

# Bauxite, Aluminium, Energy and Waste

Is the processing of bauxite to produce alumina, by Rusal at Aughinish, Shannon Estuary, a sustainable industry ?



Jack O'Sullivan

## Bauxite, Aluminium, Energy and Waste

In this brief presentation, I will look at:

- The source of the raw material (bauxite) from which aluminium is extracted;
- Mining and transportation of bauxite;
- Processing (refining) of bauxite at Aughinish; what processes take place at the plant to produce alumina (aluminium oxide);
- Storage of bauxite residue after extraction of alumina; is the storage safe?;
- Is the aluminium industry environmentally sustainable?; and,
- Could aluminium be produced within a Zero Waste framework ?

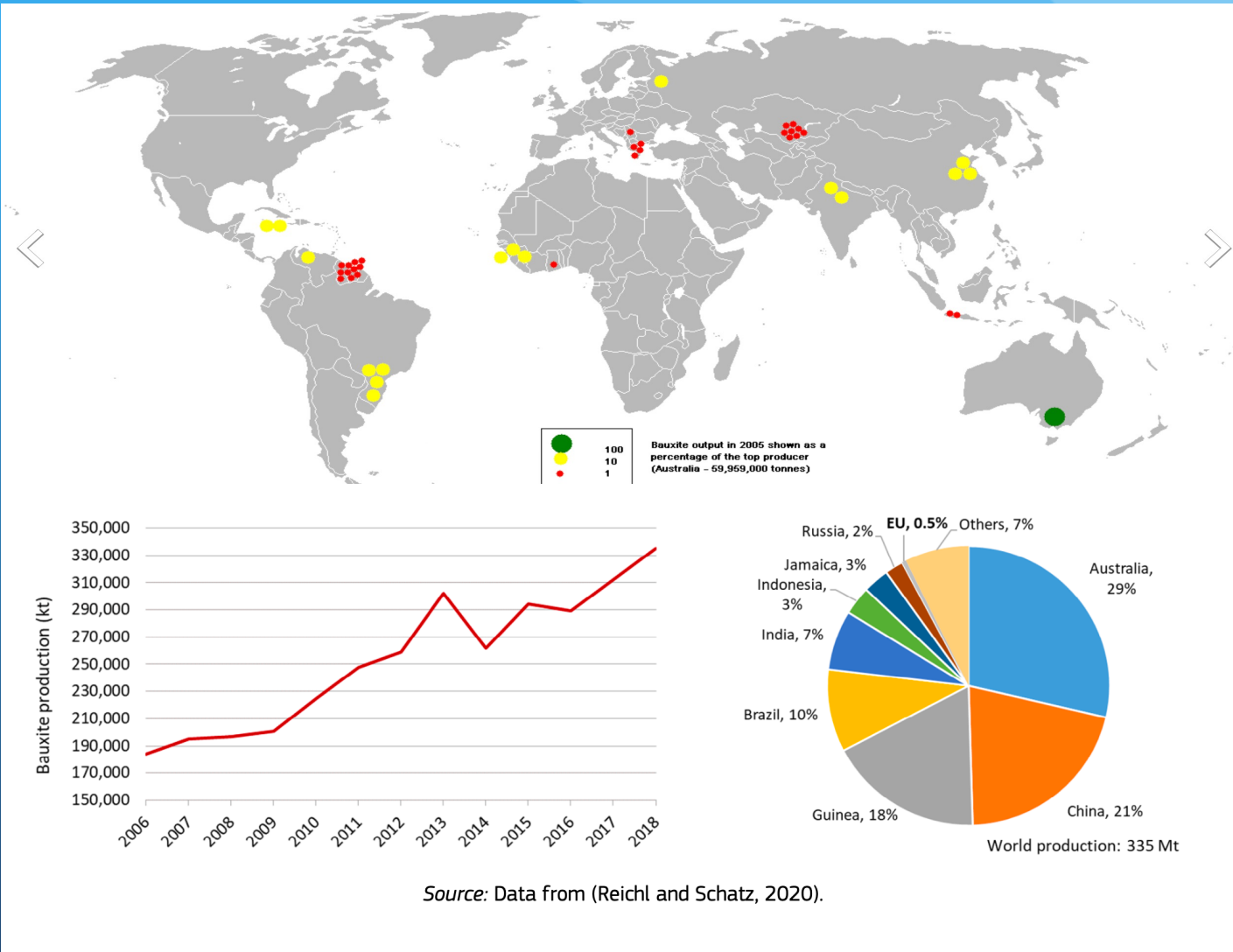
## Bauxite, Aluminium, Energy and Waste

- In the earth's crust, aluminium is the third most common element;
- In the Earth's crust, aluminium is the most abundant metallic element (8.23% by mass) and the third most abundant of all elements (after oxygen and silicon);
- Because aluminium is a reactive element, it is usually found as a highly stable complex alumino-silicate, and never in metallic form;
- Bauxite is the principal ore mined to extract alumina; it is a sedimentary rock with a relatively high aluminium content, and it is the world's main source of aluminium and gallium.

# Bauxite, Aluminium, Energy and Waste

2018 Bauxite production and reserves  
