Technical and Environmental Audit in the transformation of the Mining Sector
Case study: Samarco's operation resumption

MIT Global Summit on Mine Tailings Innovation

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Brazil Chief Executive

Since Nov/2015, AECOM has been working on the transformation of the Mining Industry in Brazil, supporting the Brazilian authorities as the Independent Technical, Environmental and Social Auditor and Expert

Independent Auditor, reporting to the Public Prosecutors' Office, the Public Defense Office, the Federal/State Government, the Federal/State Environmental Agency, and the National Mining Agency

- **Brumadinho** and **Mariana** dam failures emergency response;
- Remediation after the Brumadinho failure
- Development and implementation of the Fauna emergency response after the Brumadinho failure
- Restoration of the Candonga Power Plant
- Remediation, reinforcement, and reconstruction of the remaining structures in the Germano and Feijão mining sites
- Analysis, reinforcement, and closure of the TSF structures in the **Itabira** and **Fábrica** sites
- Development and implementation of dam break studies and emergency response plans for all mining sites owned by VALE in Minas Gerais
- Development and implementation of the fauna emergency preparedness plans for all sites owned by VALE in MG
- Negotiation of the 22 judicial agreements to decommission all upstream tailings dams in MG
- Independent Technical Expert and Advisor to the **Brazilian Mining Agency** on the 273 most critical TSFs in Brazil

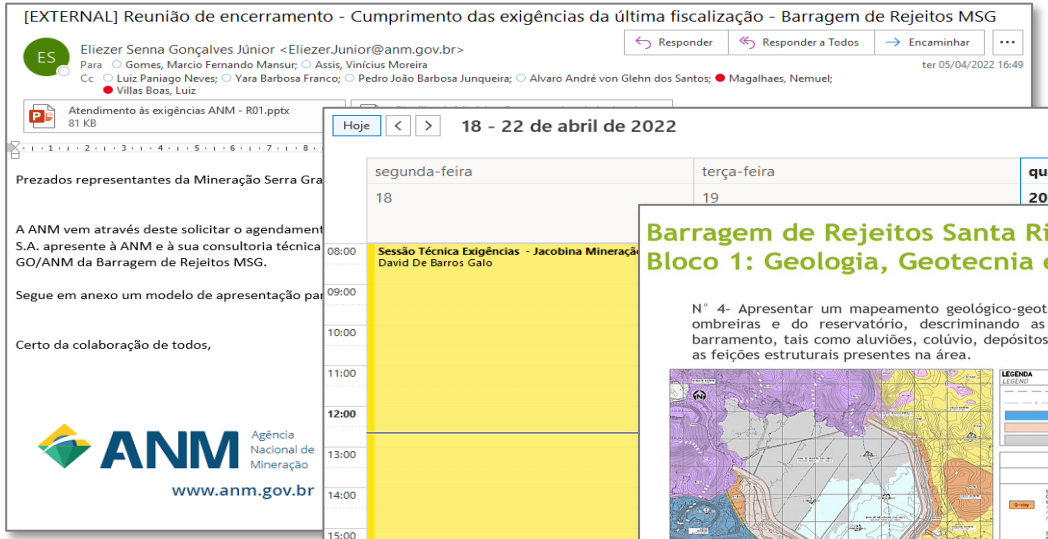
Judicial Expert, reporting to the Judge of the Samarco case and supporting the Court of Appeal on the renegotiation of the Samarco Overall Agreement

- Judicial Expert to the Judge of the **Samarco case** on Population Resettlement and Housing, Human and Ecological Risk Assessment, Food Contamination, Agricultural and Livestock Production, Water for Human Consumption, Fishery, and Aquatic Biodiversity Monitoring
- Expert to the Judge of the Appeal court in the renegotiation of the overall **Samarco Agreement**

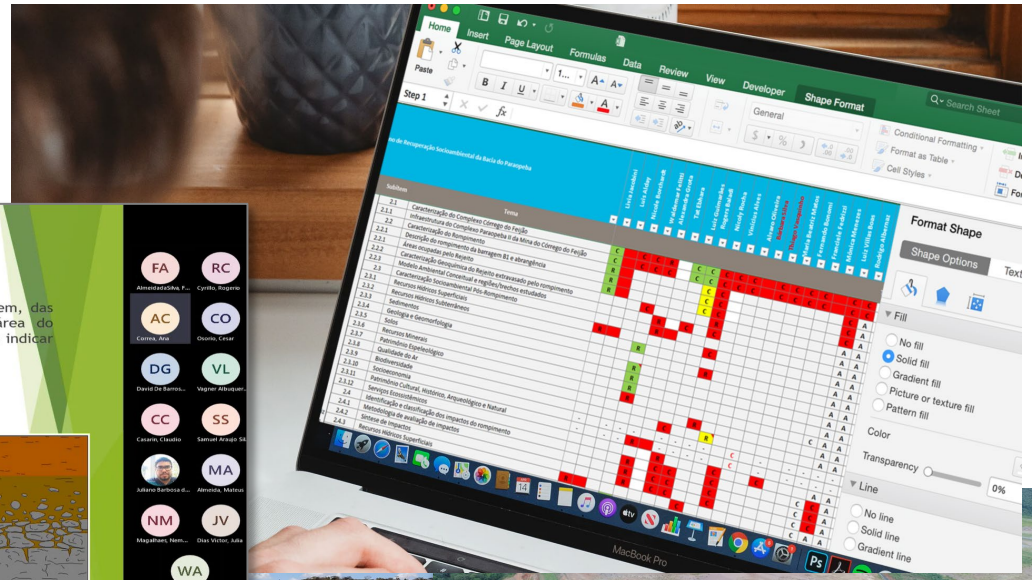
After the failures of the Fundão Dam (Mariana) and the B_1 Dam (Brumadinho) the integrated response of the Brazilian Institutions was instrumental in the transformation of the Mining Sector in Brazil

