

## Re-examining the Risks and Environmental Indicators in the Closure Governance of Bauxite Residue Sites in Jamaica

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### Abstract

Building on previous discussions of mineral resources governance as it relates to bauxite residue disposal areas (BRDA's) in Jamaica, re-examining the structure of environmental management in Jamaica is useful to map the ways in which risk assessments are being internalized into the process. Additionally, a review of the environmental indicators relating to environmental risk minimization is considered in the context of the national policies for development and the evolving metrics for environmental governance (for example, water quality impacts, closure planning oversight and community warning systems). The clear advantages of risk minimization through bauxite residue removal for reuse and recovery of constituents will be globally reviewed, however, environmental efficiency costs have to be considered, especially for closed and legacy sites in a small island developing state like Jamaica.

**Keywords:** Bauxite residue management, Environmental governance, Sustainable development goals (SDGs), Risk assessment, Community impacts.

### 1. The Jamaican Context

A full decade before Jamaica's independence in 1962, bauxite mining and refining had commenced in Jamaica. The first operating refinery was started in one of the major bauxite bearing parishes, Manchester, in the centre of the island at Kirkvine, and was owned by Alcan until 2001. Alcan then sold its Jamaica assets to Glencore, excluding several bauxite residue (BR or red mud) sites that were retained by Alcan to be closed. These BR sites were located at Kirkvine and at Ewarton, where their second alumina refinery operated [1].

There are five refinery locations in Jamaica (Figure 1), each with BR sites. Only two refineries currently remain in operation [2] – Jamalco's Clarendon Alumina Works and Windalco's Ewarton Works. JISCO Alpart suspended operations in 2019, and Kirkvine Works has not reopened since 2009 when the operations were halted during the worldwide economic crisis. Revere was closed and decommissioned in 1975; those BR sites have been mapped in Figure 1 but are derelict. The bauxite deposits are geographically located in the five central parishes of the nation, and each refinery had been strategically located to receive and process ore, as well as utilize port operations.

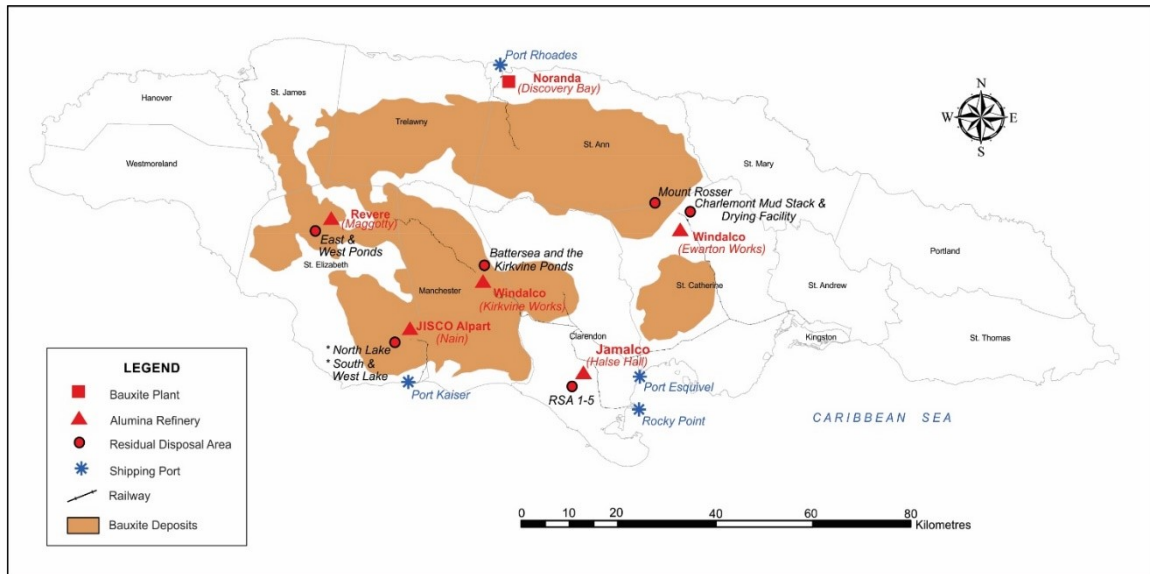


Figure 1. Location of bauxite residue disposal sites in Jamaica [2].

Jamaican bauxites generate approximately 1 tonne of BR per tonne of alumina [2], which closely resembles the global production average of 1.23 tonne of BR per tonne of alumina production [3]. The approximate BR volumes at each Jamaican location are shown in Table 1. In total, this amounts to nearly 150 million tonnes of BR stored in residue areas. Since the volumes were determined in 2022 [2], there has been marginal changes only for Jamalco and Ewarton Works, as the other refineries remain shut down.

