TETRA TECH

Landfill Closure

ARWMAS

August 2020

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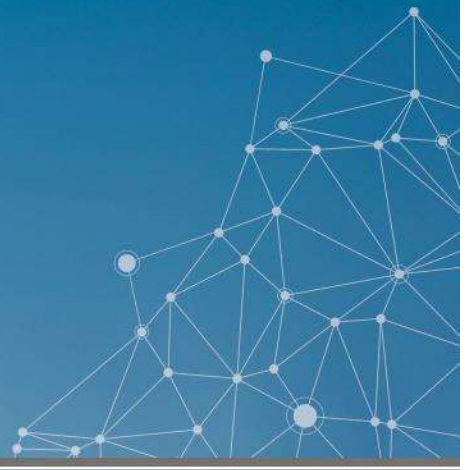
CLOSURE DISCUSSIONS

- What is Final Closure?
- Regulations
- Steps to Implement Final Closure
- Design Considerations
- Cover Systems
- Mystery Detour
- Contaminating Lifespan
- Financial Considerations



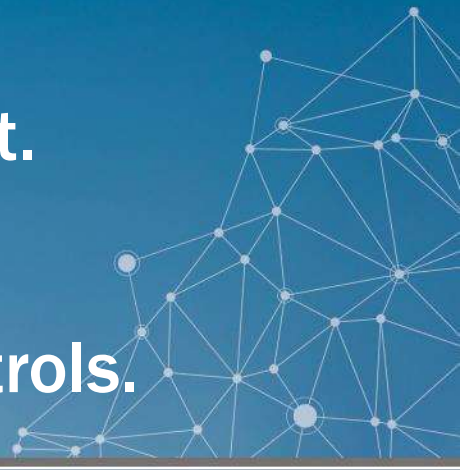
WHAT DOES CLOSURE MEAN?

- Final cover and environmental systems placed on and over the landfill once it stops accepting waste.
- Final cover provides long-term protection against vectors, while reducing infiltration and soil erosion.
- Long-term protection of ground and surface water resources.
- Closure can be final closure of a site or progressive closure of cells at an operating site.

Source: Scientific American

CLOSURE OBJECTIVES

- Minimize post-closure leachate generation (protect environment).
- Minimize post-closure maintenance.
- Allow site to return to some beneficial use as quickly as possible.
- Aesthetics.
- Accommodate for differential settlement.
- Mitigate against risk of fire.
- Monitor performance of engineered controls.

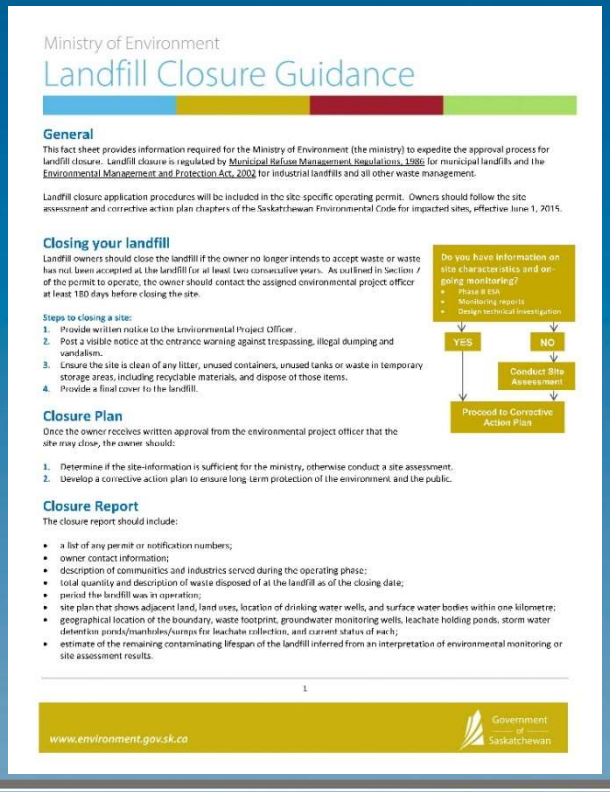


SASKATCHEWAN REGULATIONS

- Environmental Management and Protection Act (2010)
- Municipal Refuse Management Regulation (1986)
- Environmental Code – B.1 Impacted Sites (2015)
  - Site Assessment Chapter
  - Corrective Action Plan Chapter

GUIDELINES

- Saskatchewan Environmental Quality Guidelines (SEQG)
- Landfill Closure Guidance (2015)
- Impacted Sites Guidance (2015)



Ministry of Environment

Landfill Closure Guidance

General

This fact sheet provides information required for the Ministry of Environment (the ministry) to expedite the approval process for landfill closure. Landfill closure is regulated by Municipal Refuse Management Regulations, 1986 for municipal landfills and the Environmental Management and Protection Act, 2002 for industrial landfills and all other waste management.

Landfill closure application procedures will be included in the site specific operating permit. Owners should follow the site assessment and corrective action plan chapters of the Saskatchewan Environmental Code for impacted sites, effective June 1, 2015.