	REGULATOR	LEGISLATOR	JUDICIAL SYSTEM	PUBLIC SECTOR	CIVIL SOCIETY (NGOs)	MULTI STAKEHOLDERS	INDUSTRY
2014	DNPM Ordinance 526	Federal Law 12.334	ToC Legal Structure	-	GRI - Global Reporting Initiative		**ICMM - TSM**
2015	-	-	**ToC Samarco – Fundão Dam** (Mariana)	-	-	**SDG (UN)**	-
2016	-	-	-	SEMAD/FEAM No. 46.993 SEMAD/FEAM No. 2.372	-		ICMM Revision
2017	DNPM Ordinance 70.389	-	-	-	RMI - Responsible Minerals Initiative		-
2018	-	-	-	-	-	**IRMA Standard (V 1.0)**	Guidelines for Sustainable Bauxite Mining
2019	ANM Resolution 04 and 13	State Law 23.291 – Mar de Lama Nunca Mais	**ToC Vale – B_1 Dam** (Brumadinho)	SEMAD/FEAM No. 2.784	-		**RGMP**
2020	ANM Resolution 32 and 51	Federal Law 14.066	-	-	Safety First (V 1.0)	**GISTM**	Copper Mark
2021	-	-	-	-	-		-
2022+	ANM Resolution 95	-	ToC Decharacterization	-	Safety First (V 2.0)		Future Standards

We developed a full suite of tools, templates, systems, and procedures to assure technical robustness, consistency, replicability, progress tracking, risk management, and reporting



Fonte: Relatório de Projeto Detalhado Wood, 2021



AGENDA						
Dia	Horário Início	Horário Término	Local	Tipo	Descrição	
Semana 1						
ter, 04/jan	09:00	12:00	Teams	Reunião	Reunião de acomp. de recomendações - Ambiental	
ter, 04/jan	14:00	17:00	Teams	Reunião	Reunião de acomp. de recomendações - Engenharia	
ter, 04/jan	09:00	17:00	Teams	Reunião	Reunião de acomp. de recomendações - TC Água e Seg. Hídrica	
qua, 05/jan	08:00	14:00	Capim Branco	Inspeção de Campo	Capim Branco, Lagoa Azul, B-VII, Menezes I e II, Pilhas e Cava	
qua, 05/jan	08:00	17:00	Capim Branco	Inspeção de Campo	Fazenda Cachoeira / ETAF 2 / DIR SGA / ETAF 2 / Dragagem Operação / Fazenda recanto / Erosão Samambaia / Remanso 1 esquerdo / Fazenda 4 folhas / ETAF 1 / trecho entre ECP 1 e BH-1 / Dique 2 e BH-0	
qua, 05/jan	08:30	17:30	Clube Aurora	Inspeção de Campo	Copasa - Nova Captação	
qui, 06/jan	08:00	14:00	Portaria Jangada	Inspeção de Campo	Estruturas Remanescentes e de Contenção + Marco Zero	
qui, 06/jan	08:00	17:00	Portaria Jangada	Inspeção de Campo	AMBIENTAL - TBD	
qui, 06/jan	08:30	17:30	ETA Bela Fama	Inspeção de Campo	Sistema Cambimbe (TAC Água) + Clientes Essenciais + Poço Sabará	
sex, 07/jan	08:30	17:30	AECOM	Escritório	Preparação Apresentação JANEIRO/22	
sex, 07/jan	08:00	12:30	Teams	Sessão Técnica	Sessão Técnica Copasa - TC SEGURANÇA HÍDRICA	
Semana 2						
seg, 10/jan	09:00	18:00	Teams	Sessão Técnica	Sessão Técnica - AMBIENTAL 1	
seg, 10/jan	08:30	17:00	Teams	Sessão Técnica	Sessão Técnica Copasa - TC ÁGUA	
ter, 11/jan	08:30	17:30	Teams	Sessão Técnica	Sessão Técnica - ENGENHARIA 1	
ter, 11/jan	08:30	17:00	Teams	Sessão Técnica	Sessão Técnica - ERSHRE	
ter, 11/jan	08:30	17:30		Inspeção de Campo	AMBIENTAL - CAATA Bom Retiro, Fazenda BRUMA e bacias de dessedentação	
qua, 12/jan	08:30	17:30	Teams	Sessão Técnica	Sessão Técnica - ENGENHARIA 2	
qua, 12/jan	08:30	17:30	Teams	Sessão Técnica	Sessão Técnica - TC MONITORAMENTO	
qui, 13/jan	09:00	18:00	Teams	Sessão Técnica	Sessão Técnica - AMBIENTAL 1	
Semana 3						
seg, 17/jan	08:30	17:30	AECOM	Escritório	Preparação Apresentação JANEIRO/21 (Revisão CP)	
qua, 19/jan	09:30	12:30	Teams	Apresentação	Apresentação MPMG (BRUM / ERSHRE / MONIT)	
sex, 21/jan	09:30	12:00	Teams	Apresentação	Apresentação MPMG (Água e SH)	
Semana 4						
seg, 24/jan	08:30	17:30	AECOM	Escritório	Preparação Relatório JANEIRO/21 - Entrega para LC	
qua, 26/jan	08:30	17:30	AECOM	Escritório	Preparação Relatório JANEIRO/21 - Entrega para CP	

