

# SAMARCO – IMMEDIATE CAUSES TO THE FAILURE OF THE FUNDÃO DAM

SUMMARY OF CONCLUSIONS PRESENTED BY  
THE FUNDÃO TAILINGS DAM REVIEW PANEL

2016-10-12 / SVEMIN MILJÖKONFERENS / GÄLLIVARE  
SWECO GRUVDAMMAR OCH DEPONERINGSHANTERING

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# Introduction

- In 2015 on November 5 the 110 m high Fundão Tailings Dam failed in a liquefaction flowslide.
- More than 60 Mm<sup>3</sup> of tailings and water spread as a mud flow in the river system along its 650 km path to the Atlantic Ocean.
- In total 18 people lost their lives.
- The owner Samarco Mineração S.A. (BHP Billiton Brazil Ltda, Vale S.A.) initiated The Fundão Tailings Dam investigation to determine its cause

[http://www.samarco.com/en/balanco/ \(161011\)](http://www.samarco.com/en/balanco/ (161011))  
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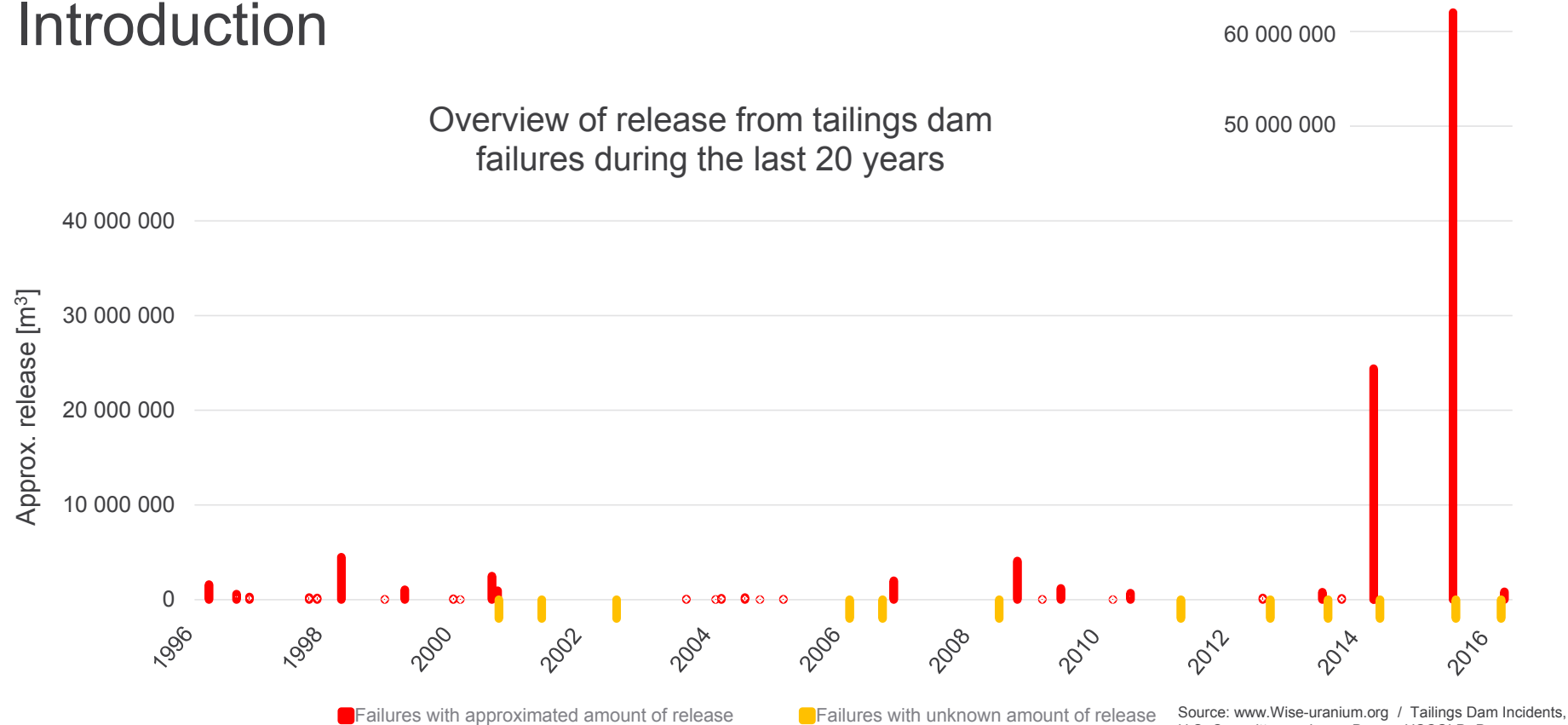
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# Introduction