Closing your landfill

Landfill owners should close the landfill if the owner no longer intends to accept waste or waste has not been accepted at the landfill for at least two consecutive years. As outlined in Section 7 of the permit to operate, the owner should contact the assigned environmental project officer at least 180 days before closing the site.

Steps to closing a site:

1. Provide written notice to the Environmental Project Officer.
2. Post a visible notice at the entrance warning against trespassing, illegal dumping and vandalism.
3. Ensure the site is clean of any litter, unused containers, unused tanks or waste in temporary storage areas, including recyclable materials, and dispose of those items.
4. Provide a final cover to the landfill.

Do you have information on site characteristics and on-going monitoring?
- Phase II ESA
- Monitoring reports
- Design technical investigation

YES | NO

Conduct Site Assessment

Proceed to Corrective Action Plan

Closure Plan

Once the owner receives written approval from the environmental project officer that the site may close, the owner should:

1. Determine if the site-information is sufficient for the ministry, otherwise conduct a site assessment.
2. Develop a corrective action plan to ensure long term protection of the environment and the public.

Closure Report

The closure report should include:

- a list of any permit or notification numbers;
- owner contact information;
- description of communities and industries served during the operating phase;
- total quantity and description of waste disposed of at the landfill as of the closing date;
- period the landfill was in operation;
- site plan that shows adjacent land, land uses, location of drinking water wells, and surface water bodies within one kilometre;
- geographical location of the boundary, waste footprint, groundwater monitoring wells, leachate holding ponds, storm water detention ponds/manholes/sumps for leachate collection, and current status of each;
- estimate of the remaining contaminating lifespan of the landfill inferred from an interpretation of environmental monitoring or site assessment results.

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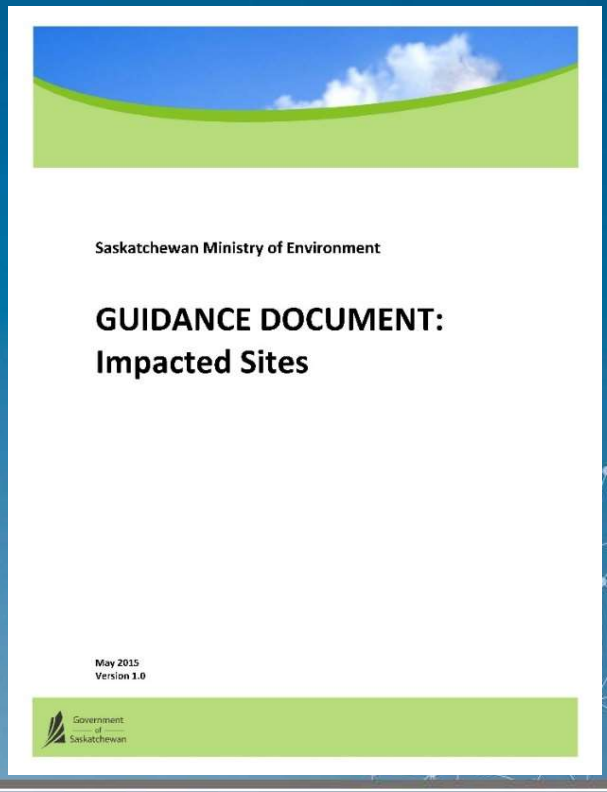
www.environment.gov.sk.ca

Government of Saskatchewan



Saskatchewan Ministry of Environment

GUIDANCE DOCUMENT:
Impacted Sites

May 2015
Version 1.0

Government of Saskatchewan

Permit to Operate

- **Permit to Operate may have requirements for:**
  - Decommissioning and Reclamation Plan; or
  - Closure Plan.
- **This requirement provides for proactive planning for future closure of cells and sites.**

Municipal Refuse Management Regulation

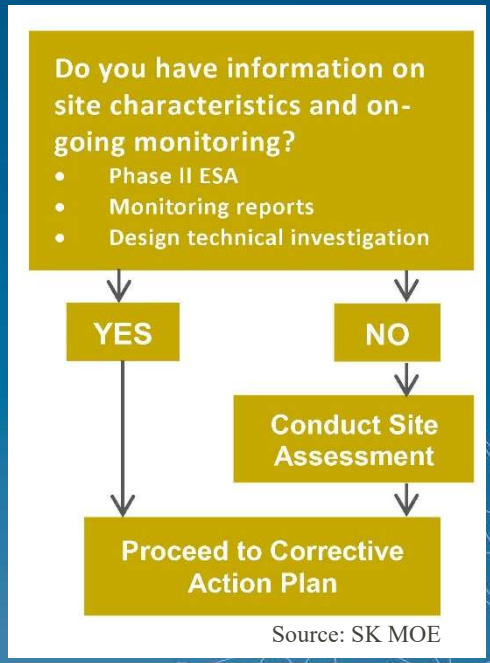
Submission of proposal and approvals required to close landfill.