Table 1. Current bauxite residue stored in Jamaica.

	Location	Parish	Area (ha)	Volume (Mt)
<b>Kirkvine Works</b>	Kirkvine Ponds and Battersea Mud Disposal Site	Manchester	100 (+ small ponds cumulative area)	22 (+ 3 in old Kirkvine Ponds)
	Mt Rosser Mud Disposal Site	St. Ann/St. Catherine	35	11
<b>Ewarton Works</b>	Charlemont Mud Stack	St. Catherine	100	16
	South/West Lake	St. Elizabeth	220	44
<b>Alpart</b>	North Lake	St. Elizabeth	40	
<b>Jamalco</b>	RSA 1-5	Clarendon	330	51
<b>Revere</b>	East Revere and West Revere Ponds	St. Elizabeth	2	0.6
<b>Total</b>			<b>627</b>	<b>147.6</b>

\*Source: Monitoring Reports, JBI Economics Division, 2024.

The sale of the Alcan asset created an unprecedented situation for closure planning in the Jamaican regulatory landscape. The way the closure plan was developed has been documented previously [1]. The intent of this paper is to reflect on the execution of the project and evaluate the achievements, specifically in relation to the governance and the indicators used.

The unique situation arose from several factors:

- Lack of environmental regulatory framework or policy to address closure plan development, as the Permits and Licences regulations had grandfathered operations in existence pre-1996 [4].
- Some of the BR sites near Kirkvine were mined-out bauxite pits and had received exemptions from the Commissioner of Mines (COM) from requirements under the Mining Act [5].
- The land arrangement between Government of Jamaica (GOJ) and Alcan, i.e. the requirement for relinquishment to the government at the end of use for mining exploitation.
- Absence of defined environmental indicators to meet objectives of closure planning [6].
- Limited globally available experience in closing and remediating BR sites [1].
- The need to convene interested government stakeholders and regulators and facilitate sign-off of the closure plan [7].

The Alcan BR sites at Kirkvine were considered to have met the closure plan objectives and the process of regulatory sign-off in 2015. The Mount Rosser BR site that straddles the St. Catherine/St. Ann parish border remains in the closure phase.

## **2. Environmental Indicators and Environmental Risk Factors for Closure Planning**

There are several target state objectives for the closure of BR sites. These include:

1. Physical and chemical stability of the residue
2. Long term safety and stability containment structures
3. Mitigation of environmental impacts (air and water quality)
4. Ascertaining if there are gaps for vegetation/biodiversity/ecological establishment
5. Considerations for socio-economic aspects and community engagement

This aligns with the structure being used by the Intergovernmental Forum (IGF) [8] and should be contemplated in the development of closure plans. Reviewing the use of the environmental indicators is not separate from addressing environmental risk minimization for the closure planning process. Nonetheless, the regulators administering the system may not understand the link with national development policies and the evolving metrics for environmental governance (for example, water quality impacts, closure planning oversight and community warning systems).

In the case of the closure plan that was developed in 2005, the principal government agency with oversight of the bauxite and alumina industry, the Jamaica Bauxite Institute (JBI), was delegated the responsibility to oversee the development of the closure plan. The JBI, as a government company, has both technical and non-technical functions that includes advisory services to support the Government's regulatory framework [9]. It is important to realize that with the absence of a conceptual plan for relinquishment of land where BR was stored, this closure plan has become the model for the industry. With the added benefit of developing a "topsoil free" method, the Kirkvine site closure became an international best practice cited in the IAI Publication on Bauxite Residue Management in 2013 [10].

The matter of developing robust closure planning – strategically, and more generally, appears to have gained traction in the global mining sector, as this aspect had not been traditionally detailed in company objectives [11].

In 2008, the International Council on Mining and Metals (ICMM) published a toolkit which took a holistic approach to considering closure planning at the outset [11]. This would result in a conceptual approach that becomes more detailed throughout the life of the mine and essentially does not appear as a sudden requirement. The figure 2 below outlines the guidance from the toolkit for development and execution of the closure plan in the mining industry. With the development of the Global Industry Standard on Tailings management (GISTM) in 2020 from the same author [12], this is a logical expansion of the approach, especially considering the catastrophic dam failures in Ajka and Brazil (Samarco and Brumadinho) [12,13]. Notwithstanding the foregoing, the matter of legacy BR sites has its own challenge of not having the luxury of industrial operations that may provide some technical solutions. The approach needs to depend on stand-alone initiatives that address the environmental risk aspects.

