Index:
The Risk..........................5
The Event .......................8
Other Brazilian Disasters 20
Lessons from “Exxon Valdez” ..........24
Conclusion..........................27
Notes and References .........28

Ratings:
A.M. Best
B++
Global (Investment Grade)
Stable Outlook

Standard & Poor’s
brA+
Local
Stable Outlook

Shareholders:

Mouth of the Doce River. Source: Reuters, Ricardo Moraes
Dear Reader,

Terra Report was an innovation created by Terra Brasis in December 2010, with the aim of disseminating consolidated data from the Brazilian Reinsurance Market in a transparent and objective manner. Along the same line of innovation, we published the Brazilian Natural Catastrophes Map in August 2013.

Maintaining this innovative line of thought, six months after the date of the accident, Terra Brasis presents a report of the catastrophe that occurred in the city of Mariana, Minas Gerais, caused by the rupture of the Fundão tailings dam. It is not our intention to exhaust the subject, nor give precise and definitive estimates of its consequences, since, given the proportions of the event, many discussions and calculations will still take place.

In a didactic manner and in an easily accessible language, based on public information available, Terra Brasis’ team of professionals attempted to provide a holistic view of the Mariana tragedy, showing the operation of a mining company, its tailings dams, and the details of the event that occurred.

We also attempted to discuss the possible extent of the economic and insured losses, and of how, in moments of catastrophes such as this one, the insurance and reinsurance industry, with appropriated products, can collaborate to minimize the effects on all those who were affected by the disaster.

The sources of information are mentioned in all the graphs, photos, and tables. Throughout the text, the sources are referenced and described with numerical notations at the end of the report.

As usually happens after accidents of this magnitude, many people rush to condemn those involved, before ascertaining, with more accuracy, the causes of the event. Astronomical fines and penalties are established by a variety of different state agencies. Society as a whole, including the authorities, should be more concerned with the accountability of risk management, such as that of the dams and others, to reduce the possibility of accidents in the future and minimize their effects.

In any event, the moment demands reflection in order for us to analyze the failures and point out new ways to avoid or minimize tragedies like the one in Mariana.

At the end of this report, we describe the accident with the supertanker Exxon Valdez in 1989, when the American authorities acted quickly, and, within a period of one year, issued new regulations for the sector. We hope that this accident, which occurred in the Gulf of Alaska, serves as an inspiration so that, with the support of the Brazilian society, our authorities may enhance the legislation in effect, adapting it to the need for protection of the people and the environment.

Happy Reading,

Carlos Zoppa
Technical Director Vice-President
Terra Brasis Resseguros
The Risk

Description

In contrast to a hydroelectric power plant, for example, in which the dam is an integral part of the generation of electric energy, the tailings dam\(^1\)\(^2\) is an earth structure built simply to store mining waste. The following illustration demonstrates the operation of this type of structure, as well as its typical dimensions and composition.

![How a Dam Works](source: Genildo Ronchi, Infografire)

The construction of tailings dams\(^3\) can be done with compacted material brought from other areas, or with the actual mining waste.

Over time, with the evolution of the mining company’s operations, there has been a need for larger areas for the deposit of the mining waste\(^4\). Usually, the structure that already exists is reused by applying a technique called raising, in order to increase the storage capacity, as illustrated below.

![Raising Process of a Dam](source: Geo Explorer Consultoria)
**Operation**

Samarco Mineração S.A. (Samarco) is a private domestic company, with a workforce totaling approximately three thousand direct employees and three and a half thousand contractors, and is equally controlled by two shareholders, the Australian BHP Billiton Brasil Ltda., and the Brazilian Vale S.A. The company produces and exports pellets and fine grain quality iron ore, and is one of the largest exporters in the country. The extraction encompasses four open pit mines in the state of Minas Gerais: Alegria Central, Alegria North, Alegria South, and Germano.

Samarco’s mining complex began its operations in 1975, with the Germano open pit mine. Afterwards, in 1992, the production was transferred to the Alegria Complex, once the Germano open pit mine was exhausted, and is now mainly used as a location to discard and store waste.

Iron ore extracted from the mines is beneficiated in three concentrators located in Germano, with the intent of separating only the “desirable” parts of the ore and reducing the particles, in order for them to be adjusted to the dimensions of the pipelines for transportation.

The “undesirable” part of the material is called “waste.” Given its characteristics, this waste from the process cannot be used as soil, fertilizer, or for any other function. Therefore, it is deposited in large areas, around which tailings dams are built for its contention. The Alegria Complex comprises the tailings dams of Santarém, Germano, and Fundão.

The mines are interconnected by three pipelines, each with approximately 400 km, with four pellet plants at the Ubu unit7, in the municipality of Anchieta, in the state of Espírito Santo.

The pellet plants produce iron ore and fine grained iron ore pellets, which are exported from the Samarco Port at the location.

---

*Flowchart of Samarco’s Operations*

Source: Terra Brasis Resseguros S.A.
Other Dams in Brazil

Currently, it is estimated that among the 15,000 dams in Brazil, there are more than 600 tailings dams. Of this total, according to the National Department of Mineral Production (DNPM), a branch of the Ministry of Mines and Energy, 24 dams are classified as high risk.

As illustrated in the table below, in considering the volume of ore production in 2014, of the 25 largest iron ore mines in Brazil, 23 are located in state of Minas Gerais and two are in in the state of Pará.

<table>
<thead>
<tr>
<th>Name of the mine</th>
<th>City</th>
<th>State</th>
<th>Mining Company</th>
<th>Production (Tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Serra Norte</td>
<td>Parauapebas</td>
<td>Pará</td>
<td>Vale S.A.</td>
<td>124,364,407,00</td>
</tr>
<tr>
<td>2 Itabira</td>
<td>Itabira</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>60,767,671,00</td>
</tr>
<tr>
<td>3 Minas Centrais</td>
<td>São Gonçalo do Rio Abaixo</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>47,995,501,00</td>
</tr>
<tr>
<td>4 Minas Itabirito</td>
<td>Itabirito</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>46,153,646,00</td>
</tr>
<tr>
<td>5 Alegria</td>
<td>Mariana</td>
<td>Minas Gerais</td>
<td>Samarco</td>
<td>48,108,000,00</td>
</tr>
<tr>
<td>6 Capão Xavier</td>
<td>Nova Lima</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>38,000,000,00</td>
</tr>
<tr>
<td>7 Paracapéia</td>
<td>Nova Lima</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>30,307,951,00</td>
</tr>
<tr>
<td>8 Vargem Grande</td>
<td>Nova Lima</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>30,229,745,00</td>
</tr>
<tr>
<td>5 Pico</td>
<td>Itabirito</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>28,561,820,00</td>
</tr>
<tr>
<td>10 Casa de Pedra</td>
<td>Congonhas</td>
<td>Minas Gerais</td>
<td>Companhia Eletrotécnica Nacional</td>
<td>25,992,000,00</td>
</tr>
<tr>
<td>11 Fábrica Norte (Complexo Mariana)</td>
<td>Catas Altas</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>16,366,503,00</td>
</tr>
<tr>
<td>12 Capitão do Malo</td>
<td>Nova Lima</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>16,000,000,00</td>
</tr>
<tr>
<td>13 Fazenda (Complexo Mariana)</td>
<td>Catas Altas</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>18,222,299,00</td>
</tr>
<tr>
<td>14 Alegria (Complexo Mariana)</td>
<td>Mariana</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>11,483,005,00</td>
</tr>
<tr>
<td>15 Cingol</td>
<td>Itacuçu</td>
<td>Minas Gerais</td>
<td>Mineração Usiminas</td>
<td>10,663,000,00</td>
</tr>
<tr>
<td>16 Comumbú</td>
<td>Comumbú</td>
<td>Minas Gerais</td>
<td>Vale S.A.</td>
<td>7,965,742,00</td>
</tr>
<tr>
<td>17 São Luiz do Oeste</td>
<td>Bom Jardim</td>
<td>Minas Gerais</td>
<td>Vallyoung Mineração</td>
<td>6,000,000,00</td>
</tr>
<tr>
<td>18 Vale do São Paulo</td>
<td>Itabira</td>
<td>Minas Gerais</td>
<td>Gerdau Agrominas</td>
<td>5,900,039,00</td>
</tr>
<tr>
<td>19 Serra Azul</td>
<td>Itacuçu</td>
<td>Minas Gerais</td>
<td>ArcelorMittal Mineração Serra Azul</td>
<td>3,615,685,00</td>
</tr>
<tr>
<td>20 Miguel Burmíner</td>
<td>Ouruí Preto</td>
<td>Minas Gerais</td>
<td>Gerdau Agrominas</td>
<td>2,466,425,00</td>
</tr>
<tr>
<td>21 Minas do Saco</td>
<td>Conceição do Mato Dentro</td>
<td>Minas Gerais</td>
<td>Anglo American</td>
<td>2,567,949,00</td>
</tr>
<tr>
<td>22 Andrad</td>
<td>Bela Vista de Minas</td>
<td>Minas Gerais</td>
<td>ArcelorMittal Mineração Brasil</td>
<td>2,500,000,00</td>
</tr>
<tr>
<td>23 Central</td>
<td>Itacuçu</td>
<td>Minas Gerais</td>
<td>Mineração Usiminas</td>
<td>2,298,000,00</td>
</tr>
<tr>
<td>24 Serra Leite</td>
<td>Parauapebas</td>
<td>Pará</td>
<td>Vale S.A.</td>
<td>2,242,610,00</td>
</tr>
<tr>
<td>25 Votorito</td>
<td>Comumbú</td>
<td>Minas Gerais</td>
<td>Votorit Mineração</td>
<td>2,237,723,00</td>
</tr>
</tbody>
</table>