Our work is based on a continuous cyclical approach

Presentation
Monthly presentation to the Public Prosecutor Office and the mining company of the results of the audit visits, including risk analysis and technical recommendations

Technical Data Acquisition
Gathering of geotechnical monitoring reports, design, construction and operation documents, planning, self evaluations etc.

Audit Report
Detailed monthly independent audit reports, including risk analysis and technical recommendations

Field Inspection
Detailed field visit to the project sites and surroundings, allowing the evolution of each of its phases to be monitored, from the perspective of geotechnical and hydraulic stability and safety and other topics defined by each scope

Technical Data Evaluation
Project audit, reports, materials, data, information, procedures, and field surveys

Technical Sessions
Working meetings with the mining team and engineering, planning, construction, environmental, and field research companies involved in the projects

Our work has generated a unique database of lessons learned, challenges, findings and risks, recommendation and action items in this long road of transformation towards

75+
Global and Local Mining Companies

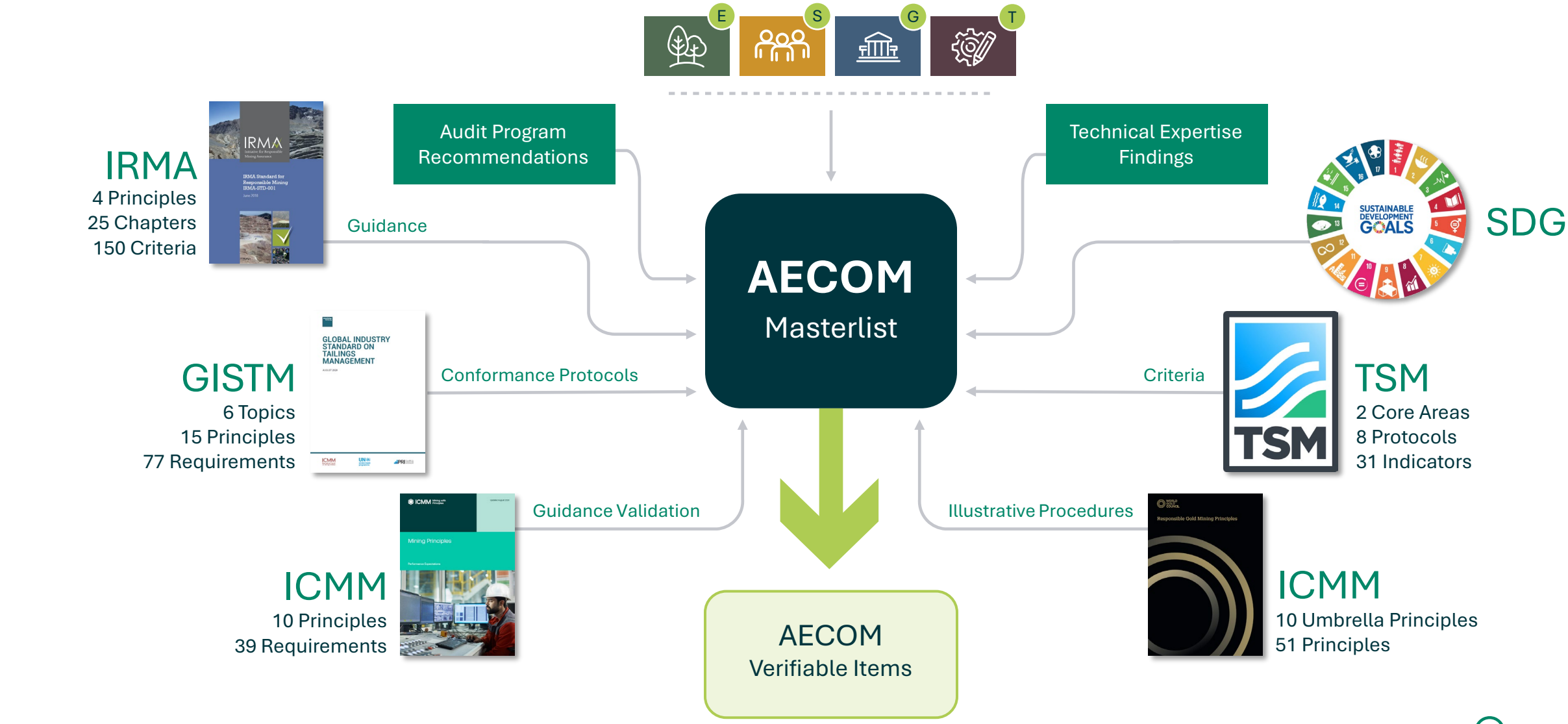
27+
Engineering and Consultants

270+
Different mining sites

89,000+
Findings and Recommendations

199,000+
Action Items

Our experience allowed us to consolidated the main Global Industry Standards with the SDGs of the UN, to propose a fact and science-based technical, environmental and social audit process



We developed HARMONIA, a digital tool to assure scalability, consistency, replicability, risk management, and reporting

6 Topics
15 Principles
77 Requirements

10 Principles
39 Requirements

10 Umbrella Principles
51 Principles

2 Core Areas
8 Protocols
31 Indicators

TSM

4 Principles
25 Chapters
150 Criteria

SUSTAINABLE DEVELOPMENT GOALS

17 Goals
169 Targets

4 Pillars	20 Topics	75 References	2,800+ AVIs	Findings + recommendations
1. Environment (Licenses, sustainability etc.)	5	15	840+	30%
2. Social (Interaction with communities, etc.)	4	14	780+	28%
3. Governance (Decision chain, communication, project management, construction management etc.)	4	21	780+	28%
4. Technical (Geotechnic, Geology, Hydrology, Hydrogeology etc.)	7	25	390+	14%

References allow risk, conformance, and action plan management

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Case study

SAMARCO’s production restart and closure of the upstream raised tailings dams

In 2017, two years after the failure of the Fundão Dam in Mariana, Samarco started the discussion with the Prosecutors' Office to created the conditions to eventually resume its operation

Challenges

Lack of credibility

- Regulators, Judicial Institutions, civil society, and the mining consultancy and engineering community