- Outline steps to be taken to protect the environment.

Ministry of Environment sets terms and conditions to carry out landfill closure, dependant upon site sensitivity.

Saskatchewan Environmental Code B.1 Environmentally Impacted Sites

- **Site Assessment**
  - Evaluation of the environmental condition of the site.
    - Establishing if contaminants are present
    - Understand the affects on the environment
    - Evaluation of risk to environment and human receptors.
- **Corrective Action Plan (CAP)**
  - Document that proposes remedial strategies to address identified environmental impacts at the site.
  - The CAP will form the basis of the Closure Plan.
  - Adaptive to site specific conditions!!



Source: SK MOE

STEPS TO FINAL CLOSURE

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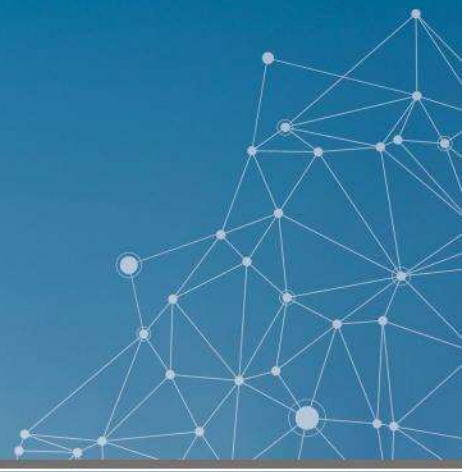
Notification	• Provide Notification to Ministry of Environment of Intent to Close the Landfill Site
Stop Accepting Waste	• Site Closure - buys time to implement the below steps.
Site Assessment & Corrective Action Plan	• Characterization of Site. Delineate extent of contamination. Propose remedial strategy.
Closure Plan	• Landfill owner submits a Proposal to Ministry of Environment, outlining the steps which will be taken in closing the landfill to protect the environment. • Environmental Monitoring Plan.
Approvals	• Obtain approval for closure prior to undertaking closure activities.
Detailed Design	• Design and construction. • Closure Report.
Post-Closure Plan	• Typically developed after closure design.
Post-Closure Monitoring	• Environmental control system performance monitoring and closure system maintenance.

CLOSURE PLAN

- Report years site in operation and quantity of waste in place.
- Schedule for completion of closure works.
- Identify site sensitivity / receptors.
- Site cleanup.
- Address storm water, leachate, landfill gas, and erosion control measures.
- Final contours and cover system design concept.
- Buffer zones and compliance boundaries.
- Water balance / long term-leachate generation.
- Decommissioning of facilities.
- Estimation of contaminating lifespan.