Source: Minérios & Minerales Magazine "200 Largest Brazilian Mines, General Ranking by Annual Production in Tons (ROM) – Base Year 2014".
The Event

According to public information⁹, around 3:15 pm on November 5, 2015, a leak was verified in the containment of the Fundão tailings dam, owned by Samarco, which is part of the complex comprised by the Fundão, Germano, and Santarém dams. At that moment, a team was sent to the location in an attempt to reduce the leak by emptying part of the reservoir.

At approximately 3:45 pm, the Fundão tailings dam burst, causing the outflow of waste deriving from the extraction of iron ore.

Source: Official Site of Mineração Samarco S.A.
Note: Barragem = Dam
According to the preliminary technical report\textsuperscript{10} by the Brazilian Institute of Environment and Renewable Natural Resources, (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis -IBAMA) this event released approximately 62 million m\textsuperscript{3} of mud.

\section*{Aerial View of Bento Rodrigues, Before and After the Rupture of the Dam}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{aerial_view.png}
\caption{Aerial View of Bento Rodrigues, Before and After the Rupture of the Dam}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{aerial_view_after.png}
\caption{Aerial View of Bento Rodrigues, After the Rupture of the Dam}
\end{figure}

\begin{multicols}{2}
Source: Google Earth
\end{multicols}

In the case of the Fundão dam, it ruptured while it was being raised\textsuperscript{11} 20 meters, from an altitude of 920 meters to an altitude of 940 meters in relation to sea level. Up until the publication of this report, there has been no definitive conclusion on the causes of the accident at the Fundão dam, and whether the raising had contributed or not to the rupture.

Initially, it was thought that both the Fundão and Santarém dams had burst. However, days after the event, Samarco confirmed that only the Fundão dam had been affected, while the Santarém dam had overflowed. However, the mud that originated from the rupture of the Fundão dam directly affected the structure of the Santarém dam, and, according to the DNPM, elevated its risk of erosion and collapse to the highest level\textsuperscript{12}. 

Aside from the damage to the dams, the rupture released a torrent of sludge with waste, which, at first, flooded the Bento Rodrigues Community, a subdistrict of the City of Mariana, which is located approximately two and a half kilometers in the valley below the dams, and left approximately 200 houses there totally destroyed.\(^{13}\)

After flooding the Bento Rodrigues Community, the mud swept through 17 other villages and subdistricts of the region, directly affecting almost eight thousand inhabitants there, until it reached the Doce River around 6:30 pm the same day. As of the date of this publication, 18 deaths were confirmed and one person remains missing.\(^{14,15}\)

Then, the mudslide ran through 55 kilometers of the Gualaxo do Norte River until it spewed into the Carmo River, running more than 22 kilometers until it reached the Doce River.
The Doce River, extending 853 kilometers, passes through 228 municipalities of the states of Minas Gerais and Espírito Santo, before emptying into the Atlantic Ocean. Its course represents the most important hydrographic basin of the southeastern region of Brazil.

During the following 17 days, the mudslide ran through the Doce River until it reached the ocean, in the municipality of Linhares, located in the north of Espírito Santo State. Of the 853 kilometers that make up the Doce River, 586 kilometers were contaminated by the mud.

![Mapping of the Mud’s Path](source-image)

Yet, on the Brazilian coast, the mudslide also reached the Comboios Biological Reserve, situated between the municipalities of Aracruz and Linhares in the state of Espírito Santo. This reserve is a coastal conservation biome that protects the only regular nesting site of the leatherback sea turtle on the Brazilian coast. It was possible to save the eggs already laid, but the effects will be felt in future nestings, due to the mud that was lodged at the bottom of the reserve.

According to reports by the Committee of the Hydrographic Basin of the Doce River, (CBH-Doce) there are 129 collection sites designated for public supply along the Doce River, being that several cities from Minas Gerais and the Espírito Santo municipalities use their water supply. One of the main cities of Minas Gerais, Governador Valadares, as well as several other smaller cities like Galiléia, Resplendor and Tumiritinga had their water supply interrupted, which led them to decree a state of public calamity, depending on the donation of drinking water and use of water tank trucks. It is estimated that 3.5 million inhabitants of the region were affected by the lack of water.

Soon after the accident, CBH-Doce, in partnership with the National Service for Industrial Training (SENAI) of Environmental Technology, intensified the monitoring of the quality of the water in the State of Minas Gerais, given the large amount of mud, aluminum, manganese, and iron that, together with the waste, flowed into the river. Despite the high quantities, compared with the historic average, according to reports issued by The Institute for Water Management in Minas Gerais, these ores are present in several natural components of nature and have no influence on the quality of the water, together with other characteristics of the river.
Regarding the other metals, like lead, on the date of the rupture and the arrival of the waste into the river, their levels were higher than the acceptable levels. However, after a few days, those levels were back to normal\textsuperscript{17}. Therefore, it was understood that the major pollutants are not the metals, but rather, the mud and the other materials brought by the mudslide.

Other than the municipalities’ use of the Doce River as water supply, according to another report by CBH-Doce\textsuperscript{21}, approximately 3,600 industries, primarily mining companies, agricultural companies, traditional tillage, coffee and sugar cane cultivation, raising beef and dairy cattle, pork and poultry industries, and reforestation enterprises use the river as a source of water supply. Further, the cellulose and dairy industries, and business and services geared towards industrial complexes, such as the generation of electric energy, stand out.

With regard to fishing, according to the Class Action filed by the Federation of the Colonies and Associations of Fishermen and Farmers of Espírito Santo (Fecopes), three-thousand fishermen can no longer work in the river. It is estimated that approximately 317 thousand workers have been indirectly affected. Further, with regard to the report by CBH-Doce\textsuperscript{21}, 11 tons of fish were killed. According to information by IBAMA (Note 2 cited in the following chapter entitled “Values Estimate”), the river is home to 80 species of fish, from which 11 are endangered and 12 are endemic, which means they only live in this hydrographic basin and may have been extinct. Environmentalists estimate\textsuperscript{18} that between fish, invertebrates, amphibians, reptiles, and birds, one trillion live organisms perished in the disaster, either by lack of oxygen in the river, or by being “cemented” by the mud. As of the date of this publication, we have not found official data or estimates on the economic losses resulting from the impossibility of using the water from the river, whether in cities or in industries. However, it is known that there were economic losses, and that they were elevated. There is still no estimate on the recovery time of the river.
Values Estimate

Economic Loss

The disaster with Samarco’s dam triggered social and environmental impacts that will have a variety of economic effects. It is still premature to specify the total values of the economic losses. However, it is possible to present an estimate, taking the extent of the damage and public information available up to now, into account.