- Unclear road towards the restauration of the natural and social environment
- Need to implement a new governance process

Lack of institutional support

- Hostile social environment due to the impact of the Fundão dam failure on community dynamics
- Workers exposed to a high-stress environment

Lack of clear concrete cases/benchmarks

- Large scale of production
- Unprecedented resumption after a catastrophic failure
- Scarcity of locations with similar rainfall patterns that have experienced similar events

+

Commitments & Additional obligations

Stop using dams to dispose tailings

- Implement technologies/alternatives to manage and dispose tailings

Close the upstream raised tailings dams

- Main Germano Dam, Germano Pit Dam, Dikes Sela, Tulipa and Selinha

Minimize overall environmental and social impacts

- Reduce new water usage
- Lower CO_2 emissions
- Reduce trucks movement on public roads
- Promote a safe and inclusive work environment
- Include local communities on the decision chain

Seek for circularity on the long term ("zero waste")

- Use tailings as construction/backfill material
- Evaluate new tailings applications
- Reprocess tailings using innovative technologies

The commitments were formalized in a judicial agreement signed by Samarco, the MPMG and AECOM, which served as the independent technical, environmental and social auditor

AECOM’s duties included: oversight and reporting to the Brazilian society, global benchmarking and submission of recommendations, risk assessment and progress tracking, disclosure

From 2017 to 2020, the focus was on the studies, engineering, tests, and build up to the operational restart

Alegria South Pit

- **Preparation** of the Alegria South Pit for slurry disposal;
- **Installation of the Pump Station and Pipeline Assembly** to allow the recirculation of water from the pit back to the concentrator
- **Set up the ground water monitoring program** to confirm the no ground water potential contamination from the slurry's deposition

Alegria South Co-disposal Pile (PDER)

- **Engineering design and tests** for the dry stacking deposition
- **Development of the operations** and quality control manual
- **Foundation Cleaning and Drainage Installation** to assure the design criteria for the start of the construction of the dry stacking pile
- **Internal Drainage System Construction** construction of internal drainage system between the foundation platform and the dry stacking.

Filtration System

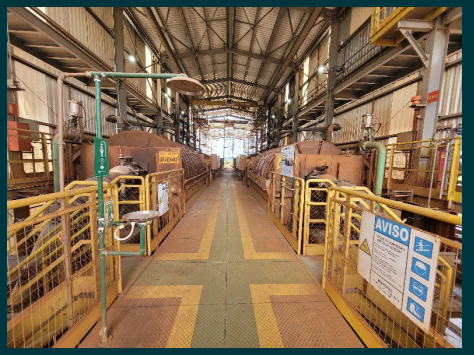
- **Engineering and construction** of the Filtration Plant
- **Engineering and construction** of the Tailings Pipeline to the Filtration Plant
- **Engineering and construction of the Conveyor Belt** to connect the filtration plant with the Alegria South Tailings Disposal System (PDER).