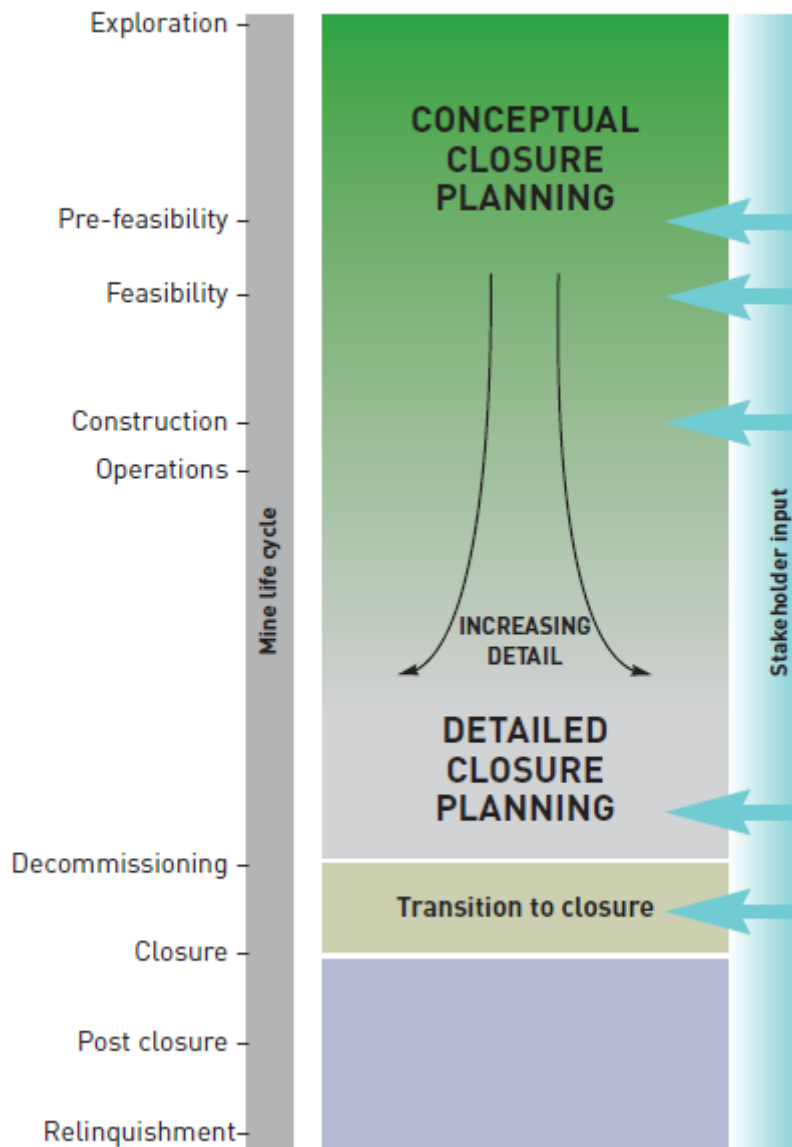


Figure 2. The path from exploration to closure [11].

## 2.1 Is Risk Minimization Achieved?

When examining the BR management framework in Jamaica, dam structural issues, general impacts on aquifers and surface waters, and the potential for large spatial impacts from failures emerge as the major risks from BR sites [2]. By including the activities to mitigate the environmental risks in the closure planning, clear metrics and post closure monitoring are the keys to demonstrating that risk minimization can be achieved.

There is a strong case for risk minimization through BR removal for reuse and recovery of constituents, however, there is a policy conflict for hazardous waste management that may create barriers for utilization [15].

The JBI is addressing the environmental risk aspects in several ways. Firstly, the goals of the closure process and the various approaches become enshrined in the operational manuals (see Figure 3 below) [16].

**Goals of the closure process**

Presently there is a requirement for Closure Planning. However, some of the older sites are legacy sites, which may or may not have had closure plans developed.

- To reprofile, stabilise, treat, vegetate and secure the exposed sites
- To minimise the hazards associated with the bauxite residue by:
  - removing any large body of ponded water
  - reduce the level of leaching into groundwater
  - create a dry and stable surface
  - To meet the agreed goals of the Closure Plan to secure all the sites as aesthetically-attractive areas of biodiversity
- To ensure all legitimate stakeholders are engaged during the process of project planning and implementation
- To seek to minimise negative and maximise positive impacts on local communities