Overview of release from tailings dam failures during the last 20 years





# Immediate causes to the Fundão dam failure

- **Start of construction:** 2007
- **Dam type:** Upstream raised tailings dam
- **Dam height at failure:** 110 m (EL +900 m)

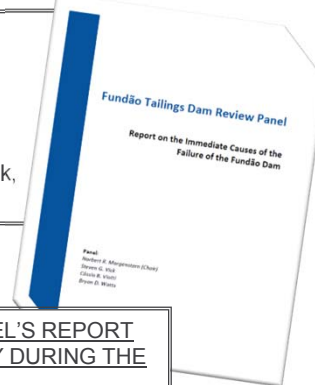
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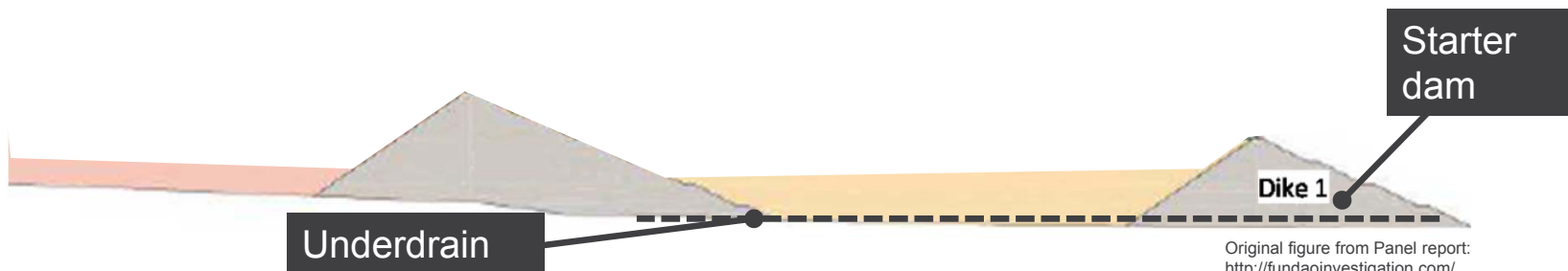
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**Panel:** Norbert R. Morgenstern (Chair), Steven G. Vick, Cassio B. Viotti, Bryan D. Watts