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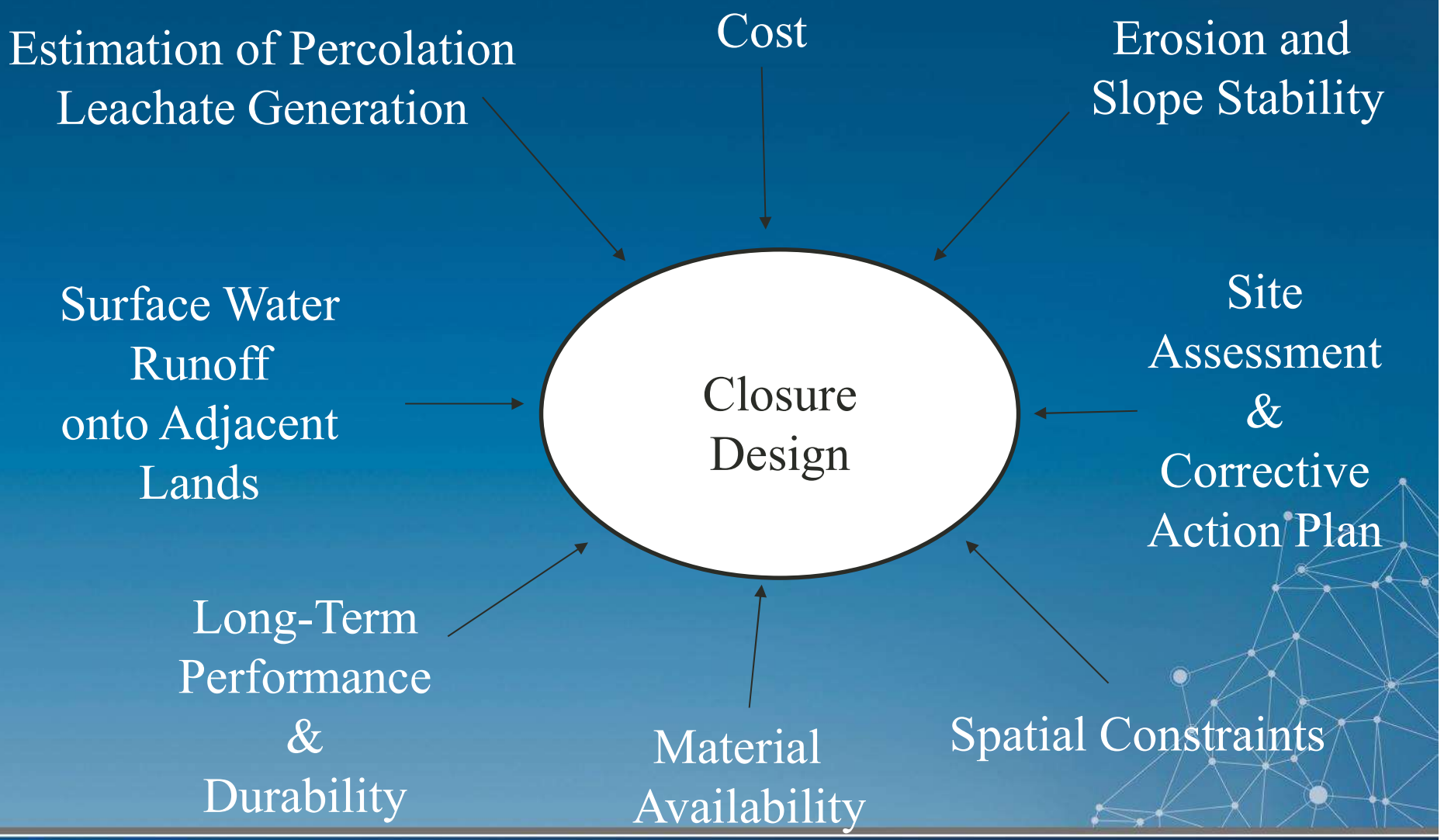
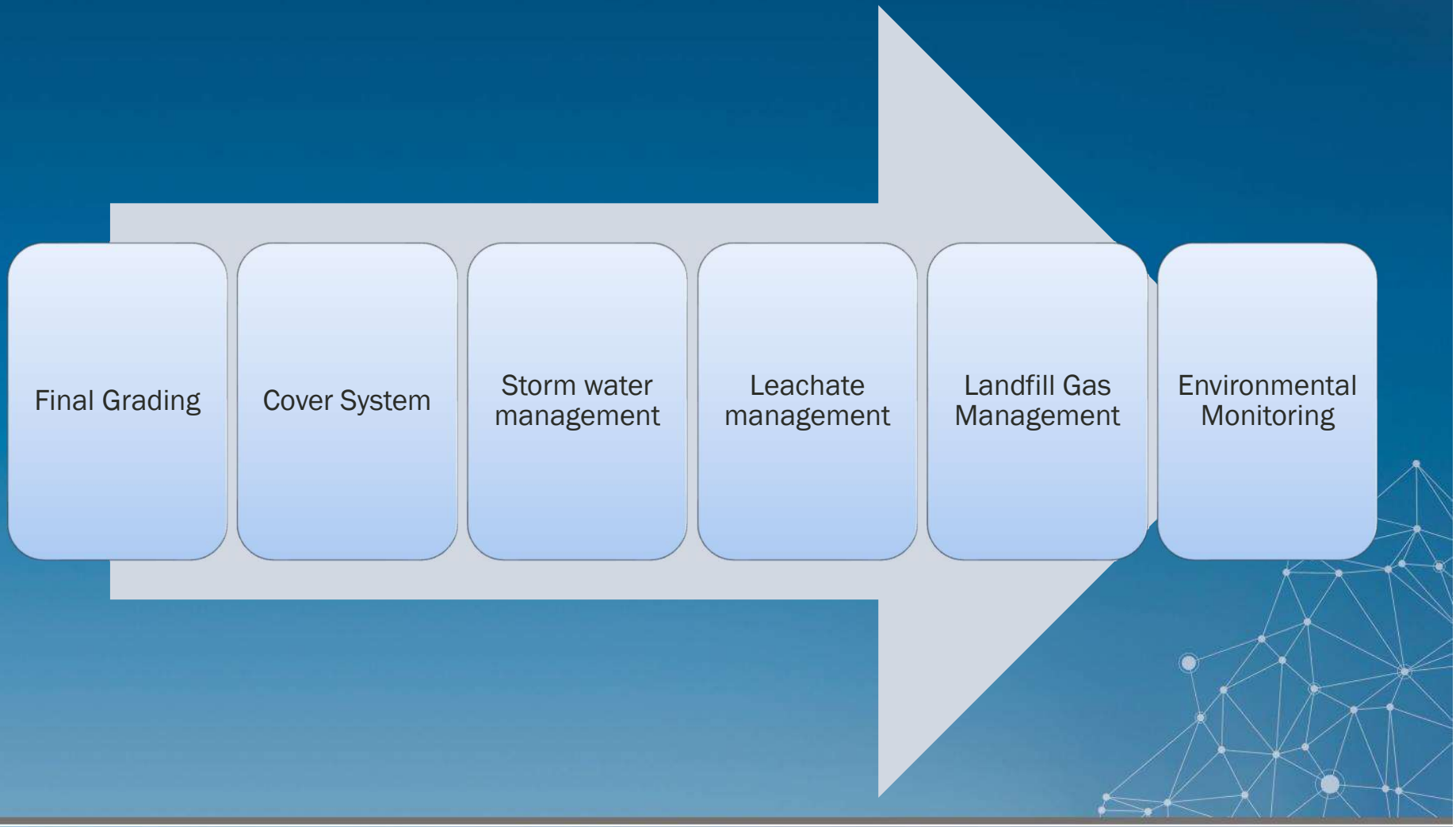
CLOSURE DESIGN CONSIDERATIONS



