assessment for Leachate Alternatives is divided into sections covering the alternatives, methods and assessment of the leachate treatment alternatives.

- **Section 1.1** provides an overview and description of the feasible leachate treatment alternatives considered.

- **Section 1.2** details the Triple Bottom Line assessment methods, including the breakdown of the weighted-criteria and their respective justifications.
- **Section 1.3** assesses the financial costs and risks associated with each leachate treatment alternative.
- **Section 1.4** assesses the environmental costs and benefits of each leachate treatment alternative.
- **Section 1.5** assesses the socio-economic costs and benefits of each leachate treatment alternative.
- **Section 1.6** provides a summary of the financial, environmental and socio-economic assessments including key trade-offs. This section also includes the recommendation for the preferred leachate treatment method.

The Triple Bottom Line Assessment as conducted for this assignment has a variety of limitations. The assessment is based on initial information available at time of reporting (e.g., the initial stages of project work program) and may change based on more information/progress of design. However, the current level of detail is considered appropriate for a Triple Bottom Line review of alternatives at this stage of project.

It is also assumed all options are considered to be technically feasible and will be accepted by the regulator as a viable technology. The risks associated with each option are considered to be 'upset conditions' likely to result in financial, social or environmental consequences. All costs are high-level and best understood as orders of magnitude for the potential costs of alternatives. The costs are not to be considered "opinions of probable costs", as these will be developed at later stages of the project. However, the costs are considered appropriate for comparison purposes. Similarly, project footprints are provided for comparison purposes but will be subject to change.

Overall, the Triple Bottom Line Assessment for Leachate Treatment Alternatives provides a recommendation for the preferred leachate treatment method, considering the potential for each alternative to impact the finances of the City and the environment including the socio-economy.

1.1 Leachate Alternatives

With reference to Phase I/Task 3 in Dillon's February 2019 proposal, as well as minutes from the project Kick Off Meeting, three leachate treatment alternatives are considered as part of this assessment:

- Aerated lagoon and Wetland Treatment Area (WTA);
- Pre-treatment and haulage to the City's wastewater treatment plant (WWTP); and
- On-site mechanical treatment.

These alternatives have different financial parameters, risks, and environmental/social costs and benefits. The nature of leachate generation in northern communities suggests that the majority of the year will see no or little leachate produced, until the snow melt occurs in June/July. At this point, any precipitation that took place during the winter and remained on the Landfill would melt and produce leachate over the summer months, in addition to rainfall received during June to September. An important aspect of the treatment system will also be its ability to scale up over the life of the Landfill. Unlike a municipal WWTP, which usually experiences moderate loading shortly after commissioning, the leachate treatment system is expected to see a more gradual increase in leachate production over its 75 year life. As new landfill cells are opened and previous cells close, leachate quantity and quality will fluctuate. The treatment system must be able to be modified over the 75 year life to handle these changes.

1.1.1 Alternative 1: Aerated Lagoon and Wetland Treatment Area

A common method of managing wastewater in both northern and southern Canada is through the use of engineered wetlands. Native plants provide a surface for biofilm to grow, which filters the water naturally as leachate passes through it. This alternative includes a constructed lagoon that receives pumped leachate from the landfill collection system. The lagoon would store and partially treat leachate that is pumped out from the landfill before discharging to a wetland area downstream. For this alternative, an area of approximately 2.5 ha for the lagoon and wetland is anticipated to be used. Plant growth would be encouraged and supported in the short-term (e.g., 1 to 3 years), following construction of the wetland, and with routine monitoring to review system performance and effluent quality on a semi-annual basis.

Capital costs would be primarily be associated with earthworks and imported liner materials related to the lagoon construction. Operationally, it would require little maintenance other than effort associated with pumping and water level monitoring.

This alternative, as expected, presents the lowest operational cost, as the only mechanical components would be transfer pumping systems and aeration equipment for the lagoon and wetland.

1.1.2 Alternative 2: Pre-Treatment and Haulage to the City's Existing Wastewater Treatment Plant

The City is currently completing construction (scheduled for completion late winter 2020) of a new WWTP to manage municipal wastewater generated within the community. The new plant is intended to serve the City through to 2041, at which point it will either require replacement or major upgrades (assuming population trends, as predicted). Based on the 2017 Nunami Stantec Report, the plant will consist of the following processes:

- Preliminary treatment to screen out coarse solids;
- Primary treatment to reduce total suspended solids;
- Secondary treatment via moving bed biofilm reactors and dissolved air flotation to reduce organic and remaining solids loading; and
- Process solids handling via belt filter press and mechanical compressor.

While the City's proposed treatment technology would likely be capable of treating some of the leachate effluent contaminants (such as biochemical oxygen demand and total suspended solids), it would not be optimized for ammonia or metals removal, which are anticipated to be present in medium-high strength in the leachate. This alternative; therefore, includes pre-treatment at the Site and on-site storage (either insulated fabricated tanks or lined earthen ponds) to balance truck haul trips to the City's WWTP. For this alternative, an area of 2.5 ha for the pre-treatment is anticipated to be used.

Operationally, this treatment selection would require chemical consumption and leachate haulage between the landfill and the City's WWTP. A project footprint at the landfill would also be required for the pre-treatment system and storage, but it would be less than that necessary for a full scale lagoon and WTA. The primary disadvantages of this alternative relate to impacts on the City's WWTP and greenhouse gas (GHG) generation from truck trips. Last, as the proposed design life of the City's WWTP is approximately one third of the overall landfill's design life, future City WWTPs would be required to handle the leachate.

1.1.3 Alternative 3: On-Site Mechanical Treatment

An on-site treatment alternative to a WTA is a mechanical treatment system that would discharge to the adjacent land environment using a level spreader or similar technology. Under this alternative, a treatment plant, somewhat similar in process technology to that of the City's new WWTP, would be constructed near the Site using an area of approximately 0.8 ha. In contrast to the previous alternative, which would also require a mechanical system for pre-treatment, this alternative would utilize a larger scale treatment plant with multiple unit processes to reduce metal concentrations in the effluent in addition to biological contaminants. It would have a smaller project footprint compared to the WTA, but would require more operator attention and carry with it high annual costs relative to other alternatives. Due to the operational complexity, the treatment system would require a qualified operator.

1.2 Triple Bottom Line Methods

The Triple Bottom Line Impact Assessment uses a weight-criteria analysis identifying the costs and benefits of the three identified leachate treatment alternatives considering the project lifecycle (75 years). Dillon has considered a variety of financial, environmental, and social factors specific to the study area and regional character. As part of the social factors, Dillon considered economic factors such as the impact of the leachate treatment alternatives on the local economy.

1.2.1 Overview of Process and Key Variables

As an initial step, Dillon highlighted key relevant baseline information based on the study report completed by EXP. Next, the team considered the project effects, costs and benefits associated with the changes based on the proposed alternatives. All items were "financialized", where possible, to standardize the units of measurement for consistent comparison. Recognizing that all items cannot be financialized, Dillon developed a weighted-criteria decision framework, where the non-financial and financial changes associated with alternatives are considered.

Weighting was developed based on established best practices and consultation with the City. The weighting was done in two stages. The first stage weighed the social, financial and environmental criteria out of 100. It was determined environmental factors would be the largest grouping due to the variety of environmental pathways of effect (40%). Financial and social considerations were slightly lower (30% each), as fewer effect pathways were developed and there was potential for interaction between these alternatives.

The second stage considered subcomponents of financial, social and environmental factors that may be impacted by the Site. Criteria were weighted based on the potential magnitude and consequences of effect for each treatment method. For example, the variety of recreation opportunities near the Site resulted in a higher weighting (or point totals) on the land use criteria where recreation and tourism is captured. Cultural resources were weighted lower as "there are no culturally designated or significant heritage features currently identified within the Site. No existing records for archaeological, paleontological or place name records occur on the Site (EXP 2018)." Therefore, it is less likely activities related to leachate construction and operation will impact cultural resources. Similar considerations were undertaken for all criteria to develop the allocation of points by area of assessment.

1.2.2 Triple Bottom Line Scoring Criteria

Based on the overall process and the key variables specific to the Site, and based on the preliminary engineering design, Environmental Site Assessment, and Physical and Biological Assessment Reports, (**Table 1**), Dillon defined the following triple bottom line assessment criteria, which utilizes a weighted-criteria method. The values associated with each item may be considered as potential weights or points with the sum of 100.