With regard to the environmental perspective, according to the Technical Note by IBAMA, approximately 1,500 hectares of riparian forest were destroyed, mainly in the Municipality of Mariana, extending at least 170 km, among which, an area of 80 square kilometers was also affected in the ocean, on the coast of Espírito Santo. Furthermore, aside from the impact on the estuary of the Doce River and its coastal region, the Mariana disaster affected 663 kilometers of a body of water in the States of Minas Gerais and Espírito Santo. The Report on the Evaluation of the Effects and the Developments of the Rupture of the Fundão Dam in Mariana, produced by the Task Force, quantified the loss of 1,000 animals, among cattle and horses, as well as animals for household consumption. Another 485 animals were lodged in a shelter by Samarco, among them dogs, cats, and chickens. Approximately 11 tons of fish perished along the Doce River, affecting hundreds of fishermen.

Samarco received preliminary fines from IBAMA, worth a total of BRL 250 million. In addition, it signed a Conduct Adjustment Term (TAC) with the District Attorney of Minas Gerais, in which it is obligated to maintain a fund in the amount of BRL 1 billion, intended solely for the recovery of the Doce River. However, it is possible that these values are not sufficient for the full recovery of the hydrographic basin.

Nevertheless, faced with the country’s largest environmental disaster, the losses are not limited to this scope. From a social point of view, according to the Preliminary Report from the External Committee of the Dam Rupture in the Mariana Region, the village of Bento Rodrigues, with approximately 200 houses and 600 inhabitants, was almost totally covered by the mud, with a loss of public infrastructure and private goods, requiring relocation. Six other communities partially affected by the mud were: Paracatu de Baixo, Paracatu de Cima, Campinas, Borba, Pedras and Bica, which are part of the District of Camargos, of the Municipality of Mariana, aside from the city of Barra Longa (MG) and they were accounted for 1,265 homeless, 18 dead, and 1 missing person.

According to the Technical Assistance and Rural Extension Company of the State of Minas (EMATER-MG), the farmers of Minas Gerais lost BRL 23 million with the Mariana event. Further, according to the above-mentioned report, jobs were lost, since various autonomous workers, at least 1,249 fishermen, depended on the Doce River for their work. The Report on the Evaluation of the Effects and the Developments of the Rupture of the Fundão Dam also highlights the paralysis in the production of milk, with estimated losses of 11,000 liters per day in Mariana, 6,000 in Barra Longa, and 4,000 in Rio Doce and Santa Cruz do Escalvado. An example of this social loss is the indigenous community Krenak, which was directly affected, among others, because of its fishing activity and use of the water. The paralysis of companies also contributed towards the highest unemployment rate in the region.

According to news published by the media, approximately 2,500 of Samarco’s employees were on paid leave until the end of December 2015. An agreement was reached between the company and the representatives of the workers, which maintained the jobs until March 1, 2016. It is possible that, since then, the number of unemployed workers has been rising.

In addition, according to the Preliminary Report, there are indications that there will be a shortage in the regional production of energy, since the activities of the hydroelectric plants of Candonga, Baguari, Aimorés, and Mascarenhas were interrupted.
From a municipal point of view, according to the Report\textsuperscript{24} on the Evaluation of the Effects and The Developments of the Rupture of the Fundão Dam in Mariana-MG, by the Task Force of the Government of the State of Minas Gerais, it is expected that there will be a reduction in the revenues collection by Mariana, due to the paralysis of the mining activities. The Mariana Mayor’s Office foresees a loss of 30% in its tax collection for January 2016. Given the radius of propagation of the mud, one can imagine that the value of the losses will be very high. From the perspective of 35 municipalities from Minas Gerais directly affected by the disaster, according to estimates from the government of Minas Gerais, a material loss of approximately BRL 1.2 billion is calculated (not considering legal proceedings). Only in Bento Rodrigues, of the 252 existing buildings, 207 were destroyed by the mud, totaling 82% of buildings affected.

The corporate credit rating, on a global scale, and the ratings of Samarco Mineração’s outstanding debt, were maintained by the risk classification agency Fitch\textsuperscript{31} and lowered by Standard & Poor’s (S&P)\textsuperscript{32} from BB- to B. The company Vale, a shareholder of Samarco, estimates a reduction of US$ 443 million on its result for the year 2016\textsuperscript{33}.

It is important to consider the effects of legal proceedings. According to the Preliminary Report\textsuperscript{28}, an important point was that there were already lawsuits at the State and Federal levels. The litigations varied, and among them, what stands out is the indemnification of BRL 20.2 billion, requested against Samarco, with the possible involvement of Vale and BHP, for the reparation of the environmental damage within a period of 10 years, and a class action filed by an American law firm against Vale to guarantee the indemnification of shareholders for omission by the company regarding losses related to its relationship with Samarco and the suspension of Samarco’s activities.

Notwithstanding the result of the research on the impact of the mud tailings, performed by a ship of the Brazilian Navy at the mouth of the Doce River being confidential for five years\textsuperscript{34}, limiting access to it only to the Union, the tendency is that lawsuits will proliferate, since innumerable individual suits may still be filed. It is worth remembering that after the first inquiry about the case, the Civil Police of Minas Gerais requested the preventive arrest of six of Samarco’s employees\textsuperscript{35}, including the president on leave. Though the Court still has not manifested itself, they were indicted for suspicion of qualified murder with intent, flooding and pollution of drinking water.

Taking into account all the damages, fines, and sanctions already applied and previously cited, as per the table below, Terra Brasis believes that the total economic loss deriving from this event will surpass BRL26 billion.

### Description of the Estimated Economic Loss (in BRL)

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indirect and Environmental</strong></td>
<td></td>
</tr>
<tr>
<td>Federal and State Environmental Actions</td>
<td>20,200,000,000.00</td>
</tr>
<tr>
<td>Material losses (estimate of Minas Gerais’ Government)</td>
<td>1,200,000,000.00</td>
</tr>
<tr>
<td>Conduct Adjustment Term (TAC) for the Rio Doce river recovery</td>
<td>1,000,000,000.00</td>
</tr>
<tr>
<td>Fine applied by IBAMA</td>
<td>250,000,000.00</td>
</tr>
<tr>
<td>Losses of the farmers</td>
<td>23,000,000.00</td>
</tr>
<tr>
<td>Stoppage of Companies (Terra Brasis estimate)</td>
<td>300,000,000.00</td>
</tr>
<tr>
<td>Independent workers/fishermen (Terra Brasis estimate)</td>
<td>25,000,000.00</td>
</tr>
<tr>
<td><strong>Direct</strong></td>
<td></td>
</tr>
<tr>
<td>Loss Estimate of the Fundão’s dam</td>
<td>216,817,000.00</td>
</tr>
<tr>
<td>Loss of Profit by Standstill (estimated 13-months of standstill)</td>
<td>3,039,343,657.00</td>
</tr>
<tr>
<td><strong>Total estimate of Economic Loss</strong></td>
<td>26,254,160,667.00</td>
</tr>
</tbody>
</table>

*Source: Terra Brasis Resseguros S.A., Financial Statements from Samarco Mineração S.A.\textsuperscript{36} and several sources and notes cited in this chapter.*
Potential Insured Value

Six months after the accident in Mariana, there is still very little defined, considering the viewpoint of the Insurer and Reinsurer markets, the coverage of the policies effectively in effect, and the determination of liabilities.

The descriptions and explanations of insurance coverages to be used, assuming they were contracted, are listed below:

1. **Property**: Property insurance, as the name implies, covers physical damage to the Insured’s material goods, and possible consequential damage.

Other than all the structures, machines, equipment, dams, materials, raw materials, pipes, among others, it may also cover the Insured’s Loss of Profit resulting from Material Damage covered by the policy.

Thus, should it be concluded that the rupture of the dam is indemnifiable under the Insured’s Property Policy, the Loss of Profit shall also be indemnified up to the contracted values.

In Samarco’s case, the potential indemnification of the Loss of Profit is much greater than the Material Damage associated with the dams and the possible equipment or other assets that were also affected, since Samarco’s operations were totally paralyzed after the event.

Samarco’s production flow is mass production, or, rather, any massive interruption in any of the points of the Insured, (Mariana, ore pipelines, or Ubu) will probably represent the total stoppage of the insured.

With the rupture of the tailings dam, the mining activities were suspended, and even the operations in the Ubu plant, located 400 kilometers from the location affected, were paralyzed because the stock of ore ran out, and there were no new “raw materials” originating from the mine in Mariana.

