1421 Miracerros St.☐ Santa Fe ☐ NM ☐ 87505 ☐ USA ☐ etechinternational.org
Richard Kamp, Director ☐ richardkamp@etech-intl.org

Causes of Tailings Dam Failures

29 August 2024

Overview

Tailings dams fail for a variety of reasons related to errors in engineering, meteorologic and geologic events and conditions, regulatory deficiencies, and human error. Figure 1 highlights some of the primary technical causes of tailings dam failures, including liquefaction, upstream dam construction, weak underlying geology, earthquakes, overtopping, and continual modifications of the dam. Areas with high precipitation and high seismicity are especially prone to tailings dam failures because they can cause some of the primary failure modes (Lyu et al., 2019; Koppe, 2021). One of the primary causes of the Mount Polley disaster in Canada in 2014 was building the dam on an unrecognized deep layer of glacial lake clay that caused dislocation of the embankment due to foundation failure (Independent Expert Engineering Investigation and Review Panel, 2015). The failure mode for the 2015 Fundão and the 2019 Brumadinho tailings dams in Minas Gerais, Brazil, was liquefaction flow (Koppe, 2021).

The increase in the number of mines around the world and the extreme weather events resulting from climate change are likely to increase the number of future tailings dam failures (Chambers, 2019; Lyu et al., 2019). Lax regulations, monitoring, and enforcement can also decrease chances for preventing dam failures and increase the likelihood that potential dam failures will not be discovered until it is too late (Lyu et al., 2019; Earthworks et al., 2020). But improved regulation and engineering alone will not stop tailings dam failures, which have been increasing in severity in recent years (Bowker and Chambers, 2015). Best practice for tailings storage facilities is moving toward using filtered tailings, which will decrease the number of catastrophic failures due to the low amount of water held behind a tailings dam (Earthworks et al., 2020). Best practice and best management approaches are available from ICMM (2021), the Mining Association of Canada (2023), and IRMA (2023).

Relevance to the Mirador Mine in Ecuador

The Mirador Mine in southeastern Ecuador has two large tailings impoundments: The existing Quimi and the new Tundayme facilities. The Tundayme tailings dam has a proposed height of 320 meters – currently the highest in the world. In addition, the mine is situated in a seismically active area with high precipitation. These conditions increase the likelihood of a catastrophic failure of the tailings dams and constitute an imminent endangerment to the people, property, and environment below.

E-Tech International commissioned the development of an engineering model in 2023 that evaluated the downstream effects of a tailings dam failure of the Quimi and Tundayme dams (separately and together) – and a 2024 model that incorporates the proposed greater height of the Tundayme tailings dam. The models were developed by Riada Engineering and are available on our website.[1] Based on the results of our studies, top priorities should be developing and implementing an emergency preparedness and response plan for communities living in all potentially impacted areas, and improving plans for mine operations, monitoring, and evaluation that would prevent a future tailings dam disaster.