The adopted strategy was based on a Phased Approach to tackle the challenges and deliver on the commitments and obligations

2020 — 2025 — 2028 — 2041

1st Phase

Resumption of operations after the main failure (One Concentrator)

Decommissioning of the upstream raised tailings dams

2nd Phase

Resumption of 2nd Concentrator

Reclamation of **Fundão Valley**

Final steps of the decommissioning

3rd Phase

Full operations the operation with resumption of 3rd Concentrator

Long-term operation aiming at "**zero waste**"

Scale + complexity

Production		Tailings	
17.9M ton/year	ROM	7.0M ton/year	sandy tailings
9.3M ton/year	iron ore	1.6M ton/year	slurries
		8.6M ton/year	

Production		Tailings	
33.0M ton/year	ROM	13.7M ton/year	sandy tailings
16.3M ton/year	iron ore	3.0M ton/year	slurries
		16.7M ton/year	

Production		Tailings	
52.6M ton/year	ROM	21.5M ton/year	sandy tailings
26.9M ton/year	iron ore	4.2M ton/year	slurries
		25.7M ton/year	

The adopted strategy was based on a Phased Approach to tackle the challenges and deliver on the commitments and obligations (cont.)

Main objective

do not use dams to dispose tailings	reduce slurries storage	active total circularity, seek "zero waste"

Other commitments and conditions

- Improve process water reuse
- Reduce CO_2 emissions
- Limited of volume available to storage tailings in existing open pits
- Alegria South Pit disposal must be temporary
- Competition for material and service suppliers due to extensive decommissioning projects in the state of Minas Gerais
- Determined timeframe to decommission the upstream raised tailings dams
- Challenging materials handling situation

- Continuous improvement of process water reuse
- Continuous reduction of CO_2 emissions
- Limited capacity in the Alegria South Pit to store slurries
- Intensified competition for material and service suppliers due to extensive decommissioning projects in the state of Minas Gerais
- Reclamation of Fundão Valley introduces the necessity for 77.5M m^3 of material (tailings + overburden)
- Determined timeframe to decommission the upstream raised tailings dams

- Continuous improvement of process water reuse
- Continuous reduction of CO_2 emissions
- Necessity to move slurries from Alegria South Pit to a definitive deposition location to allow the continuation of exploration
- Increased tailings and mine waste generated due to full production