Table 1: Triple Bottom Line Scoring Methods

Criteria	Value	Description
Financial	30	Limited capital is available for construction and operation of the facility overall; subsequently, the leachate treatment. Cost-effective alternatives with lower capital and operating costs that minimize risk are more desirable.
-Financial Performance	25	*The financial score is equal to the lowest cost alternative over the cost of the alternative multiplied by the number of available points (25). Therefore, the alternative with the lowest financial cost scored 25 points and all other scores are relative to that.*
-Financial Risk	5	*Financial risk considered the likelihood of additional capital or operating costs associated with the leachate treatment alternatives. It is preferable to develop and alternative with the lowest risk of additional costs associated with the construction and operation of the leachate treatment.*
Environmental	40	The leachate treatment for the project will have an impact on the local environment, including land, air, water and ecosystems. It will also contribute to climate change through the emission of GHGs. These impacts are undesirable. Alternatives that minimize environmental impacts and risk are very desirable, as shown by the greatest weighting being provided to environmental factors. The subcategories provided below align with the Global Reporting Initiative Standards environmental aspects.

Criteria	Value	Description
-Materials	*3*	*It is preferred to minimize the amount of natural resources and manufactured chemicals. Leachate treatment may involve the use of chemicals, which may also increase the risk of a spill.*
-Energy	*5*	*The leachate treatment alternatives will have varying energy consumption. It is preferred to minimize the amount of amount of energy required.*
-Water	*3*	*Leachate treatment alternatives will have varying water requirements. It is preferred to minimize the amount of water that is required/consumed and maximize the amount of water recycled/re-used.*
-Biodiversity	*5*	*The leachate treatment for the* project *may have an impact to ecosystems, vegetation and wildlife.*
-Emissions, effluent, waste	*3*	*The leachate treatment alternative may result in waste. It is preferred to minimize the amount of waste generated.*
	5	*Water discharge quality associated with leachate treatment may impact surface water, groundwater, or soil.*
	5	*The leachate treatment alternative may have varying GHG outputs.*
	6	*The leachate treatment method may alter noise and air quality (NO_x, SO_x), including odour at receptor sites.*
-Transport	*5*	*Transport associated with leachate treatment alternatives (including the number and frequency of trucks) will have an impact on GHGs emissions and noise.*
Socio-economic	30	The social environment surrounding the project has the potential to be altered by how the new facility treats leachate. Physical disturbances to the land and environmental nuisance effects may impact community members. Alternatives that minimize negative effects or result in positive changes to the human environment are preferred.
-Socio-community	*6*	*Nuisance effects associated with the treatment of leachate may have an impact on the community including water quality, odour, noise and air quality. It is preferred to minimize nuisance effects.*
-Land Uses	*8*	*The treatment with leachate will change existing uses of the land impacting the* Site *and the surrounding area. This may include disrupting existing industrial/recreational uses and visual changes. It is preferred to minimize disturbances to land users.*
-Economic	*4*	*The procurement of capital and labour throughout the lifecycle of the* project's *leachate treatment may have an impact on the local economy. It is preferred to maximize economic benefits within the local community.*
-Human Health	*4*	*The treatment of leachate may carry risks that could impact human health for those near the* Site*. It is preferred to minimize human health risk.*
-Indigenous Rights and Interests	*5*	*Traditional uses of the land may be impacted by the* project's *leachate treatment alternative due to the nuisance effects and physical land use. It is preferred to minimize disturbances to traditional activities.*
-Cultural resources	*3*	*Cultural heritage and archaeological sites may be altered by the* project*. It is preferred to minimize disturbances to these sites.*

Note:
Financial, Socio-economic and Environmental scores are the sum of the scoring criteria below the entry. For example, the environmental 40 points is the sum of materials, energy, water, biodiversity, emissions and transport scores.

Methods for calculating individual costs and benefits for specific disciplines are included in subsequent sections. Relevant baseline and project information relating to the specific discipline is also included in these sections.

1.3 Financial

The financial costs related to construction and operations of the leachate treatment system are considered as part of the preferred alternative, as there are limits to the capital available for the construction of the project. This directly impacts the capital available for leachate treatment construction. Operations costs also affect the viability of the project, as financial constraints will exist during the operation stage.

1.3.1 Construction Costs

Each alternative will have construction costs associated with the construction of the leachate treatment. Costs associated with the Triple Bottom Line Assessment are estimates as of May 1, 2019, as described in **Section 1.0**. These costs were prepared in April 2019, and are expected to have a large variance from the actual construction costs identified in future design and reporting documents. The purpose of providing costs in this section is to provide comparative costs for the leachate treatment alternatives.

Costs for the aerated lagoon and WTA alternative are estimated to be $3.44 million. These costs would include earthworks, liner, fencing, an aeration system, control structures, distribution piping and portable pumping systems.

The pre-treatment and haul to the City's WWTP alternative is estimated to be $2.18 million. These costs include earthworks, pond liner, treated holding tank/pond, the treatment system and building.

The on-site mechanical treatment alternative is estimated to be $4.85 million. These costs include earthworks, liner, a biological treatment system, a metals treatment system, treatment building and pumping systems. All alternatives assume a 50% contingency.

Additional detail and key assumptions for the capital cost estimate are provided in **Table 2**. Costs should be viewed as orders of magnitude and should be used for comparison purposes only. These costs do not reflect the actual construction cost estimates for any option.

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Table 2: Leachate Option Capital Cost Summary ($millions)

Item	#1: Aerated Lagoon & WTA		#2: Pre-Treat & Haul		#3: On-Site Mechanical Treatment	
	Assumption	Cost	Assumption	Cost	Assumption	Cost
Earthworks	40,000 m^3	$1.20	15,000 m^3 plus holding tank for trucking	$0.60	15,000 m^3	$0.45
Pond liner	14,000 m^2	$0.49	5,000 m^2	$0.18	5,000 m^2	$0.18
Treatment equipment	Aeration equipment	$0.25	Metal precipitation system	$0.50	Metal precipitation and biological treatment systems	$2.30
Pumping & piping systems	Control MHs, transmission piping, pump station	$0.13	Control MHs, transmission piping, pump station	$0.08	Control MHs, transmission piping, pump station	$0.11
Ancillary items	Fencing, gates, signage,	$0.21	Treatment building	$0.10	Treatment building	$0.20
Contingency	50%	$1.15	50%	$0.73	50%	$1.61
TOTAL	**Order of magnitude**	**$3.44**	**Order of magnitude**	**$2.18**	**Order of magnitude**	**$4.85**

Notes:

1) Options #2 and #3 would also require additional engineering design costs (typically 8-12% of capital value), as the assumption at the request for proposal stage was on a lagoon and wetland treatment system.

2) Lagoon and WTA based on sufficient pond sizes to hold one years' worth of leachate to balance freeze/thaw periods.

3) Both mechanical treatment options (#2 and #3) are based a physical-chemical separation process for heavy metals. Option #3 includes an additional biological treatment step for biological oxygen demand and total suspended solids removal.

4) All systems are based on approximately 4,400 m^3/year of low-strength leachate treatment.

5) Land based effluent disposal assumed (no outfall infrastructure).

6) Generator costs excluded and assumed to be covered under general landfill budget.

7) 50% contingency carried due to level of design completed and uncertainty regarding each option.

1.3.2 Operating Costs

Each proposed alternative will have costs over the 75 year operation period. Similar to construction costs, operation costs are estimates based on assumptions. These costs are expected to have a large variance from the actual operation costs identified in future design and reporting documents. The purpose of providing costs in this section is to provide comparison costs for leachate treatment alternatives. Costs were inflated by approximately 2% annually, the midpoint of the Bank of Canada's inflation target (Bank of Canada 2019). These costs are likely to include:

- **Labour** – It is assumed labourers will receive the median wage for Iqaluit of $70,695 prorated over the work period annually (Statistics Canada 2017). The on-site mechanical treatment alternative operator is identified as requiring additional skills so a 20% premium is added to their wages. Part-time employment is assumed to be 50% of median income.
  - The aerated lagoon and WTA alternative assumed a part-time operator for 12 months.
  - The pre-treatment and haul to the City's WWTP alternative assumed one part-time operator for eight months and one full-time operator for four months. In addition, there will be two full-time truck drivers for four months.
  - The on-site mechanical treatment alternative assumed one part-time operator for eight months and one full-time operator for four months.
- **Upkeep** – Assumed to be 1% of equipment costs in all cases.
- **Fuel usage** – The projected motor size was assumed for each alternative. It was assumed the motor would run constantly for four months. Diesel was assumed to cost $0.50 per kWh (Sullivan 2017).
- **Testing/Process Improvements** – Assumed based on experience with similar systems.
- **Chemical Consumption** – Assumed based on experience with similar systems.
- **Major Equipment Replacement** – Assumed that each alternative is expected to have three major equipment replacement intervals over the 75 year life of the landfill. They are expected to occur on or around years 20, 40 and 60 for the pre-treatment, and hauled to the City's WWTP alternative and the on-site mechanical treatment alternative, and years 25, 50 and 75 for the aerated lagoon and WTA alternative.

The total costs for operation of the leachate treatment alternatives during the lifecycle of the project are provided in **Table 3**.