(kilotonnes)<sup>[7][8]</sup>

	Country	Production	Reserves
	<b>World</b>	<b>327,000</b>	<b>30,000,000</b>
	↕	↕	↕
1	Australia	110,000	6,000,000
2	Guinea	82,000	7,400,000
3	China	60,000	1,000,000
4	Brazil	35,000	2,600,000
5	Indonesia	23,000	1,200,000
6	India	22,000	660,000
7	Jamaica	7,700	2,000,000
8	Russia	6,100	500,000
9	Kazakhstan	5,800	160,000
10	Vietnam	4,000	3,700,000
11	Saudi Arabia	4,000	200,000
12	Greece	1,800	250,000
13	Guyana	1,700	850,000
14	Other countries	9,000	3,740,000





## Bauxite, Aluminium, Energy and Waste



This is what Bauxite looks like

Photo by saphon - Own work, CC BY-SA 1.0,  
<https://commons.wikimedia.org/w/index.php?curid=2099323>

## Bauxite, Aluminium, Energy and Waste



The Bel Air bauxite mine, 15km from the Cap Verga peninsula, Guinea, West Africa

Open-cast mining is the usual method of extraction



## Bauxite, Aluminium, Energy and Waste



Bauxite mining is destroying ancient forests in countries where bauxite is being extracted



# Bauxite, Aluminium, Energy and Waste

Loading bauxite



Bulk carrier transporting bauxite



Rusal jetty,  
Shannon Estuary

IMO has issued a warning to masters of vessels sailing with bauxite cargoes after the loss of the *Bulk Jupiter* in January 2021, carrying 46,000 tonnes of bauxite, resulting in the death of 18 of the 19-man crew on board the ship