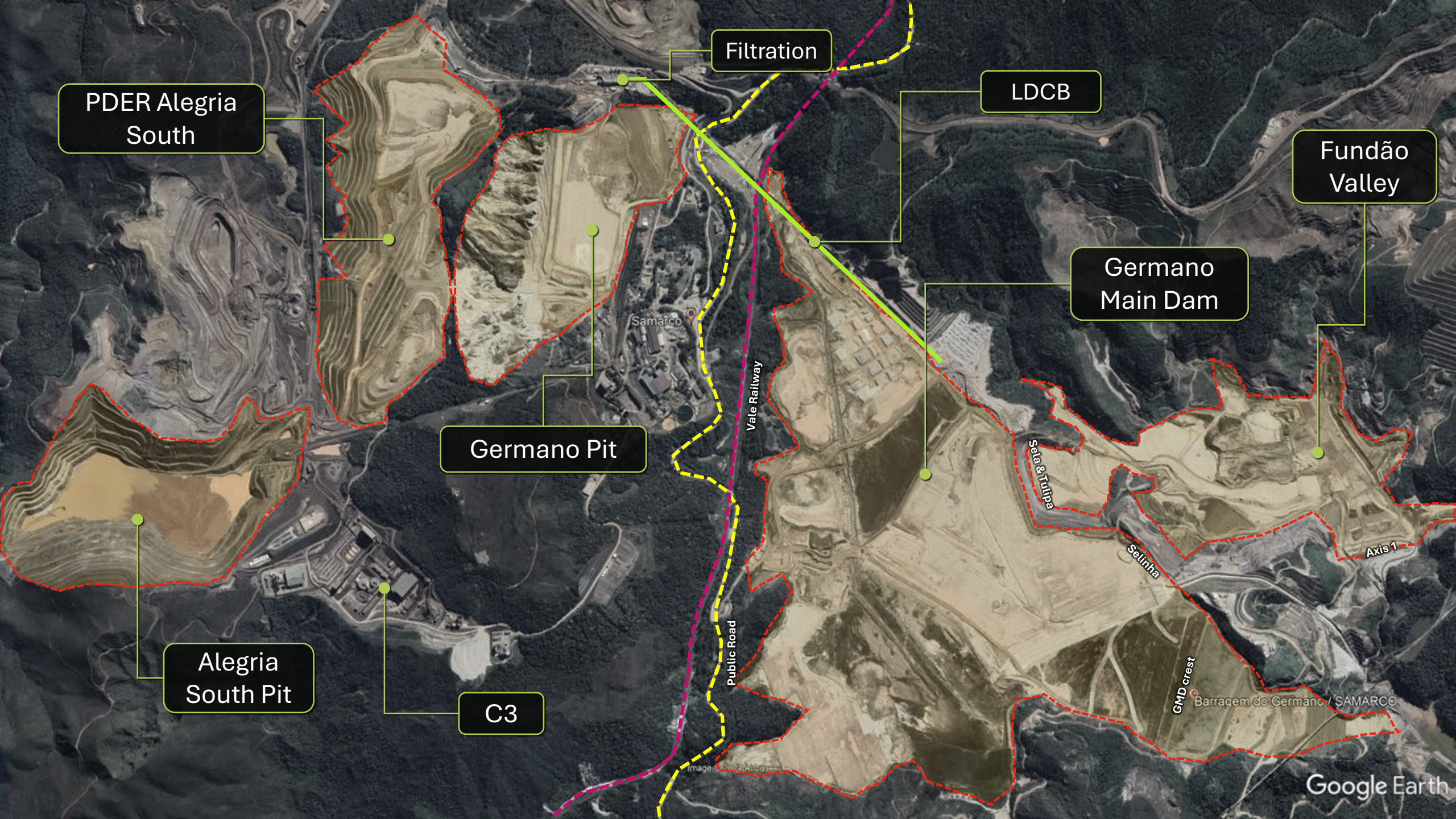
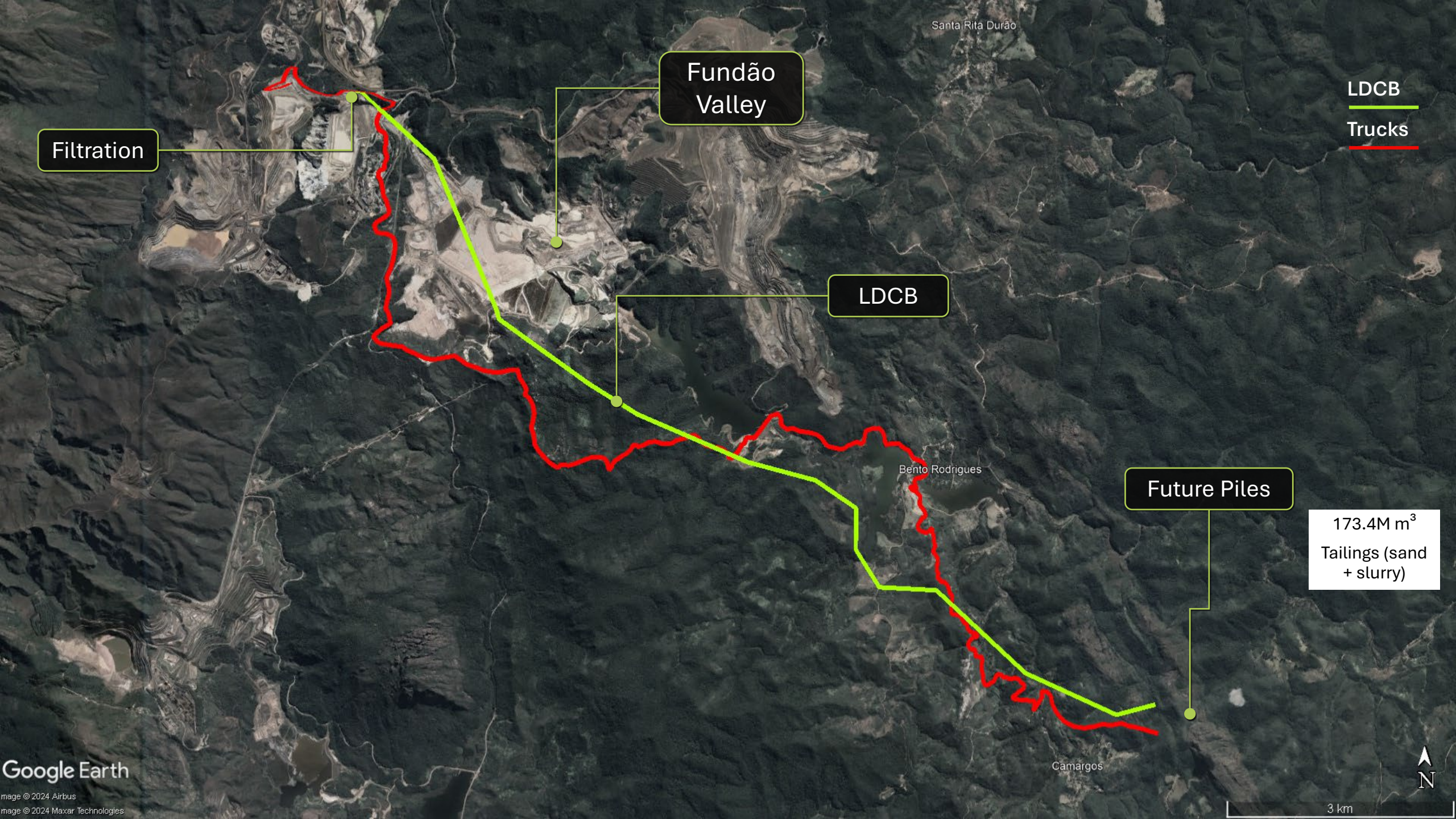

Filtration
PDER Alegria South
LDCB
Fundão Valley
Germano Main Dam
Germano Pit
Alegria South Pit
C3
Samarco
Vale Railway
Public Road
Sela & Tulipa
Selinha
Axis 1
GMD crest
Barragem do Germano / SAMARCO
Google Earth