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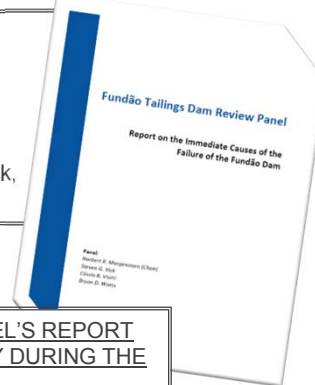
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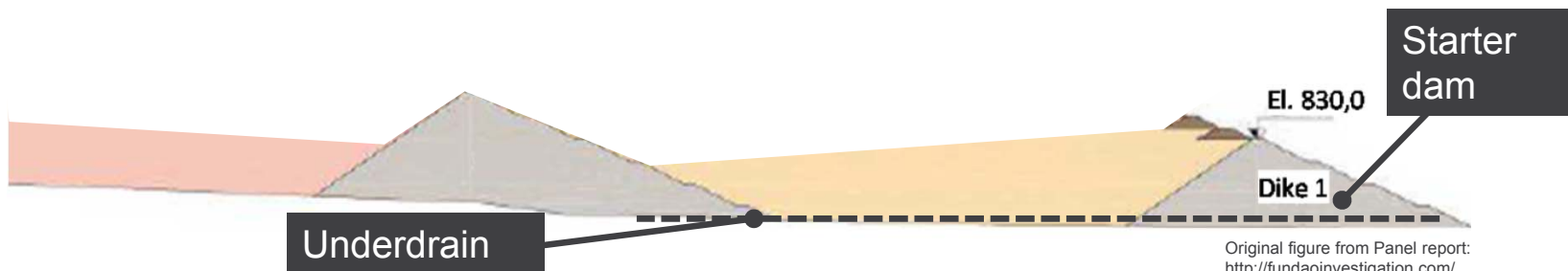
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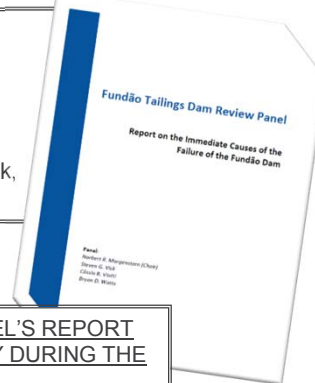