2. **Contractors’ All Risks - CAR**: The CAR guarantees civil works in construction, and may also guarantee the installation and assembly of equipment. It is an all risks type of coverage, which means that it covers all risks except those explicitly excluded, and may offer protection for material damage caused to the construction, as a consequence of a project error, riots, and debris removal, among others.

At the time of the event, work was being done to raise the Fundão dam. If an Engineering Risk Policy exists, it could provide coverage.

According to the information disclosed, the dam raise project would have started approximately two months before the date of the rupture. In this case, the amount to be indemnified would be proportional to the planning curve of the work and its current stage at the time of the accident.

3. **Liability**: The Liability Policy guarantees protection to the Insured against claims for which it would be legally liable in relation to involuntary, material and personal damages caused to third parties.

In this event, the damage done to third parties, resulting from the rupture of the dam, would be indemnified. The damages caused to third parties were significant, and therefore the adjustment will require an exhaustive work from the Loss Adjustment team.

4. **Construction Liability**: A Construction Liability Policy guarantees material or personal damages caused to third parties, resulting from civil works.
Since the factor that caused the event is still not defined, there is no basis to discuss possible liabilities, from civil works. However, should such liability be materialized, it is probable that the insured value will be used up, since experience indicates that in Brazil, these values in insurance are small in light of the magnitude of the event.

5. Employer’s Liability: The Employer’s Liability insurance guarantees civil liability of the insured company against personal damages suffered by its workers during the work period. It is possible to cover material damages by means of specific provisions contracted separately.

In the case of this event, the workers who were present at the scene of the accident died. Some were workers of Samarco and others were from construction companies, which can put the policy on notice.

6. D&O: It is an abbreviation for Directors and Officers Liability Insurance. The objective of this insurance is to protect the property of individuals who occupy management positions or functions in the company. These people, as managers, make decisions that can cause harm to third parties. The Insurance provides financial support to individuals and, possibly, corporate bodies, in legal and extrajudicial disputes related to their managerial decisions.

Should there be indications that, due to negligence, imprudence or malpractice from any of the directors or managers, some recommendation referring to improvement points in the dams or adoption of certain contingent plans were not implemented, they may be liable and the D&O policy may be put on notice.

In specific cases, as in environmental issues, the legal responsibility can be passed on to the responsible director/manager, who will have to respond directly. Further, the D&O policies of the main shareholders of Samarco, may also be affected.

7. E&O: The Professional Civil Liability insurance (Errors & Omissions) aims to insure damages that may be caused as a result of the failure to render professional services due to professional errors or omissions, and also guarantees the costs incurred with the defense of the Insured in a possible legal action. In this case, it is possible that the construction companies involved in the work on the dam at the moment of its rupture, may be held responsible for the accident, if, for instance, it was due to a project error, putting the E&O policy of the contractor on notice.

8. Life: Since the deaths of employees were confirmed, the Life Insurance Policies may be put on notice.

After having analyzed all the potential insured values, based exclusively on public sources, Terra Brasis estimates that the amount to be covered by the insurance market may reach BRL 2.25 billion.

<table>
<thead>
<tr>
<th>Description of the Estimate of the Insured Amount (in BRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insurance Coverage</strong></td>
</tr>
<tr>
<td>Property</td>
</tr>
<tr>
<td>Legal Liability</td>
</tr>
<tr>
<td>Environmental insurance</td>
</tr>
<tr>
<td><strong>Total estimate of the Insured Amount</strong></td>
</tr>
</tbody>
</table>

Source: Terra Brasis Resseguros S.A., several sources and notes cited in this chapter.
Distribution of Liabilities Among Insurers, Local Reinsurers, and Offshore Reinsurers

Using information from Terra Report and data available in the database of the Superintendence of Private Insurance (Susep), based on possibly insured lines of business and on its average percentages of retention and cession of reinsurance and retrocession, we estimated the distribution of liabilities between the Insurers, Local Reinsurers, and Offshore Reinsurers, as illustrated below:

Source: Terra Brasis Resseguros S.A., SUSEP

Based on Terra Brasis’ experience in similar risks, probably between two and five Insurers participate in this insurance in different policies and through the use of co-insurance. Taken as a whole, and based on the average retention and retrocession indexes used by the corporate risks market made available by Susep, we estimate that Insurers retained 1.1% of the total of the risks, and Local Reinsurers received 71.9% in reinsurance, retaining 12.1%, and retroceding 59.8% abroad.

According to this estimate, between Insurers and Local Reinsurers, 13.2% of the liabilities insured (close to BRL 300 million), will be retained in Brazil, while 86.8% (BRL 1,950 million) will be assumed by offshore reinsurers.

The Local Insurance and Reinsurance Markets deserve two exceptional marks in relation to these figures. The first refers to what seems to be a symptom of technical maturity, as they bought strong protection to withstand a loss of this magnitude, reducing their retention to close to 13% of net liability, when we know that the average retention of the Local Markets, including all reinsured risks, is between 40 and 45%.

Secondly, it is important to note the vigor and capacity of the Local Insurance and Reinsurance Markets which, coherently with their correct capacity, are able to retain in Brazil close to 13% of a risk of this magnitude, and be prepared for an indemnification estimated at BRL 300 million, while maintain, without significant repercussions, their high solvency.
Probable Risks Not Covered by Insurance

Environmental Risks

Currently, the purchase of Environmental Insurance in Brazil is in its early stages of development, having presented a written premium volume of approximately BRL 45 million39 in 2015. We believe that, because of this, there is a great probability that such coverage for the Mariana event41 is nonexistent.

Some confusion about the concepts between the protections of the Clause of Sudden and Accidental Pollution of Liability Insurance (Susep’s line of business code 51) and the Environmental Insurance per se, the Environmental Risks, (Susep’s line of business code 13) can be noticed, and such lack of knowledge may result in the absence of interest to its purchase. Therefore, in events like the one exposed in this report, the affected company may incur a massive loss, which may even compromise its solvency and continuity, when the insurance could assist in the mitigation of such losses and help the insured.

It is important to stress such relevant differences between the Clause of Sudden and Accidental Pollution of the Liability Insurance and the Environmental Insurance. In general, the first one is contracted as an ancillary coverage of the Liability Insurance and is limited to cover only damages caused by the insured, limited to third parties and by means of temporary limitations in terms of the beginning and cessation of pollution events. On the other hand, the Environmental Insurance comprises hybrid coverages, i.e., it guarantees indemnifications to the actual insured locations and properties, as well as those related to third parties and ecological damages.

The Environmental Civil Liability of the Insured in an Environmental Insurance is characterized by Material and/or Personal and/or Moral Damages, aside from environmental damage or damage to natural resources, involuntary damages resulting from pollution and/or contamination by a sudden and accidental leakage and/or gradual leakage of dangerous products, pollutants or contaminants, resulting from the Insured’s operations.

For the purpose of this insurance, sudden pollution is understood as pollution that arises from an accidental, sudden, abrupt and unintentional event, like, for example, the rupture of a duct by the impact of an object during maintenance. Yet, gradual pollution is the one that occurs gradually and may manifest in the future, causing cumulative and sequential harm. It is important to stress that, among other exclusions, this insurance does not guarantee fines or penalties of any nature, or damages resulting from misconduct imposed on the Insured.

Further, still for the purpose of the insurance, environmental pollution is understood as the emission, dispersion, or deposit of a substance or product that will harm the conditions of the atmosphere, water, soil, and other natural resources that previously existed before the arrival of the polluting factor or event.

Reparation of the damages may be demanded in the form of an indemnification of actual or legally presumed losses, or in the restoration of what was polluted, destroyed, or degraded. In addition, the costs of minimizing the effects may also be covered.

Environmental Insurance is a global tendency and, many times, is mandatory for certain economic activities, as is the case in Europe, USA, and Argentina. The United States was a pioneer in this insurance modality, which appeared in 197743 and nowadays, represents a market worth more than one billion dollars, with more than 40 Insurers operating in this line of business in the country.
Brazil is going through a moment of recent and gradual implementation of the Environmental Insurance and is still in the phase of general awareness about the theme. Estimates indicate that nearly 90% of the 1,000 largest companies in Brazil still do not purchase it.