Futureproof Clare Press Conference, Dublin, 28 June 2022

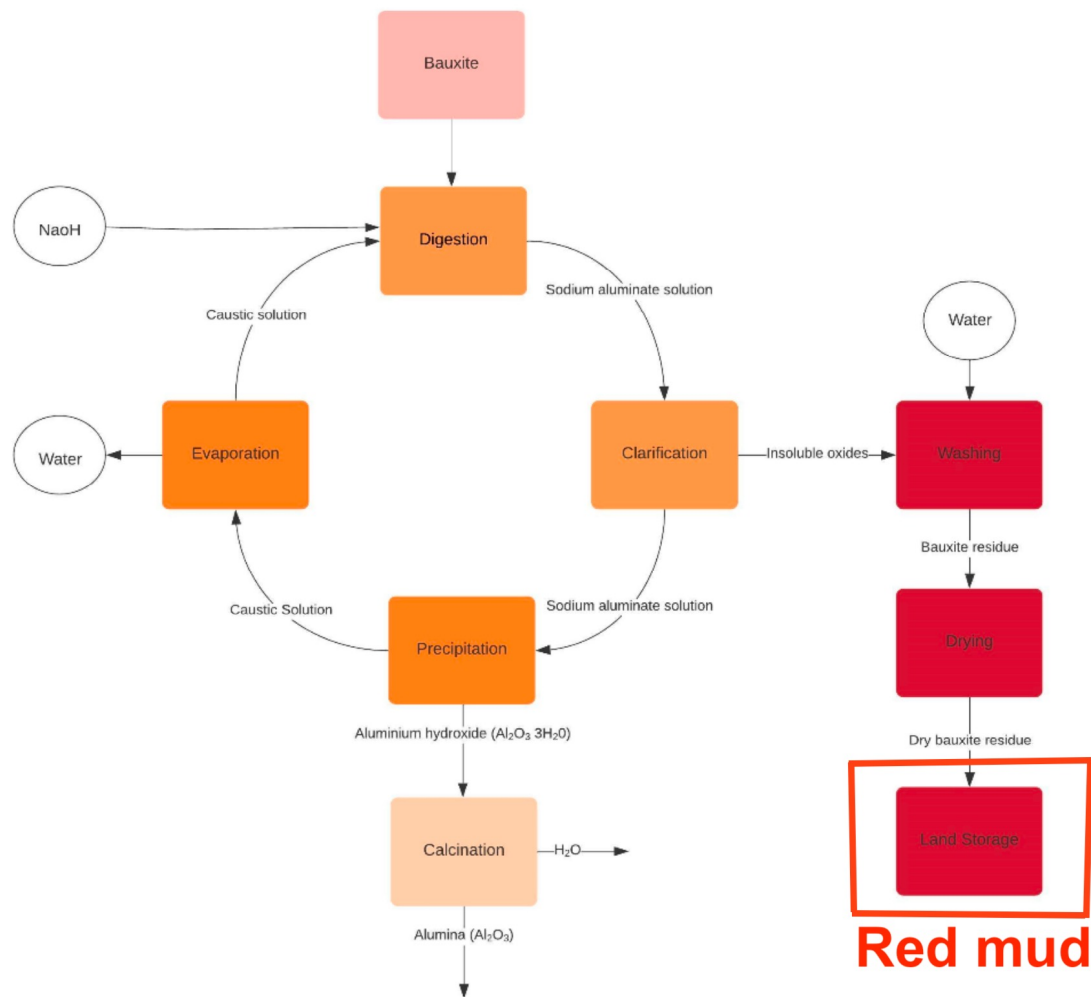
## Bauxite, Aluminium, Energy and Waste

### What happens at Rusal Alumina, Aughinish

The Bayer process, developed in 1888, is used to extract alumina from bauxite, and this process typically consists of the following stages:

- Preparation of bauxite (bauxite crushing & grinding);
- Digestion under pressure and heat (hydrothermal leaching);
- Solid-liquid separation; or clarification, where the aluminium-rich solution and undissolved components of bauxite (bauxite residue) are separated;
- Precipitation and crystallization of aluminium hydroxide (alumina tri-hydrate);
- Calcination, where alumina tri-hydrate is heated to form alumina; and,
- Export of chemical grade or metallurgical alumina, for the production of aluminium.