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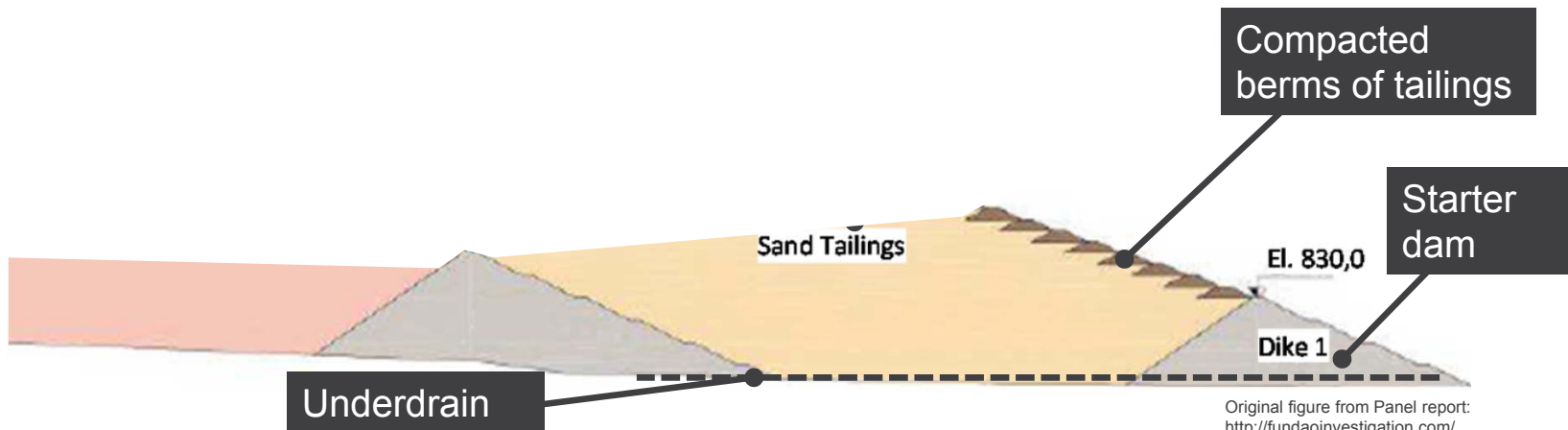
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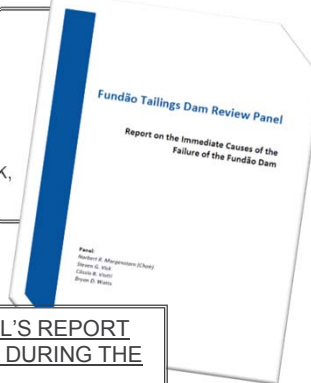
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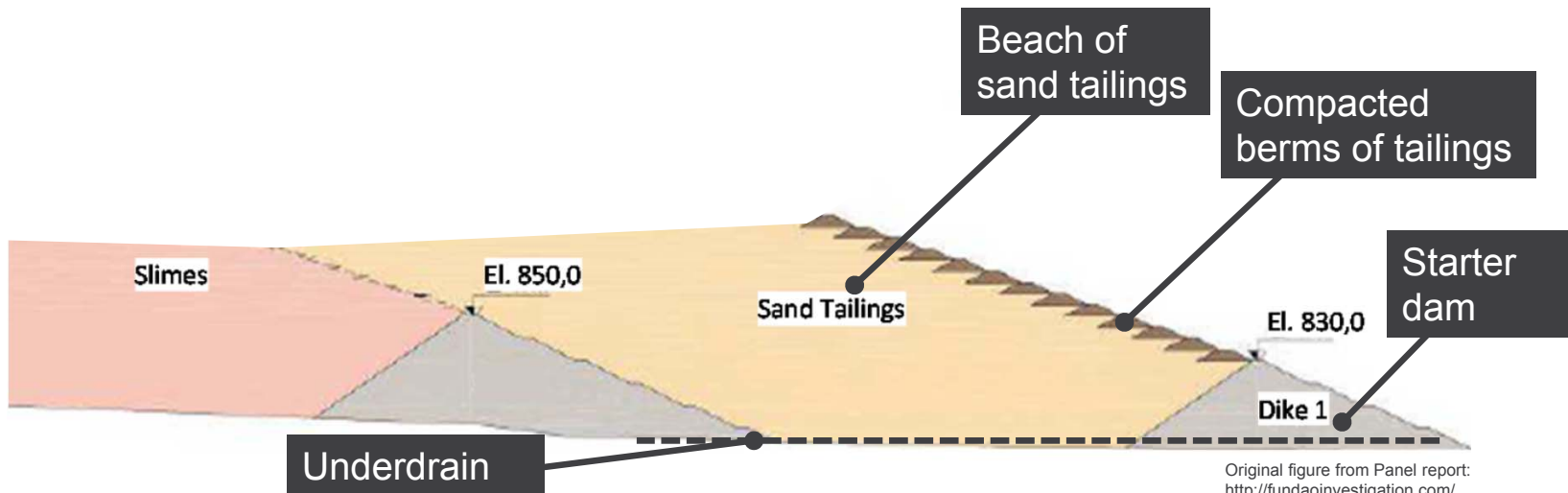
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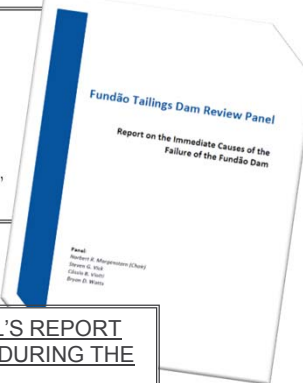