Not only cultural issues, but also a supervisory system with ineffective accountability and the lack of a legal regulatory framework, among other factors, make a faster development of the Environmental Insurance more difficult. Even with these difficulties, the increase in the number of professionals dedicated to the matter and in the quality of the studies that were conducted and publications that were produced, is clearly noted. The increase in the number of Insurers that have been trying to develop more adequate products tailored to Brazil’s environmental reality, which is very peculiar, is also very clear.

The “Mariana” event is an example that massive losses can occur. It highlights the importance of the purchase of Environmental Insurance, which emphasizes even more the need to minimize and manage the risks of companies exposed to such types of occurrences, and may help the Insured in the preventive management of its environmental risks, minimizing the effects on society, in the event of its real manifestation.
Other Brazilian Disasters

The rupture of Samarco’s dam is probably the largest environmental disaster ever that occurred in Brazil, and is the largest disaster caused by ore waste worldwide.

Not even the oil spills that already occurred on the Brazilian coast or fires of large proportions, like the one at the Port of Santos, resulting in a caramel waterfall originating from the melting of sugar thrown into the sea, or by the fuel tanks that remained burning for a week, caused damages of such a scale.

The examples below serve to verify that events in Brazil, which cause economic and environmental impacts that are under insured, do occur regularly. These events cause almost irreparable environmental and economic damages. They are usually not covered by insurance, in the majority of cases given the lack of people’s knowledge, but also due to a sub dimension of the size of operation, or even due failures during the structuring process of the insurance program.

For these cases, the insurance would not only be a way to repair the damage from an economic point of view, but rather as one of its functions, to assist the insured in the management of its risks, preventing accidents or minimizing the effects or losses.

As a comparison, we describe below some events of large economic and environmental impact that occurred in Brazil and that had some insurance protection.

Oil Platform P-36

On March 20, 2001, Petrobras’ P-36 Oil Extraction Platform in the open sea, which was the largest in the world at the time, sank to a depth of 1,200 meters, with an estimate of 1,500 tons of oil still onboard, at the Campos Basin in Rio de Janeiro. At the time of the accident, there were 175 people on board, 11 of whom died.

A few days before it sank, three explosions occurred in one of the platform’s columns, and according to the Brazilian National Agency of Petroleum, Natural Gas, and Biofuels (ANP), they were caused by the “non-conformity with regard to the operational maintenance and project procedures”. After the explosions, the platform inclined, due to the penetration of water from the sea, which led to its sinking.

The insured loss was around US$ 500 million, an amount not far from the total financial impact for Petrobras, which amounted to approximately US$ 700 million, considering the loss of revenue and the value
of the actual platform. Without taking into account the environmental damage of the oil thrown into the Campos Basin, the incident generated economic losses to the country estimated at US$ 2 billion⁷.

**Port Terminal of Santos**

On April 02, 2015, a fire of large proportions spread to six tanks of a company that, among other activities, distributes fuel, and is located at the Port of Santos in the state of São Paulo⁸. It took firefighters approximately nine days to control the fire.

Aside from combatting the flames, the firefighters were controlling the protection of neighboring tanks, fearing that the fire would spread to highly inflammable materials contained in the tanks. Firefighters from nearby cities and states were recruited, resulting in approximately 900 men taking part in the operation.

Aside from material damages and damage to the cargoes, which belonged to third parties, the environmental and social impacts had become noticeable from the first day of the fire. Water contaminated with fuel, which was thrown into the water near the Port of Santos, in mangroves and in the lake beside the terminal caused the death of several fish, harming local fishing, with reports that hundreds of fishermen from the region were without work for months.

According to the São Paulo State Environmental Company (CETESB)⁹, approximately 8.5 tons of fish died. Another effect of the fire was the interruption of activities in other terminals that were located on the right side of the Port, an area responsible for approximately 55% of the port’s daily volume, and that receives between 9 and 12 thousand trucks per day.

There are published reports⁵⁰ that the company relies on an insurance policy with a limit of US$ 550 million, in addition to a Liability Policy. We believe that the extent of the economic damages may have reached approximately two times the amount insured, or, rather, approximately US$ 1.1 billion.

**Tropical Cyclone Catarina**
On March 24, 2004, a tropical cyclone started forming in the State of Santa Catarina, reaching its peak of intensity with winds up to 155 km/h on March 28, resulting in the phenomenon that came to be known as Cyclone Catarina51.

The damage was severe, being that, according to the Civil Defense of Santa Catarina, 1,000 residences were destroyed and another 36,000 were damaged 9. Regarding agriculture, approximately 85% of the banana production and 40% of rice production, were destroyed. Moreover, nearly 30,000 people were dislodged and became homeless, and other than the 518 injured, three people died.

<table>
<thead>
<tr>
<th>Damage Resulting From Tropical Cyclone Catarina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Damage</td>
</tr>
<tr>
<td>Displaced people</td>
</tr>
<tr>
<td>Homeless people</td>
</tr>
<tr>
<td>Displaced people</td>
</tr>
<tr>
<td>Injured</td>
</tr>
<tr>
<td>Deaths</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Source: Civil Defense of Santa Catarina, The Impact of the Climactic Catastrophes on the Solvency of the Insurers, René Henrande Vieira Lopes, Terra Brasis Resseguros S.A.

At the time, the economic loss was estimated at BRL 602 million, being that we believe the environmental damage was not accounted for. There is no precise information on the insured amount. Nevertheless, the residential as well as agricultural insurance penetration at the location of the occurrence is too low. We believe the insured value to be approximately 5% of the economic damage, or, in other words, BRL 30 million.

**Landslide in Rio de Janeiro**

In the early morning of January 12, 2011, the Cities of Nova Friburgo, Petrópolis, Teresópolis, Sumidouro, São José do Vale do Rio Preto, and Bom Jardim in the Central-Southern Region of Rio de Janeiro, were hit by flooding and landslides that, according to the study by the World Bank51, left 916 dead, approximately 350 missing and more than 300 thousand people directly affected, or 42% of the population of these municipalities. A mudslide destroyed everything that was in its path.

The estimated economic losses reached BRL 4.78 billion. After the tragedy, the federal government immediately made BRL 780 million available for assistance in the recovery of the affected areas. Estimates indicate that there is an insured value of BRL 92 million.

There is no precise information on the losses that were insured in this event, but they were very low, given the characteristics of the locations affected.

As a result of the lack of urban planning, and, consequently, the lack of infrastructure, Brazil is very exposed to the risk of landslides, especially in the Southeastern and Southern regions.
Train Derailment in the Countryside of São Paulo

On June 10, 2013, a freight train headed to Paulínia-SP, derailed in Uberaba-MG, causing the largest environmental disaster of the Triangulo Region of Minas Gerais.

The train, which had 18 wagons, was transporting octanol, methanol, isobutanol, and potassium chloride. The toppling was followed by explosions, and, in order to contain the fire, the Fire Department worked during seven uninterrupted days.

Some of the consequences of the accident were the 1,000 meters of devastated riparian forest, several dead animals, and the Alegria stream, one of the tributaries of the Uberaba River, which supplies almost 250 thousand people, contaminated with 670 tons of chemical products.

At the time, a TAC worth BRL 13 million, aside from work to improve the city, was signed with the company that owned the train. However, more than 10 years after the accident, the contaminated area is still isolated, is monitored 24 hours a day, and protective equipment is still needed to enter it. To date, chemical substances are still found in the area of the river.

There is no precise information on the economic and insured loss. However, a stream, a tributary of the Uberaba River, and 2.5 hectares of land are still contaminated, harming the environment and the population that lives there.

