PAPER 17

BLUEPRINTS REIMAGINED: PRESERVING MUNICIPAL LANDFILL AIRSPACE AS A STRATEGIC INFRASTRUCTURE ASSET – WHY THE CHEAPEST TENDER OFTEN CREATES THE MOST EXPENSIVE LANDFILL

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ABSTRACT

Modern municipal engineering often falls into the trap of viewing landfill management through a narrow lens of immediate disposal, overlooking the looming financial liabilities of site closure and post-closure rehabilitation. This paper argues for a transition away from a revenue-centric "gate fee" model toward a strategy of Optimal Operating Costs. By reimagining the landfill blueprint as a managed asset, municipalities can prioritize targeted operational spending to mitigate long-term fiscal and environmental risks.

Central to this approach is the effective management of landfill airspace. (*Airspace meaning the remaining engineered volume within a landfill that is available for the safe disposal of waste*). As the landfill's most valuable and finite asset, every cubic metre of airspace can only be used once. Its preservation depends on sound engineering design and operational practices, including efficient waste compaction, disciplined cell development, and appropriate cover application, in accordance with the principles contained in South Africa's National Norms and Standards for Disposal of Waste to Landfill (GN R636 of 2013) and the Minimum Requirements for Waste Disposal by Landfill (DWAF, 2nd Edition, 1998).

The core of "judicious" management lies in understanding that sub-optimal spending today creates exponential costs tomorrow. Many municipalities fail to account for the true cost of airspace depletion. Every cubic meter lost to poor compaction or inefficient cell design—often the result of hiring incompetent contractors under the "cheapest price" principle—is a direct hit to the municipal balance sheet. Furthermore, the cost of remediating groundwater contamination caused by substandard daily operations far exceeds the initial investment in technical integrity.

Prioritizing optimal operation from "day one" offers three critical risk-mitigation advantages:

- Airspace Preservation: Using professional-grade plant and skilled operators to maximize the lifespan of the existing site, deferring the massive capital cost of new land acquisition.
- Liability Smoothing: Implementing phased, incremental rehabilitation to avoid the "financial cliff" of a lump-sum closure liability that many municipalities cannot afford.
- Environmental Shielding: Maintaining rigorous technical standards to protect the Accounting Officer from the legal and financial consequences of non-compliance and water source contamination.

This presentation challenges municipal leaders to shift focus from "waste burial" to strategic risk mitigation. By optimizing daily operating expenditures, municipalities can transition from managing an environmental burden to overseeing a stable, compliant infrastructure asset.

INTRODUCTION

For decades, municipal landfill facilities have been viewed primarily as waste disposal sites. Success has traditionally been measured through waste tonnages received, regulatory compliance and annual operating expenditure. While these indicators remain important, they fail to recognise the true value of landfill infrastructure and the growing financial risks associated with diminishing disposal capacity, increasing environmental obligations and long-term closure liabilities.

South African municipalities face increasing pressure from rising waste generation rates, ageing infrastructure, stricter environmental regulation and constrained capital budgets. Simultaneously, the development of new landfill infrastructure has become increasingly expensive due to more stringent engineering standards, environmental authorisations, groundwater protection requirements and post-closure obligations.

Historically, landfill management focused on the efficient burial of waste. Modern landfill economics require a fundamental shift in thinking. The most valuable component of a landfill is not the waste it receives, but the airspace it preserves.

Unlike many other forms of municipal infrastructure, landfill airspace is finite and cannot easily be replaced once exhausted. Additional capacity typically requires significant capital investment, extensive environmental approvals and lengthy implementation periods. Every operational decision therefore influences not only current landfill performance, but also future municipal expenditure, environmental liability and infrastructure resilience.

This paper argues that municipal landfills should be managed as strategic infrastructure assets and that landfill airspace should be regarded as a measurable municipal resource requiring active preservation. Operational decisions, procurement approaches and diversion initiatives should therefore be evaluated according to their ability to preserve airspace, extend landfill lifespan, reduce future liabilities and defer capital expenditure.

The paper further demonstrates that the lowest-cost landfill operation may not necessarily represent the lowest-cost landfill solution when lifecycle infrastructure value, closure liabilities and future replacement disposal costs are considered.

THE HIDDEN MUNICIPAL ASSET: AIRSPACE

Airspace as Infrastructure Capacity

Every landfill contains a finite volume of authorised disposal capacity. This airspace represents a strategic infrastructure asset that is progressively consumed throughout the operational life of the facility.