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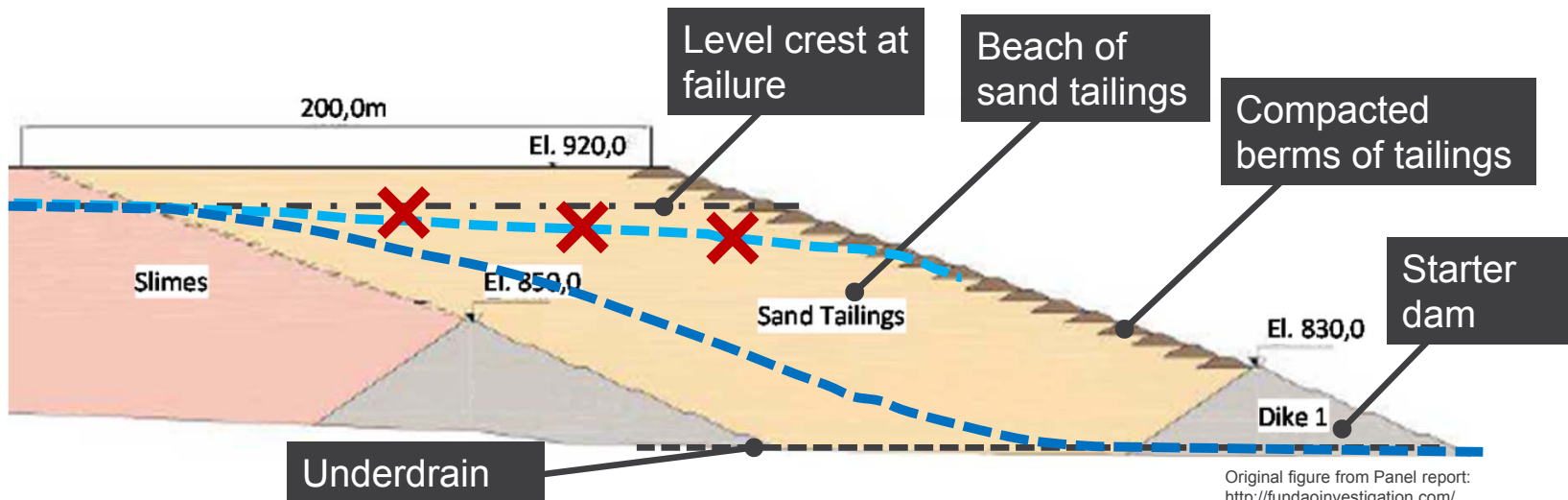
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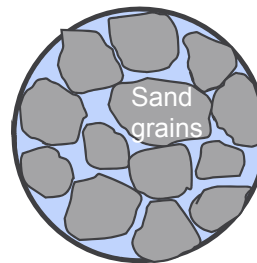
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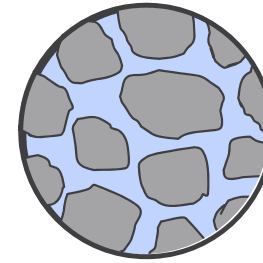
# Liquefaction