Summary of Information on Human, Environmental, Economic, and Insured Losses

<table>
<thead>
<tr>
<th>Brazilian Disaster</th>
<th>Year of occurrence</th>
<th>Human and Environmental Loss</th>
<th>Estimated Economic Loss (BRL million unless indicated)</th>
<th>Estimated Insured Loss (BRL million unless indicated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mariana</td>
<td>2015</td>
<td>18 confirmed deaths, 1 missing, 853 km of river polluted, 3.5 million people without drinkable water, 11 tons of dead fish, 11 endangered fish species.</td>
<td>26,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Port Terminal of Santos</td>
<td>2015</td>
<td>Property and cargo damage. Contaminated water poured in the water caused the deaths of 8.5 tons of fish, harming the local fishing.</td>
<td>3,443</td>
<td>1,721</td>
</tr>
<tr>
<td>Landslide in Rio de Janeiro</td>
<td>2011</td>
<td>916 confirmed deaths, 350 missing, 300,000 people directly affected.</td>
<td>4,780</td>
<td>92</td>
</tr>
<tr>
<td>Tropical Cyclone Catarina</td>
<td>2004</td>
<td>30,000 people were displaced and left homeless. In addition to 518 injured, three confirmed deaths.</td>
<td>602</td>
<td>30</td>
</tr>
<tr>
<td>Train Derailment in the Interior of São Paulo</td>
<td>2003</td>
<td>1000 meters of devastated riparian forest, a river that supplies about 250 thousand people contaminated with 670 tons of chemicals.</td>
<td>Uncertain</td>
<td>Uncertain</td>
</tr>
<tr>
<td>Oil Platform P-36</td>
<td>2001</td>
<td>11 confirmed deaths, 1,500 tons of oil released into the ocean.</td>
<td>1,462 (USD 700mm)</td>
<td>1,045 (USD 500mm)</td>
</tr>
</tbody>
</table>

Source: Terra Brasis Resseguros S.A., IBAMA, World Bank, Globo, Government of the State of São Paulo
Lessons from “Exxon Valdez”

On March 24, 1989 the supertanker Exxon Valdez collided with Bligh Reef in the Gulf of Alaska and, at the time, caused the largest oil spill in the history of the United States. Back then, it was an unprecedented environmental disaster in the United States of America (USA), and, in a certain way, with proportions analogous to the Mariana event.

Aside from the precautions taken immediately to minimize the effects of the catastrophe, the event unleashed a wave of environmental regulatory changes and prevention against oil spills in the USA.

Immediately after the event, the governor of Alaska, Jay Hammond, authorized the creation of the research group Alaska Oil Spill Commission to examine the causes of the oil spill and issue recommendations regarding possible legislative changes. The Commission issued 52 recommendations for the improvement of the sector and for regulation at the state and federal levels. The U.S. Congress adopted 50 of the 52 recommendations by the Commission.

In 1990, only one year after the event, the U.S. Congress promulgated the Oil Pollution Act (OPA) that introduced legislative innovations in the sector. It created a legal liability system, where the companies responsible for the spill would have to pay for the cleanup costs. Under this framework, the liability for economic damages and damage to the environment by offshore installations was established at US$ 75 million per incident. Damages higher than this amount would be able to be paid by the fund called the Oil Spill Liability Trust Fund, which is financed primarily through a tax on the national crude oil produced and imported oil.
Before OPA, federal law established that only people who had been physically touched by the oil could be indemnified for physical or economic damages caused by the oil spill. New legislation provided that those who had suffered economic losses would have the right to reparation of economic damages, even if they were not physically touched by the oil.

Among other preventive measures\(^{62,63,64}\), the ships were required to have double-hull tankers to transport oil in US waters. Aside from the controversy caused by cost x benefit studies\(^ {65}\), it is believed that if the Exxon Valdez ship had such a structure, approximately half of the oil would not have not leaked.

Moreover, the OPA outlined the procedures that should be carried out before beginning the perforation, and the compulsory simulation of leakages or oil spills, allowing for more effective, cautionary measures.

Analogous to the Exxon Valdez case, after the Mariana event some movements were observed, with the intention of changing and improving the prevention of similar occurrences.

Just as the Oil Spill Commission was created, the External Parliamentary Commission was instituted in the Chamber of Deputies in Brasilia to follow the developments of the rupture of the dam. On November 16, 2015, the Chamber of Deputies approved a Preliminary Report\(^ {66}\) with proposals to alter the legislation and increase the security of the mineral production sector.

Without exhausting the theme, the scope of some points discussed in the commission referred to above, included the following legal alterations:

- Reinforce the emergency measures consubstantiated in the Emergency Plan of Action already provided by Law, which shall be mandatory for all the dams;
- Increase the limit of the amount of the fine from BRL 50 million currently, to a limit of up to one-hundred times, in the case of an environmental disaster, in proportion to the level of damage caused to human health or to the environment;
- Clarify in the legislation that, regardless of when the amount of the fine is converted into services, the offender is not excused from the recovery of the damages it caused.
- Consider as dangerous waste, the mining waste deposited in the dams downstream, in which there are communities that can be affected by their possible rupture and foresee the use of economic instruments to reduce the production and the use of this waste, as well as the development of technologies with a greater social gain and a lower environmental impact. This entails that such waste be submitted to the provisions set forth in Chapter IV of the Environmental Crimes Law;
- Mandatory purchase of insurance to protect against the rupture or leakage of dams.

Other measures may also be observed, such as Decree # 8.572/2015, of November 13, 2015\(^ {67}\). Not excluding the mining company’s liability, it considers natural disaster the event resulting from the rupture or the collapse of dams that causes the movement of masses with damages to residential units. The measure aims to release funds from the Government Severance Indemnity Fund (FGTS) for the victims of the rupture of the dams in Minas Gerais.
In Brazil, the non-existence throughout all industrial segments, of a contribution fund designed as the ones introduced by the OPA, is noted. However, in both cases, before the events no such funds were effectively constituted, with the intention of mitigating losses deriving from similar occurrences.

In Brazil, the District Attorney’s Office of Minas Gerais signed a TAC with Samarco to guarantee up to one billion Reais to repair the environmental damage caused by the disaster. This is a measure, probably a first step, which reinforces the need to consider a permanent fund, similar to that which was created by the OPA.

Brazil is suffering the consequences of the largest environmental disaster in its history, and, as with what happened after the “Exxon Valdez” event,” one hopes that changes will also occur here. Though there is a long road ahead, the measures from good regulations and preventive techniques, that minimize the impacts and reduce the probability of future events, are emphasized.
Conclusion

"The Mariana Event," “The Mariana Disaster,” “The Mariana Tragedy.” When a title needed to be chosen for this special edition of Terra Report, we studied these and other alternatives. Finally, we simply opted for “Mariana”, the largest environmental disaster in the history of Brazil, and, from what we know, the largest tailings dam disaster that has ever occurred worldwide.

The manufacturing of this report, done by the team of analysts and executives from Terra Brasis, is something new, required research efforts, selection of information, conferences, calculations, organization of texts, and many editions, but at the end provided us with a feeling of great satisfaction and pride for complying with the obligation of collaborating for the improvement of our industry.

The work begins by presenting the description of a tailings dam and its operation, which is an activity that was not too well known or studied before the rupture of the Fundão Dam. We now know that in Brazil, there are approximately 600 tailings dams, of which 24 are considered of high risk.

Then, it describes the full details of the rupture of the Fundão Dam, with the release of 62 million tons of mud and waste, the overflow of the Santarém Dam, and the enormous negative consequences in lives and properties, that occurred during the trajectory of destruction and contamination of nearly 700 km, by the remaining sludge, through 17 days, and approximately 300 municipalities, until it reached the Atlantic Ocean.

Six months after "Mariana," the formal assessment of the economic and insured losses is still in the beginning. Even with the limitations and difficulties of financial estimates that an event such as this one presents, we decided to be daring and through the use of public information, collected and carefully grouped, presented, within our possibilities, the best possible estimates of the measurable losses. As detailed in the text of the work, we concluded that there was a measurable economic loss of BRL 26.3 billion, of which, also by our estimates, only BRL 2.3 billion would be insured.

For the purpose of comparison, the work concludes with the presentation of other large disasters that occurred in Brazil and with the presentation of the consequences of the collision of the supertanker Exxon Valdez in the Gulf of Alaska in 1989, causing the largest oil spill in the history of the US at the time. The comparison of “Exxon Valdez” with “Mariana” can be a strong indicator to us, of what should be improved in the market in general, from the specific legislation of the mining industry and other industries, to the most adequate insurance products to the Insurers, and even encompassing the most efficient recovery procedures of the losses that occurred and the fastest return to normal activities.

The occurrence of losses of great proportions is a reality in Brazil, and it demonstrates that there is still a large area so that, with efficient products, disseminated and well known, insurance and reinsurance may be improved, grow and render assistance to Insureds and Third Parties affected in such situations. The technical support from Insurers to Insured starts in the acceptance of risks, passing by its management and reaching an efficient regulation and indemnification of possible losses.

