WORLD MINE TAILINGS FAILURES
15 Cove Meadow Road Stonington Maine 04681 USA
+1 207 367 5145 compiler@worldminetailingsfailures.org

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Contact: Lindsay Newland Bowker, Executive Director +1 207 367 5145 compiler @worldminetailingsfailures.org

GOVERNMENT UNEXAMINED RISK IN USA'S PORTFOLIO OF 1232 TAILING FACILITIES TOO HIGH FOR COMFORT OR ADEQUATE COMMUNITY AND INVESTOR SECURITY

World Mine Tailings Failure's (WMTF) analysis of the 1232 tailings facilities included in the recently released Army Corps of Engineers National Inventory of Dams (NID) 2019 offers little reassurance of U.S.A. State and Federal Government due diligence to protect communities or investors from the consequences of catastrophic failures. Our analysis suggests a high level of potential risk in the USA tailings portfolio and a low level of Government due diligence for the physical integrity of the nation's 295 facilities with a high hazard potential. This is the first NID that has allowed public access to hazard potential classification. Based on this data it seems possible, perhaps even likely, that much of the 12.2 billion cubic meters of tailings in 1,232 facilities in the United States have piled up with little guidance from stability analysis and with infrequent inspections subject to Government oversight in any form.

VOLUME OF USA ACCUMULATED TAILINGS BY HAZARD CLASS AND DATE OF LAST INSPECTION

LAST INSPECTION	ACCUMULATED TAILINGS VOLUME (CUBIC METERS)				
	HIGH	SIGNIFICANT	LOW	NOT GIVEN	TOTAL
SINCE 10/01/15	1,728,600,105	960,247,035	269,573,724	2,399,119	2,960,819,982
	32%	20%	14%	0%	23%
10/1/2012-09/30/2015	347,176,391	2,862,521,889	414,585,826	9,101,849	3,633,385,955
	6%	60%	22%	1%	28%
BEFORE 10/01/12	60,557,454	2,256,706,229	235,475,526	60,894,687	2,613,633,896
	1%	47%	13%	7%	20%
NOT GIVEN	3,322,131,684	1,191,225,342	941,381,414	744,357,605	6,199,096,045
	61%	25%	51%	6%	48%
TOTAL	5,458,465,634	4,787,011,002	1,861,016,490	816,753,260	12,923,246,386
% of Total Vol or Num	42%	37%	14%	6%	100%

NUMBER OF USA TAILINGS FACILITIES BY HAZARD CLASS AND DATE OF LAST INSPECTION

LAST INSPECTION	NUMBER OF TAILINGS FACILITIES				
	HIGH	SIGNIFICANT	LOW	NOT GIVEN	TOTAL
SINCE 10/01/15	93	101	68	1	263
	8%	16%	17%	1%	21%
10/1/2012-09/30/2015	23	70	82	1	176
	2%	17%	21%	1%	14%
BEFORE 10/01/12	11	98	52	23	184
	1%	29%	13%	20%	15%
NOT GIVEN	168	162	188	91	609
	57%	38%	48%	78%	49%
TOTAL	295	431	390	116	1232
% of Total Vol or Num	24%	35%	32%	9%	100%

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SOURCE Army Corps of Engineers 2019 National Inventory of Dams

42% of the 12.2 billion cubic meters of accumulated tailings in the United States are in 295 tailings facilities rated as "high potential hazard" in the event of failure. Only 8% (93) of these have Government reported or "known to Government" inspections since October 1, 2015. Governments across the country had no inspection information on 57% (168) "high hazard potential" facilities containing 61% of accumulated tailings volume.

Government will generally only have inspection dates and report content that is required by law and actually compiled by Government through statutorily mandated reporting. Few Governments require this even though assurance of physical safety is a primary aspect of the public interest justifying mining regulation. That Government has no information on 57% of high potential hazard facilities suggests a massive gap in the legal framework for public safety assurance. Ordinary buildings receive more scrutiny. A failure to regulate public safety of such very large structures with a known high hazard potential puts communities water resources and lands needed to sustain life downstream of these facilities at risk of generational non remediable loss. This gap in public oversight directly creates loss and volatility in the pension funds, retirement savings, and college funds of teachers, firemen, sanitation workers and mill workers with significant holdings in the minerals sector. Globally," *from 2010–2015, the top 40 impaired the equivalent of a staggering 32% of the capex incurred.* $36 billion, (68% of the total impairments), were taken by Glencore, Freeport Vale and Anglo. The top 40 took a collective net loss of $27 billion". (Bowker Chambers 2017) These data reflect poorly on Government due diligence for investors and downstream communities throughout the USA.

The Church of England Pension Fund (COE) tailings disclosure compilation, expected to be released on October 31, also includes "potential hazard" classifications and last inspection date reported by mine owners and operators. It will hopefully provide some insight on total safety effort, both owner/operator initiated and legally mandated.