Table 3: Summary of Estimated Operational Costs ($ million) – 75 Year Life Cycle

Operational Area	Aerated Lagoon and WTA	Utilizing the Existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Labour	$6.04	$16.10	$8.85
Upkeep	$0.85	$ 1.37	$2.05
Fuel Usage	$9.39	$12.81	$25.62

Operational Area	Aerated Lagoon and WTA	Utilizing the Existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Testing/Process Improvements	$2.56	$5.12	$8.54
Chemical Consumption	-	$34.16	$42.70
Major Equipment Replacement	$2.14	$3.42	$8.21
Total Operation Costs	$20.99	$72.98	$95.96

Note:
Sums may not add up due to rounding.

1.3.3 Revenue

None of the three leachate treatment alternatives are expected to generate direct revenue for the Site. In some larger cities throughout North America, the sludge that is produced, as part of the treatment process, can be further treated and conditioned into a soil amendment product and sold to the general public; however, that is not considered to be a viable alternative for the Iqaluit landfill for various reasons:

- Very high capital investment cost;
- Variability in leachate quality could impact finished product quality (this process is typically reserved for municipal wastewater);
- Operational requirements and complexity are quite high; and
- The market for soil amendment products in Iqaluit and the surrounding areas would be limited.

The costs associated with leachate treatment may impact other design areas for the project. Therefore, project revenue and costs cannot be held constant, allowing for a return on investment calculation on leachate treatment methods. As result, revenue generation was not considered as part of the financial evaluation of alternatives for leachate treatment.

1.3.4 Construction and Operational Financial Risk

With any wastewater treatment system, there are risks associated with capital construction and short-/long-term operations. This assessment considers only the financial risks or risks that could result in financial consequences related to construction and operation of the leachate treatment at the Site throughout the project lifecycle. Financial risks may alter the total cost of the project throughout its lifecycle. It is desirable to minimize financial risk associated with the project.

Table 4 provides an outline of the risk likelihood criteria for scoring. Different types of risks have different likelihoods of risks. For example, an operational risk is best measured by the frequency of its expected occurrence. However, a construction or capital expenditure risk is better measured by the probability or likelihood of occurrence.

Table 4: Likelihood of Risks

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

Table 5 provides a summary of the magnitude of risks. Different types of risks are best measured by different parameters. As result, financial risks are broken down into operational and capital losses. Financial risk is the only parameter considered for the magnitude of risks in this case. However, interruption of activities or non-compliances have financial consequences for the Site such as fines or lost revenue. All risks are classified as either operational or capital risks. Capital risks include major replacements expected throughout the lifecycle of the facility.

Table 5: Magnitude of Risks

Score	Descriptor	Financial Loss (Capital)	Financial Loss (Operational)
1	Low	≤ $ 200K	≤ $ 2K
2	Moderate	>$ 200K - ≤ $1.5M	>$ 2K - ≤ $15K
3	Significant	>$1.5M - ≤ $5M	>$15K - ≤ $50K
4	Serious	>$5M - ≤ $10M	>$50K - ≤ $100K
5	Severe	> $10M	> $100K

Leachate treatment risks are summarized in **Table6**, using the scoring criteria outlined in **Table 4** and **Table 5**. Individual risks are scored by multiplying the likelihood by the magnitude – called individual risk score. The total risk score for each alternative is tabulated by summing the individual risk scores for each risk. For each alternative, a minimum total risk score and a maximum total risk score are tabulated. The minimum total risk score is equal to the number of risks multiplied by the minimum possible individual risk score, which is “1”. The minimum total risk scores for each alternative are:

- **Aerated Lagoon and WTA**: 7 (7 risks, and minimum individual risk score of 1);
- **Pre- treatment and haul to the City’s WWTP**: 5 (5 risks, and minimum individual risk score of 1); and
- **On-site mechanical treatment**: 5 (5 risks, and minimum individual risk score of 1).

The maximum possible total risk score is equal to the number of risks multiplied by the maximum individual risk score, which is "25". The individual maximums for each risk are:

- **Aerated Lagoon and WTA**: 175 (7 risks, and maximum individual risk score of 25);
- **Pre- treatment and haul to the City's WWTP**: 125 (5 risks, and maximum individual risk score of 25); and
- **On-site mechanical treatment**: 125 (5 risks, and maximum individual risk score of 25).

Using the range of potential risk scores established for each alternative, a qualitative descriptor of risk is used for each alternative. These descriptors are low, low-medium, medium, medium-high and high. Qualitative classifications are based on quintiles identified in the ranges. For example, risks scores in the lowest quintile are classified as low risk.

Based on the risk scoring criteria outlined above, points will be allocated for the financial risk component of the triple bottom line assessment. Allocated points correspond with the qualitative descriptions where lower risk is identified, as preferable. For example, a low risk alternative would be allocated the maximum score of 5 points.

Table 6: Construction and Operation Risks associated with Leachate Treatment

Option	Risk	Risk Type	Likelihood	Magnitude	Description	Score
Aerated Lagoon and WTA	Availability of raw construction materials (engineered liner, suitable gravels)	Capital	3	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is possible these materials are located in the area; therefore, it is expected materials will need to be procured from other regions.	**6**
	Availability of suitable contractors	Capital	2	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could moderately increase the financial costs of construction. While it is possible these contractors may not be available, it is unlikely to happen.	**4**
	Ability to encourage and sustain suitable plant growth in the WTA	Operation	4	4	The performance of plant growth can be difficult to accurately predict. It is estimated that it would take at least 3 to 4 years for plant growth to be at a level where treatment performance would be accepted. This may result in levels of service interruption which could have serious financial consequences including stalled operations, and non-compliance fines or litigation. It is anticipated this is likely to occur at some point in the project lifecycle.	**16**
	Ability to find suitable terrain/constructability around existing contours	Capital	3	1	Inability to find suitable terrain for construction may result in revisions to studies and project planning to revise the design of the project to consider an alternative leachate treatment system. If this alternative is pursued, it will remain possible that the terrain is not suitable. If the terrain is not suitable, additional engineering costs would be required to design a new treatment alternative.	**3**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Based on the size of the leachate treatment footprint and other physical constraints at the Site, it is possible the management of leachate will result in larger than expected financial costs associated with phasing and expansion. Moderate consequences, including capital costs and non-compliance, may result from these issues.	**6**
	Ability to consistently meet wastewater discharge parameters	Operation	5	4	While lagoons and WTA have a long history in treating municipal wastewaters across northern and southern Canada, their track record related to industrial or leachate treatment is very limited. Constituents in the raw leachate (e.g., metals, salinity, ammonia) may inhibit plant growth and significantly hinder performance. It is likely the aerated lagoon would experience these consequences once every 1 to 5 years. Non-compliance would be a major regulatory breach and would be likely to result in ligation or major service interruption. These breaches could result in fines and other legal costs impacting the operation of the Site.	**16**
	Ability to identify a central point of compliance and satisfy regulators, acknowledging nature of land treatment	Operation	2	2	Aerated lagoon and WTAs in the north have issues identifying a central point for monitoring the compliance of effluent from the Site. It is unlikely this would occur and would only result in minor non-compliance issues. The non-compliance issues may have a negative impact on operations leading to moderate financial losses	**4**
Pre-treatment and Hauling to the City's WWTP	Availability of raw materials	Capital	4	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is likely there will be additional costs associated with the availability of raw materials and this could result in moderate additional financial costs.	**8**
	Availability of suitable contractors	Capital	3	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could increase the financial costs of construction. The availability of these contractors within the expected costs for the project is possible and the magnitude could be moderate additional financial costs.	**6**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Significant capital costs may be associated with difficulty managing the expansion of the WWTP, as it is expected the City's current WWTP will need major upgrades during the project lifecycle based on population growth projections. It is possible this will result in financial costs, which would be classified as moderate.	**6**
	Requires that City WWTP is willing/able to accept leachate over the life of the landfill	Operation	3	5	The City's WWTP may not be willing to accept leachate. This would create an immediate disruption to landfill operations, and likely carry with it serious capital and regulatory issues. It is possible this would occur, and it will result in significant financial costs associated with stalled operations and operational costs.	**15**
	Availability of annual chemical supply/shipment	Operation	3	5	Pre-treatment will require some type of chemical treatment. These chemicals will need to be shipped to the Site and stockpiled for annual use. If the chemical supply was ever interrupted, treatment would not meet requirements. It is possible this would occur based on transport within the region. If this occurs, the service interruption would be likely to exceed one month, which carries financial consequences including potential regulatory issues and operational costs.	**15**