COMPONENTS OF CLOSURE SYSTEM



FINAL GRADING

- Final grading a key component in landfill closure often not given its due.
- Slopes typically between 5 and 33 percent.
- Settlement of 10 percent (or more) of total waste height should be expected for MSW. Differential settlement common.
- Crest slope critical.
- Drainage from slopes.

TYPES OF COVER SYSTEMS

- Numerous types of landfill cover systems have been developed.
- Suitable cover system options are site specific based upon factors such as:
  - Regulations
  - Native Soils
  - Climate
  - Env. Sensitivity
  - Expertise

ROLES OF COVER SYSTEM COMPONENTS

- Vegetative Cover – reduces infiltration, wind erosion, and improves slope stability.
- Filter Layer – Prevents sifting of cover soil into drainage layer.
- Drainage Layer – provides conduit for water to exist cover system.
- Barrier Layer – minimizes infiltration through cover, barrier for vectors, and odour control.

CLAY COVER SYSTEMS

Advantages

- Readily constructible.
- Low capital cost (if suitable material available)
- Approvals well defined.

Disadvantages

- Susceptible to shrinkage cracking and/or freeze/thaw cycles.
- Typically higher permeability than base liner.
- May be susceptible to damage from differential settlement.
- May not be available locally trucking can be costly.

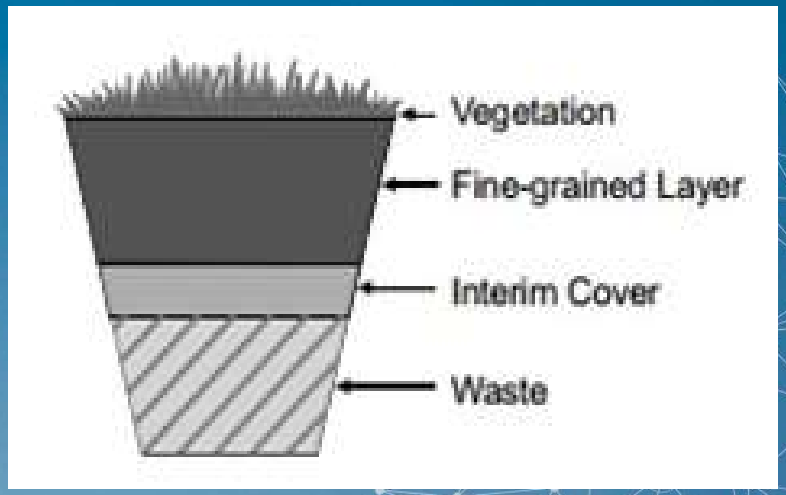
EVOPOTRANSPIRATION (ET) COVERS

Advantages

- Suitable for semi-arid environments.
- Not significantly impacted by drying or freeze/thaw cycles.
- May be more effective than compacted clay covers.
- Material may be available locally

Disadvantages

- Design and regulatory approvals more intensive.
- Climatic specific.
- Suitable soils required.



COMPOSITE COVER SYSTEMS

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Advantages

- Excellent performance with very low infiltration rates possible.
- Suitable for high sensitivity.
- Not affected by freeze/thaw or drying.
- Decreased profile depth.

Disadvantages

- May have higher capital costs relative to clay.
- Design and regulatory approvals may be more intensive.
- Require specialized installation and QA/QC.


DETOUR

New Kid in Town!!

ETLBC!!