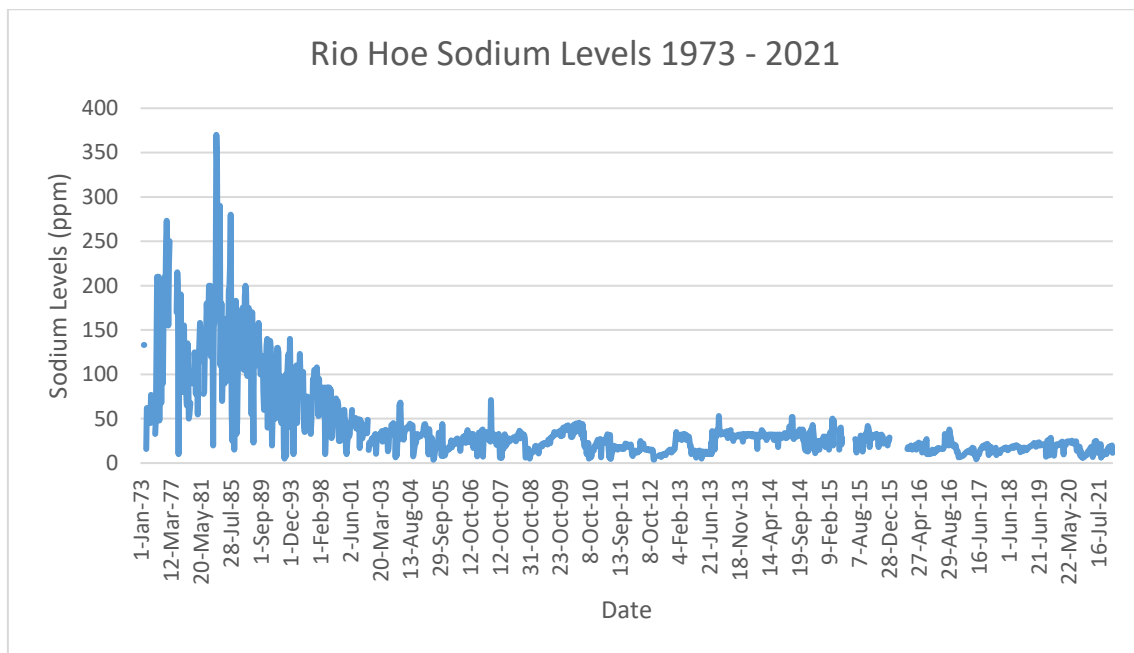
**Figure 3. Goals of closure process for BR sites in Jamaica [16].**

Secondly, strategically this supports the objectives for waste management and water impacts through continually developing the sustainability index criteria for closure of BR sites by considering:

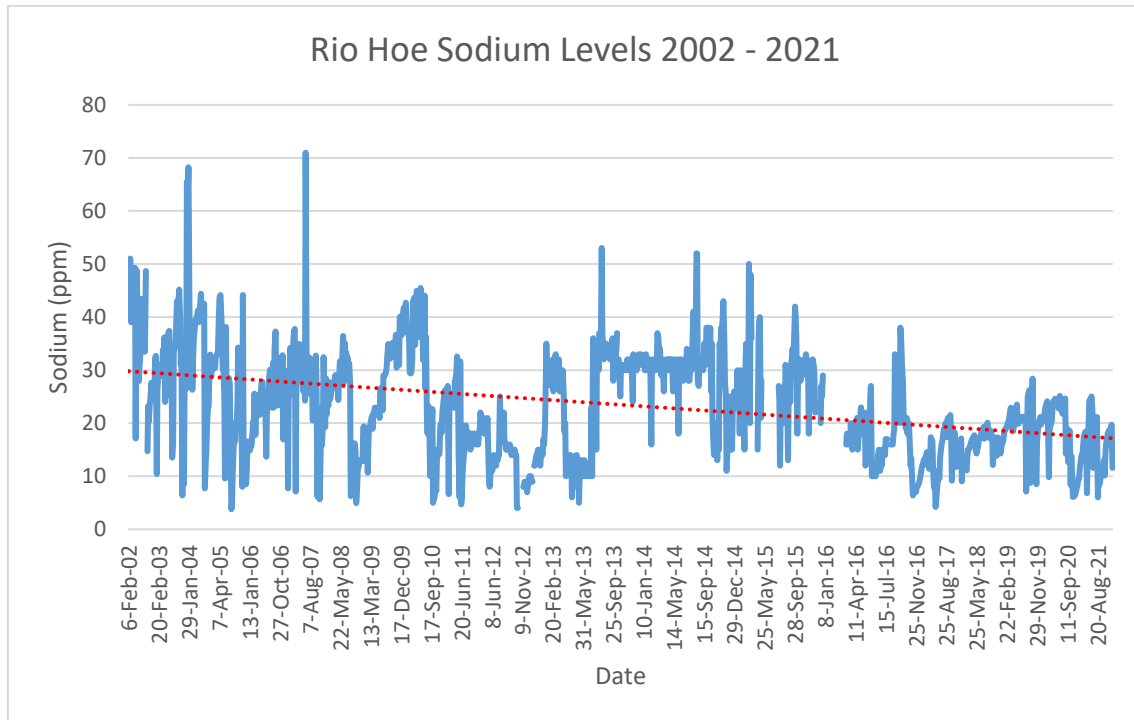
- Physical characteristics of the various sites and governance issues (infrastructure, land ownership)
- Environmental parameters – aquifer protection and monitoring
- Ground water modelling reviews
- Risk Assessment requirements for dams and constructed impoundments