While the NID2019 data indicate a need for a higher level of regulatory oversight and analysis of inspections of high potential hazard dams, that alone will not improve TSF safety assurance without concomitant changes in law and regulation to require competent independent stability analysis, something not presently required in most regulatory regimes nationwide, in Canada, or globally.

We know from our continuous research on TSF design and management at WMTF that the total level of effort behind the assessment of TSF safety is certainly higher than what the law requires. We know that the results of mine owner/operator inspections and stability analysis usually only comes into the public domain and to specific Government awareness post failure. We know that TSF safety recommendations made by Engineers of Record (EOR) or Independent Tailings Review Boards (ITRB's) and other expert advisers are ignored or avoided by mine owner's and operators if that advice means production delays or reduced production volumes. That is clear in the cause of failure reports of catastrophic failures and in the history of catastrophically failed facilities including Mt Polley, Samarco/Fundao. Gaps in law make this avoidance possible.

WMTF's latest predictions and stats show that the present combined level of effort by Government and industry to assess and reduce risk in the world's total portfolio of 18,000 TSF's has not been effective in reducing the frequency of catastrophic failures relative to mineral production volumes or the severity of these high damage failures.

Hazard Designation Not A Measure of Actual Risk Of Failure But Highly Correlated with Actual Harm When Failure Occurs.

A hazard designation is not a measure of the risk of failure. It defines the area which would be affected in the event of failure and estimates the level of harm that would result. In most jurisdictions which require a hazard classification as part of the mine application and approval process, more frequent inspections are required for "high potential hazard" class facilities. The 2019 NID, just released, is a compilation of information supplied by federal and state TSF regulators from May to November of 2018.

WMTF's analysis of known pre failure hazard classifications in our publicly downloadable database of World Mine Tailings Failures suggests a high level of correspondence between pre failure designations of "high" and "extreme" hazard potential and high magnitude of failure when failure occurs. The actual magnitude of the Brumadinho failure assigned by measurement in the WMTF database post failure corresponded well to the Columbia Water Center's pre failure severity score in the event of failure.

It is important both to community and investor security that hazard potential be a part of all legal frameworks and that it apply to all large TSF's both existing and proposed. Mt Polley, had a default classification of "low hazard potential" as all existing TSF's were grandfathered when Canada's hazard classification system was enacted. That mis classifcation of actual hazard potential exempted Mt Polley from the otherwise mandated more frequent inspections. That mis classification of "hazard potential" also undermined Knight Piesold's efforts to secure a stability assessment for the changes made to its "as approved" design. As State governments introduce or improve their present frameworks for inspection frequency, content and reporting to Government, it should apply to all TSF's not closed and remediated without grandfathering.

Brazil did not grandfather existing TSF's so Brumadinho, though designed and built long before Brazil's legislation, was correctly classified as "high hazard" and otherwise subject to all new law on TSF safety including a very specific annual inspection protocol for all large TSF's.

If there is any good news in this NID, it is that the USA has a much lower "potential hazard" profile than Brazil where 93% of all accumulated tailings are in "high potential hazard" tailings facilities.

DISTRIBUTION OF BRAZIL'S TAILINGS BY HAZARD CLASS AND WATERSHED

Watershed	VOLUME OF TAILINGS BY Government Assisgned Hazard Class			Overall Burden	
	Lo (i)	Moderate(ii)	High (iii)	Total	% of tailings
Afluentes do rio Verde Grande		cubic meters			in hazard class 3
Rio das Velhas	24,557	1,065,718	4,910,220	6,000,496	82%
Rio Doce	18,381,331	126,015,536	766,122,516	**910,519,383**	84%
Rio Grande	18,458	740,168	2,952,000	3,710,626	80%
Rio Jequitinhonha	30,875		21,650,000	21,680,875	100%
Rio Mucuri		26,000		26,000	0%
Rio Paraíba do Sul		285,288	15,995,423	16,280,711	98%
Rio Paranaíba	2,838,600	4,786,000	349,271,290	356,895,890	98%
Rio Paraopeba	122,190	220,369	11,866,600	12,209,159	97%
Rio Pardo			5,870,000	5,870,000	100%
Rio Piracicaba	2,640	71,350		73,990	0%
Rio Piracicaba/Jaguari	17,800	517,600	1,887,823	2,423,223	78%
Rio S.,o Francisco	923,839	12,867,983	914,152,070	**927,943,892**	99%
Rio Santo AntÙnio		318,400	40,000,000	40,318,400	99%
Grand Total	22,360,290	146,914,413	**2,136,217,651** 93%	**2,305,492,354**	93%

Lindsay Newland Bowker WORLD MINE TAILINGS FAILURES 2019
Data Compiled by Paulina Lamauri & Upmanu Lall Columbia Water Center
Pivot Tables from which data extracted By Dmitry Grishini

Inspections Don't Measure Actual Risk of Failure. Only Stability Analysis Does That

In modern society we almost automatically equate frequent and rigorous inspections with safety but that isn't fully transferable to tailings facilities. Frequent inspections are essential, of course, and may indicate a need for stability analysis but monitoring and inspections are not a substitute for stability analysis. At the moment of failure Vale had continuous state of the art monitoring in place on Dam 1 Brumadinho. Tthe feed from that that gave us the video of 30+ workers across the face of the TSF, both consultants and Vale employees, being swallowed in the mudflow of failure some frozen in awareness of what was happening, some attempting to run for safety.