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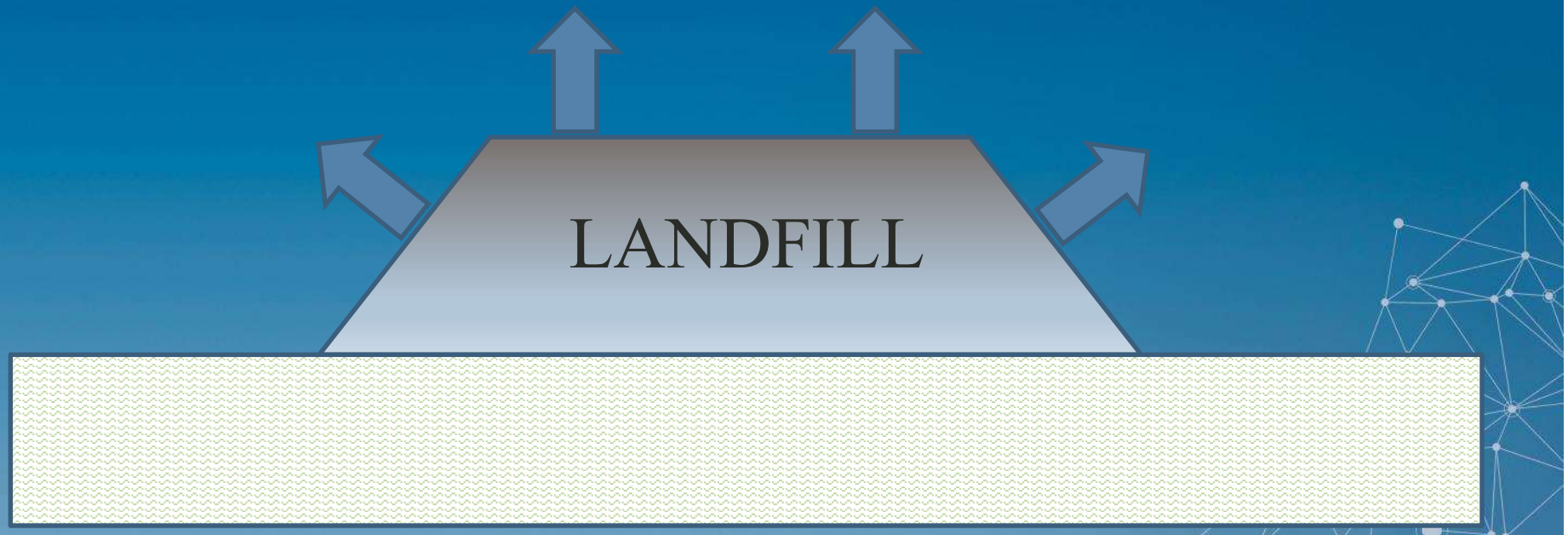
Methane is a Potent GHG with Global Warming Potential

Methane 25x CO_2

LANDFILL GAS

Carbon Dioxide



What is an Evapotranspiration Landfill Biocover?

Evapotranspiration Cover Systems

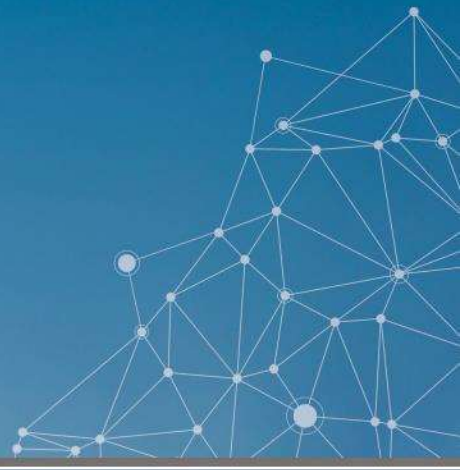
- Store moisture in soil - evaporation and transpiration
- Effective at limiting infiltration and leachate generation

Methane Oxidation

- Naturally occurring, aerobic organisms
- Methanotrophs convert CH_4 to CO_2

ET Biocover Closure

- Suitable to semi-arid regions.
- Acts like a sponge to store moisture.
- Can outperform clay caps is suitable environments.
- Provides a suitable habitat for bacteria to convert methane to carbon dioxide.



Hat-Trick!

1. Organics diversion
2. Use for previously landfilled by-product
3. Reduced emissions

1. Organics Diversion

- Composting programs
- Reduce LFG emissions
- Reduce settlement, increase airspace opportunity

2. Previously Landfilled Byproduct

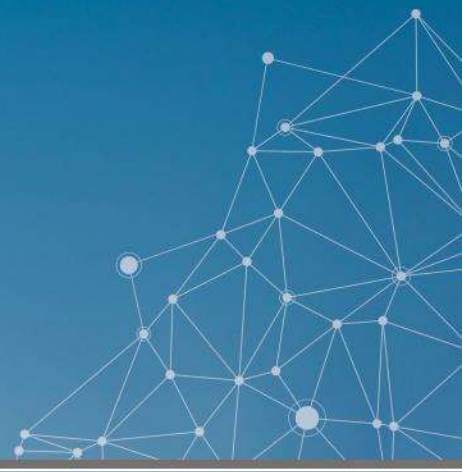
- Screenings from compost are typically landfilled
- Opportunity to use as soil amendment
- Nutrient supplement for methanotrophs

3. Reduced GHG Emissions

- Methanotrophic oxidation of methane
- Reduced GHG fugitive emissions

How does the ET Biocover compare to a conventional cover?

- **Materials used**
  - Fine grained soil and compost
  - Soil requirements not as stringent as with clay
- **Material sourcing**
  - Much wider selection of soils available
- **Ease of installation**
  - No compaction required as with clay barrier layer
  - Less material testing
- **Grading**
  - Use the same grades as clay or geomembrane cover




AND NOW BACK TO
OUR REGULARLY
SCHEDULED
PROGRAMMING

STORMWATER MANAGEMENT

- Manage, at a minimum the 1:25 year event. May be required to manage the 1:100 year event depending on site conditions and receptors.
- Balancing Act: Preserve hydrologic cycle and getting storm water off limit of waste area ASAP.
- Ongoing maintenance and inspection.