Option	Risk	Risk Type	Likelihood	Magnitude	Description	Score
On-Site Mechanical Treatment	Availability of raw materials	Capital	3	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is possible these materials will not be located within the expected cost limitations for the project. Additional costs would be anticipated to be moderate.	**6**
	Availability of suitable contractors	Capital	4	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could increase the financial costs of construction. The availability of these contractors within the expected costs for the project is possible and the magnitude could be moderate additional costs.	**8**
	Optimizing treatment process for short-term (summer) operation	Operation	3	5	As part of the full on-site treatment process, some level of biological treatment is anticipated. It can take time (days to months) to establish suitable biomass that will achieve the desired treatment performance. Depending on the process, this may be difficult in the Nunavut climate. It is possible suitable biomass may not be established. If it is not established, the result will be serious non-compliance and associated financial costs.	**15**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Significant capital costs may be associated with difficulty managing the expansion of the WWTP at the Site, as the mechanical treatment plant will require various upgrades and expansions at significant capital costs. These changes may alter the lifecycle capital cost. Based on the scale and nature of the plant, the operational burden is likely to be moderate, if the expansion is managed incorrectly.	**6**
	Availability of annual chemical supply/shipment	Operation	3	5	Pre-treatment will require some type of chemical addition. These chemicals will need to be shipped to the Site and stockpiled for annual use. If the chemical supply was ever interrupted, treatment would not meet requirements. It is possible this would occur based on transport within the region. If this occurs, the service interruption would be likely to exceed one month, which carries financial consequences.	**15**

Based on **Table 6**, each leachate treatment alternative would result in financial risk associated with construction and operation of the Site. The risk scores and their associated ranges include:

- **Aerated Lagoon and WTA**: 60 (range of 1 - 175);
- **Pre- treatment and haul to the City's WWTP**: 50 (range of 1 - 125); and
- **On-site mechanical treatment**: 50 (range of 1 - 125).

As result, all alternatives are determined to have low to medium risk. The aerated lagoon and WTA alternative has the most risks associated with it but these tend to have lower individual risks cores. While the pre-treatment and haul to the City's WWTP alternative and on-site mechanical treatment alternative have fewer risks, they have higher individual risk scores.

1.3.5 Summary of Financial Costs

Table 7 presents a summary of the financial costs and risks associated with the project. The aerated lagoon and WTA alternative is financially preferable, as costs are approximately one third and one quarter of the cost of the pre-treatment and haul to the City's WWTP alternative and on-site mechanical alternative, respectively. All alternatives are anticipated to carry low to medium financial risk.

Table 7: Summary of Financial Costs and Benefits

Criteria	Aerated Lagoon and WTA	Utilizing the existing City WWTP	Mechanical Treatment Plant at the Landfill
Construction Cost ($ million)	3.44	2.18	4.85
Operation Cost ($ million)	20.99	72.98	95.97
Total Cost	24.43	75.16	100.82
Financial Score (out of 25)	25	8.1	6.1
Risk Classification	Low to medium	Low to medium	Low to medium
Risk Score (out of 5)	4	4	4
Total Financial Score (out of 30)	29	12	10

Note:

1. The financial score is equal to the lowest cost alternative over the cost of the alternative multiplied by the number of available points (25). Therefore, the alternative with the lowest financial cost score 25 points and all other scores are relative to that. The remaining 5 points are awarded based on the project's financial risk.
2. Scores were round to the nearest whole number.

1.4 Environmental

The leachate treatment alternatives will have differing environmental impacts. Areas in which the leachate alternative may impact the environment include:

- Materials;
- Energy;
- Water;
- Biodiversity;

- Emissions; and
- Transport.

The potential impacts to environmental factors based the leachate treatment method are provided below.

1.4.1 Materials

Environmental impacts related to materials used in each of the treatment alternatives considered:

- Depletion of natural resources (e.g., quantity of new materials required for construction and operation); and
- Impacts of these materials on environment (e.g., hazardous nature of materials, emissions, potential for spills).

Environmental impacts related to materials were evaluated out of a possible three points. The materials considered are categorized into chemical and physical materials, including those required to treat the leachate and those required to construct treatment plants and retention structures on-site. Two points were allocated to chemical materials and one to physical materials.

Chemical materials refer to any manufactured chemicals used during treatment of leachate or effluent. The aerated lagoon and WTA alternative does not require chemicals to treat leachate, as this method makes use of natural biological activity to treat leachate to acceptable levels for discharge into the environment. In order to prepare leachate to be transported to the WWTP, as in the pre-treatment and haul to the City's WWTP alternative, both physical and chemical treatment of the leachate is required. The risk to environmental and natural systems includes leaking of treatment chemicals into downstream surface environments and groundwater systems. Surface water on the Site is transported into a stream that flows into Carney Creak and an unnamed lake, just west of the Site. The Site and its environs are home to several species of wildlife, including arctic char and lemming, which are a major food source for arctic predators. A leak of treatment chemicals could travel overland and potentially into subsurface channels, negatively impacting humans, plants and wildlife utilizing the Site.

Physical materials considerations should include construction requirements for each of the alternatives. In the aerated lagoon and WTA alternative, the treatment lagoon will need to be lined with either compacted clay, geosynthetic liner (bentonite-infused fabric), or geomembrane (HDPE) materials and then populated with natural plant life capable of removing contaminants from incoming leachate. Although HDPE is a fossil-fuel derivative with a high embodied energy coefficient, it is designed to be long-lasting and should not need to be replaced for the lifetime of the lagoon. The construction of a treatment plant - either the pre-treatment and haul to the City's WWTP alternative or the on-site mechanical treatment alternative, would require the use and transportation of all materials normally associated with building construction.

1.4.2 Energy

Energy use for each of the leachate treatment alternatives are evaluated based on electricity and fuel use. A total of 5 points is allocated to energy considerations. This is an important metric for the City; electricity costs in Nunavut are the highest in the country and fuel is imported from neighbouring provinces during certain times of the year, when roads are usable. Efficiency and low energy use are of a high priority under these conditions. Based on the design stage, qualitative estimates of energy consumption were used. Energy use was considered relative to other options, as the purpose of the assessment is to compare alternatives relative to each other.

The aerated lagoon and WTA alternative would require the least amount of energy consumption. This plan consists of pumping systems to move leachate from the landfill to the lagoon, and from the lagoon to the wetland downstream, as well as an aeration system for the lagoon (and possibly wetland). The equipment required for both the pumping system and the aeration system consume minimal electricity compared to more complex systems (i.e., the other two treatment options). For reference, a lagoon would use less energy daily than a typical household.

In the pre-treatment and haul to the City's WWTP alternative, pre-treatment requires both physical and biochemical treatment. Leachate would need to be pumped from the landfill into the treatment facility, moved around within the facility to different forms of treatment and then pumped into retention structures awaiting transportation to the City's WWTP. The pumping and treatment systems (depending on the types of systems selected) may consume as much electricity as a typical household in a day. However, as personnel would be required to run the pre-treatment site, the building will require space heating, using diesel fuel.

For the on-site mechanical treatment alternative, the complexity of the multiple processes would result in higher electricity consumption levels than either of the other two alternatives. Systems needed for operating the plant include pumps, blowers, control systems, gear boxes, motors, etc. Additionally, this building would be regularly staffed during the summer months and possible shoulder months; therefore, would consume fuel to maintain reasonable interior temperature conditions (likely higher fuel consumption than the smaller pre-treatment facility).

1.4.3 Water

Water is an essential natural resource that should be conserved, where appropriate. Treatment options are evaluated based on their consumption and use of water throughout the treatment cycles. A total of 3 points are available for each leachate treatment alternative.

The aerated lagoon and WTA alternative does not require the use of any additional water in treatment – precipitation and leachate is anticipated to adequately fill the lagoon. Both of the other leachate treatment alternatives are expected to require little water, in the range of about 1000 L/day (for reference, the average water use per person in Canada was 466 L/day in 2013). The water will be used as part of the operation of the treatment plants for each alternative. However, for the pre-treatment and haul to the City's WWTP alternative, it is reasonable to account for water used by the haulers to clean out the trucks used for leachate transportation, which would increase total water usage for this option.

1.4.4 Biodiversity

Biodiversity, or biologic diversity, refers to the variability among species/organisms in an ecosystem, from all sources. Many interactions occur among species within an ecosystem, which all play an important role in ecosystem function; loss of biodiversity can significantly impact the ecosystem's capacity to support and promote life of all flora and fauna within. Each of the leachate treatment alternatives are scored out of 5 points for their impacts to biodiversity, which include risks to the Site's current plant and animal life (3 points), as well as potential loss of biodiversity (2 points).

Leachate is generally characterized by high chemical oxygen demand, biological oxygen demand, pH, ammonia nitrogen and heavy metals, but varies depending on landfill composition. According to a review study completed in 2018 (Bederma et al, 2019), leachate is toxic, mutagenic, genotoxic and estrogenic, even at low concentrations. It poses a risk to both humans and plants/wildlife. Additionally, some contaminants contained within leachate can bioaccumulate up the food chain, posing long-term risks to apex species.

The Site is currently home to 23 plant species and 11 wildlife species. Each treatment alternative will have a potential impact on these species in varying ways.