Municipal infrastructure assets are generally valued according to the service capacity they provide. Reservoirs provide storage capacity, wastewater treatment works provide treatment capacity, and road networks provide transport capacity. Similarly, landfill facilities provide disposal capacity in the form of authorised airspace. Consistent with the principles of GRAP 17

(Accounting Standards Board, 2021) and the National Treasury Municipal Asset Management Guideline (National Treasury, 2021), landfill airspace should be managed as an infrastructure asset based on the service potential it provides, rather than solely as a remaining physical volume. This approach aligns asset management decisions with long-term service delivery, lifecycle costing, and financial sustainability

TABLE 1: *Municipal Infrastructure Capacity Metrics*

Infrastructure Asset	Capacity Metric
Dam or Reservoir	Storage Volume
Wastewater Treatment Works	Treatment Capacity
Road Network	Traffic Carrying Capacity
Landfill Facility	Airspace Capacity

Unlike many other municipal assets, landfill airspace cannot easily be expanded once exhausted. Additional disposal capacity typically requires environmental authorisation, engineering design, specialist construction, public participation processes and significant capital investment.

The preservation of landfill airspace therefore creates measurable municipal value by extending facility lifespan, deferring future capital expenditure and reducing exposure to replacement disposal costs.

Airspace Loss as Asset Depreciation

The consumption of landfill airspace is unavoidable. However, the rate at which airspace is consumed is heavily influenced by operational performance.

Practices that accelerate airspace depletion include:

- Inadequate waste compaction.
- Excessive cover material utilisation.
- Poor cell planning.
- Inefficient waste placement.
- Failure to divert suitable waste streams.
- Uncontrolled working face management.

Each of these factors reduces the quantity of waste that can be accommodated within the authorised disposal footprint.

From an infrastructure management perspective, unnecessary airspace consumption should be regarded as a form of asset depreciation. Every cubic metre of airspace lost through poor operational practices represents a permanent reduction in municipal infrastructure capacity and may accelerate the need for costly replacement disposal infrastructure.

Airspace Creation Value

The cost of creating engineered landfill airspace has increased significantly due to increasingly stringent environmental and engineering requirements. Under the norms and standards for disposal to landfill (GNR 636) landfills are classified based on the level of environmental risk.

Class A: High Risk

Class B: Moderate Risk.

Class C: Low Risk

Class D: Minimal Risk.

TABLE 2: *Airspace Creation Cost Benchmarks (2024-2026)*

Facility	Capital Cost (R million)	Airspace Capacity (m^3)	Cost per m^3
Facility A	115.0	1.25 million	R92/m^3
Facility B	47.5	545 000	R87/m^3
Facility C	110.0	1.1 million	R100/m^3
Facility D	93.97	271 000	R347/m^3

This paper is focused on Class B landfills for municipal solid waste.

The benchmark data indicates that the cost of developing engineered landfill airspace ranges between approximately R92/m^3 and R347/m^3 depending on site-specific conditions, scale and engineering requirements and infrastructure.

For strategic planning purposes, an indicative creation value of approximately R150/m^3 may be adopted as a representative benchmark.

Airspace Asset Management Framework

The primary service provided by a landfill is authorised disposal capacity in the form of landfill airspace. The preservation of this capacity should therefore become a primary asset management objective.

An Airspace Asset Management Framework is proposed whereby landfill performance is evaluated according to its ability to:

- Preserve authorised airspace.
- Extend landfill lifespan.
- Delay future capital expenditure.
- Reduce closure liability growth.
- Defer replacement disposal costs.
- Improve municipal resilience.

This framework positions landfill management within conventional municipal infrastructure asset management practice rather than solely within waste management operations.

AIRSPACE LIFECYCLE VALUE

Beyond Construction Cost

The value of landfill airspace extends beyond the capital cost required to create disposal capacity. Every cubic metre consumed also contributes towards future closure and rehabilitation obligations.

Historically, landfill infrastructure has often been evaluated solely in terms of development and operating costs. Modern municipal accounting standards and environmental regulations require a broader perspective that incorporates future rehabilitation liabilities and post-closure obligations.

Closure Liability Allocation

A recent closure cost estimate prepared for a Class B-lined municipal landfill with approximately 3.5 million m^3 of authorised airspace estimated a final capping obligation of approximately R84.9 million.