Much will still be debated regarding the largest environmental disaster in the history of Brazil. Terra Brasis hopes that the work done by its team, which resulted in this special edition of Terra Report, may stimulate the debate, and that “Mariana” serves as a warning to our society, and as stimulus so that our insurance industry as a whole, the Insureds, Brokers, Insurers, and Reinsurers, seek the path of a market that is increasingly more efficient for the protection of our population and development of our nation.

Terra Brasis Resseguros Team
Notes and References

Chapter: The Risk

1 - Barragem de Rejeito
http://www.maxwell.vrac.puc-rio.br/20720/20720_3.PDF

2 - O que é barragem de rejeitos?
Equipe ONB, 06/Nov/2015.
http://organicsnewsbrasil.com.br/meio-ambiente/o-que-e-barragem-de-rejeitos/

3 - Barragem de Rejeito: Avaliação dos parâmetros geotécnicos de rejeitos de minério de ferro – informações sobre os rejeitos e métodos construtivos de barragens.
Nathalia Christina de Souza Tavares Passos, 2009.

4 - Tese: Técnicas para a disposição de rejeitos de minério de ferro
Djanira Alexandra Monteiro dos Santos; Adilson Curi; José Margarida da Silva.

5 - Segundo o Ministério de Minas e Energia, o beneficiamento ou tratamento de minérios visa preparar granulometricamente, concentrar ou purificar minérios por métodos físicos ou químicos sem alteração da constituição química dos minerais.

6 - Partículas de hematita são aquelas desejáveis no processo de extração.

7 - Relatório: RIMA da 4ª usina de pelotização em Ponta de Ubu, ES
http://www.meioambiente.es.gov.br/download/RT_409_09_RIMA.pdf

8 - 200 Maiores Minas Brasileiras, Ranking Geral por Produção Anual em Toneladas (ROM) - Ano Base 2014

Chapter: The Event

9 - O que se sabe sobre o rompimento das barragens em Mariana (MG)
UOL, 06/Nov/2015.

10 - Rompimento liberou 62 milhões de metros cúbicos de rejeitos, diz mineradora
Maiana Diniz, 06/Nov/2015.

11 - Tremor? Chuva? Mas e a obra que estava sendo feita na barragem da Samarco?
Fernanda Britto, 06/Nov/2015.

12 - Samarco trabalha para evitar que mais uma barragem se rompa em Mariana – MG
Bruno Lyra, 11/Nov/2015.

13 - Rompimento de barragem da Samarco, em Mariana, completa um mês
G1, 08/Jan/2016. 
http://especiais.g1.globo.com/minas-gerais/2015/desastre-ambiental-em-mariana/1-mes-em-numeros/

14 - Veja lista de mortos e desaparecidos no rompimento de barragem em MG 
G1, 07/Nov/2015. 
http://g1.globo.com/minas-gerais/noticia/2015/11/veja-lista-de-desaparecidos-no-rompimento-de-barragens.html

15 - Bombeiros dizem ter encontrado corpo de vítima de rompimento de barragem da Samarco 
Extra, 09/Mar/2016. 
http://extra.globo.com/noticias/mundo/bombeiros-dizem-ter-encontrado-corpo-de-vitima-de-rompimento-de-barragem-da-samarco-18841412.html

16 - Mesmo sem ser tóxica, lama de barragem em Mariana deve prejudicar ecossistema por anos 
BBC BRASIL, 07/Nov/2015. 
http://noticias.terra.com.br/brasil/mesmo-sem-ser-toxica-lama-de-barragem-em-mariana-deve-prejudicar-ecossistema-por-anos,3ce8571d4e8c79e1272a82f93b6d9ef975spir6u.html

17 - O que sabemos até agora sobre os riscos à saúde da lama da barragem 
Gil Alessi, 06/Nov/2015. 
http://brasil.elpais.com/brasil/2015/11/06/politica/1446841211_527388.html

18 - Potencial poluidor de resíduo sólido da Samarco Mineração: estudo de caso da barragem de Germano 
José Maurício Machado Pires; Jorge Carvalho de Lena; Carlos Cardoso Machado; Reginaldo Sérgio Pereira, Jun/2013. 

19 - Monitoramento da Qualidade de águas superficiais do Rio Doce 
Instituto Mineiro de Gestão das Águas 

20 - Documentos sobre a Bacia 
CBH-Doce Comitê da Bacia Hidrográfica do Rio Doce 
http://www.cbhdoce.org.br/categoria/informacoesrompimentodasbarragens/

21 - Governo de Minas levanta Prejuízos e propõe Medidas 
CBH-Doce Comitê da Bacia Hidrográfica do Rio Doce 

Chapter: Values Estimate

22 - Nota Técnica nº 001/2016 IBAMA 
Brasília, 2016. 
www.ibama.gov.br

23 - Ibama diz que quase 15 mil hectares foram destruídos por desastre 
Raquel Freitas, 01/Dez/2015. 
24 - Relatório: Avaliação dos Efeitos e Desdobramentos do Rompimento da Barragem de Fundão em Mariana-MG
http://www.agenciaminas.mg.gov.br/ckeditor_assets/attachments/770/relatorio_final_ft_03_02_2016_15h5min.pdf

25 - Lama de barragem já causou a morte de 11 toneladas de peixes
Leonardo Augusto. 26/Nov/2015.
http://brasil.estadao.com.br/noticias/geral,lama-de-barragem-ja-causou-a-morte-de-11-toneladas-de-peixes,1802710

26 - Multa preliminar à Samarco soma R$ 250 milhões, afirma Dilma
Marcos de Moura, 12/Nov/2015.

27 - MPMG e MPF assinam Termo de Compromisso Preliminar com a Samarco, garantindo montante mínimo de R$ 1 bilhão para tutela ambiental emergencial
Ministério Público de Minas Gerais, 16/Nov/2015.
https://www.mpmg.mp.br/comunicacao/noticias/mpmg-e-mpf-assinam-termo-de-compromisso-preliminar-com-a-samarco-garantindo-montante-minimo-de-r-1-bilhao-para-tutela-ambiental-emergencial.htm#.VuqogeIrIdU

28 - Relatório: Comissão Externa do Rompimento de Barragem na Região de Mariana — MG (CEXBARRA)
Comissão de Deputados, Dez/2015.
http://www2.camara.leg.br/atividade legislativa/comissoes/comissoes-temporarias/externas/55a-legislatura/rompimento-de-barragem-na-regiao-de-mariana-mg/documentos/outros documentos/relatorio-apresentado-em-15-12-2015

29 - Produtores rurais têm prejuízo de R$ 23,2 milhões com rompimento de barragem em Mariana
Thiago Fernandes, 16/Fev/2016.
http://www.emater.mg.gov.br/portal.cgi?flagweb=site_tpl_paginas_internas2&id=17593#.VuqsBuIrIDU

30 - Mais de 2.500 funcionários da Samarco entram em licença remunerada
Carlos Eduardo Cherem, 09/Nov/2015.

31 - Não obstante, destaca-se que a agência de rating Fitch manteve a grade da companhia diante da expectativa de recuperação
Jornal Valor Econômico, 01/Fev/2016.

32 - Standard & Poor’s rebaixa rating da Samarco de BB- para B; perspectiva negativa
Jornal do Comércio, 03/Fev/2016.

Rafael Rosas, 01/Dez/2015.
34 - Marinha coloca relatório da lama do Rio Doce sob sigilo por 5 anos
Diony Silva, 18/Abr/2016.

35 - Polícia pede prisão de ex-presidente da Samarco e mais 6 por tragédia
Marcos de Moura e Souza, 23/Fev/2016.

36 - Demonstrações Financeiras da Samarco Mineração S.A. de Dezembro de 2015
Samarco Mineração S.A., 2016

37 - Willis é a corretora da apólice da Samarco, com ACE em seguro de Property e com Allianz em RC

38 - REUTERS informa que apólice de RC tem IS de US$ 70 milhões
Sonho Seguro, 10/Nov/2015.

39 - SES - Sistema de Estatísticas da Susep
http://www2.susep.gov.br/menuestatistica/SES/principal.aspx

40 - Terra Report - Edição número 18 – Dezembro 2015

41 - Muitas empresas brasileiras ainda não possuem proteção contra danos ao meio ambiente
Rodrigo Carvalho, 12/Fev/2016.