# Bauxite, Aluminium, Energy and Waste



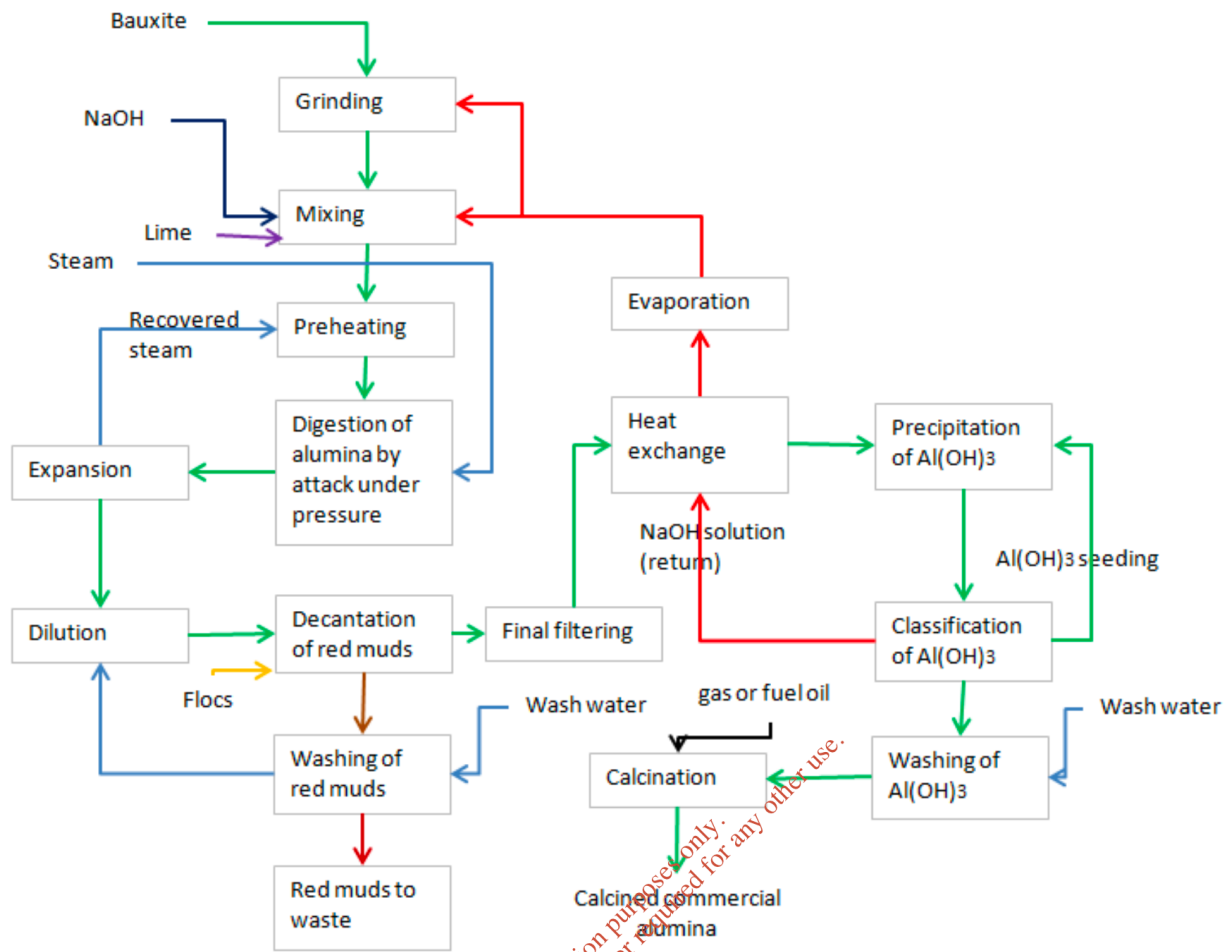
Source: JRC

## The Bayer process

## Bauxite, Aluminium, Energy and Waste

- The bauxite ore is crushed and washed, then goes through a process to remove any silica found in the bauxite, which would otherwise hinder the process and result in a product of lesser quality.
- The bauxite ore is heated under pressure in a caustic soda solution in order to dissolve the aluminium-bearing minerals, yielding a sodium aluminate solution
- $\text{Al}_2\text{O}_3 + 2 \text{NaOH} \rightarrow 2 \text{NaAlO}_2 + \text{H}_2\text{O}$  (digestion)
- Low temperature digestion is carried out at 105 to 150 degrees C; high temperature digestion at 230 to 250 degrees C
- Precipitation of alumina:  $2\text{NaAlO}_2 + 4\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} + 2\text{NaOH}$  (sodium hydroxide is recovered)
- Calcination at a temperature of 1,000 to 1,100 C:  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O}$
- The bauxite residue is then separated from the solution by sedimentation.