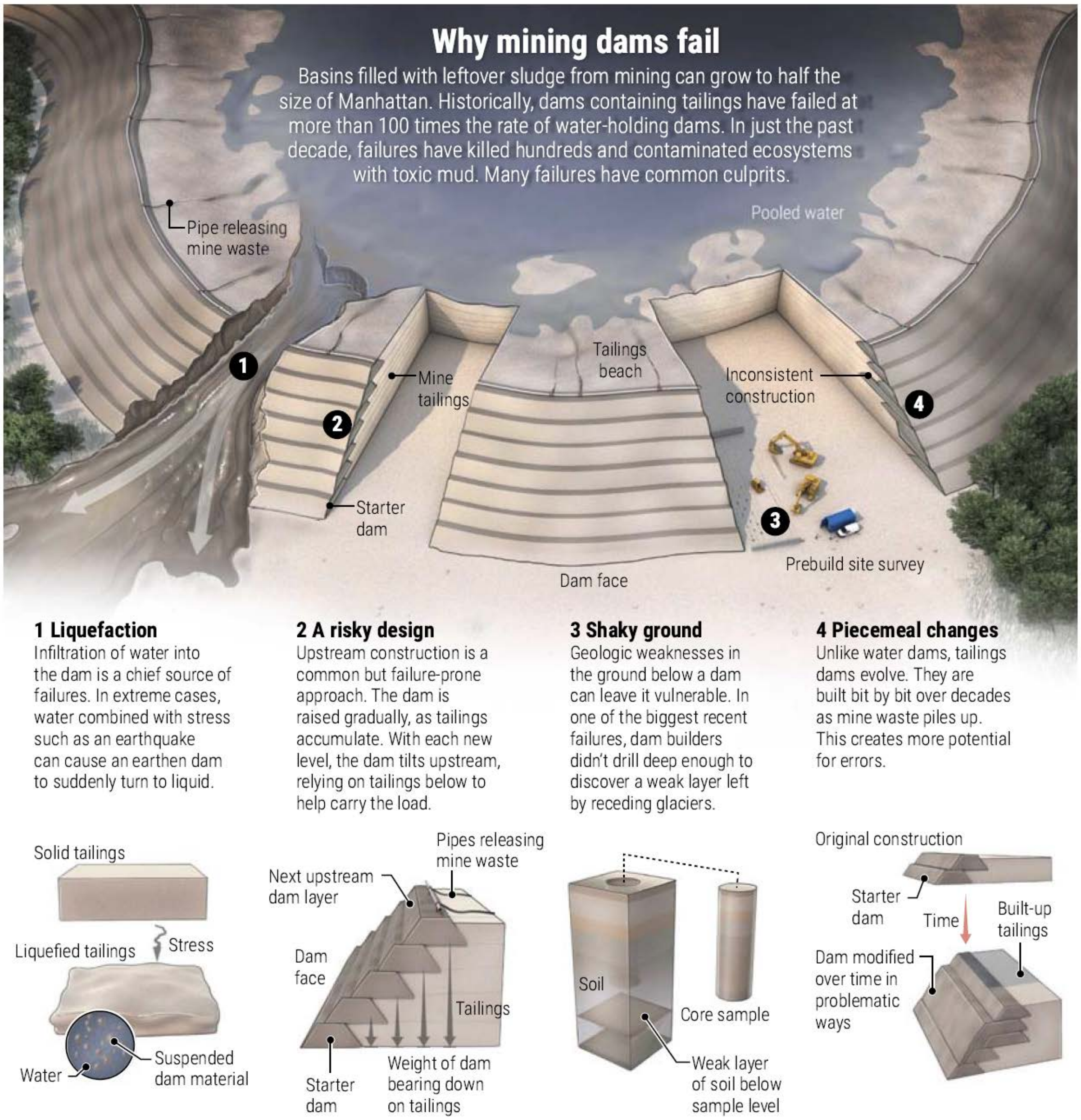

Figure 1. Why tailings dams fail.
Source: ScienceMag.org, 2020.

[1] Results from the 2023 model are available here: https://etechinternational.org/mirador-flo-2d-simulation/ The results of the 2024 model will be available this fall.

References

Bowker LN, Chambers DM, 2015. The risk, public liability, & economics of tailings storage facility failures. 56 pgs. https://earthworks.org/assets/uploads/archive/files/pubs-others/BowkerChambers-RiskPublicLiability_EconomicsOfTailingsStorageFacility%20Failures-23Jul15.pdf

Chambers D, 2019. The increasing number of tailings facility failures: Navigating the decade 2020-2029. Canadian Dam Association 2019 Annual Conference. Calgary, AB, Canada, October 6-10. http://www.csp2.org/files/reports/Increasing%20Number%20of%20Tailings%20Facility%20Failures%20-%20Chambers%20Oct19.pdf

Earthworks et al., 2020. Safety First. Guidelines for Responsible Mine Tailings Management. June. https://www.earthworksaction.org/safety-first

ICMM (International Council on Mining and Metals), 2021. Conformance Protocols: Global Industry Standard on Tailings Management. https://www.icmm.com/en-gb/our-principles/tailings/tailings-conformance-protocols

IRMA (Initiative for Responsible Mining Assurance), 2023. Draft Standard for Responsible Mining and Mineral Processing 2.0. https://responsiblemining.net/resources/#standard2

Independent Expert Engineering Investigation and Review Panel, 2015. Report on Mount Polley Tailings Storage Facility Breach. https://www.mountpolleyreviewpanel.ca/sites/default/files/report/ReportonMountPolleyTailingsStorageFacilityBreach.pdf

Koppe JC, 2021. Lessons Learned from the Two Major Tailings Dam Accidents in Brazil. *Mine Water and the Environment*, 40:166–173. https://doi.org/10.1007/s10230-020-00722-6

Lyu Z, Chai J, Xu Z, Qin Y, Cao J, 2019. A Comprehensive Review on Reasons for Tailings Dam Failures Based on Case History. *Advances in Civil Engineering*. https://doi.org/10.1155/2019/4159306

Mining Association of Canada, 2023. Towards Sustainable Mining – Canada Tailings Management Protocol. https://mining.ca/wp-content/uploads/2024/03/Tailings-Management-Protocol-2023-03-09-ENG.pdf

ScienceMag.org, 2020. Catastrophic failures raise alarm about dams containing muddy mine wastes. By Warren Cornwall, Aug. 20. Science. https://doi.org/10.1126/science.abe3917