The aerated lagoon will require management of introduced plant life, in order to build up capacity to properly treat leachate. It is estimated that it would take at least 3 to 4 years for plant growth to be at a level where treatment performance would be accepted; however, the lagoon is not likely to fill to capacity during that period of time. The nature of developing a lagoon and wetland on-site allowss the continued diversity of plant life within this ecosystem. Although, it may require the removal of an area of approximately 2.5 ha of existing, untouched land, occupied by native plant and wildlife species in a well-established ecosystem. An additional possible risk to the environment that exists for this option is the potential for insufficiently treated effluent to overflow into the WTA, during extreme weather events.

The construction of a pre-treatment plant on-site would have a project footprint of approximately 0.5 ha, including the pre-treated leachate retention structures. Trucks would require access to retention structures and the pre-treatment site; therefore, additional road allowances may need to be constructed. All of these activities - treatment site construction, trucking, and retention structure creation and use - will have an impact to the biodiversity of the Site. In addition, potential upset conditions, such as oil and gas leaks from truck traffic, a spill of untreated leachate during transfer or from retention structures into the environment could harm existing plant and wildlife, and/or result in habitat loss or degradation.

The on-site mechanical treatment alternative would also require the construction of a treatment plant at this location. An area of approximately 0.8 ha may be required and may require external retention structures. In terms of biodiversity loss due to land disturbance, this alternative is the least impactful. Additionally, the risks of leachate leaking from the building's treatment systems are minimal and can be mitigated.

1.4.5 Emissions

1.4.5.1 Waste

Waste generation resulting from leachate treatment can be categorized into chemical waste, biological/hazardous waste and construction waste. Each is evaluated out of 1 point.

Chemical waste refers to unused or spilled chemicals required for treatment. In the lagoon treatment option, there will be no chemical usage; therefore, no chemical waste. The pre-treatment and haul to the City's WWTP alternative will involve chemical, physical and biological treatment of waste prior to hauling it to the WWTP; therefore, there is a possibility of chemical waste. The mechanical treatment plant alternative would have the highest potential chemical waste, as this alternative is the most chemical intense.

Biological/hazardous waste refers to the residual solid components of treatment (i.e., sludge) that may need to be disposed of as hazardous waste due to the chemical and biological components contained within. Sludge can often be applied to land as a soil enhancer (after being treated for bacteria like e.coli). However, with leachate treatment, when heavy metals and other inorganic chemicals are potential contaminants, this sludge would likely need to be treated as hazardous waste. Sludge would be generated through processing in all three leachate treatment alternatives, although timing and frequency of need for sludge disposal may be vastly different. For instance, lagoons need to be dredged after a certain period, as they accumulate solids. The pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative both require preliminary solids removal and primary treatment to reduce total suspended solids, generating sludge that would require safe disposal. The frequency of need for solid waste disposal from both treatment facilities would be similar, as sludge is developed during the first stage of treatment.

As a result of construction of either the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative, construction waste would be generated on-site. The larger the structure, the more construction waste is likely to be generated (depending upon the type of buildings being constructed and whether or not pre-fabrication is considered).

1.4.5.2 Water

Water emissions refer to the quantity and quality of treated leachate discharged into the local environment from on-site activities. Contaminants within untreated leachate can be toxic to living organisms and cause long-term damage to ecosystems.

Natural discharge and dispersion are the methods of release for treated leachate from the lagoon and WTA alternative. No on-site water discharge is anticipated for the pre-treatment and haul to the City's WWTP alternative; treated leachate is discharged with the City's treated wastewater. The on-site mechanical treatment alternative involves treated water discharge, in line with best practice through natural dispersion.

1.4.5.3 GHGs

Climate is characterized by the seasonal weather conditions of a region over an extended period of time, which can include temperature, humidity, precipitation, sunshine, cloudiness and winds. It is understood that GHG releases on a global scale from both natural processes/sources and human activities are increasing global concentrations of GHGs in the atmosphere, and they contribute to climate change. Project-based releases of GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are typically used establish a project's contribution to climate change.

Releases of GHGs and their accumulation in the atmosphere influence global climate and may affect emission reduction targets for GHGs that have been set or are being developed federally and provincially/territorially.

An aerated lagoon and WTA has the potential for generating CH_4 (a potent GHG),emitted from the soil, as organic matter that is present in the soil and overburden decays. The potential for GHG emissions to occur from organic decay increases with increasing temperature, and given the location and cooler climate of the region, it is likely that the potential for GHG emissions is fairly mitigated due to an overall expected low rate of generation of CH_4. There would also be minor indirect GHG emissions from energy consumed in the aerators in the lagoon and associated pumping. Otherwise, this alternative does not require any substantive energy use compared to other alternatives, and apart from CH_4 generation due to organic matter decay, assuming there are no pumping needs between the lagoon and the wetland, it would be expected to have fairly minimal direct GHG emissions.

Conversely, the presence of an engineered wetland and the bacteria contained in its soils may serve to fix carbon dioxide into the soils, thereby acting as a carbon dioxide sink. However, because the CH_4 that would be generated in the wetland as a result of organic decay is a 21 times more potent GHG than the carbon dioxide the wetland might absorb/fix, it is likely that an aerated lagoon and WTA alternative would be a net emitter of GHG, as opposed to a net GHG sink.

The pre-treatment and haul to the City's WWTP alternative would require additional electrical consumption due to the presence of a pre-treatment plant; hence, increase indirect GHG from energy use, as compared to other alternatives.

The on-site mechanical treatment alternative would require additional electrical consumption beyond that required for the other two alternatives (given the likely size and complexity of the mechanical plant process); hence, increase indirect GHGs from energy use, as compared to other alternatives. In addition, potential fugitive emissions of GHGs such as CH_4 may occur from organic matter in the treatment process itself.

1.4.5.4 Noise and Air Emissions

Air Quality

Air quality has an intrinsic or natural value because the atmosphere helps maintain the health and well-being of humans, wildlife, vegetation, and other biota. Emissions from the project to the air (including odour) may cause adverse environmental effects through the various transport, dispersion, deposition, and transformation processes that occur in the atmosphere. Project effects on air quality include emissions of contaminants (including odour) to the atmosphere during construction and operation of the project, which may present a pathway for humans and biota to be exposed to air contaminants.

The Environmental Guideline for Ambient Air Quality issued by the Government of Nunavut Department of Environment set standards for the maximum permissible concentrations for five air pollutants, namely: total suspended particulate (TSP), fine particulate matter, sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3).

Given the passive nature of the treatment process used by the aerated lagoon and WTA alternative, this alternative is expected to produce limited on-site emissions of the regulated air contaminants. Minor direct and indirect emissions of air contaminants would be expected as a result of energy use in the aerators for the lagoon.

The pre-treatment and haul to the City's WWTP alternative would require additional electrical consumption to operate the pre-treatment plant. Therefore, indirect emissions would arise from this energy use.

The third alternative of an on-site mechanical treatment plant would require additional electrical consumption that presumably exceeds that of the other alternatives given the larger size and likely complexity of the treatment process; hence, indirect emissions arising from this energy use.

Odour

Odour is another consideration with respect to air quality. Odour can be related to a variety of factors, sources and compounds. Odour is not necessarily related to one specific compound (and often is not or cannot be addressed from a regulatory or health limit basis for a specific compound). Its effect is relative to an individual's perceptible limit and tolerances, and because of this inherent subjectivity, odour is therefore more frequently treated as a nuisance issue. There is potential for odour for each potential treatment alternative, and odour generation and detection may vary depending on the process and/or meteorological conditions. There is potential for odour to be perceived at locations beyond the facility property during specific meteorological conditions, for any alternative.

For the aerated lagoon and WTA alternative, there are typically two primary compounds that contribute to odour as a result of fugitive gas releases from wetlands: reduced sulphur compounds and CH_4 (both from organic decay processes). Like with GHGs, the potential for odour emissions to occur from organic decay increases with increasing temperature, and given the location and cooler climate of the region, it is likely that the potential for odour emissions is fairly mitigated due to an overall expected low rate of generation of odourous compounds. Recreational use is primarily to the west and southwest of the Site, and since the dominant wind direction is from the northwest, the potential for odour to affect the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

For the pre-treatment and haul to the City's WWTP alternative, odours potentially arising from the treatment of leachate from the Landfill would not be expected to be distinguishable from odours generated by the treatment of other wastes at the WWTP. There is potential for odour emissions from pre-treatment at the Site; however, the potential for odour emissions increases with increasing temperature, and given the cooler climate of the region, it is anticipated that the probability of significant odour incidents is low.

The third alternative of an on-site mechanical treatment plant at the landfill would have the potential for fugitive emissions; hence, odours from the treatment process itself. The dominant wind direction is from the northwest; therefore, receptors to the southwest would have a higher potential to experience odours more frequently, if odours were present. Recreational use is primarily to the west and southwest of the Site; as such, the potential for odour to impact the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

Noise

The type, frequency, intensity and duration of noise (unwanted sound) all contribute to the effect on a recipient in the outdoor environment. For certain industrial processes that generate significant noise, it may be treated as a health and safety issue in close proximity to these operations. In the surrounding environment, noise is often treated as a nuisance issue. There are no regulatory criteria established for noise by the Government of Nunavut.