## Bauxite, Aluminium, Energy and Waste



Other processes include desilication, where dissolution and crystallisation of silicates occur prior to the digestion process, lime addition to control digestion reactions, flocculant addition to control residue settling, and oxalate removal.



## Bauxite, Aluminium, Energy and Waste



View of the Rusal plant at Aughinish



Futureproof Clare Press Conference, Dublin, 28 June 2022



## Bauxite, Aluminium, Energy and Waste



Aughinish Alumina site, 2014

Futureproof Clare Press Conference, Dublin, 28 June 2022

## Bauxite, Aluminium, Energy and Waste

- Rusal Aughinish Alumina is the largest alumina refinery in Europe and the largest of the alumina facilities operated by UC RUSAL.
- The plant was built between 1978 and 1983 and had an initial rated capacity of 800,000 tonnes a year. The current annual capacity of the refinery is in excess of 1.9 million tonnes of alumina.



## Bauxite, Aluminium, Energy and Waste



### The Bauxite Residue Disposal Area (BRDA)

Approx. 180 hectares

Rainwater falling on the BRDA runs off the surface and percolates through the inner retaining limestone rock dyke into the BRDA perimeter channels from where it is pumped to the Storm Water Pond; then pumped to the Waste Water Treatment Plant for neutralisation. The clarified overflow goes to the Liquid Waste Pond before being discharged through a diffuser into the Shannon estuary.



## Bauxite, Aluminium, Energy and Waste



This type of machine is used to encourage the drying out of the surface of the bauxite residue **storage** area.

## Bauxite, Aluminium, Energy and Waste

### **Bauxite residue, or Red Mud - a toxic waste**

- Red mud is a by-product of the Bayer process, and is a serious environmental hazard because of its composition and high alkalinity;
- In 2010, red mud from an alumina plant in Hungary broke free from a retention pond, contaminating the surrounding area, killing several people, and injuring many more;
- For every tonne of metallic aluminium produced, around two tonnes of red mud are also produced, with annual production worldwide of around 30 million tons per year (dry basis);
- The red mud “stack” at Aughinish is estimated to hold between 50 - 75 million tonnes of toxic bauxite waste; and,
- Efforts are underway by Rusal to find possible beneficial reuses for red mud, with some potential applications on the horizon.

## Bauxite, Aluminium, Energy and Waste

The total volume of RUSAL red mud generated in 2021 was 14.1 million tonnes, 0.9 million tonnes of which were “returned to economic turnover”.

Aughinish Alumina is involved in several research projects:

- **RECOVER**: production of inorganic polymers using bauxite residues;
- **RemovAL**: reduction of soda content in sludge, use of a blend of sludge and ash in road construction; and,
- **ReActiv**: application of sludge to produce new cement products with a low carbon footprint.

**Red mud** is also supplied to cement production plants in Ireland, as a raw material in the cement production process.

Ferrous metallurgy, road construction and production of construction materials are possible ways of using alumina production sludge as a secondary material.