LEACHATE MANAGEMENT

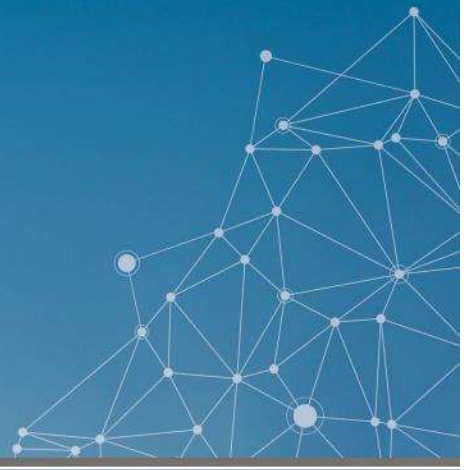
- Leachate Management ranges from natural attenuation to active treatment.
- Active treatment range from on-site treatment, wetlands, to pumping via force main to off-site treatment facility.

ENVIRONMENTAL MONITORING

- Monitoring performance of environmental controls, and closure systems.
- Groundwater
- Surface water
- Soil gas

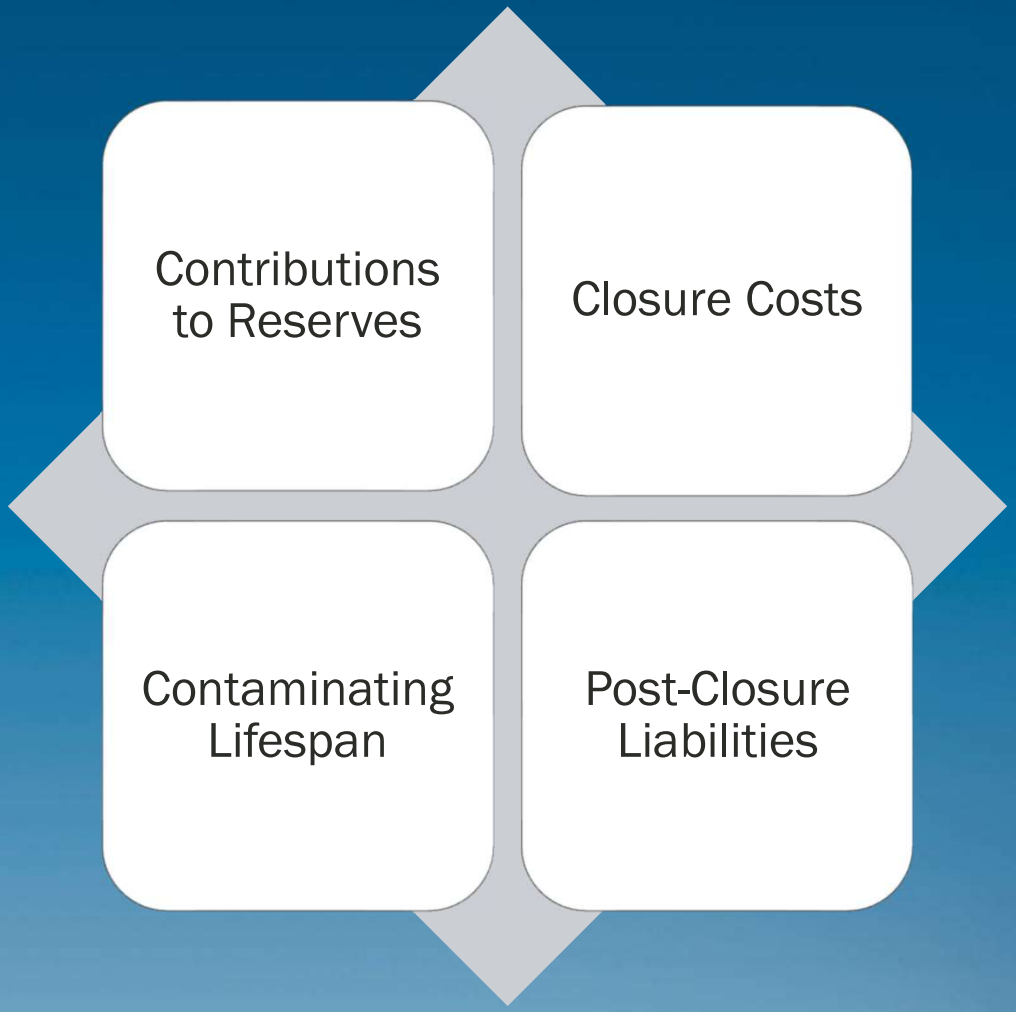
POST-CLOSURE PLAN

- Address long-term site inspection, monitoring and maintenance.
- Address post-closure reporting and record keeping requirements.
- Ongoing post-closure care through “Contaminating Lifespan” of site.