## 2.2 Case Study Relating to Water Management

From construction of the alumina refinery at Ewarton in 1959 and until 1991, BR from the refinery was disposed of in the dammed Mount Rosser area approximately 3 km from the refinery. The BR was pumped as a 20 % slurry from the alumina refinery to the BR site. Following a decision to close the Mount Rosser disposal area, the first environmental priority was the minimization of water quality impacts. Rio Hoe north of the Mount Rosser site was a key monitoring point with a direct relationship to the site. Figure 4 below shows a nearly fifty-year timeline of decrease in sodium concentration when the site went out of primary use in 1986 and Figure 5 shows the timeframe of the closure plan initiation in 2005. The trendline in Figure 5 moves from 30 ppm to less than twenty ppm in approximately twenty years. It is thought that the unimpacted water quality in Jamaica could be of the order of 4–12.5 mg/L [18] so closure has resulted significant improvement of the impacted aquifer – a thirty percent reduction from 2002 to present.



**Figure 4. Sodium levels at Rio Hoe monitoring point from 1973 – 2021.**



**Figure 5. Sodium levels at Rio Hoe monitoring point from 2002 – 2021.**

### 2.3 Case Study Vegetation Acceptability

Will the site itself be *safe*? The requirement to establish vegetation, and by extension biodiversity, addressed the issue of element flows in the ecosystem at the old Kirkvine Ponds. Once the vegetation gap is closed, other aspects such as aesthetics are addressed and the area becomes attractive to fauna. At this point in time no community-specific objectives are considered for these areas as they remain contiguous to industrial sites. Figures 6 and 7 show one of the first open ponds at Kirkvine that required closure on a twenty year timeline. The perspectives are a little varied but the remarkable vegetation establishment is evident.



**Figure 6. Kirkvine Pond 6 2005.**



**Figure 7. Kirkvine Pond 2024.**

### **3. Future Considerations**

The transition to best practice for all locations for BR management technology in Jamaica is also desired – this is one clear pathway to improve water balance management and maximize geospatial footprints [2]. Mud (BR) filtration technology is being considered by some stakeholders which would result in drier materials ending up in the BR sites and reduce water management needs in closure planning. However, environmental efficiency may be a factor – the cost of implementation versus the gains for environmental risk reduction. There are more general discussions in the environmental management community for natural resource valuation (NRV) – the need for examining impacts at the ecosystem level and integrating those recovery objectives in closure planning; certainly, in the management of BR, this is not straightforward. A robust closure plan should address the degraded environmental values in a measurable manner.

A major gap in the existing framework is the consideration of closure assurances. These will need to be carefully developed to account for the types of costs incurred for incomplete closure plans or abandoned sites. There is a desire to improve national capacity in this area and improve the management of the BR sites in need of closure, including legacy sites.

### **4. Conclusion**

There is an element to governance that is dependent on the jurisdiction. Yet this is a global matter; and the risk is that the approach cannot be adopted due to political discontinuities. The oversight requires technical capacities within government, and this is often variable (in terms of qualification and experience), there is high turnover of staff and individual interest often becomes the key to the execution of the framework of policy implementation for BR sites. There is an increasing need for a robust *system* that is stronger than the individual moving parts, within changing objectives of a ministry, a government, or of policy. The questions themselves will endure: Will the environmental indicators used for BR closure planning stand up to scrutiny? Have the risks been addressed in the closure planning?

The last twenty years overseeing an operational closure plan has brought significant learnings and insights into how challenging closure can be. In the absence of a rule book for BR sites, and with new requirements and resources developing, the experience has been dynamic and required

adaptability. Global objectives for the role of mining in development [17, 3], has underscored that a sound approach to manage and close BR sites can yield measurable results.

Going forward, the precedent has been set in Jamaica, there is a strong approach for closing BR sites. Should the sites be considered useful for other types of exploitation, that mechanism would go through its own feasibility study and would further reduce the environmental impacts of BR sites.

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