Under Brazil's law, mandated annual inspections of large TSF's wrongly trumps mandated annual stability analysis. Dam1 was rated as "low risk of failure" by the Governments precise statutory "risk assessment" checklist , a reporting summary form for mandated annual inspections. It is on the basis of this inspection based safety audit check list risk that mandated warnings and corrections were ordered.at 94 Brazilian facilities. The measurements from annual required stability analysis submitted to the Government per statutory requirements showed the TSF to be hovering on the brink of failure but triggered no actions, warnings, relocations or risk assessment/risk reduction measures. (Details and links to actual reports are presented at www.worldminetaiingsfailures.org.)

More frequent inspections of existing USA TSF's not suitable for their location, climate and contents, will do little to identify and reduce risk. The WMTF analysis of the pre failure history at Brumadinho assesses the failure as beginning with a wrong design for the setting and for the nature of the materials. If addressed early enough, TSF's that are wrongly designed can sometimes be corrected through modifications as illustrated in the classic "Tale of Four Upstream Dams" by Davies. Martin and McRoberts.

In the USA we are not aware of any state Government that requires stability analysis by competent experts and in accordance with appropriate parameters and analysis techniques as a foundation for approved TSF design, for assessment of raises and modifications life of facility or when inspection conditions indicate a need for stability analysis(e.g. erosions, surges, pooling of water at the face of the structural containment wall, high water level with in the structure). As the work of Roberto Rodriguez, WMTF Compiler, Engineering has shown, failure conditions can emerge and persist even in facilities in stand by (not receiving depositions). So it s important as legal frameworks to improve dam safety assessment are developed that they apply to all TSF's not closed and remediated not just to those currently receiving depositions or planned new facilities.

NDI 2019 does not request or track the annual or planned depositions to U.S.A. facilities but we are looking forward to what the COE disclosure compilation may tell us about this important aspect of TSF safety assessment. WMTF highlighted this in its winter 2019 investor presentations to UBS, COE and CERES and COE has included it in its survey. We expect the COE data on this to have statistical clarity and to be extremely useful as our first documentation on how tailings capacity for the worlds' mineral supply is being met. We know already that it is being met in existing TSF's and often by stretching existing facilities beyond intended capacity and size.

If stability analysis isn't built into the process of design, including all projected raises and modifications to original design, the opportunity for correction may be missed as happened at Mt Polly, Samarco, and Brumadinho.

In the Samarco cause of failure press briefing and in the report Dr. Morgenstern, one of the world's leading experts on TSF stability, presenting on behalf of the expert team retained by Samarco, described the failure conditions as not observable or detectable by inspection but already inexorably formed within the tailings stack. In the Mt Polley cause of failure analysis, the expert panel determined through forensic stability analysis that the design deviation from a planned centerline to an ad hoc nearly upstream series of raises continued against the advice of Knight Piesold as designer and Engineer of Record, would have held had the rock wall re enforcement also recommended in the original design been built. Imperial resisted both the Government's and the EOR's advice to Imperial to build that wall but had weak authority in law to compel it in opposition to the successor EOR's (AMEC) resistance.

The difference between "inspection" and "stability analysis " is at the very crux of how we might assess community of origin security (ie the safety of the people, lands, waters and essential habitats within the identified "mining affected area". It's at the very heart of Government due diligence to its people and to

the investors it looks to to identify, assess and develop its mineral resources. And yet, even fewer Governments issuing permits for mining than require hazard potential classification, address stability at all in their legal frameworks or require that design and prospective raises be evaluated by stability analysis and monitored via stability analysis life of facility.

Stability Analysis Properly Applied is the Only Actual Measurement of Risk Of Failure.

Stability is about mathematical analysis estimating/measuing/predicting the complex interaction between the characteristics of contents (planned and as materialized) and the capacity of the shell and its drainage systems to withstand the stresses and strains of deposited materials and the affects of external triggers , especially earthquakes and external water influxes from weather and land drainage..

Without stability analysis there is no actual risk assessment.

We are aware of no state government with a statutorily mandated stability analysis protocol for design, modification, raises or analysis of trouble indicators like a high water level in the facility.

We have no compiled publicly available information at all on whether and how frequently any actual stability analysis guided the design and expansion of the USA portfolio of 1232TSF's or how many of those classified as high hazard in the event of failure have ever actually had a stability analysis at any point life of facility.

The level of unexamined risk in the USA's portfolio of 1,232 tailings facilities is clearly too high for comfort.

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