When allocated across the authorised disposal capacity:

R84.93 million ÷ 3.5 million m^3 = R24.27/m^3

This indicates that every cubic metre of landfill airspace consumed carries an associated future closure liability of approximately R24/m^3 before consideration of post-closure groundwater monitoring, leachate management, landfill gas management and long-term environmental maintenance requirements.

Airspace Lifecycle Value

Every cubic metre of airspace consumed therefore carries both an infrastructure value and a future rehabilitation obligation.

TABLE 3: *Airspace lifecycle value model*

Component	Value
Airspace Creation Value	R150/m^3
Closure Liability Allocation	R24/m^3
Airspace Lifecycle Value	R174/m^3

Airspace Asset Value

A landfill with 96 604 m^3 of remaining authorised airspace possesses an indicative airspace asset value of:

96 604 m^3 × R174/m^3 = R16.81 million

If poor operational practices result in the unnecessary loss of 15% of the remaining airspace:

14 491 m^3 × R174/m^3 = R2.52 million of municipal infrastructure value destroyed.

This illustrates how operational decisions directly influence municipal infrastructure value and future financial exposure.

Strategic Airspace Replacement Value

While Airspace Lifecycle Value represents the historic cost of creating and closing landfill capacity, municipalities approaching landfill exhaustion face a different economic reality.

Where municipalities become dependent on a Metropolitan-area regional landfill facility, disposal costs may exceed R750/t. At a representative landfill density of approximately 950 kg/m^3 this equates to approximately R713/m^3.

This Strategic Airspace Replacement Value substantially exceeds the historic lifecycle value of the airspace itself and becomes increasingly important as landfill capacity declines.

THE CHEAPEST TENDER PARADOX

Lowest Cost versus Lowest Lifecycle Cost

Municipal procurement systems are designed to promote transparency, competitiveness and value for money. However, landfill operating contracts are frequently evaluated and awarded based primarily on annual operating expenditure rather than total lifecycle cost.

The true lifecycle cost of landfill disposal extends far beyond the annual operating contract and includes:

Lifecycle Landfill Cost = Operating Cost + Airspace Value Destroyed + Closure Liability Growth + Future Disposal Replacement Cost + Deferred Capital Requirements

Traditional procurement approaches frequently compare only operating expenditure while overlooking the remaining cost drivers.

Consequently, the cheapest operating contract may ultimately become the most expensive landfill solution. This approach is consistent with the Local Government: Municipal Finance Management Act *(Act No. 56 of 2003)*, which requires municipalities to utilise public resources effectively, efficiently and economically, ensuring that decisions deliver value for money across the full lifecycle of municipal infrastructure rather than focusing solely on the lowest initial cost.

OPERATIONAL PERFORMANCE AND AIRSPACE PRESERVATION

The Importance of Density

Landfill density is one of the most important indicators of operational efficiency.

Higher waste densities allow greater quantities of waste to be accommodated within the same authorised disposal volume, thereby extending landfill lifespan and delaying future capital expenditure. Conversely, poor compaction accelerates airspace consumption and reduces the useful life of the facility.

Measured density data from four municipal landfill facilities operating under South African conditions demonstrates the significant variation that can be achieved through operational management.

TABLE 4: *Measured Density Benchmarks*

Facility	Average Density
Facility A	924 kg/m^3
Facility B	980 kg/m^3
Facility C	1 050 kg/m^3
Facility D	1 100 kg/m^3

These densities were achieved using 28-ton landfill compactors under normal South African operating conditions.

Airspace Preservation Through Improved Density

To illustrate the practical impact of operational performance, consider a landfill receiving 100 000 tonnes of waste.

At a density of 924 kg/m^3:

100 000 ÷ 0.924 = 108 225 m^3 consumed.

At a density of 1 100 kg/m^3:

100 000 ÷ 1.100 = 90 909 m^3 consumed.

Difference:

17 316 m^3 preserved.

Using an Airspace Lifecycle Value of R174/m^3:

17 316 × R174 = R3.01 million of infrastructure value preserved.

Strategic Replacement Cost Perspective

The economic significance of airspace preservation becomes even more apparent when future replacement disposal costs are considered.

Where municipalities exhaust available landfill capacity and become dependent on external disposal facilities, disposal costs may exceed R750/t.

At an average landfill density of approximately 950 kg/m^3 this equates to approximately R713/m^3.

Using the previous density example:

17 316 m^3 × R713 = R12.35 million of future replacement disposal costs potentially avoided.