Photo: SAMARCO – Germano Mining Complex (Source: AECOM)


Santa Rita Durão
Fundão Valley
Filtration
LDCB
LDCB
Trucks
Bento Rodrigues
Future Piles
173.4M m³
Tailings (sand + slurry)
Camargos
Google Earth
mage © 2024 Airbus
mage © 2024 Maxar Technologies
N
3 km

Each Phase deployed a specific set of technical, environmental and engineering solution

2020 — 2025 — 2028 — 2041

1st Phase

Resumption of operations after the main failure (One Concentrator)

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Long-term operation aiming at "**zero waste**"

Solutions

Restart of C3

- Employ the existing Alegria South Pit only for the temporary disposal of slurries
- Introduce filtration of coarse and fine tailings
- Build piles to mechanically dispose filtered tailings with compaction and drainage control
- Design and operate for closure phase (continuous closure approach)
- Recirculate process water from filtration and Alegria South pit disposal

Decommissioning

- Utilize filtered tailings as a construction material
- Mechanically dispose tailings with compaction control to improve geotechnical stability
- Introduce long-distance conveyor belt to improve material handling efficiency

Restart of C2

- Expand filtration of coarse and fine tailings + slurry
- Use filtered tailings as a construction material
- Introduce filtration of blended coarse tailings (94%) and slurries (6%) to minimize water consumption in the dry season
- Improve the reuse of filtration and Alegria South Pit process water

Reclamation of Fundão Valley

- Utilize filtered tailings as a construction material
- Mechanically dispose tailings with compaction control to improve geotechnical stability
- Expand the long-distance conveyor belts

Restart of C1

- Expand filtration of coarse and fine tailings + slurry
- Use filtered tailings as a construction materials for the closure and reclamation projects
- Implement new technologies to reprocess tailings (up to 40% iron ore content)
- Extend the long-distance conveyor belts to allow disposal on areas outside Germano Mining Complex
- Study the viability of the use of coarse tailing on other projects beyond the mining industry

Water use reduction from Phase 1

	Before	After
Total	7,970 m^3/h	7,970 m^3/h
Recirculation water	6,142 m^3/h 77%	7,026 m^3/h 88%
New water	1,828 m^3/h	944 m^3/h

Reduction of

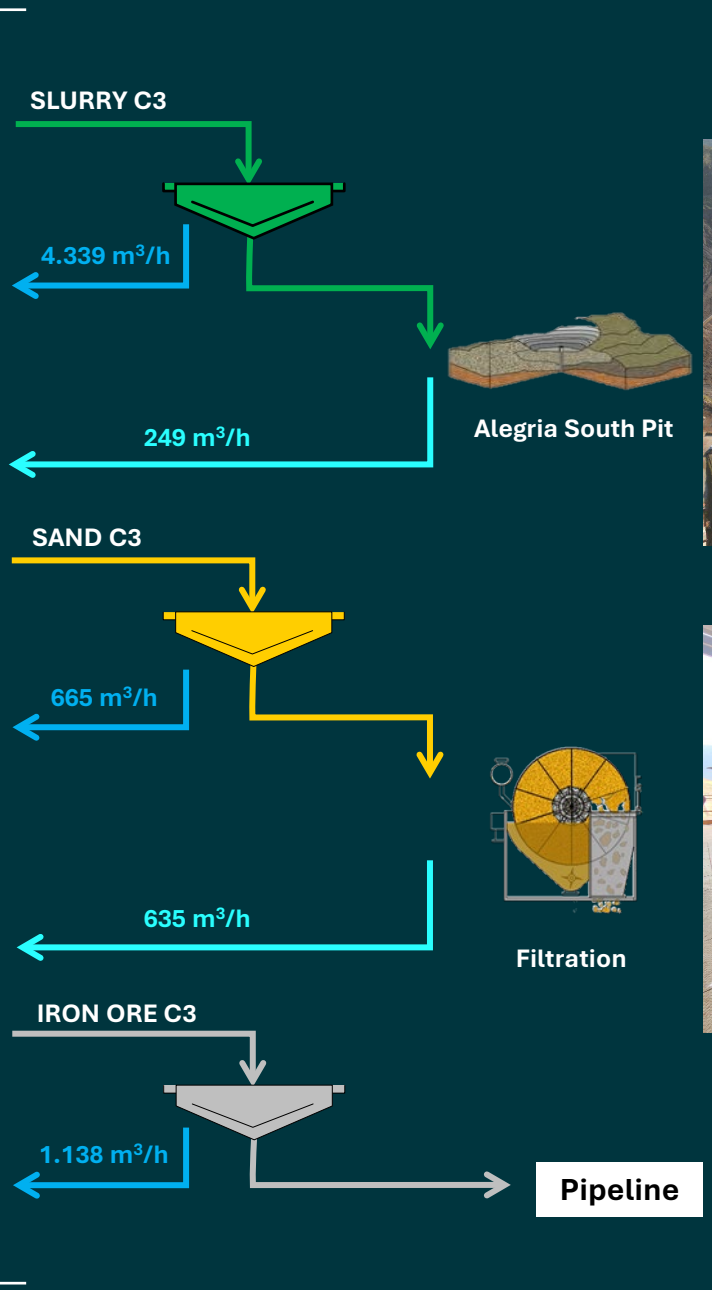
7.74 M m^3/year

Considering UN standard of 110 l/day/person, the reduction of new water use can supply