- Conditions required:
  - **Contractive material** > volume decreases during shearing because the particles move together.
  - **Saturation** > all voids are filled with water. If shearing occurs in a saturated contractive tailings excessive pore pressure may generate.
  - **Trigger mechanism, rate of loading vs. drainage capacity** > if the loading (shearing) is large enough or repeated many times the pore pressure in the voids may increase to such extent that friction between the grains is lost.



## Normal pore water pressure

Saturated soft sand.  
Strength maintained because friction from the grains touching.



## High pore water pressure

Saturated soft sand.  
High pore water pressure may break the friction between the grains causing liquefaction.

# Series of events and conditions

- The dam failure occurred because of a series of events and conditions that allowed the failure to take place

## Main incidents and conditions:

- a) Year 2009 - Damage to starter dam
- b) Year 2011,12 - Slime deposition issues
- c) Year 2012 - Shift of the dam crest alignment (the “set back”)



## Year 2009: Damage to the Start dam (Dike 1)

- April 2009, large seepage flows carrying tailings on the downstream slope.
- Seepage flows emerged above underdrain outlet level.

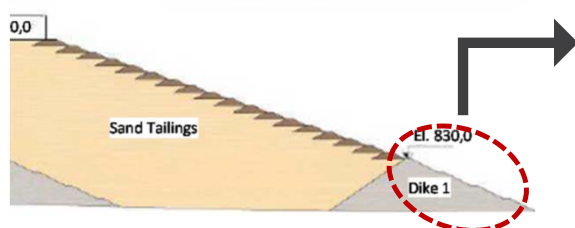
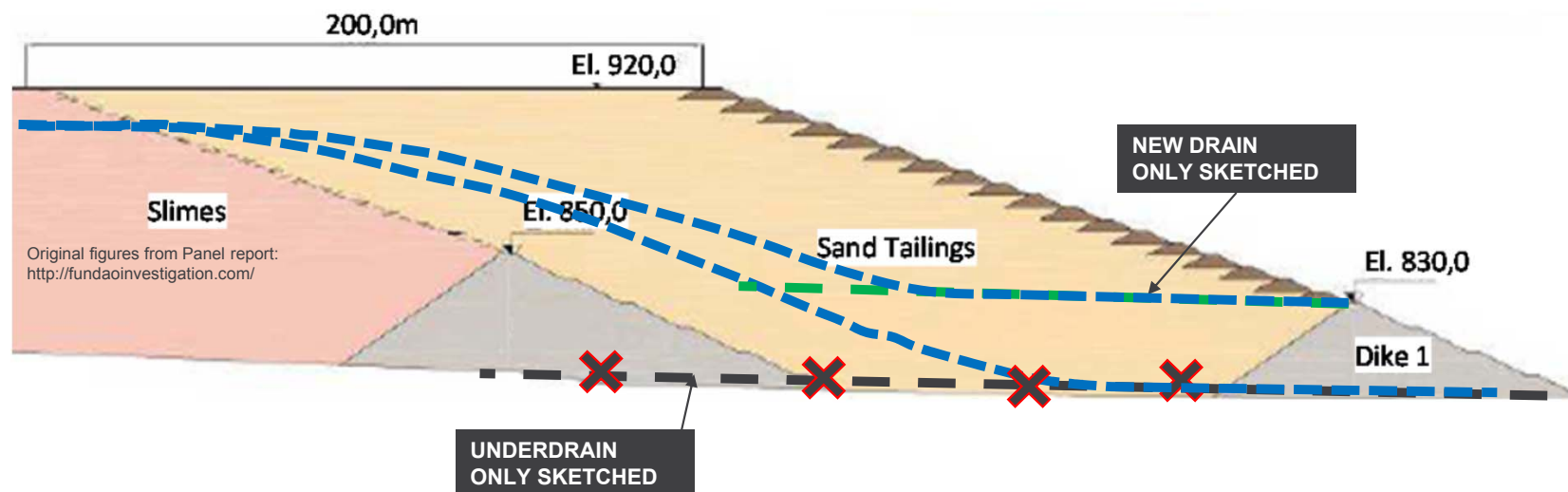


Figure from Panel report:  
<http://fundaoinvestigation.com/>



# Consequences

- Underdrains were sealed as they could not be repaired. → One of the most important element became inoperative
- A new blanket drain constructed on the surface of the tailings → The sand tailings below and upstream of the new blanket drain remained saturated



## Year 2011/12 – Slime deposition issues

- During 2011 and 2012 slime was rerouted through an overflow channel into the Fundao reservoir.
- The original and revised design specified a minimum 200 m wide beach of sand tailings to control saturation.