This demonstrates that landfill operations should be viewed not merely as waste management activities but as infrastructure preservation interventions.

TABLE 5*: Density Improvement and Asset Preservation Example*

Density	Airspace Consumed
924 kg/m^3	108 225 m^3
1 100 kg/m^3	90 909 m^3
Difference	17 316 m^3

Preserved Asset Value: R3.01 million

Avoided Future Disposal Cost: R12.35 million.

CLOSURE SHOCK AND GRAP 19

The Growing Cost of Landfill Closure

The closure of a modern landfill facility extends far beyond the placement of final cover.

Closure obligations typically include:

- Engineered capping systems.

- Stormwater infrastructure.
- Leachate management systems.
- Landfill gas management.
- Groundwater monitoring.
- Environmental auditing and reporting.
- Long-term maintenance and monitoring.

Many of these obligations continue for decades after waste disposal operations have ceased.

GRAP 19 and Municipal Financial Exposure

GRAP 19 requires municipalities to recognise future rehabilitation and closure obligations as financial provisions.

This means landfill liabilities begin accumulating from the day waste is deposited.

Every tonne of waste received therefore contributes not only to airspace consumption but also to future financial obligations.

Many municipalities continue to underestimate the scale of these liabilities, creating significant long-term financial exposure.

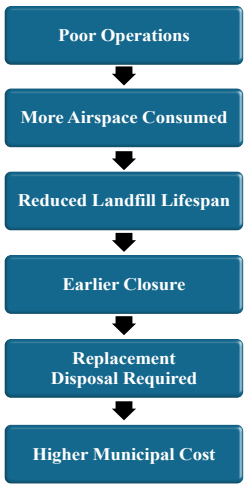


FIGURE 1: *The Airspace Value Chain*

Closure Shock

Premature airspace depletion creates a cascading series of financial consequences.

This sequence may be described as "*Closure Shock*".

Closure Shock occurs when municipalities simultaneously face:

- Closure expenditure.
- Rehabilitation obligations.
- Development of replacement infrastructure.
- Increased disposal tariffs.
- Long-term monitoring obligations.

Closure Liability as an Operational Consideration

Traditionally, closure liabilities have been viewed as future environmental obligations. This paper argues that they should also be viewed as operational considerations.

Every operational decision that preserves landfill airspace delays the timing of closure expenditure, extends infrastructure life and reduces immediate pressure on municipal finances.

CIRCULAR ECONOMY AND AIRSPACE PRESERVATION

Beyond Recycling

Circular economy initiatives are frequently justified on environmental and social grounds. While these benefits remain important, the circular economy also provides a significant infrastructure preservation benefit.

From a municipal asset management perspective, every tonne of material diverted from landfill preserves finite disposal capacity and extends the useful life of existing infrastructure.

Airspace Preservation as Capacity Creation

Disposal capacity can be created through operational and diversion interventions.

Every cubic metre of landfill airspace preserved through:

- improved compaction;
- reduced cover utilisation;
- diversion of recyclable materials;
- recovery of organic waste,

creates additional disposal capacity within the existing facility footprint.

Material Recovery Facilities (MRFs)

Material Recovery Facilities should not be evaluated solely according to:

- Commodity revenues.
- Operating expenditure savings.
- Tonnes diverted.

Their value should also include:

- Airspace preservation.
- Deferred capital expenditure.
- Employment creation.
- Waste picker integration.
- Environmental benefits.
- Municipal resilience.

Consequently, MRFs should be evaluated within a broader circular economy and infrastructure preservation framework.

CAPACITY CREATION HIERARCHY

Rethinking Municipal Capacity Planning

Municipalities facing diminishing landfill capacity have several options available to create additional disposal capacity.

A hierarchy of preferred interventions is proposed (figure 2).

Prioritising Existing Assets

The hierarchy prioritises interventions that maximise the value of existing municipal infrastructure before pursuing capital-intensive replacement options.

The cheapest cubic metre of landfill airspace is often the cubic metre that never needs to be created. **Airspace does not "age" — its cost increases with time and inefficiency.**

Similarly, the cheapest disposal facility is frequently the facility whose lifespan has been extended through effective asset management.