42 - Seguro Ambiental como Instrumento Econômico de Proteção Ambiental
Marco Antônio Parreira Ferreira e outros – 18 Congresso Brasileiro de Direito Ambiental – 2013

43 - O seguro ambiental como ferramento de gerenciamento de áreas contaminadas.
Nathália Suarti Gallinari; Pery Saraiva Neto
Livro: Aspectos Jurídicos dos Contratos de Seguro Ano III

Chapter: Other Brazilian Disasters

44 - Em 2001, explosão da plataforma P-36 deixou 11 mortos na Bacia de Campos
O Globo, 12/Ago/2013.

45 - Explosão é 3º maior acidente em plataformas da Petrobrás
Estadão, 12/Fev/2015
http://acervo.estadao.com.br/noticias/acervo,explosao-e-3-maior-acidente-em-plataformas-da-petrobras,10761,0.htm
46 - Petrobras recebe seguro da P-36
Gazeta Mercantil, 19/Jul/2001
http://infoener.iee.usp.br/infoener/hemeroteca/imagens/52961.htm

47 - Inferno na P-36 da Petrobras
Istoé, 21/Mar/2001
http://istoe.com.br/39570_INFERNO+NA+P+36+DA+PETROBRAS/

48 - Cetesb multa Ultracargo em R$ 22,5 milhões pelo incêndio em Santos
Governo do Estado de São Paulo, 15/Abr/2015.

49 - Impactos ambientais do maior incêndio de SP, no terminal da Ultracargo no Porto de Santos, podem durar 5 anos
Carol Daemon, 19/Abr/2015

50 - Operação da Ultracargo tem seguro com cobertura até R$ 550 milhões
Valor, 03/Abr/2015

51 - Terra Report Edição Especial Nº 1: Catastrofes Naturais Brasileiras
Terra Brasis Resseguros – Março 2012

52 - Ciclone Catarina
Wikipédia, a enciclopédia livre.

53 - Relatório: Avaliação de perdas e danos – Região Serrana do Rio de Janeiro
Banco Mundial, Jan/2015.
http://www.mi.gov.br/pt/c/document_library/get_file?uuid=74dde46c-544a-4bc4-a6e1-852d4c09be06&groupId=10157

54 - Desastre ambiental em Uberaba após descarrilamento de trem faz 10 anos
G1, 10/Mar/2013.

Chapter: Lessons From Exxon Valdez

55 - Oil Spills and Safety Legislation
Emilia Luoma, Publications from the Centre for Maritimes Studies, University of Turku, 2009.

56 - Oil Tracking, Containment, and Recovery During The Exxon Valdez Response

57 - Response of Common Murres to the Exxon Valdez Oil Spill and Long-Term Changes in the Gulf of Alaska Marine Ecosystem

58 - Trouble On Oiled Waters: Lessons from the Exxon Valdez Oil Spill
59 - Pill – The Wreck of the Exxon Valdez
Alaska Oil Spill Commission – Final Report

60 - Case Study: The Oil Pollution Act of 1990
Washington College of Law.
https://www.wcl.american.edu/environment/iel/sup6.cfm

61 - The Oil Spill Liability Trust Fund (OSLTF)
United States Coast Guard
http://www.uscg.mil/npfc/About_NPFC/osltf.asp

62 - Maritime Pollution – OPA 90
http://www.law.tulane.edu/WorkArea/DownloadAsset.aspx?id=7614

63 - Deepwater Horizon and the Patchwork of Oil Spill Liability Law

64 - Then & Now: Changes Since the Exxon Valdez Oil Spill
http://nsgl.gso.uri.edu/aku/akuw94001/akuw94001_part2h.pdf

65 - The economics of double-hulled tankers
Brown, Scott and Savage, Ian, Northwestern University: vol 23, n. 2. 1996.
http://faculty.wcas.northwestern.edu/~ipsavage/419-manuscript.pdf

66 - Relatório: Comissão Externa do Rompimento de Barragem na Região de Mariana – MG (CEXBARRA)
Comissão de Deputados, Dez/2015.

67 - DECRETO Nº 8.572, DE 13 DE NOVEMBRO DE 2015
Brasília, 13 de novembro de 2015
# Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Telephone</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paulo Eduardo de Freitas Botti</td>
<td>President, CEO</td>
<td>+55 11 3320 5056</td>
<td><a href="mailto:paulo.botti@terrabrasis.com.br">paulo.botti@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Carlos Roberto De Zoppa</td>
<td>Director Technical Vice President</td>
<td>+55 11 3320 5058</td>
<td><a href="mailto:carlos.zoppa@terrabrasis.com.br">carlos.zoppa@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Bernardo Nolasco</td>
<td>Investments Director</td>
<td>+55 11 3320 5165</td>
<td><a href="mailto:bernardo.nolasco@terrabrasis.com.br">bernardo.nolasco@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Rodrigo Botti, ARe</td>
<td>General Director, CFO &amp; COO</td>
<td>+55 11 3320 5050</td>
<td><a href="mailto:rodrigo.botti@terrabrasis.com.br">rodrigo.botti@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Paulo Hayakawa</td>
<td>Underwriting Diretor</td>
<td>+55 11 3320 5053</td>
<td><a href="mailto:paulo.hayakawa@terrabrasis.com.br">paulo.hayakawa@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Beatriz Americano</td>
<td>Administrative Director</td>
<td>+55 11 3320-5051</td>
<td><a href="mailto:beatriz.american@terrabrasis.com.br">beatriz.american@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Rafael Abad</td>
<td>Underwriting Consultant</td>
<td>+55 11 3320 5082</td>
<td><a href="mailto:rafael.abad@terrabrasis.com.br">rafael.abad@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Arthur Sanches</td>
<td>Underwriting Coordinator</td>
<td>+55 11 3320 5074</td>
<td><a href="mailto:Arthur.sanches@terrabrasis.com.br">Arthur.sanches@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Priscila Grossi, ARe</td>
<td>Risk Analyst</td>
<td>+55 11 3320 5080</td>
<td><a href="mailto:priscila.grossi@terrabrasis.com.br">priscila.grossi@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Juliana Miranda</td>
<td>Claims Analyst</td>
<td>+55 11 3320 5077</td>
<td><a href="mailto:juliana.miranda@terrabrasis.com.br">juliana.miranda@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Gustavo Palheiro</td>
<td>Legal Analyst</td>
<td>+55 11 3320 5078</td>
<td><a href="mailto:gustavo.palheiro@terrabrasis.com.br">gustavo.palheiro@terrabrasis.com.br</a></td>
</tr>
<tr>
<td>Bianca Traszi</td>
<td>Risk Intern</td>
<td>+55 11 3320 5066</td>
<td><a href="mailto:bianca.traszi@terrabrasis.com.br">bianca.traszi@terrabrasis.com.br</a></td>
</tr>
</tbody>
</table>
This document was prepared by Terra Brasis Resseguros S.A. ("Terra Brasis Re") for informational purposes only.

Terra Brasis Re, its partners, companies under common control, its directors, employees and agents do not express any opinion, do not guarantee nor assume any responsibility for the adequacy, consistency, or completeness of any information contained herein, or any omission regarding this report. This publication is also not designed to be a complete statement or summary of markets or strategies discussed in this document. None of the people mentioned in this paragraph shall be liable for any loss or damage of any kind arising from the use of the information contained herein, or which may be obtained by third parties by any other means. Terra Brasis Re should not be construed as providing financial, tax, or legal advice.

The information contained herein was obtained from public sources, and Terra Brasis Re has not conducted an independent verification of this information. Any projections or forecasts contained in this report are based on subjective estimates and assumptions about events and circumstances that have not yet occurred and are subject to significant variations. Thus, it is not possible to ensure that results from any projects or forecasts contained in this document will be effectively verified.

This publication is only valid on the date hereof, and future events can undermine its conclusions. Terra Brasis Re assumes no responsibility to update, revise, amend, or cancel this publication due to any future event, unless previously requested.

It is not the obligation of Terra Brasis Re to implement the procedures in this document, nor is Terra Brasis Re responsible for any inaccuracies in any negotiations or transactions relating to this report. No investment or financial decision should be based solely on the information presented here.

Any opinion related to the object of this document that may be manifested by Terra Brasis Re should be considered solely as a suggestion of the best way to bring about the various subjects of this report.

All information contained in this report should be kept strictly confidential and can only be released, quoted or reproduced in whole or in part, with the prior written consent of Terra Brasis Re for people who have agreed to treat such information as confidential.