192,873

persons/year

CONCENTRATOR 3



Phase 1 reduction of CO_2 emissions by introducing long-distance conveyor to improve material handling efficiency

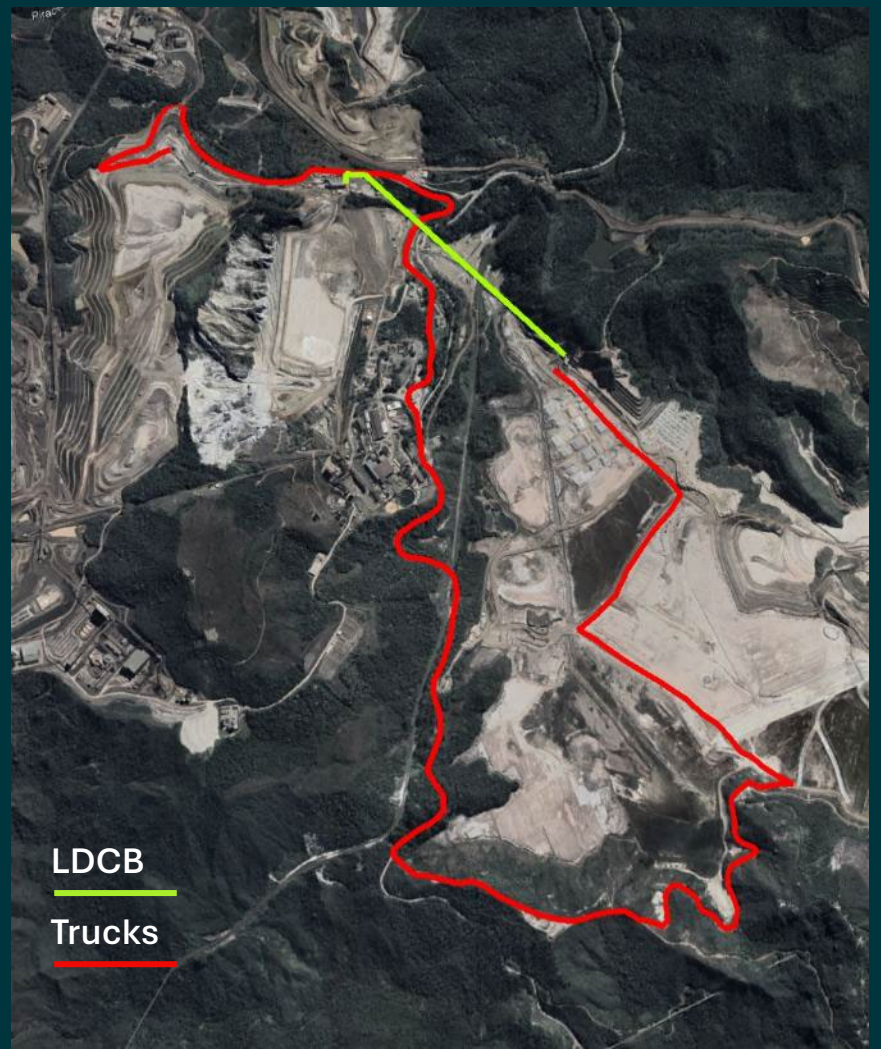
	Trucks	LDCB
Volume	15.1 M m^3	15.1 M m^3
Trips	1.08 M	-
Average Transportation Distance	7.46 miles	2.49 miles
Total distance	8.04 M miles	2.68 M miles
CO_2 emission	6,903 tonCO_2	2,301 tonCO_2

Reduction of

4,602 tonCO_2

Equivalent to

1,350 ha of tropical forest preserved



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Phase 2 and Phase 3 will further increase the positive environmental impacts of an innovative tailings management strategy

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Improvement of water reuse

Reuse of

7.74 M m^3/year

Volume enough to supply

192,873 persons/year

Reuse of

13.76 M m^3/year

Volume enough to supply

342,788 persons/year

Reuse of

20.36 M m^3/year

Volume enough to supply

507,021 persons/year

Reduction of CO_2 emission

Reduction of

4,602 tonCO2

Equivalent to

1,350 ha of tropical forest preserved

Reduction of

10,631 tonCO2

Equivalent to

3,118 ha of tropical forest preserved

Reduction of

60,101 tonCO2

Equivalent to

17,625 ha of tropical forest preserved

Additional mid to long term technical, environmental and social positive impacts

- Increased geotechnical safety
- Improved health and safety
- Reduced decommissioning and closure timeframe and costs
- Extended production time horizon
- Improved operational resilience

New potential applications of tailings and mining waste continue to be studied and developed, within and beyond the mining industry

AECOM

Delivering a better world