For the aerated lagoon and WTA alternative, there is potential for noise from the aeration at the lagoon, as well as from pumping; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas. Given the passive nature of a wetland, a WTA is not expected to have any substantive sources of noise.

For the pre-treatment and haul to the City's WWTP alternative, there is potential for noise from the pre-treatment process on-site; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

The third alternative of an on-site mechanical treatment plant at the landfill has the potential for noise from various parts of the process; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

1.4.6 Transport

All three alternatives would likely have GHG, air contaminant and noise emissions associated with transporting goods and service providers to the Site, including depending on the alternative, raw materials, prefabricated structures, contractors, machinery and supplies.

The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase in direct GHG emissions. The GHG emissions arising from trucking activity would be expected to far exceed GHG emissions from any other alternative. This alternative will result in increased trucking traffic; therefore, an increase in direct emissions of air contaminants from fuel combustion. Powering the pre-treatment process would result in indirect emissions of regulated air contaminants. The increased trucking traffic would result in increased noise associated with vehicle traffic along the haul route.

During operation, no transport is required for the aerated lagoon and WTA alternative, nor the on-site mechanical treatment.

1.4.7 Summary of Environmental Impacts

Table 8 presents a summary of the environmental impacts. These costs and benefits include:

- **Materials**
  - The use of chemicals for leachate treatment at the Site is apparent in the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical alternative. Chemical leakage has the potential to harm humans, plants and wildlife near the Site. Therefore, the pre-treatment and haul to the City's WWTP alternative is allocated zero (0) points. As the aerated lagoon and WTA alternative and the on-site mechanical treatment option have no chemicals or easily mitigated chemical risks, they are allocated 2 points.
  - The aerated lagoon and WTA alternative is allocated 1 point, as the physical materials associated with the leachate materials may be derived from fossil fuels but are durable throughout the lifecycle of the Site. The pre-treatment and haul to the City's WWTP

alternative and the on-site mechanical treatment alternative will produce a significant amount of construction waste, and as result, are allocated zero (0) points.

- **Energy** – The aerated lagoon and WTA alternative is anticipated to use the least electricity, less than a typical household daily. As result, this alternative is allocated 5 points. The pre-treatment and haul to the City's WWTP alternative is likely to consume electricity similar to a typical household. As result, 3 points are allocated to this alternative. The on-site mechanical treatment is allocated 1 point, as it is likely to consume the most energy.
- **Water**– Both the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative would require water approximately equivalent to two days of use for the average Canadian. Additional water would be used to in the pre-treatment process to clean the haul trucks. As result, this option is allocated 1 point, while the full treatment plant is allocated 2 points. No additional water is required for the aerated lagoon and WTA option. Therefore, the maximum 3 points is allocated to this alternative.
- **Biodiversity** – The aerated lagoon and WTA is allocated 2 points for biodiversity, as it will support continued diversity of plant life on-site. However, some biodiversity loss will also occur as an area of approximately 2.5 ha of the Site is disturbed from use by native plants and wildlife. The pre-treatment and haul to the City's WWTP alternative treatment site construction will have some biodiversity loss as an area of approximately 0.5 ha of the Site are disturbed from use by native plants and wildlife. In addition, potential for upset conditions (e.g., spills) related to trucking and retention structure may impact the biodiversity of the Site. Due to the risks to the Site's biodiversity associated with these activities, the pre-treatment and haul to the City's WWTP alternative has been allocated 2 points. The on-site mechanical treatment alternative is allocated 4 points, as it is anticipated to be least impactful to biodiversity.
- **Emissions, Waste and Effluent**
  - Each type of waste (chemical waste, biological/hazardous waste, and construction waste) may occur depending on the leachate treatment alternative. The aerated lagoon and WTA alternative is allocated 2 points, as it may result in biological/hazardous waste in the form of sludge. The pre-treatment and haul to the City's WWTP alternative is allocated zero (0) points, as it may result in chemical, biological/hazardous waste and construction waste. The on-site mechanical treatment alternative is allocated zero (0) points, as it may result in chemical, biological/hazardous waste and construction.
  - Four (4) points are allocated to the water discharge associated with the aerated lagoon and WTA, as there is a small risk of insufficiently treated leachate being released accidentally during extreme weather events. The maximum 5 points are allocated to the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative, as water discharged is fully treated and safe for release.
  - Emissions of GHGs are associated with all three alternatives. The aerated lagoon and WTA would be a net carbon emitter but its emissions are anticipated to be less than the other alternatives. Therefore, it is allocated 3 points. The pre-treatment and haul to the City's WWTP alternative would result in emissions associated with electricity

consumption and is allocated 2 points. The on-site mechanical treatment alternative would result in the most emissions associated with electricity consumption and treatment of organic materials. This alternative is allocated 1 point.
    - Noise and air emissions are associated with all three alternatives. The aerated lagoon and WTA is expected to have minimal noise, air contaminant and odour emissions. As result, this alternative is allocated 4 points. Noise and air contaminant emissions would result from the operation of the pre-treatment plant or the on-site mechanical treatment plant. The mechanical treatment plant may also have odour emissions. As result, the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative is allocated 3 and 2 points, respectively.
- **Transport** – The transportation of the goods and services for constructing the leachate treatment methods at the Site would result in GHG, air contaminant and noise emissions. Transportation is only required during operations for the pre-treatment and hauling to the City's WWTP alternative. Therefore, 2 points are allocated to the pre-treatment and hauling to the City's WWTP alternative. As no transportation is associated with the operation of the other alternatives, they are allocated 4 points.

Based on the environmental criteria, the aerated lagoon and WTA alternative is most preferred by a wide margin (9 points). With the exception of biodiversity, this alternative is the most preferred for all environmental criteria. In the case of biodiversity, the aerated lagoon and WTA alternative is second most preferred. These results are carried forward to **Section 1.6**.

Table 8: Summary of Environmental Costs and Benefits

Criteria	Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Materials (out of 3)	3	0	2
Energy (out of 5)	5	3	1
Water (out of 3)	3	1	2
Biodiversity (out of 5)	2	2	4
Emissions, effluent, waste (out of 19)	13	10	8
Transport (out of 5)	4	2	4
Total Environmental Score (out of 40)	30	18	21

1.5 Socio-economic

The leachate treatment alternatives have differing socio-economic impacts. Potentially effected socio-economic conditions include:

- Socio-community;
- Land uses;
- Local economy;

- Human health;
- Indigenous Rights and Interests; and
- Cultural resources.

The potential impacts to the socio-economic environment based the leachate treatment method are provided below.

1.5.1 Socio-community

Changes to the socio-community, as result of leachate treatment, is tied to the environmental changes and land use disturbances associated with the Site. While the leachate treatment is not anticipated to negatively impact the community well-being or the enjoyment of the community directly, nuisance effects may indirectly negatively impact the environmental conditions of areas surrounding the Site utilized by community members. Nuisance effects, for this assessment, are considered to be noticeable and beyond historical conditions at the Site. The assessment is anticipated to be binary. If the change is not anticipated to be noticeable and beyond historical conditions, the alternative receives a score of 1.5. A total of 6 points are available, 1.5 points for each potential nuisance identified as potentially altering community enjoyment associated with the leachate treatment alternative.

Water Quality

All three leachate treatment alternatives are not likely to result in nuisance effects on the socio-community and land users based on potential changes to water quality.

Further information on potential impacts to water quality is provided in **Sections 1.4.5.1**.

Air Quality

Given the passive nature of the treatment process used by an aerated lagoon and WTA, this alternative is not expected to have any substantive on-site emissions of the regulated air contaminants. The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase in direct emissions of air contaminants from fuel combustion. Air quality is not expected to be a nuisance regardless of leachate treatment method.

Further information on air quality is provided in **Sections 1.4.5** and **1.4.6**.

Odour

For the aerated lagoon and WTA alternative, it is likely that the potential for odour emissions due to organic decay is fairly mitigated due to cooler temperatures and an overall expected low rate of generation of odourous compounds. For the pre-treatment and haul to the City's WWTP alternative, there is potential for odour emissions from pre-treatment at the Site. However, it is anticipated that the probability of significant odour incidents is low. The on-site mechanical alternative would have the potential for fugitive emissions; hence, odours from the treatment process itself.

For all alternatives, the dominant wind direction is from the northwest; therefore, receptors to the southwest would have a higher potential to experience more frequently, if odours were present. Recreational use is primarily to the west and southwest of the Site; as such, the potential for odour to affect the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

Further information on odour is provided in **Sections 1.4.5**.