## Bauxite, Aluminium, Energy and Waste

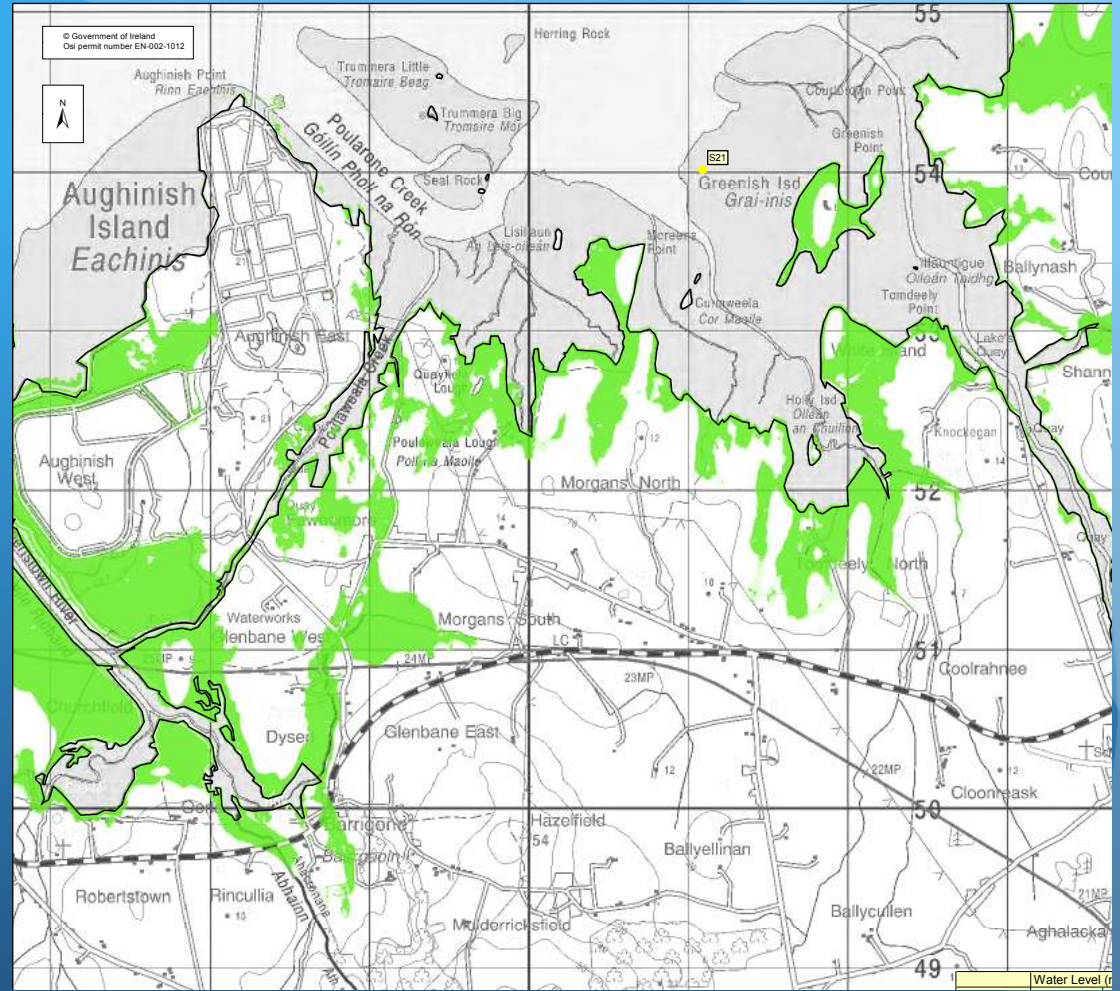
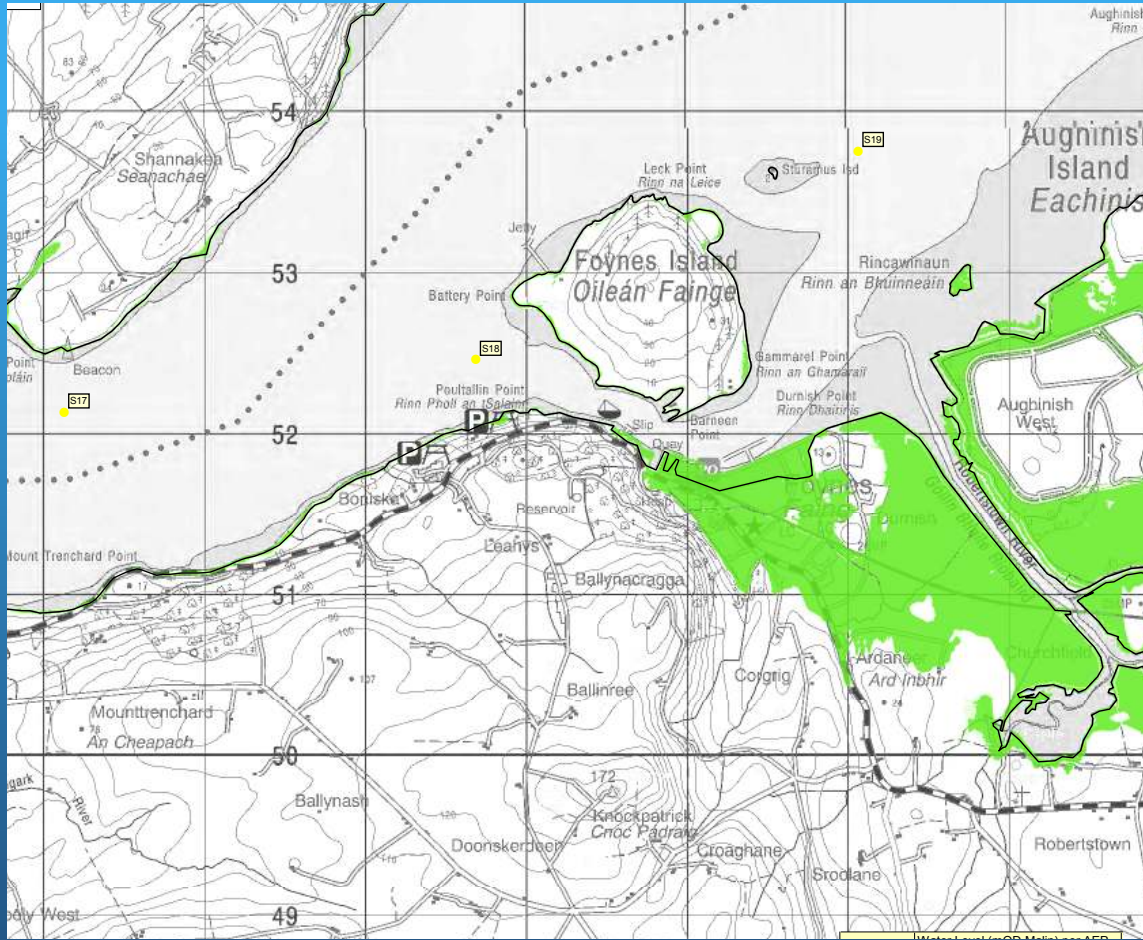


Rusal has also applied for permission to extend an existing borrow pit, located to the north-east of the “Bauxite Residue Disposal Area (BRDA).

This extension, if permitted, would increase the footprint of the borrow pit from c.4.5ha to c.8.4ha, and is being opposed by Futureproof Clare and other environmental NGOs.



# Bauxite, Aluminium, Energy and Waste



Effects of sea level rise; mid-range predictions, 2013. From Irish Coastal Protection Strategy Study Phase 4 - Shannon Estuary, Nov-2013.

Futureproof Clare Press Conference, Dublin, 28 June 2022

## Bauxite, Aluminium, Energy and Waste

I hope that you have found this presentation useful, and perhaps even interesting !

Thank you very much for listening



Jack O'Sullivan

E-mail [jackosullivan2006@gmail.com](mailto:jackosullivan2006@gmail.com) and [jack@zerowasteireland.com](mailto:jack@zerowasteireland.com)

Futureproof Clare Press Conference, Dublin, 28 June 2022