Original figures from Panel report: <http://fundaoinvestigation.com/>

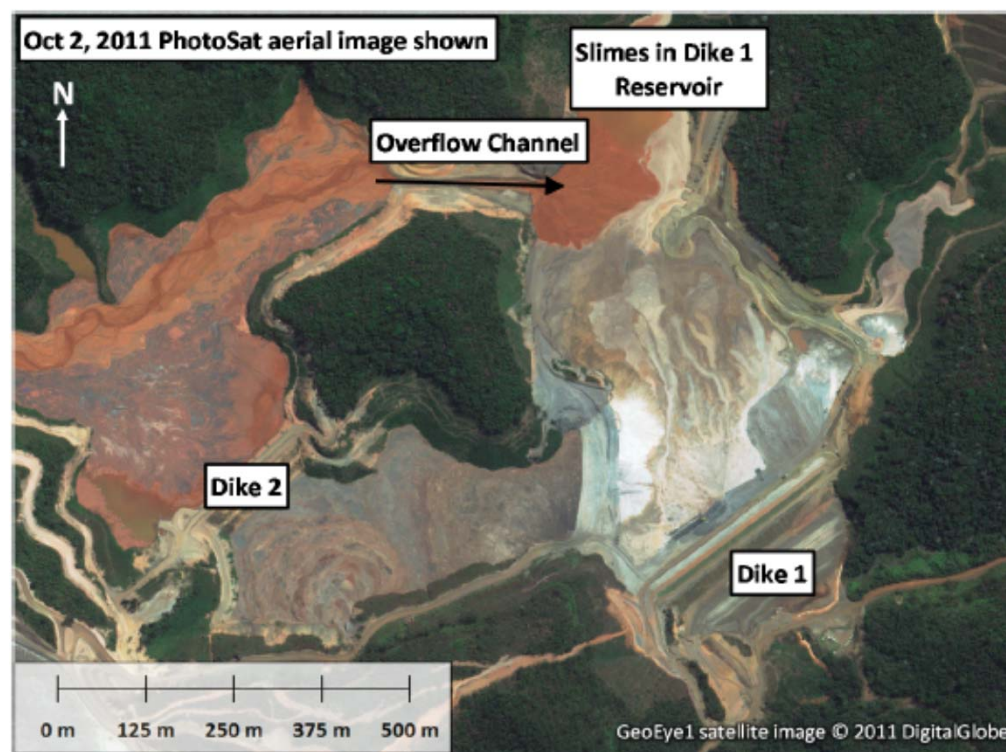
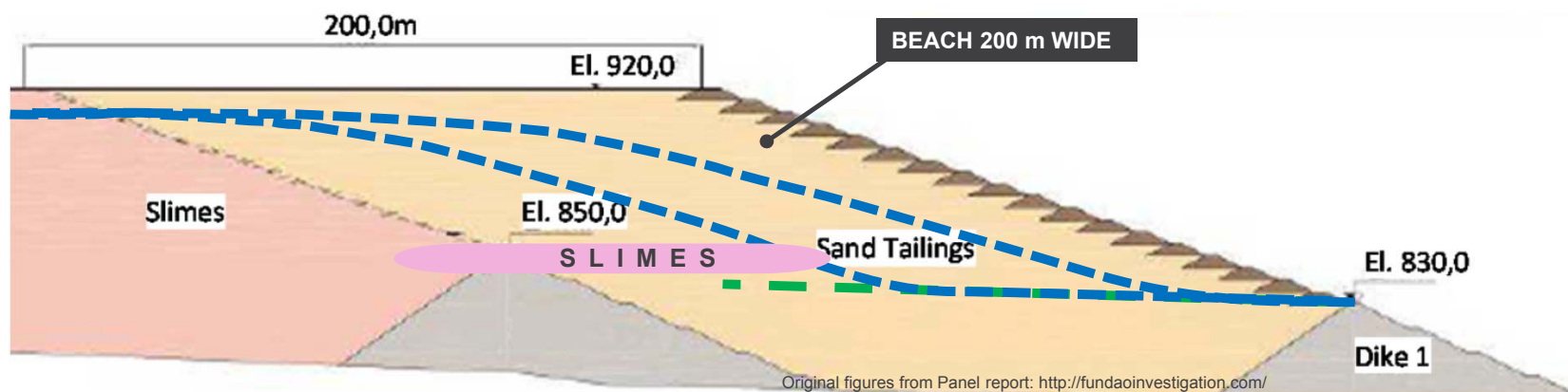