Noise

For the aerated lagoon and WTA alternative, there is potential for noise from the aeration at the lagoon, as well as from pumping. The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase noise associated with increased vehicle traffic along the haul route. There is potential for noise from the pre-treatment process on-site. The on-site mechanical treatment alternative has the potential for noise from various parts of the process. In all cases, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

Further information on noise is provided in **Sections 1.4.5** and **1.4.6**.

Summary

Each alternative is anticipated to result in varying nuisance effects for community members due to anticipated changes in environmental conditions associated with leachate treatment. Changes to environmental conditions are unlikely to be perceived by community members and are not anticipated impact the enjoyment of the use of lands near the Site for various activities. The exception is odour, which may have an impact to land users and community members.

1.5.2 Land Uses

Changes to land use are associated with the physical project footprint of the leachate treatment method and the visual nuisance effects associated with the treatment method. These changes are likely to influence land users. Land uses in the project area are defined by four separate anticipated changes to the land use environment, which may change as result of the preferred leachate treatment method: protected areas, recreation, industry and visual changes. Each of these four changes has 2 points associated with it. The magnitude of anticipated effect associated with each alternative is reflected in the scoring with lower impact magnitudes being desirable.

Protected Areas

Three designated and protected areas overlap or are in proximity to the Site according to the EXP report (2018). These include an arctic char area of abundance, a water management area and Sylvia Grinnell Territorial Park. These areas were identified as Valued Socio-Economic Components for the Site. The leachate treatment alternative has the potential to impact these land uses.

Arctic char areas of abundance are identified by the Department of Fisheries and Oceans where arctic char are commonly found (EXP 2018). Char are an anadromous species; therefore, these areas include marine areas and adjacent fresh water rivers and streams. Arctic char are known to migrate up the Sylvia Grinnell River to spawn within the river and connecting inland lakes (EXP 2018). Leachate treatment associated with all three alternatives is unlikely to impact water areas used for spawning by arctic char.

The Site falls within the Frobisher Bay water management area (EXP 2018). Water management areas correspond with watersheds in Nunavut. These areas are expected to be an important component of future generations because of the inter-connectivity between land and water throughout Nunavut (EXP 2018). The leachate treatment method is not anticipated to alter water management within the Frobisher Bay water management area.

Sylvia Grinnell Territorial Park is located 2 km west of Site (EXP 2018). Primary features of the park include recreation and cultural features (Travel Nunavut N.d.). A variety of archaeological features exist related to settlement of the lands by a variety of cultures predated and including the Inuit. Fishing, hiking and camping are identified as common activities within the park (Travel Nunavut N.d.). Nuisance effects or disturbances from the leachate treatment alternative are not anticipated to impact the use of the land by tourists and recreationalists viewing cultural heritage sites or undertaking recreation activities.

Overall, the leachate treatment alternative is not anticipated to alter the use of protected areas. Discharge from the leachate treatment is not anticipated to have an impact on surrounding water quality. Sylvia Grinnell Territorial Park is too far west of the Site to be impacted by nuisance effects.

Recreation

EXP identified lands adjacent to the Site used for recreational use, including ski trails used by the Aniirajak Ski and Adventure Club in Iqaluit occur on the Site (EXP 2018). All three leachate treatment alternatives are likely to displace a portion of the existing trail used by the club. However, the aerated lagoon and WTA alternative is likely to displace more of the existing trail, as the trail runs through the proposed treatment area.

An unnamed lake west of the Site is used for camping and fishing by local community members (EXP 2018). A trail to the west of the Site is used by locals to access fishing and hunting areas north of the Site (EXP 2018). The Site is used for berry picking, dog walking, picnicking and camping. Campers occasionally drink water from Carney Creek south of the Site (EXP 2018). Some of these activities are likely to be displaced due to the presence of leachate treatment alternatives on the Site. Additionally, the leachate treatment alternative may alter existing access features, including an ATV trail used to access these activities (EXP 2018).

Camping was observed with a fire pit identified on the Site (EXP 2018). All three leachate treatment methods are anticipated to remove the camping area on the Site, where the fire pit was observed.

Industry

A Proposed Transportation Corridor runs through the Site to an area of high mineral potential. A Proposed Transportation Corridor is defined as a corridor through which an application to construct has been submitted but not yet approved (EXP 2018). The width of this corridor is much larger than the Site and provides the proponent the opportunity to construct their infrastructure in other areas of the corridor. According to the Draft Nunavut Land Use Plan, this corridor is still designated as a Proposed Transportation Corridor as of April 2017. No other industrial land uses or access features are identified on the site area (Government of Nunavut 2017).

Visual

An aerated lagoon would be a visual disturbance on the existing viewscape relative to existing conditions. The lagoon would have a project footprint of an estimated 2.5 ha. The lagoon would appear as a wetland and plant native plant growth would be encouraged. However, fencing and signage would surround the Site, which would reduce the natural look of the leachate treatment area.

The pre-treatment and haul to the City's WWTP alternative would have a prefabricated building, and a small holding tank or pond. The treatment plant would have a visual contrast relative to the existing landscape. The contrast would be noticeable and may present a nuisance beyond historical norms for land users in the area.

A mechanical treatment plant would represent the largest visual disturbance on the landscape, as it is most likely to be visible from the furthest distance and will be in contrast to the existing landscape. This is due to the prefabricated building, which is expected to be larger than pre-treatment building identified in the pre-treatment and haul to the City's WWTP alternative. The contrast would be noticeable and may present a nuisance beyond historical norms for land users in the area.

1.5.3 Economic

The construction and operation of a leachate treatment alternative for the project results in changes to the local economy associated with the procurement of goods and services. These benefits will take place over the course of the project lifecycle. Economic benefits will include jobs and spending directly associated with the Site that may have indirect and induced economic benefits for the community. The primary benefit would be the magnitude of the economic activity. However, additional weight is also being given to the presence of long-term opportunities associated with direct spending from the Site, including jobs and procurement. Preference is also being given to alternatives that rely on local procurement of goods and services for the construction and operation of the Site.

For all alternatives, a part-time operator is anticipated during the winter months, where leachate production is expected to be limited. This operator would be responsible for conducting routing checks of the system and preparing the selected treatment system for summer operation. During the treatment season (July to September), operator attention would increase for all three alternatives. In addition, approximately 15 days would be required for preparing and shutting down the system before and after the treatment season. Therefore, there would be a total of four months of increased operator attention.

Capital costs and labour associated with the aerated lagoon and WTA alternative are anticipated to be $3.44 million. These costs are likely to include capital and labour costs associated with earthworks and imported liner materials associated with the lagoon construction. The aerated lagoon and WTA is most likely to utilize a local contractor for construction of the lagoon and local materials in the construction. This will aid in reducing leakage from the local economy. Leachate treatment through an aerated lagoon is likely to have the least operational costs and labour required associated with the leachate treatment. Operational costs are expected to be $0.11 million (2018 dollars) annually over the 75 year lifecycle. These costs are likely to include one additional part-time operator for the summer months, fuel, maintenance and other miscellaneous costs. In addition, major capital replacements valued at $0.25 million (2018 dollars) are anticipated at years 25, 50 and 75.

Capital costs associated with the pump and hauling of leachate to the City's WWTP would initially include a pre-treatment plant, a retention structure, and vehicles for the hauling of waste. Total capital costs are anticipated to be $2.18 million. Capital costs are likely to be spent beyond the local economy, as the manufacturing required for these buildings does not take place in Iqaluit. Operational costs are likely to include the maintenance of existing equipment, chemical consumption, labour and fuel. The anticipated labour associated with pre-treatment and hauling of leachate is expected to include one full-time operator and two truck drivers during the summer months. Operational costs are anticipated to be $0.41 million (2018 dollars) annually. In addition, major capital replacements valued at $0.50 million (2018 dollars) are expected to occur in years 20, 40 and 60.

A mechanized treatment plant is anticipated to cost $4.85 million. This includes earthworks, liner, a biological treatment system, a metals treatment system, treatment building and pumping systems. Capital costs are likely to be spent beyond the local economy, as the manufacturing required for these buildings does not take place in Iqaluit. Operational costs associated with the Site would include maintenance, energy, labour and chemicals. In addition to the part-time operator during the winter months, a full-time operator will be required for the summer months. Annually, these costs are anticipated to be $0.51 million (2018 dollars). The operator required for the Site will require specialized skills and is unlikely to be found from beyond the local economy. As this is a seasonal opportunity, it is not certain the operator will permanently relocate to the area and leakage may result as the consumption from this employee could occur externally. Also, major capital replacements valued at $1.20 million (2018 dollars) are expected to occur in years 20, 40 and 60.

As described above the capital and operational costs associated with each alternative will generate economic activity within the local economy. However, the capital and operational costs will vary based on the chosen leachate treatment alternative. Each alternative has varying labour and capital requirements in all phases. Each is also likely to vary in its local content and resulting leakage associated with procuring services and materials from beyond the local economy.