Financial Considerations

FINANCIAL CONSIDERATIONS



ELEMENTS OF POST CLOSURE CARE

Final Cover System	Storm water management	Leachate Management	Landfill Gas Management	Environmental Monitoring
• Erosion control • Mowing and Overseeding • Invasive Species	• Ditch maintenance • Pond dredging • Damage due to large storm events	• Leachate treatment and disposal • Maintenance, flushing and inspection	• LFG collection system operations, maintenance. • Equipment replacement.	• Groundwater • Surface water • Soil gas

CONTAMINATING LIFESPAN

- **How long before I can walk away from a landfill site?**
- **Termination of post-closure care when:**
  - Contaminants of concern do not exceed background concentrations.
  - Waste stabilization.
- **Landfill contaminating lifespan site-specific and can be significantly longer than 25 years.**

The Big Question – "will closure / post-closure reserve funds cover long-term liabilities?"

So…..How Much??

- $10-25 pre square metre for ET or ETLBC cover when materials readily available.
- $15-35 per square meter for compacted clay cover systems when materials readily available.
- $30-50 pre square metre for ET or ETLBC cover when materials not readily available.
- $35-50 per square meter for compacted clay covers systems when material scarce.
- $50-75 per square meter for geosynthetic composite covers for high sensitivity areas where “entombment” is required.

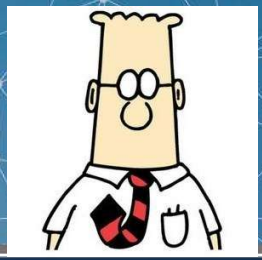
CLOSURE / POST-CLOSURE RESERVES

Planning for landfill closure is a lot like planning for your retirement!!

- Start early.
- Be conservative with length of contaminating lifespan.
- Account for closure, post-closure activities, and a contingency fund to replace the hot water tank and roof.

How much to stash away per year into a reserve fund?

- Life cycle cost analysis.
- Talk to your financial Advisor (or friendly neighborhood Engineer)



"RULE OF THUMB" STUFF

If all else fails....

- $4 to $6 per tonne is a good place to start, depending upon size of site and time until closure.
- Post-closure monitoring & reporting : $20,000 to $50,000.
- Post-closure maintenance: $10,000+
- Leachate management and disposal – current unit costs.

CLOSURE EXAMPLE

- Rural attenuation (unlined) landfill.
- Low sensitivity.
- Existing GW monitoring wells (3).
- No storm water infrastructure.
- Closure area of 1.2 hectares (3 acres).
- Topsoil stockpiled on site.
- Readily available clay barrier soil.
- Some regrading required to achieve 3H:1V (33 percent) slopes.

CLOSURE COSTS

Item	Description	Unit	Approx. Quantity	Unit Price	Total Price
Administration and Execution Requirements	Bonds, Insurance, Mobilization, Demobilization, Temporary Controls and Closeout (15%)				$53,025
Closure / Reclamation	Grading	Cubic Metre	1,500	$15	$22,500
	Final Cover / Reclamation - supply, place, compact, grade, and seed	Square Metre	12,000	$25	$300,000
Stormwater	Ditching	Liner Metre	400	$40	$16,000
	Stormwater Pond	Lump Sum			$15,000
				Subtotal	$375,525
				Engineering and Approvals (10%)	$37,553
				Total (Excluding GST)	$413,078

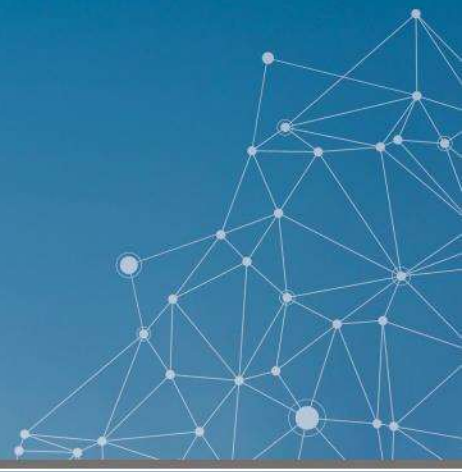
*Approx. 75% of closure costs are cover material and placement

POST CLOSURE LIABILITIES

Description	Annual Costs
Environmental Monitoring (3 wells, bi-annual)	$14,000
Final Cover Maintenance	$5,000
Stormwater Management Maintenance	$5,000
General Maintenance Reserve	$5,000
Total (Per Year)	**$29,000**

Financial Analysis Summary

- **Based upon 25 year post closure liabilities**
  - Total Cost: $1.1M
  - Net Present Value:
    - Discount Interest Rate: 3.5%
    - Inflation Rate: 2.0%
    - NPV: $995,000
- **Based upon 50 year post closure liabilities**
  - Total Cost: $1.8M
  - Net Present Value:
    - Discount Interest Rate: 3.5%
    - Inflation Rate: 2.0%
    - NPV: $1.4M



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SWANA

Northern Lights Chapter