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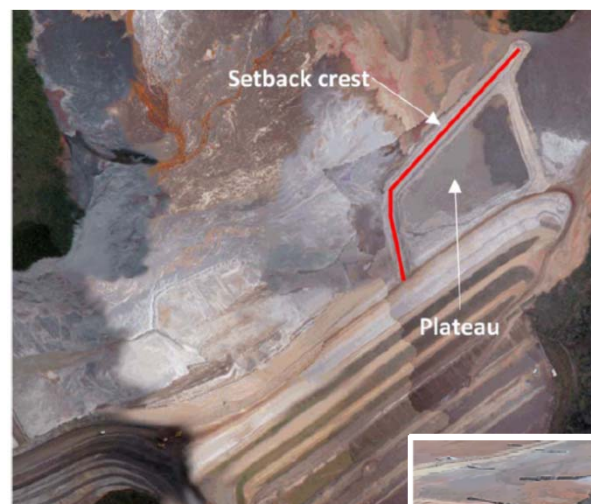
# Consequences

- Deposition of slimes in areas where this was not intended in design
  - At times beach only 60 m wide.
  - Slimes near the downstream slope and below the raised dam construction.



## Year 2012: The left abutment “Set back”

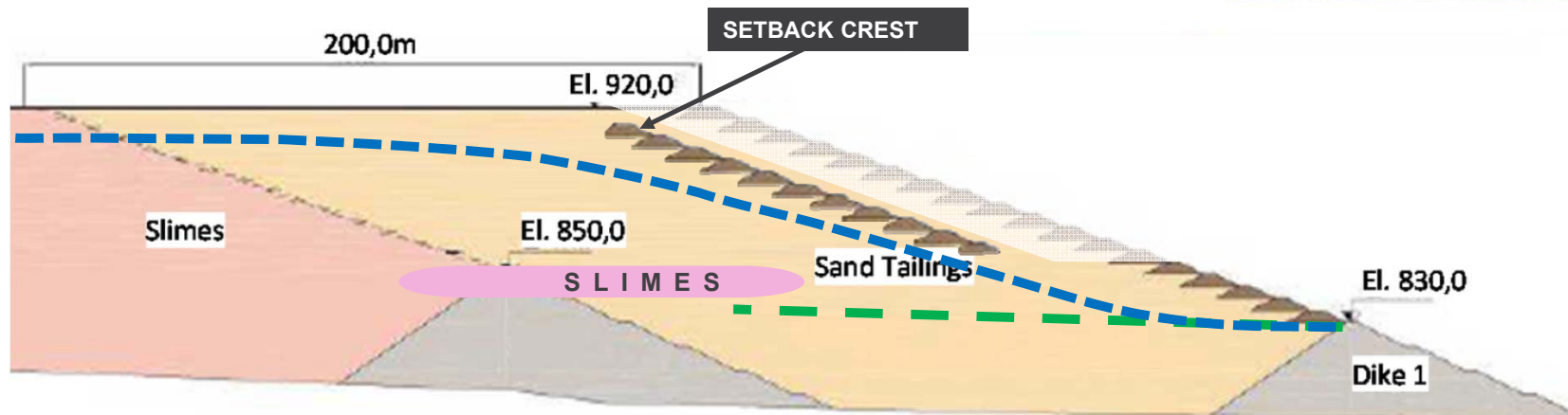
- In October 2012 the dam alignment (crest) was moved upstream from its original design, called the “setback crest”.
- The change due to structural integrity issues of a abutment concrete gallery, that drained left abutment run-off water.





# Consequences

- The setback had significant effects. Moving the embankment back, toward the impoundment, caused it to be raised over the slimes deposited in 2011 and 2012.



Original figure from Panel report: <http://fundaoinvestigation.com/>

# Immediate causes to the Fundão dam failure

- Liquefaction:



Contractive (loose) material



Saturation



Trigger mechanism – liquefaction by lateral extrusion [[Movie clip 2.5 min, start at 2:53](#)]



Thanks for your attention!!



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