1.5.4 Human Health

Impacts to human health include exposure to untreated leachate (skin/lung/eye exposure and inhalation exposure of possible emissions associated with the leachate treatment), as well as exposure to chemicals used as part of the treatment alternatives. As these two issues represent the primary human health risk associated with leachate treatment, 2 points are allocated to each, with minimizing risks to human health being considered preferable.

The risk to physical exposure of untreated leachate is similar in all treatment alternatives. In each scenario, leachate is pumped from the landfill into a receptacle (whether that is a lagoon or retention structure) and retained for a certain period of time. Human intervention is required to ensure that the pumping system is functioning properly and that the retention structures are holding up. As such, there is the risk of exposure to on-site staff if there are leaks detected. More time is required of staff to ensure proper working condition of equipment for both treatment facility alternatives, thereby increasing the small risk of exposure to untreated leachate. Risks of exposure may be elevated in the pre-treatment approach, due to transfer of leachate from the pre-treatment facility to the municipal WWTP.

Operationally, the use and storage of chemicals poses risks to human health, for those within the exposure zones. Chemical treatment is unnecessary for the lagoon and WTA alternative; therefore, this risk is limited. The pre-treatment facility will use both physical and biological/chemical treatment to prepare leachate for transport to the WWTP. In this scenario, there is a risk related to chemical exposure to staff in the facility. A slightly elevated risk exists for staff operating the full treatment plant, as treatment of leachate is more complex and requires more chemicals.

1.5.5 Indigenous Rights and Interests

Indigenous Rights and Interests may be disturbed by the preferred leachate treatment method, as it will have a physical disturbance on the land. Project lands are identified as lands used for traditional activities. As a result, the presence of leachate treatment will displace areas with the potential for traditional activities.

The physical project footprint of leachate treatment alternatives will remove lands from traditional use. The aerated lagoon and WTA alternative would have the largest project footprint of approximately 2.5 ha. The pre-treatment and haul to the City's WWTP alternative would require approximately 0.5 ha. The on-site mechanical treatment alternative would have a physical project footprint of approximately 0.8 ha.

In addition, nuisance effects near the Site may negatively impact the environmental conditions for traditional activities near the Site. Perceptions of value for these activities could be impacted by these nuisances and disturbances.

1.5.6 Cultural Resources

According to the EXP Physical and Biological Assessment for the Proposed New Landfill Site (2018), "there are no culturally designated or significant heritage features currently identified within the Site. No existing records for archaeological, paleontological or place name records occur on the Site." As a result, the leachate treatment for the project is not anticipated to result in any disruption of cultural heritage resources.

1.5.7 Summary of Socio-economic Impacts

Table 9 presents a summary of the socio-economic costs and benefits. These costs and benefits include:

- **Socio Community**
  - It is unlikely the three leachate treatment alternatives would impact water quality. The aerated lagoon and WTA alternative has the potential to impact water near the Site but it is unlikely to occur. The other alternatives will not impact water quality near the Site. Therefore, 1.5 points are allocated to each alternative.
  - No noticeable air emissions that would qualify as a nuisance are expected from any alternative considered. Therefore, 1.5 points are allocated to each alternative.
  - Odour emissions from the aerated lagoon and WTA alternative and on-site mechanical treatment alternative may be a nuisance to land users southwest of the Site. No noticeable odour emissions that would qualify as a nuisance are expected from the pre-treatment and haul to the City's WWTP alternative. Therefore, 1.5 points are only allocated to the pre-treatment and haul to the City's WWTP alternative.
  - No noticeable noise emissions that would qualify as a nuisance are expected from any alternative considered. Therefore, 1.5 points are allocated to each alternative.
- **Land Uses**
  - None of the alternatives are expected to alter protected areas so each are allocated 2 points.
  - All three alternatives are expected to remove recreation features though the aerated lagoon and WTA is expected to remove more of the existing ski trail. As result, mechanized treatment and pre-treatment and hauling to the City's WWTP receive 1 point, while the aerated lagoon and WTA receives zero (0) points.
  - All three alternatives are located within the proposed transit corridor area. However, the presence of the Site would likely remove this area as accessible for a transit corridor regardless. The corridor is wide and provides other opportunities for the proponent to locate their infrastructure. As result, all three alternatives are awarded 2 points.

  - The visual changes would be most severe in the case of a mechanical treatment plant (0) compared to an aerated lagoon (1 point) or a smaller pre-treatment plant associated with hauling leachate to the City's WWTP (1 point).
- **Economic** – Economic scoring is based on a combination of capital costs, operational spending, labour force requirements and local content. The aerated lagoon and WTA alternative is allocated 2 points, as it is most likely to use local raw materials and contractors, is likely to have some local labour, and a high capital cost. Pre-treatment and hauling to the City's WWTP receives a score of 3 points ,as it will require high operating costs and local labour for the operation of the Site. In addition, some capital costs will be associated with the pre-treatment plant. Mechanical treatment receives 2 points, as it is expected to have a high capital cost and high operations costs. However, the operator is unlikely to be locally sourced based on the skills required and little labour is required for operating the plant. Furthermore, most of significant operating costs, such as chemical and major replacements, are likely to be procured beyond the local area.
- **Human Health** – Impacts to human health include exposure to untreated leachate (skin/lung/eye exposure and inhalation exposure of possible emissions associated with the leachate treatment), as well as exposure to chemicals used as part of the treatment alternatives.
  - Exposure to untreated leachate is a baseline risk in all three of the treatment alternatives, as they all require pumping from the landfill into a retention structure. The nature of treatment for the pre-treatment alternative likely poses the highest risk of all three alternatives, due to the added transportation requirement of partially-treated leachate. Therefore, the lagoon and WTA, and the full treatment alternatives are allocated 2 points each, while the pre-treatment alternative is allocated 1 point.
  - Exposure to chemicals during treatment is a risk to those operating the treatment plants. The lagoon and WTA alterative requires no chemical treatment; therefore, it receives a score of 2 points. The pre-treatment alternative receives a score of 1 point resulting from potential chemical exposure during pre-treatment, while the full treatment alternative receives a score of zero (0) for added risk of chemical exposure due to a more operationally-intense process.
- **Indigenous Rights and Interests** – All three as are equally preferable receiving 4 points as they will remove small areas of territory used for traditional activities and one campsite that could have been used for traditional activities. As the three alternatives remove small portions of territory and only one site (which has not specifically been identified for traditional use), only 1 point is deducted from the maximum of 5 points.
- **Cultural Resources** – All alternatives are equally preferable as no cultural heritage resources are identified in the vicinity. Therefore, no cultural heritage resources will be impacted. Since no cultural heritage impacts are expected to occur, all alternatives are allocated the maximum 3 points.

The overall scoring for the socio-economic is relatively similar. Therefore, considering socio-economic factors, the pre-treatment and haul to the City's WWTP alternative would be the preferable leachate treatment alternative. However, the variance in allocated points is low (range of 3.5). The pre-treatment and haul to the City's WWTP alternative is the most preferred for all socio-economic criteria, except for human health. These results are carried forward to **Section 1.6**.

Table 9: Summary of Socio-economic Costs and Benefits

Criteria	Aerated Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Socio-community (out of 6)	4.5	6	4.5
Land Uses (out of 8)	5	6	5
Economic (out of 4)	2	3	2
Human Health (out of 4)	4	2	2
Indigenous Rights and Interests (out of 5)	4	4	4
Cultural Resources (out of 3)	3	3	3
Total Socio-economic Score (out of 30)	22.5	24	20.5

1.6 Triple Bottom Line Assessment

The Triple Bottom Line Assessment provides the assessment of the environmental, social and financial trade-offs between the three alternatives. This section arbitrates between alternatives by providing overall scores for each alternative. A shown in **Table 10**, *the aerated lagoon and WTA alternative was identified as most preferred based on the financial costs and the environmental criteria*. While this option was not the most preferred socio-economic option, the variance in socio-economic impact dependent on leachate treatment alternative is minor. Considering all criteria, the aerated lagoon and WTA alternative was most preferred for:

- Financial Cost;
- Materials;
- Energy;
- Water;
- Emissions, effluent, waste;
- Transport;
- Human health;
- Indigenous Rights and Interests; and
- Cultural resources.

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Table 10: Triple Bottom Line Assessment

Criteria	Aerated Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Life Cycle Cost ($ million)	24.43	75.16	100.82
Annual Financial Benefits (30%)	29	12	10
Environmental Cost/Benefit Score (40%)	30	18	21
Socio-economic Cost/Benefit Score (30%)	22.5	24	20.5
Overall Score[1]	81.5	54	51.5

Note:

1. The overall score is the sum of the financial, environmental and socio-economic scores.

Conclusion - Dillon recommends the City use an aerated lagoon and WTA leachate treatment system for the Site based on the Triple Bottom Line Assessment for Leachate Treatment Alternatives.

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