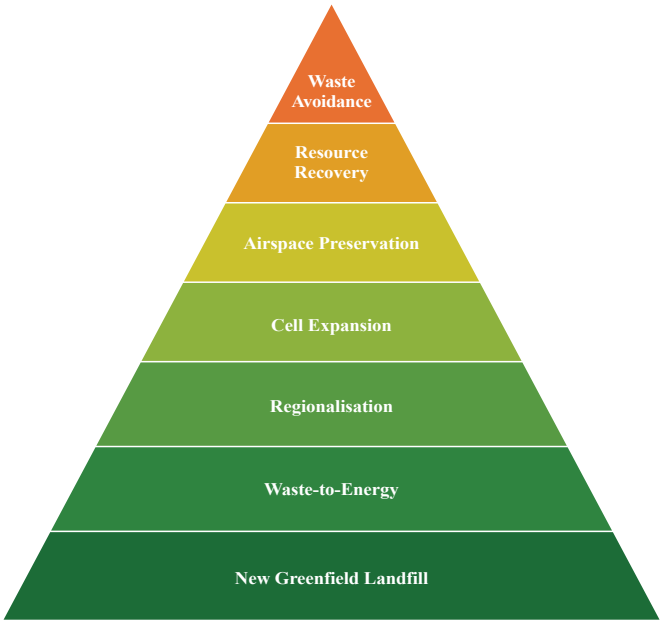


FIGURE 2: *Capacity Creation Hierarchy*

FUTURE DISPOSAL COSTS AND REGIONALISATION

The Cost of Exhausted Airspace

The value of landfill airspace increases significantly as available disposal capacity declines.

For municipalities approaching landfill capacity limits, future disposal may require transportation to regional landfill facilities.

Based on current disposal tariffs at a Metropolitan-area regional landfill facility, disposal costs may exceed R750/t and at waste-to-energy facilities at R1500/t.

At a representative landfill density of approximately 950 kg/m^3 this equates to approximately R713/m^3.

Airspace Lifecycle Value versus Strategic Replacement Value

The Airspace Lifecycle Value represents the cost of creating and ultimately closing landfill capacity.

TABLE 6: *Airspace Value Framework*

Measure	Indicative Value
Airspace Lifecycle Value	R174/m^3
Strategic Replacement Value	R713/m^3

The Strategic Replacement Value represents the cost incurred when that capacity no longer exists and replacement disposal must be sourced elsewhere.

Regionalisation and Municipal Risk

Regionalisation of disposal facilities can offer operational efficiencies and economies of scale.

However, municipalities that become dependent on external disposal facilities may also become exposed to:

- Increasing disposal tariffs.
- Transport cost escalation.
- Reduced disposal flexibility.
- Future capacity constraints.
- External operational risks.

The preservation of existing landfill airspace therefore provides not only an engineering benefit but also a strategic risk mitigation function.

CONCLUSION

Municipal landfill airspace represents one of the most valuable and least recognised infrastructure assets within local government.

The paper demonstrates that landfill airspace possesses measurable creation value, closure liability and strategic replacement value. Operational decisions therefore influence municipal infrastructure value, future financial obligations and long-term service sustainability.

The preservation of landfill airspace delays capital expenditure, extends landfill lifespan, reduces environmental liabilities and improves municipal resilience.

Municipalities often believe they are purchasing waste disposal services. In reality, they are managing one of their most valuable and irreplaceable infrastructure assets.

Every operational decision either preserves or destroys landfill airspace and therefore either protects or erodes long-term municipal value.

Municipalities do not inherit landfill airspace from previous generations; they borrow it from future generations. The way that airspace is managed will determine not only the cost of waste disposal, but also the long-term financial resilience of municipal infrastructure systems.

Ultimately, the cheapest landfill contractor is not necessarily the contractor with the lowest annual operating cost. The contractor is responsible for preserving the maximum quantity of municipal landfill airspace for the longest possible period through innovative solutions.

RECOMMENDATIONS

Municipalities should:

- Recognise landfill airspace as a strategic infrastructure asset.
- Incorporate landfill airspace into municipal asset management frameworks.
- Adopt lifecycle costing methodologies when evaluating landfill performance.
- Include airspace preservation metrics within landfill operating contracts.
- Implement outcome-based contracting models that reward landfill lifespan extension and infrastructure preservation.
- Improve technical oversight of landfill operations and compaction performance.
- Monitor waste density as a key performance indicator.
- Implement progressive rehabilitation programmes to reduce long-term closure risk.
- Evaluate circular economy initiatives as mechanisms for preserving municipal infrastructure capacity.
- Consider future replacement disposal costs when planning landfill capacity and regionalisation strategies.
- Integrate landfill management, financial planning and asset management processes to improve long-term municipal resilience.

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